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MASTER'S THESIS

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1 Preface

This master's thesis is based on my experience working within concept and field developments for the oil and gas industry during the last eight years. The agile methodology developed is based on the belief that the current standard project management models can be improved. The work and processes developed in this thesis are my own work. However, the thesis has benefitted from many colleagues' experience and hard work. Developing an oil and gas field is a team effort and so is developing a new way of working. The target audience is oil and gas professionals interested in exploring how agile models can be applied to field development projects within the oil and gas industry. There is limited literature on this subject, and this thesis does not aim to fully cover the complex task of implementing an agile PMLC model for oil and gas field development projects. Rather, the goal is to demonstrate the potential for improvement and outline an agile PMLC model that can be developed further.

The thesis was written in collaboration with Equinor ASA.

Lastly, I would like to thank Hanne for all the support and encouragement.

2 Abstract

This master's thesis explores a new way of working in early phase oil and gas field development projects by developing an agile PMLC model for concept development for field development project and for unmanned concept facility design.

Use of the agile model for field development project makes it easier to identify the most optimum concept, delivering reduced cost and increased quality. Identification of the optimum concept with a minimum amount of resources is critical for the future of the oil and gas industry, with low oil prices, increased competition and a strong focus on sustainability. The proposed agile PMLC is to be set up so that iterations, or cycles, can be performed on the complete business case as early as possible. The project should develop a Minimum Viable Product concept early on and then perform iterations on the overall business case. This will ensure that global project KPIs are optimized and energy is spent on improving the areas with the biggest impact, thereby avoiding sub-optimization and waste. The approach requires an innovative approach and specific attention to the PMI knowledge areas of integration, scope, HR and communication management across the project. Systems and tools to effectively manage these knowledge areas are developed in detail as part of this work.

Several challenges have been identified for implementation of the agile PMLC model. Most of these relate to the complex nature and size of oil and gas field developments. Ways of effectively managing change, communication and interfaces will be critical in order to expand the typical team size for agile projects. A digital tool known as a Business Case Simulator is outlined in this thesis in order to mitigate some of that risk by enabling effective communication of basis of design, changes and monitoring of KPIs.

The potential of the agile model has been proven through literature study and personal experience, but further work is needed to mature the model further, including supporting tools and verification of the potential through implementation in a project. Due to time and budget limitations it has not been possible to verify the agile PMLC model as part of this thesis, however, based on discussions with senior project managers at Equinor is it likely that it will succeed. This thesis forms the basis for further work that is necessary to establish a strong foundation for the broad implementation of agile PMLC in early phase oil and gas projects. A stepwise approach is suggested for implementation at Equinor, with a pilot on a small greenfield project in order to test the model, develop contract strategies appropriate for agile models and acquire knowledge for further improvements.

Developing and designing an unmanned and remote operated facility set high requirements to optimum solutions designed for maximum operability. An agile PMLC model for facility design has been developed in order to ensure high degree of user involvement in design, which is key in order to identify the optimum unmanned solutions. The principles of such a model have been developed in Equinor during the last years and referred to as Design-2-Operate process. The agile iterative model as described in this thesis are my work based on those principles. Key principles are co-management of design between facility and operations, based on iterative design process where main operability KPI's are reviewed at end of each iterations forming the basis for prioritization of tasks in the iteration. This agile model is ready for implementation in concept studies for an unmanned facility project.

3 Introduction

This thesis is based on personal experience gained from project work from 2016 to 2020 within concept development for unmanned and remotely operated field developments at Equinor. I had the opportunity to work in the early phases of several field development projects during this period, which has given me a broad understanding of concept development in complex environments.

My aim is to reflect on the experiences gained from concept development work during these years and connect these experiences, both good and bad, to literature and research. The early phase of a field development project shares many similarities with product development and IT projects, which use an agile Project Management Life-Cycle model with promising results. Compared to a typical oil and gas project which is based on a standard PMLC model with stage gates, how can an agile work methodology be applied to major oil and gas projects? This thesis will explore how agile methodology can be applied to early phase field development projects and propose a new way of working based on agile principles.

3.1 Background

Equinor have launched a program called "New Ways of Working" to challenge the organization to find smarter and more efficient ways of working. The importance of working more efficiently, finding the best solutions and reducing overall costs has become increasingly important given the recent development in oil price following the coronavirus crisis. The early phase, up to the selection of a concept, of a field development project is defined by high uncertainty with respect to technical solutions and varying degrees of clarity on what the ultimate goal actually is. The similarities with a product development project and/or start-up company are undeniable, with high uncertainty and large span in possible solutions. The rate of change is high as the project develops based on knowledge learned from studies and analysis. My personal experience is that this high rate of change is challenging for the project and work processes are usually not setup to handle continuous changes to scope. This results in added hours and costs, and in the worst-case scenario deliverables are misaligned with company strategies and goals. What can the oil and gas industry learn from other industries and literature on how projects are organized and executed in order to perform product development, improve product quality and handle a high degree of change?

Equinor has also launched a program to develop Remote Operated Factories (ROF^{TM}) as a tool to enable development of marginal offshore fields as a response to lower commodity prices (Figure 3-1). In order to be successful, Remote Operated Factories require a different focus than traditional projects. The consequences of a design error or faulty equipment that results in maintenance or downtime is much higher than on traditional manned projects, as there are no onsite personnel to perform corrective actions. Reducing maintenance and improving availability is therefore even more critical for project success than for manned field developments. Therefore, it is more critical than ever to set up project organizations and cooperative structures capable of finding and developing the optimum concept with respect to maintenance, availability and cost. In order to respond to the increased focus on user design and collaboration, is it interesting to explore how agile methodologies can be applied to facility engineering.

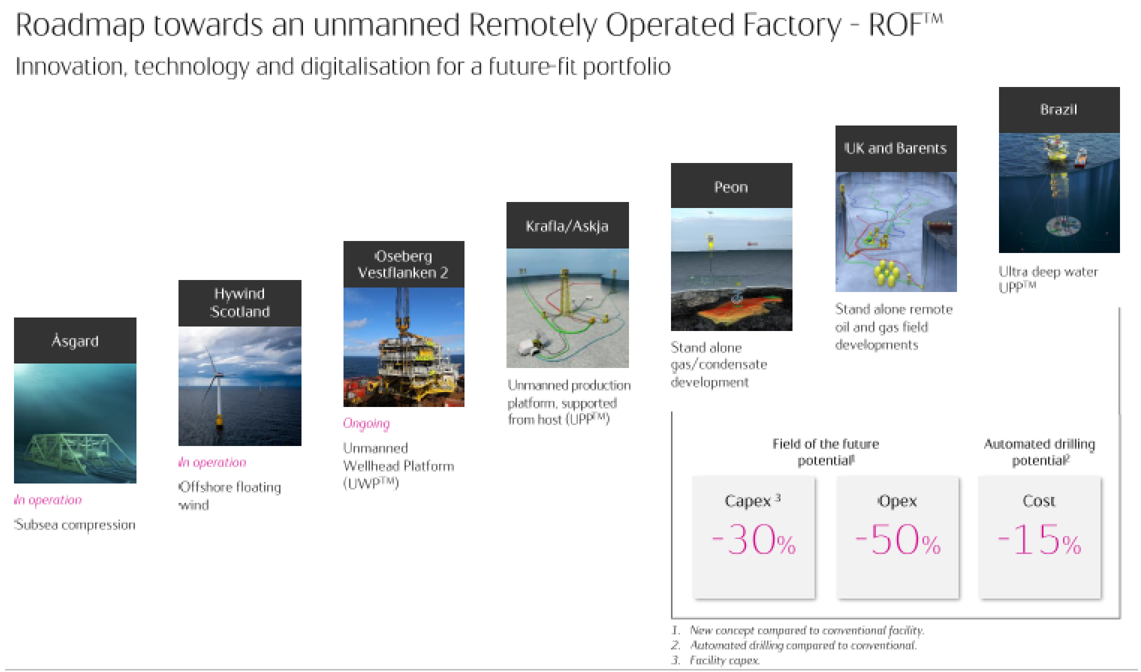

Figure 3-1 – Equinor Remote Operated Factories roadmap, Capital Market Update presentation 2018 (Equinor, 2018).

3.2 Problem statement

This master's thesis will investigate how an agile PMLC model can be applied to concept development phase of an oil and gas field development project and maturation of a Remote Operated Factories concept.

The following two problem statements will be addressed:

1. Develop an agile PMLC model that can be implemented in Equinor for a field development up to DG2 milestone (concept select).
2. Develop an agile PMLC model that can be implemented in Equinor for maturation of Remote Operated Factories facility design to DG2 milestone.

In addressing the above problem statements, this study will use works in the literature, personal experience and the results of discussions with Equinor senior project management personnel.

It will not be feasible to test or verify the effect of the developed PMLC model as part of this thesis, as that will require establishing a field development project and tracking the results for a 2- to 3-year period, which is a typical timeline for a project from its inception to concept select[1]. The discussion and conclusion will therefore be limited to personal experience, studies in the literature and company experience. Then conclusions can be made on the likelihood of success and the way forward.

A PMLC model will be developed with an outline of critical deliverables and activities, based on the 5 process groups as defined by Project Management Institute (PMI) (scope, planning, execution, monitor and control, close out) and the 10 knowledge areas. In addition, the thesis discusses how

[1] Refers to project milestone (DG2) where main concept for the field development is selected

digital tools and software can be developed in order to assist implementation and success of the developed agile PMLC model.

Due to time constraints, the following items are not part of the scope of this work. These are, however, critical items that must be developed in parallel:

- company organization, capacity and strategy for agile methodology
- procurement models, contracts and cooperation with contractors and vendors for agile methodology

This thesis will build on the existing governing documentation and processes at Equinor and seek to adapt already existing requirements and processes to the needs of the thesis instead of developing new ones. This will reduce the added workload and ease implementation in the Equinor organization.

4 Literature review

The literature review gathers information on the existing Equinor governing system and also relevant information from the literature. This, together with personal experience, will form the basis for development of an agile PMLC model and how it can be implemented in Equinor's project execution model.

4.1 Equinor requirements and experiences

Project execution in Equinor is governed by FR05, Project Development. All projects are to follow a stage gate model as shown in Figure 4-1. A long list of concepts will be developed to DG1 and concept selected at DG2.

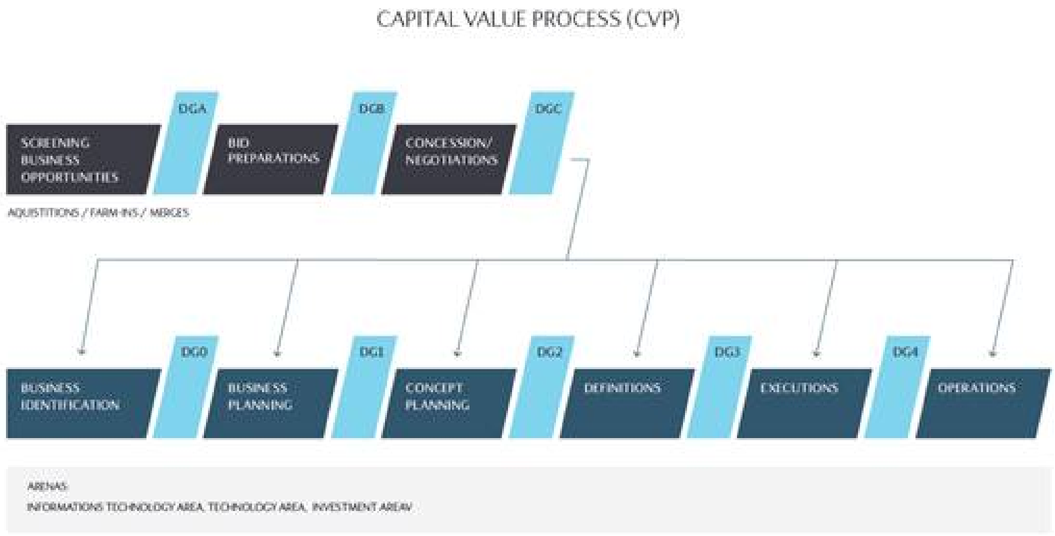

Figure 4-1 - Equinor Capital Value Process, stage gate.

A set of work processes is required between each decision gate, specifying the work to be done. According to the PD233 process in Equinor governing systems, DG1 to DG2 will be run in two phases, with screening studies in phase 1 up to SSVP (SubSurface Validation Point) where the design basis is updated according to the latest subsurface information. Phase 2 follows with concept studies based on the updated design basis. Concept select is based on the concept studies in phase 2.

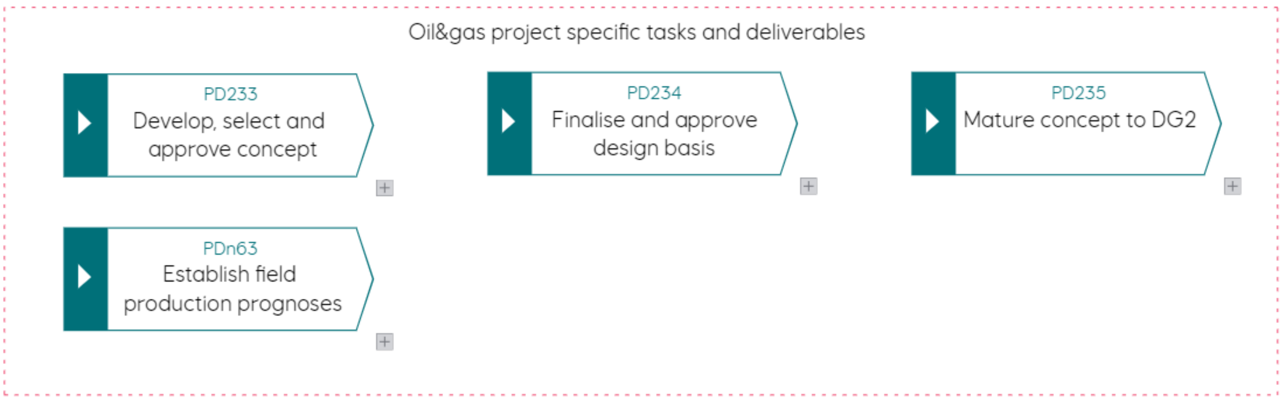

Figure 4-2 - Main work processes DG1 to DG2 for field developments in Equinor.

Deliverables at each decision gate are given in WR2704 as "deliverable list for Investment projects". This together with the technical deliverables at each milestone described in TR1244 as "technical requirements for facilities scope and cost estimate classes – offshore projects" form the requirements for each decision gate.

Experience transfer and interviews have been performed with key personnel from relevant projects combined with personal experience from concept development for large offshore field developments. As a significant amount of information is viewed as critical to business, it is not disclosed here. However, this background is important for the conclusion of this thesis.

4.2 Project experience

This section briefly describes how working and adjusting the total business case based on iterations and focus on total business case drivers resulted in significant improvement in project economics. There are several factors affecting the improvement seen in Figure 4-3. However, the main factor is that a holistic view of the entire business case is taken. By ensuring focus on the entire business case, key business case drivers were identified, and actions taken to improve these. (Note: due to classified information, the figure has been anonymized.)

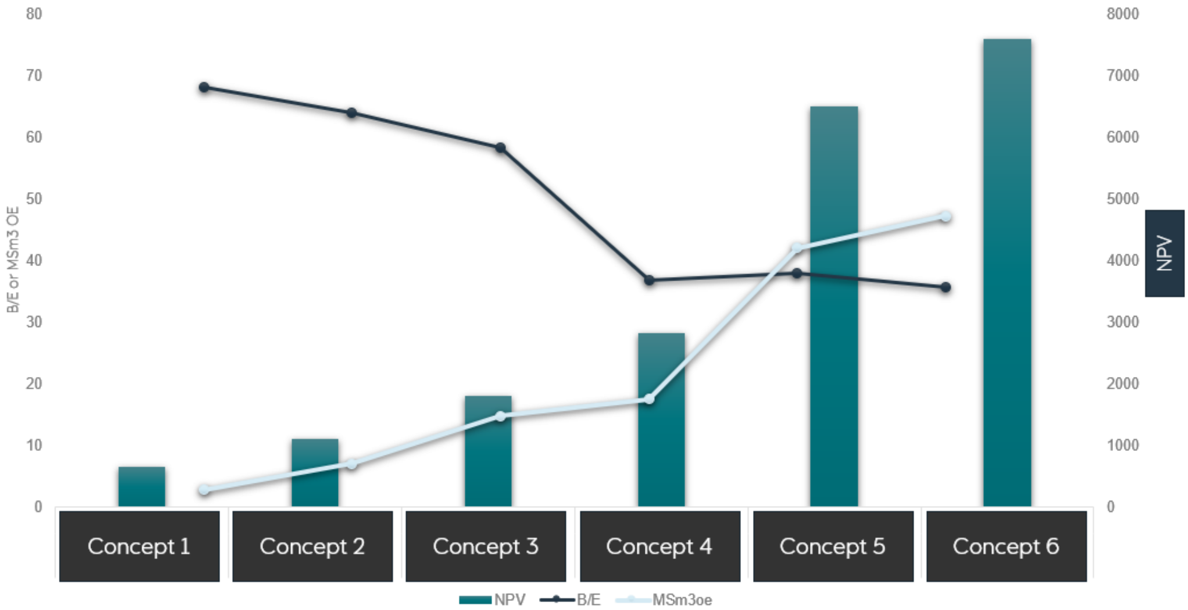

Figure 4-3 - Concept development for an Equinor Field Development (Source: Equinor ASA).

The work method for each concept was an iterative approach to each business case, as can be seen in Figure 4-4. A significant number of iterations were run on each case in order to optimize the entire business case. This process tells us that an iterative method with total business case focus gives better results. The drawback was that the work was time consuming and a significant number of hours were lost in unproductive coordination of input to run the calculations, combined with misalignment between the sub-projects. The experience gained from this work is one of the main pillars of the agile PMLC model developed in this thesis.

		Key economical targets					CAPEX [MNOK'16]					
Rank	Tag #	project B/E [USD/bbl]	NPV [MNOK]	IRR [%]	CEI	Total Capex	Brownfield facility	Greenfield facility	SURF	D&W	Pre DG3 engineering	Other
iter1_0	UWSOf_6_13_2_000_rev1	43,1	5 470	24,1 %	0,93	18 604	1576	5 189	6 419	5 221	200	0
iter1_5	UWSOf_6_11_2_000_rev1	45,9	5 172	23,2 %	0,93	18 775	1576	3 443	8 192	5 364	200	0
x1	UWSOf_7_12_2_000_rev1	46,1	5 467	22,7 %	0,94	19 925	1576	3 443	8 643	6 064	200	0
iter1_6	UWSOf_6_12_2_000_rev1	43,8	5 911	23,8 %	1,03	19 614	1576	3 443	8 643	5 753	200	0
x2	UWSOf_7_13_2_000_rev2	45,1	5 462	24,64%	0,97	18 577	1576	4 501	6 918	5 135	447	0
	UWSOf_9_11_3_000		-	0,0 %	0	0	0	0	0	0	0	0
	UCSOf_9_14_3_000		-	0,0 %	0	0	0	0	0	0	0	0
	UCSOf_12_17_3_000		-	0,0 %	0	0	0	0	0	0	0	0
	UWSOf_9_14_3_000a	41,3	5 189	23,35%	0,88	19 276	1576	3 559	8 843	4 851	447	0
	UWSOf_9_14_3_000b	43,0	4 780	21,34%	0,81	19 276	1576	3 559	8 843	4 851	447	0
x2	UWSOf_9_14_2_000_rev2	43,0	6 445	24,46%	1,13	19 527	1576	4 401	7 163	5 940	447	0
x2	UWSOf_9_14_2_001_rev2	42,2	6 657	25,69%	1,16	19 527	1576	4 401	7 163	5 940	447	0
iter2_4	UWSOf_9_14_2_002_rev2	40,0	7 346	30,06%	1,26	19 716	1576	4 591	7 163	5 939	447	0
x1	UWSOf_8_15_2_000_rev1	45,0	5 836	23,2 %	0,98	20 252	1576	4 996	7 431	6 050	200	0
x1	UWSOf_9_17_3_000_rev1	44,7	6 168	22,7 %	0,98	21 103	1576	3 455	9 997	5 876	200	0
x1	UWSOf_10_19_2_000_rev1	44,9	6 312	23,1 %	1,04	21 654	1576	6 387	6 123	7 368	200	0
iter1_1	UWSOf_10_19_3_000_rev1	45,4	6 244	22,4 %	0,97	21 927	1576	4 782	8 789	6 581	200	0
x2	UWSOf_11_18_3_000_rev2	42,9	7 111	25,02%	1,17	21 986	1576	4 287	8 308	7 368	447	0
x2	UWSOf_11_18_3_001_rev2	42,6	7 252	25,47%	1,20	21 984	1576	4 287	8 308	7 366	447	0
x2	UWSOf_11_18_3_001a_rev2	42,1	7 420	26,22%	1,22	21 984	1576	4 287	8 308	7 366	447	0
x2	UWSOf_11_18_3_001b_rev2	43,6	6 981	24,35%	1,15	21 984	1576	4 287	8 308	7 366	447	0
x2	UWSOf_11_18_3_001c_rev2	0,0	-	0,0 %	0	20 859	1576	4 287	8 308	6 241	447	0
x2	RNB2017_20160915_rev2	44,9	6 550	23,65%	1,08	21 629	1 221	4 287	8 308	7 366	447	0
x2	APZ_OPT_20161007_rev2	43,6	6 934	24,76%	1,14	22 157	1576	4 460	8 308	7 366	447	0
iter2_1	UWSOf_11_18_3_002_rev2	41,0	7 806	28,97%	1,27	22 162	1576	4 476	8 296	7 366	447	0
x2	UWSOf_11_18_3_002a_rev2	40,5	7 954	29,79%	1,29	22 162	1576	4 476	8 296	7 366	447	0
x2	UWSOf_11_18_3_002b_rev2	41,7	7 571	27,74%	1,23	22 162	1576	4 476	8 296	7 366	447	0
x3	UWSOf_11_18_3_003a_rev3	41,1	7 970	27,58%	1,27	21 408	1576	4 875	8 072	6 437	447	0
x3	UWSOf_11_18_3_003b_rev3	40,9	8 023	27,06%	1,28	21 384	1576	4 875	8 049	6 437	447	0
x3	UWSOf_11_18_3_003c_rev3	44,4	6 892	23,22%	1,10	21 384	1576	4 875	8 049	6 437	447	0
x3	UWSOf_11_18_3_003d_rev3	42,5	7 702	25,63%	1,21	21 682	1576	4 875	8 347	6 437	447	0
x3	UWSOf_11_18_3_003e_rev3	41,7	7 967	27,26%	1,21	22 142	1576	4 969	8 713	6 437	447	0
x3	UWSOf_11_18_3_003f_rev3	40,8	8 063	27,97%	1,28	21 408	1576	4 875	8 072	6 437	447	0
x3	UWSOf_11_18_3_003g_rev3	40,1	7 363	28,65%	1,25	19 276	1576	3 559	8 843	4 851	447	0
x3	UWSOf_11_18_3_003h_rev3	0,0	-	0,0 %	0	19 276	1576	3 559	8 843	4 851	447	0
x3	UWSOf_11_18_3_003i_rev3	0,0	-	0,0 %	0	19 276	1576	3 559	8 843	4 851	447	0
x3	UWSOf_11_18_2_000_rev3	0,0	-	0,0 %	0	20 725	1576	6 305	5 603	6 793	447	0
x1	UWSOf_10_19_4_000_rev1	46,3	6 140	21,6 %	0,93	22 752	1576	3 391	10 856	6 730	200	0
x1	UGfSOf_8_12_2_000_rev1	45,0	5 551	21,9 %	1,04	19 033	1576	3 356	7 754	6 147	200	0
x1	UGfSOf_7_12_2_000_rev1	45,9	5 297	21,1 %	0,98	18 921	1576	3 356	7 991	5 798	200	0
iter1_2	UGfSOf_10_17_2_000_rev1	45,2	5 663	21,3 %	1,02	19 683	1576	4 961	6 526	6 419	200	0
x2	UGfSOf_9_13_2_000_rev2	44,1	5 905	23,05%	1,10	18 194	1576	4 367	6 229	5 575	447	0
iter2_2	UGfSOf_9_14_2_000_rev2	40,3	7 355	28,00%	1,32	19 179	1576	4 520	6 698	5 939	447	0

	OPEX		Resource utilization		Execution		Operation				HSE		
Tag #	Abandonment	OPEX total [MNOK'16]	Total recoverables	Scalability / tie-in	Facility tech risk	D&W tech risk	Ease of operation	PE	petec risk	Third-party dependency / lifetime	Environment	Energy Efficiency	Safety
UWSOf_6_13_2_000_rev1	2 834	4 080	2	3	3	2	3	3	3	3	2	1	1
UWSOf_6_11_2_000_rev1	2 499	8 354	0	0	0	0	0	0	0	0	0	0	0
UWSOf_7_12_2_000_rev1	2 636	8 381	0	0	0	0	0	0	0	0	0	0	0
UWSOf_6_12_2_000_rev1	2 636	8 549	0	0	0	0	0	0	0	0	0	0	0
UWSOf_7_13_2_000_rev2	3 043	10 903	0	0	0	0	0	0	0	0	0	0	0
UWSOf_9_11_3_000	0	0											
UCSOf_9_14_3_000	0	0											
UCSOf_12_17_3_000	0	0											
UWSOf_9_14_3_000a	3 229	12 622	0	0	0	0	0	0,87	0	0	0	0	0
UWSOf_9_14_3_000b	3 229	12 845	0	0	0	0	0	0,87	0	0	0	0	0
UWSOf_9_14_2_000_rev2	3 149	11 158	0	0	0	0	0	0	0	0	0	0	0
UWSOf_9_14_2_001_rev2	3 149	11 158	0	0	0	0	0	0	0	0	0	0	0
UWSOf_9_14_2_002_rev2	3 149	11 158	0	0	0	0	0	0	0	0	0	0	0
UWSOf_8_15_2_000_rev1	2 935	9 531	0	0	0	0	0	0	0	0	0	0	0
UWSOf_9_17_3_000_rev1	3 013	9 164	0	0	0	0	0	0	0	0	0	0	0
UWSOf_10_19_2_000_rev1	3 130	10 705	0	0	0	0	0	0	0	0	0	0	0
UWSOf_10_19_3_000_rev1	3 394	10 318	0	0	0	0	0	0	0	0	0	0	0
UWSOf_11_18_3_000_rev2	3 606	12 148	0	0	0	0	0	0	0	0	0	0	0
UWSOf_11_18_3_001_rev2	3 606	12 148	0	0	0	0	0	0	0	0	0	0	0
UWSOf_11_18_3_001a_rev2	3 606	12 148	0	0	0	0	0	0	0	0	0	0	0
UWSOf_11_18_3_001b_rev2	3 606	12 148	0	0	0	0	0	0	0	0	0	0	0
UWSOf_11_18_3_001c_rev2	3 406	11 966	0	0	0	0	0	0	0	0	0	0	0
RNB2017_20160915_rev2	3 606	12 148	0	0	0	0	0	0	0	0	0	0	0
APZ_OPT_20161007_rev2	3 606	12 148	0	0	0	0	0	0	0	0	0	0	0
UWSOf_11_18_3_002_rev2	3 606	12 560	0	0	0	0	0	0,00	0	0	0	0	0
UWSOf_11_18_3_002a_rev2	3 606	12 560	0	0	0	0	0	0	0	0	0	0	0
UWSOf_11_18_3_002b_rev2	3 606	12 560	0	0	0	0	0	0	0	0	0	0	0
UWSOf_11_18_3_003a_rev3	3 606	15 381	0	0	0	0	0	0,87	0	0	0	0	0
UWSOf_11_18_3_003b_rev3	3 606	15 381	0	0	0	0	0	0,87	0	0	0	0	0
UWSOf_11_18_3_003c_rev3	3 606	15 381	0	0	0	0	0	0,87	0	0	0	0	0
UWSOf_11_18_3_003d_rev3	3 606	15 419	0	0	0	0	0	0,87	0	0	0	0	0
UWSOf_11_18_3_003e_rev3	3 606	15 466	0	0	0	0	0	0,87	0	0	0	0	0
UWSOf_11_18_3_003f_rev3	3 606	11 648	0	0	0	0	0	0,89	0	0	0	0	0
UWSOf_11_18_3_003g_rev3	3 229	12 845	0	0	0	0	0	0,87	0	0	0	0	0
UWSOf_11_18_3_003h_rev3	3 229	12 845	0	0	0	0	0	0,87	0	0	0	0	0
UWSOf_11_18_3_003i_rev3	3 229	12 845	0	0	0	0	0	0,87	0	0	0	0	0
UWSOf_11_18_2_000_rev3	3 606	11 366	0	0	0	0	0	0,87	0	0	0	0	0
UWSOf_10_19_4_000_rev1	3 478	9 405	0	0	0	0	0	0	0	0	0	0	0
UGfSOf_8_12_2_000_rev1	2 543	7 856	0	0	0	0	0	0	0	0	0	0	0
UGfSOf_7_12_2_000_rev1	2 582	7 877	0	0	0	0	0	0	0	0	0	0	0
UGfSOf_10_17_2_000_rev1	2 441	7 724	0	0	0	0	0	0	0	0	0	0	0
UGfSOf_9_13_2_000_rev2	2 819	10 819	0	0	0	0	0	0	0	0	0	0	0
UGfSOf_9_14_2_000_rev2	2 991	14 861	0	0	0	0	0	0,00	0	0	0	0	0

Figure 4-4 - Case matrix for per cycle (Source: Equinor ASA).

4.3 External literature

A literature review was performed in order to gather relevant information to be used as the basis for this work. Searches were performed in relevant databases and in the literature along with keywords. This section presents the main findings that are used as input and references for the work performed. In the book *Effective Project Management* (Wysocki, 2019) are Figure 4-5 used to illustrate which PMLC model to use depending on the solution and the goal uncertainty. The theory behind this is that a project with unkown solution and/or uncertain goal require a model that is better suited to adapt to changes and develop the optimal solution. A standard project model will not be suitable for an environment with a high frequency of change.

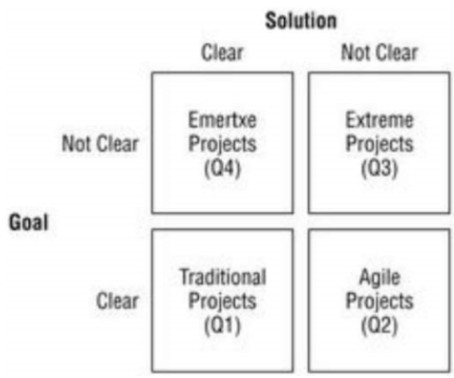

Figure 4-5- Categorization of project models after goal and solution uncertainty (Wysocki, 2019).

Wysocki proposes the use of a comanager project organization in order to effectively ensure that the customer is involved and directs project work (Figure 4-6). Experience from using such a model is reported to be positive in aligning business/customer needs with project prioritization. User involvement is critical for success in an agile project model life cycle, which can be secured by using a comanager model.

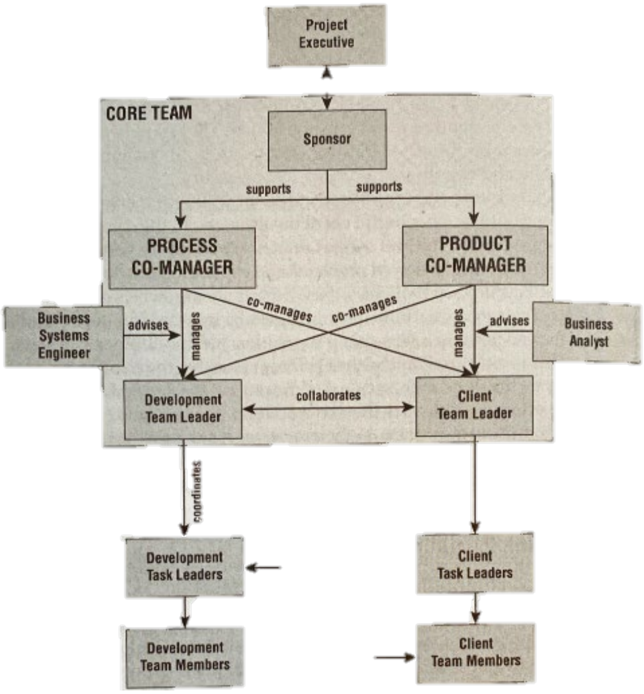

Figure 4-6 - Comanager project organization (Wysocki, 2019).

In the SPE article "Agile Field Development Planning: A Systems Approach" (Ciccarelli, McLachlan, Singh, & Thomson, 2018), an agile project model based on system thinking for early phase concept optimization and selection is presented. The method developed for oil and gas projects builds on what can be learned from other industries, such as the automotive, aerospace and software industries. The approach resulted in 30% cost savings and 18 months' reduced schedule, which are significant improvements. The main elements can be interpreted as the following:

- integrating team with all functional areas with a holistic view of the total business case
- utilizing sprints instead of large and lengthy work packages
- developing smart models that capture the complete system-enabling rapid iterations
- using Minimum Viable Product (MVP) design thinking
- ensuring quality and consistency in decision making and avoid biases

"By starting with the end in mind; using integrated multi-discipline teams; applying Decision Quality to guide and judge concept select work; and incorporate systems thinking to better model assets/projects, certainty can be increased, returns can be maximized as cognitive bias is minimized" (Ciccarelli et al., 2018).

Scrum-based project management for oil and gas is explored in the article "Agile-Scrum for Facility Design Project Management" (Sljivar & Gunasekaran, 2018), and the main workflow elements are presented. The article concludes that "during waterfall design project management phase gate process change adversely affects the project because defined planning approach is used for non-defined creative/empirical/unpredictable design work. This leads to end users conflicting with the collaboration. Cost savings could be realized by choosing an AS framework and having frequent collaborations with operations and construction during the design phases of the capital project.

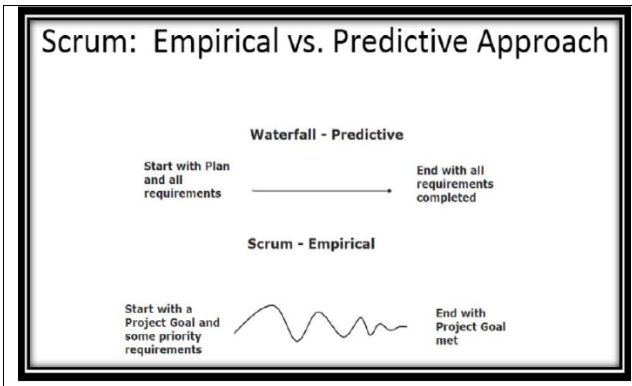

Figure 4-7 - Traditional versus Scrum-based project management (Sljivar & Gunasekaran, 2018).

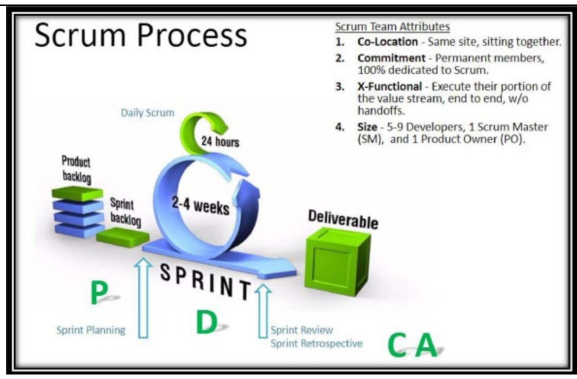

Figure 4-8 – Scrum process (Sljivar & Gunasekaran, 2018).

(Praveen Sam & Airani, 2017) showed how correct implementation of digital tools during project execution and building a digital ecosystem for the plant benefit both the project and the operational phase. Implementation of IT tools and continuous development of these from the engineering phase to the operational phase are critical. The age of digitalization can provide the foundation needed to run agile PMLC models on larger projects, at least in the early phase. (Ayca Tarhan, 2013) finds that agile model had a 79% increase in productivity and 57% reduction in defects compared to an iterative work approach for software development. This illustrates the potential gain for agile work methods. Similar results could be expected with correct implementation of agile work processes for early phase field development in oil and gas. On the other hand, Schmidt's (2018) conference paper, which investigated the actual effect compared to expected effect of agile methodologies on physical product development, found that expectations are usually higher than the actual real effects. The same paper argued that agile work methodologies for physical products are immature, and expectations are likely too high. The conclusion is that proper implementation will give better results; however, these results will likely be below the expected top management level.

The term "fuzziness" is an important parameter-setting direction when selecting a project management model. In this thesis the term is used to describe the degree of unknowns for a project based on the definition given by (Brun, 2011) (Figure 4-9).

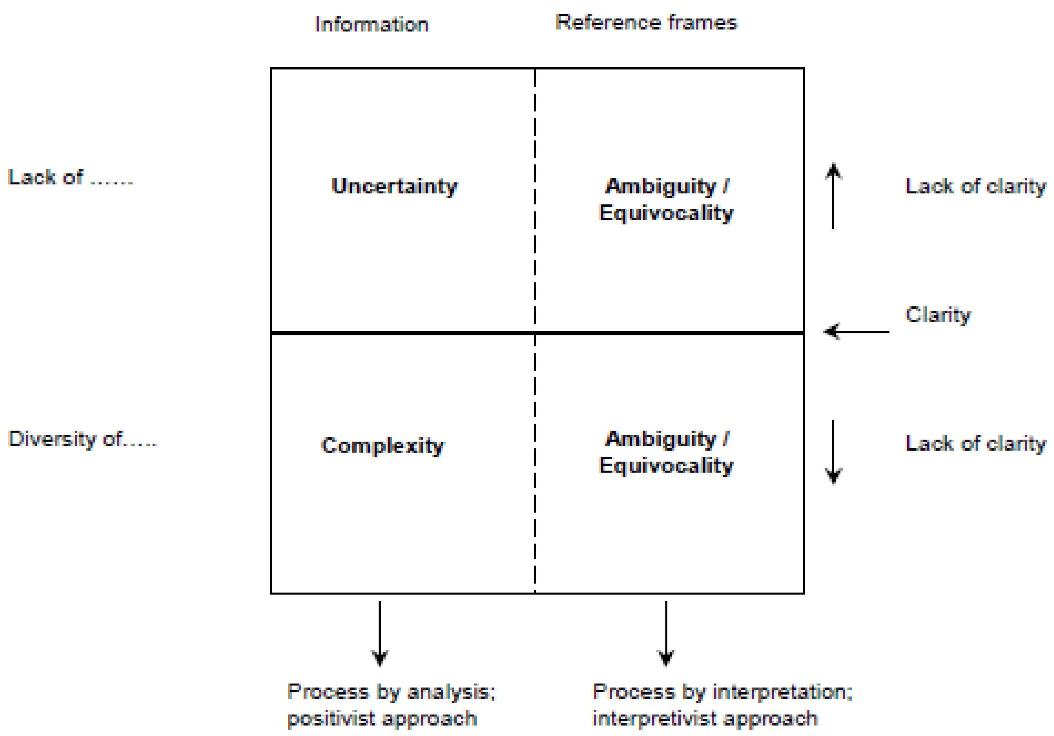

Figure 4-9 - Classification of fuzziness as defined by Brun (2011).

5 A new approach to early phase field development

In this section an agile PMLC model will be developed for early phase oil and gas field development projects and will look at how such a model can be implemented at Equinor. The discussion and information provided is based on personal experience from early phase work with greenfield projects combined with literature and best practices in other industries. The goal is to develop a work methodology that can reduce man hours on a project while improving decision quality and identifying the optimum concept with respect to the identified selection criteria.

My own personal experience is aligned with findings from (Ciccarelli et al., 2018), in which a significant cost reduction and accelerated schedule was found for the concept through an agile work process based on system thinking. Working on a greenfield FPSO project toward a feasibility decision gate, using a small integrated team consisting of highly skilled persons covering the total business case (subsurface, drilling and well, facility and commercial), delivered significant improvements to the project's economic robustness. Similar experience and improvements were achieved for a greenfield development in the North Sea (see Section 4.2), where the concept was optimized by running several iterations on the total business case over a relatively short period of time (4 to 5 months). The total business case was optimized by utilizing prototype design thinking, instead of optimizing separate parts of the product: This enabled alignment with and focus on the main project drives. Both the literature and my personal experience show that the use of small integrated teams working in an agile PMLC model with a holistic business case approach is more likely to succeed and to identify the optimum business case or product (Wysocki, 2019).

A greenfield oil and gas development is complex and typically requires a broad spectrum of competences, ranging from subsurface, drilling and well expertise, to topside facilities and commercial experts. Due to the scale and complexity involved in an oil and gas field development project is a key success factor to ensure integration and alignment across the project's organization. The magnitude and complexity of interfaces within the project are the main challenges to an effective agile work process. The challenge lies in the details of how to organize a project according to agile principles and work process/tools that can support an agile way of working. Based on own work experience, teams tend to spend too much time on details, study the wrong concepts (or too many concepts), and are unable to identify solutions that require "outside the box" thinking. In addition, there are iteration periods in the total business case that are too long because of the excess time spent on the input coordination of economic analysis, risk and quality assessments.

Based on the literature and personal experience in other industries, an agile PMLC model for the total business case should be able to reduce engineering hours, deliver concepts that are more aligned to company goals, and improve overall quality. The following section will look into how an early phase oil and gas field development project could be run according to agile principles and how digital tools could facilitate the successful implementation of said project.

5.1 Agile PMLC model for early phase field development

Firstly, there is overwhelming evidence that an agile PMLC model will deliver better results and products for a project with a high degree of fuzziness (Wysocki, 2019). Early phase field developments are categorized by high uncertainty and an ever-changing framework. There is not much information nor many facts available; and what information is available is typically uncertain (subsurface data and physical facts) combined with a large cohort of stakeholders that influences how the concept shall be developed (selection criteria). Following the literature recommendation, an early phase oil and gas field development should therefore be implemented after an agile PMLC model, or in some extreme cases, in order to effectively handle the high frequency of change and adapt to overall strategy adjustments.

For large companies with extensive project portfolios, it is important to maintain a stage gate model with quality control and top-level management involvement in way that ensures alignment with company strategy and prioritization of projects across the company portfolio. Between the decision gates, the project follows an agile PMLC model in its early phase up to the concept select. Maintaining the stage gate model will simplify implementation in Equinor ASA, as this is a familiar process. There is typically one year between each stage gate, from DG0 to DG3, and a distinct change in work and mentality between each gate, making it feasible to combine a stage gate and agile model.

As the project moves through the different phases, fuzziness is reduced, and the project model must adapt to an increasing number of project members, contractors and vendors. In a typical field development, the interfaces and project members increase significantly from the early phase to the execution stage, and a more traditional project setup is likely the best choice in FEED and afterward. Due to the significant increase in man hours, contracts and interfaces will consequently change handling be complex and lengthy. The change and interface management process is likely to break down if following an agile model for the field development. However, sub-projects or parts of the delivery could be organized after agile principles as long as scope changes do not influence other sub-projects.

The following PMLC model is proposed in order to facilitate optimum concept development (Figure 5-1 and Figure 5-2), while maintaining the stage gate model used at Equinor. The choice between adaptive or iterative method will depend on degree of fuzziness and the specificities of the project.

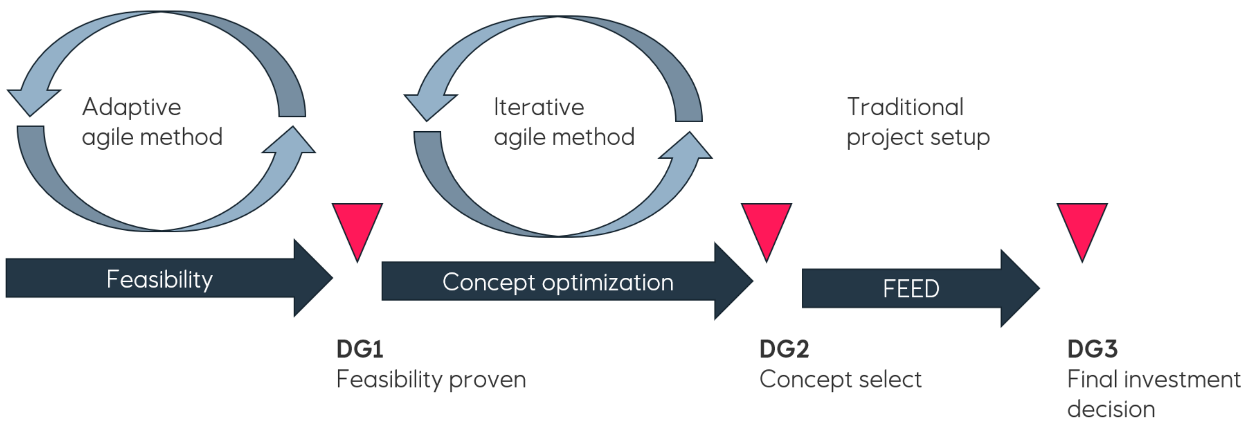

Figure 5-1 - PMLC model for early phase project development: a combination of agile and stage-gate models.

The PMLC model between each decision gate is shown in Figure 5-2 based on (Wysocki, 2019). The typical time frame between each decision gate is around 12 months, making it possible to run several iterations or cycles between the decision gates.

The setup for the cycle or iterative approach would be similar; however, the scope changes are less significant in an iterative approach. For example, changes to the main project drivers and strategic goals impact the project significantly and should be defined at decision gate 1, and changes from DG1 to DG2 are based on technical or economic changes improving project economics and targets. As the structure would be similar for both approaches, the phase from DG1 to DG2 will be used as the basis for this study.

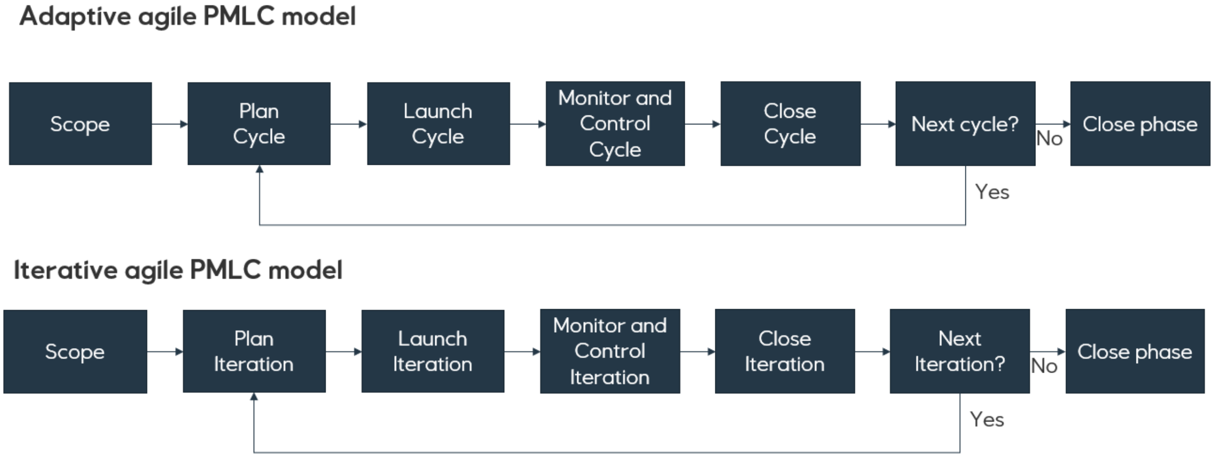

Figure 5-2 - Agile PMLC models for adaptive and iterative workflows (Wysocki, 2019).

An iterative agile process with 4 iterations is described in more detail in Figure 5-2. Depending on time and complexity, the number of iterations should be adjusted and optimized for each project. At the start of each iteration tasks are agreed on and prioritized by all team members. Deliverables at end of each iteration must be agreed on at iteration kick-off with respect to detail and quality. It is important that each iteration ends with a complete business case, or Minimum Value Product, such that alternatives can be compared, and improvements can be made to the overall business case (Ciccarelli et al., 2018). The level of detail will increase from iteration to iteration, as more of the conceptual decisions are frozen and analyses performed.

For a field development project there are a number of activities that can and must progress outside of the conceptual iteration cycles: for example, technology qualification programs, technical surveys and data analysis such as seismic interpretation. Results from these independent activities must feed into the iteration cycle at the appropriate times, and the concept must be adjusted accordingly. Understanding new information from surveys and technology development critically impact the concept, and functionality must not be frozen before the best data is made available.

Management of the project management knowledge areas (e.g. scope management) are described in the following sections.

Figure 5-3 and Table 1 shows an overview of process groups and knowledge areas with key deliverables. This thesis will only focus on the key deliverables that require something different than a traditional PMLC model, marked in green. Key success knowledge areas in an agile early phase PMLC model are: integration, scope, HR and communication management. Each of these topics will be addressed in this section. Time, cost, quality and procurement are not the most important areas in the early phase, as cost level and contract complexity are limited. Only through excellent management of the other knowledge areas can time, cost and quality be handled efficiently by highly skilled project personnel.

A key knowledge area for concept development of a field development project is integration management, which ensures that all parts of the project deliver on the optimization goals of the total business case.

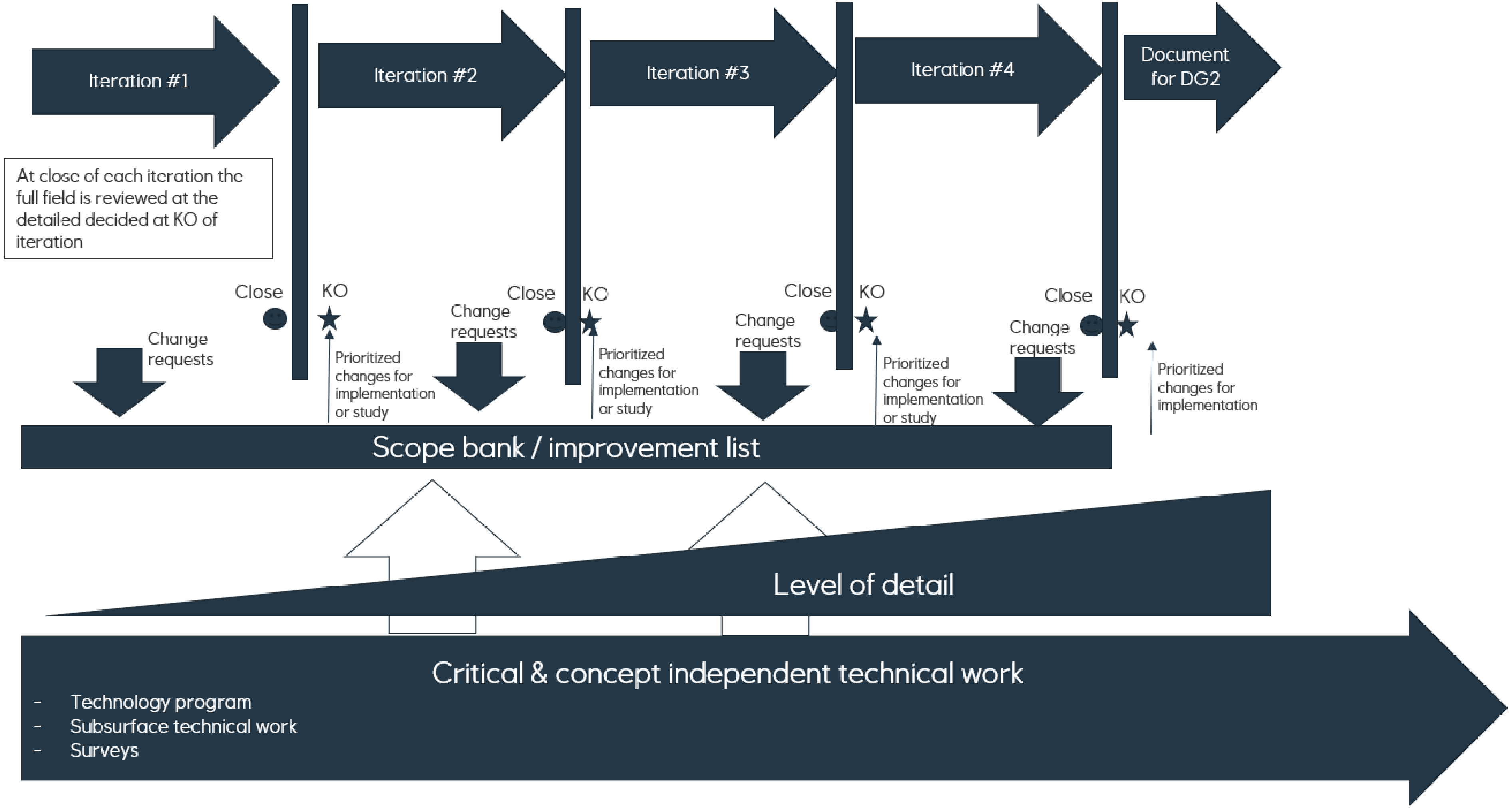

Figure 5-3 - Concept optimization iterative agile workflow from DG1 to DG2.

Table 1 - Overview PMI knowledge areas and process groups (Institute, 2017). Key areas prioritized, up to DG2, for discussion are marked in green, with key deliverables in the matrix.

Knowledge areas	Process Groups				
	Initiating	Planning	Execute	Monitor & control	Closing
1. Integration mgmt.	- Develop project charter and mandate	- Update design basis	- Execute meeting structure		- Finalize design basis
2. Scope mgmt.	- Develop requirement document structure	- Define work packages - Develop contractor scope of work - Update functional requirements	- Maintain scope bank		- Finalize functional requirement documents
3. Time mgmt.					
4. Cost mgmt.					
5. Quality mgmt.					
6. Human resources mgmt.		- Project manning and competence			
7. Communication		- Develop meeting structure - Develop information sharing structure			
8. Procurement					
9. Stakeholder					

5.1.1 Integration management

A field development project consists of several significantly different functional areas (Figure 5-6). Each area requires a different set of work methods and expertise. Aligning schedule, prioritizing of tasks, risk assessments and technical understanding across the functional areas are challenging due to project organization size, drives, knowledge and location. Keeping the project aligned, ensuring consistency and delivering on the same improvement targets are the key success factors for the project. Personal experience has been that the most important factors in the early phase are the interface between functional areas and a holistic view of the complete business case. In the phase leading up to DG2 the maturation of the subsurface occurs, which is highly important, and the leveraging of new information to improve the business case is critical. Changes as the result of better subsurface understanding are key for the project in this phase, and all other functional areas must follow this development.

The design basis document must be established early and is the only document to store information relevant for all parts of the project, thereby keeping all functional areas in the project aligned. This document should contain information that influences more than one functional area and should include the basis for change control on overall business case. Equinor's governing process, PD233, has two milestones related to updates of the design basis during the concept phase, 1) at start of concept studies and 2) after the SSVP milestone, as described in 4.1. Following an agile approach two updates, or iterations, are likely not enough to identify the optimum business case over a 12-month project period. The frequency of design basis updates, which are the same as number of iterations, must be project specific; in my personal experience, the best approach consists of 4 to 5 updates with around 2 months of work between each iteration. However, too many updates will generate significant reworking, team frustration and a loss of focus. On the other hand, too few updates and limited details lead to missed opportunities, limited ability to work and agree on improvements and low-quality decision documentation.

Functional areas (meaning sub-projects such as drilling & well, subsurface, Facility) should perform iterations with the same frequency as the overall project. A typical facility study and a primary engineering contractor is set up according to traditional project models with waterfall deliveries and a final product. Where deliverables are produced in sequence. Following an agile approach, this must be changed to a model where the product is developed early and through iterations with increasing levels of detail. This will also reduce the risk of spending too much time studying the wrong concept and/or maintaining an inappropriate level of detail, which is a current problem that leads to wasted man hours. Developing the total business case early will most likely increase team members' awareness of main drivers and enable the team to take the best possible action in order to improve the overall business case.

Changing the way facility contractors work and their contract strategy can be substantial problems; however, neither are covered in this thesis due to time limitations. This is, however, an important step and must be addressed to successfully implement the agile PMLC model. Meeting structure and how to effectively communicate changes are elaborated on in Section 5.1.4.

5.1.2 Scope management

The deliverables at the end of each cycle or iteration are important and must be agreed upon from the start. The deliverables should be continuously updated throughout the cycle, and iterations should occur with increasing accuracy and appropriate levels of detail. The same deliverables should be used as documentation and as the basis for quality control for the closing out of each phase/decision gate. The proposal for deliverables is shown in Figure 5-4 and Figure 5-5.

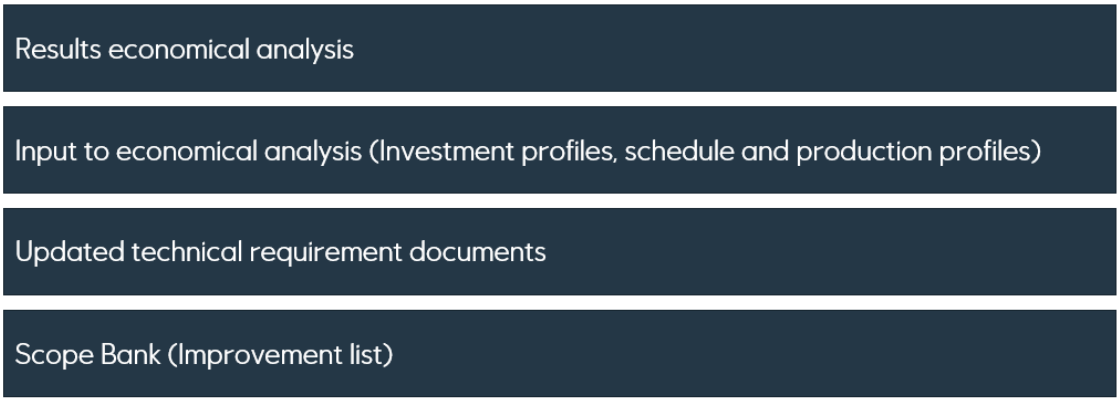

Figure 5-4 - Overview main deliverables at business case level for each cycle/iteration.

Scope, time frame and level of detail of the deliverables must be agreed at the start of the iteration. New ideas and improvements to the business case are captured in the Scope Bank document. At the end of each iteration the Scope Bank documents are reviewed, and improvement ideas are prioritized for implementation or study in the iteration. The Scope Bank must be set up with different levels for total business case and for each functional area.
Approved scope changes are included in the updated version of the design basis and functional requirement documents, forming the basis for the next iteration.

Figure 5-5 shows the typical setup for functional requirement documents at Equinor. These documents will be established at start of each iteration and updated following approved scope changes. These documents should be continuously updated, capturing the development and maturation of the project. At the decision gate these documents will form the basis for the quality control and approval process.

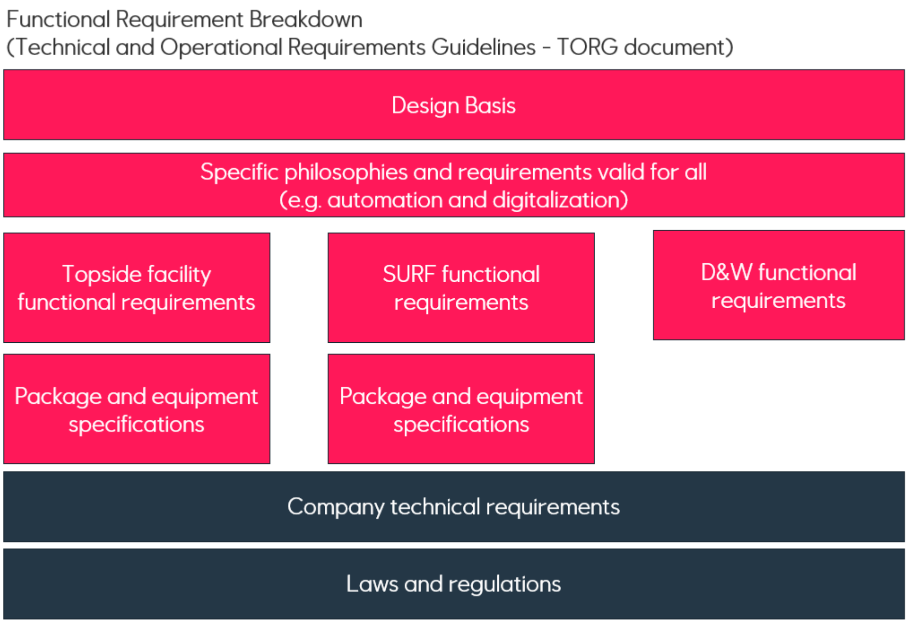

Figure 5-5 - Overview of technical requirement documents for a typical Equinor project.

5.1.3 Human resource management

A key criterion for a successful agile project is to have a few highly skilled persons who efficiently handle interfaces, management changes and company communication (Wysocki, 2019). Staffing the project with personnel who have appropriate skills and competence is critical, and team members should have expertise that covers a wide range of competences (Wysocki, 2019).

Figure 5-6 is based on a typical management team in an Equinor field development. This structure captures the whole value chain, or business case, and effectively works within the agile work method to optimize the overall concept. The core concept team is responsible for planning, prioritization of tasks and handling of deliverables between each cycle or iteration.

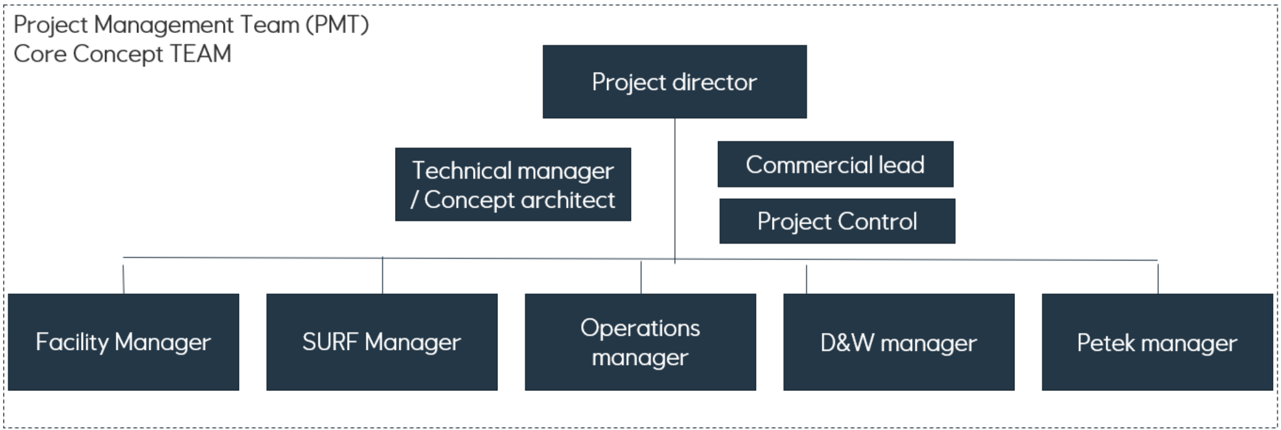

Figure 5-6 - Project organization early phase.

The project director is responsible for the overall business case along with project managers for each functional area. Each functional manager is responsible for deliverables within their respective area and to ensure a contribution to the business case. The functional area is staffed with project personnel according to project needs. In the early phase it is critical to ensure integration and alignment at discipline level between the functional areas. The best way to achieve this is to limit the number of team personnel, as this will also limit man hours expended on unnecessarily detailed studies. Ensuring integration between the different functional areas is the responsibility of the technical manager, and this role is critical for ensuring optimization of the total business case and avoiding sub-optimizations. The role should be responsible for the design basis, Scope Bank, change management and facilitating cross-functional integration meetings.

5.1.4 Communication management

Communication management is important to ensure that information is efficiently and uniformly distributed across the project. This is often challenging when projects are staffed with personnel across multiple locations and who have different technical and ethnic backgrounds. Setting up a clear information distribution strategy, with rules on how information is distributed (and who distributes it) is important. From my personal experience, this is the main obstacle preventing effective implementation of agile PMLC model in early phase projects. The number of personnel and contracts becomes too large to manage changes effectively, and changes cannot be communicated adequately throughout the project. My belief is that effective communication management is key to ensure integration and scope management across the entire project organization thereby increasing the size of the project where agile PMLC model can be applies. Enabling use the agile PMLC model for early phase oil and gas projects.

Effective use of digital tools such as the Microsoft 365 Office package, and specifically use of "Teams", "Planner" and "OneNote", will help to effectively manage information flow among project team members. To properly communicate and develop the understanding of business case drivers, a new digital tool needs to be developed that effectively reflects the current status of the total business case. This idea of a "Value Chain Simulator" is further developed in Section 5.1.5.

5.1.5 Business Case Simulator as a tool to execute agile PMLC

In addition to the demanding information flow described in Section 5.1.4 are a significant amount of hours spent on manual copying and pasting information from the different functional areas into spreadsheets or software that calculates the business case drivers (such as Net Present Value, cost profiles and revenue). My personal experience is that there is potential for significant reduction of waste and man hours, while increasing quality and consistency across the interface between functional areas. The time used to transfer and interpret data between the functional areas reduces the potential for agile methodology, as it can take up to several weeks to assemble cost, schedule, revenue estimates and perform economic analysis. In order to effectively manage agile iterations or cycles, this processing time must be significantly reduced.

The following list shows the foundational elements that comprise the idea of the Business Case Simulator tool. This tool will enable an agile work methodology in early phase project development by reducing time used to coordinate input, run final analysis on the complete business case and communicate business case drivers. The software must function as a "one-stop shop" for all conceptual information during the early phase and later into execution. The goal of such a simulator must be to:

- collect and outline main technical building blocks
- enable semi-automated (or automated) optimization on total business case
- ensure transparency and ranking of evaluated concepts, including quality assessment of input data
- eliminate all manual transfer of information/datasets between subsurface, flow assurance and process
- eliminate all manual transfer of information input to economic analysis, such as investment profiles and revenue profiles
- enable use of company core experience in cost and weight to estimate investment/cost profiles
- improve interface, change handling and communication by making information accessible and consistent for all team members
- enable all team members to explore how identified upsides impact total business case

Figure 5-7 shows the outline of how such a model could be set up with information flows.

Value chain simulator delivers the following;

- List of evaluated concept, with scoring on selection criteria's and quality assessment of input
- Design basis at end of cycle (can be virtual or pdf)
- Improved interface and communication by «One stop shop» for all concept related information
- Traceability and interface for quality assurance

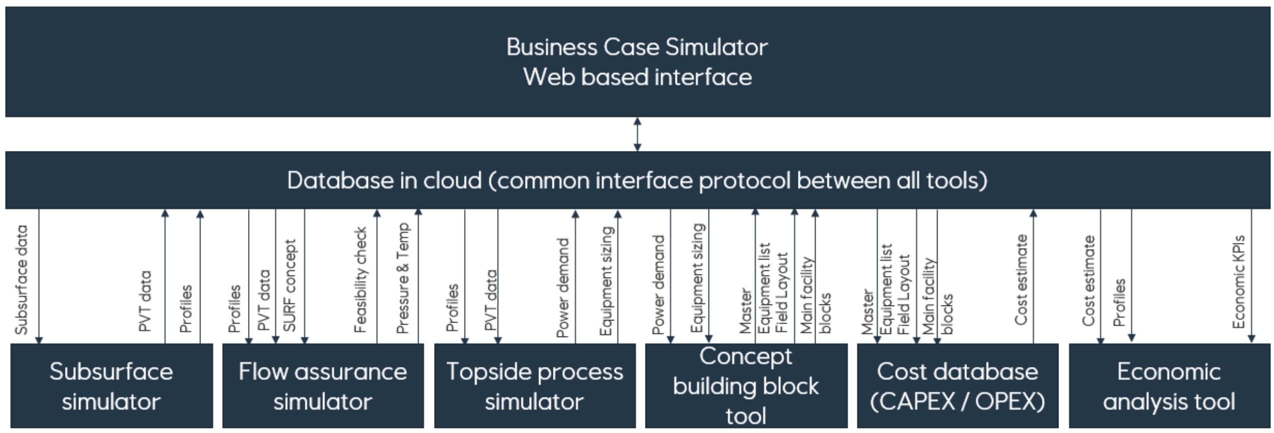

Figure 5-7 - Outline for Business Case Simulator.

The software should be web based, such that anyone with a predefined access can view and export data. Key information for the concept and business case should be displayed as a project "one-pager". The project's technical manager is responsible for keeping the information updated and for implementing changes to the concept based on the approval process. By implementing an update in the software, all those working on the project will be made aware of both the change and the impact on the business case. In addition, information on the interface between the different functional areas should be displayed.

To enable fast iterations on the total business case, the tool must be able to extract input to the economic analysis from each functional area, such as production profiles from subsurface and cost estimates from facilities and drilling as well. This requires that each functional area upload the latest status in a common database based on the same protocol. This should be possible with the implementation of a program such as Microsoft Azure or a similar program. The software must then be able to automatically import the data to an economic analysis tool performing the calculation of project key numbers. If successful, this approach will reduce the iteration period significantly, which is key in order to effectively monitor progress and prioritize tasks for the next iteration. The role of the discipline engineer will be to control input and to spend more time on value-added tasks instead of copying and pasting.

Challenges for implementation will be that different software and other functional areas must share a common protocol and setup to ensure that information can be correctly exported and imported automatically. This is not easy, as there are several software vendors within each functional area and that vary from area to area. This will also require all discipline engineers to deliver data using the same format and setup. The Business Case Simulator tool could be developed further to serve as the only decision documentation needed at the early phase decision gates. This would reduce the required paper documentation and revisions prior to any decision gate, which is a substantial accomplishment. An additional benefit would be that all projects will have the same document format and information at the same decision gates, simplifying work for those performing quality control on multiple projects.

5.2 Agile PMLC model for conceptual facility design

This section specifically investigates agile principles as they are applied to the functional area of facility design and engineering in its early phase. The section will look at an unmanned facility concept where the potential to improve quality and concept based on agile principles has been identified through personal project experience. Based on project management literature, the concept development phase for an unmanned and Remote Operated Factory should be run as an agile PMLC and potentially until the Final Investment Decision (FID), if needed. An unmanned facility, before standardized solutions are implemented, must be regarded as a project with high fuzziness and uncertainty. The facility project will also be a vehicle to drive innovation and unlock new operating models/strategies as new technologies and concepts are developed. The combination of high fuzziness, lack of technical solutions and project strategy all confirms that an agile methodology should be used ("Business strategy and project capability," 2005), (Wysocki, 2019). However, my personal experience is that new field development concepts are typically run as a standard PMLC model, resulting in significant issues with change management due to the high fuzziness associated with most early phase oil and gas projects and the development of frame conditions. Typical examples can be new understandings related to reservoirs, resulting in changes in drainage strategy or changes to company strategies and focus areas.

The work process described here is based on personal experience over several years working with unmanned concept development. The process as described is the result of my own work but based on input, discussion and work from many project members and coworkers at Equinor. The term "Design-2-Operate" was coined over the last years in Equinor and is used to define an engineering process that ensures user (or operational) experience and influence on facility design based on agile principles and methodology. There is currently no single term specifying the content, and the process as described here is my view of how to execute an agile PMLC model for early phase facility design.

For an unmanned concept, optimization of maintenance and facility availability is as important as economic parameters and must be carried out as an integrated part of the optimization of facility and concept. Designing for operation and the end user is critical and must be given even more attention than typical offshore field developments. User involvement in operations is vital, and handover from engineering to operations must happen seamlessly. (Wysocki, 2019) suggested a comanager model for projects requiring good integration and interaction with the client/user. This also aligns with a typical Equinor scenario where the operations manager and facility manager share equal responsibilities on the project management team. However, additional emphasis on the collaboration between facility and operations should be done as suggested in Figure 5-8. The close collaboration must extend to engineering contractors and equipment vendors, as illustrated in Figure 5-9.

The end user is the operations manager, who must be an integrated part of the design work. For the organization and collaboration to be successful, there must be an open, trusting and hands-on attitude from all employees. Respective leads must be able to operate without constant management, setting high knowledge and skill standards both in management and the disciplines. Management must trust and empower the disciplines to drive design development according to goals set by the leadership team. Empowerment and competence are key success criteria for such an integrated approach. Without highly skilled personnel from operations, engineering and vendors, this setup cannot succeed.

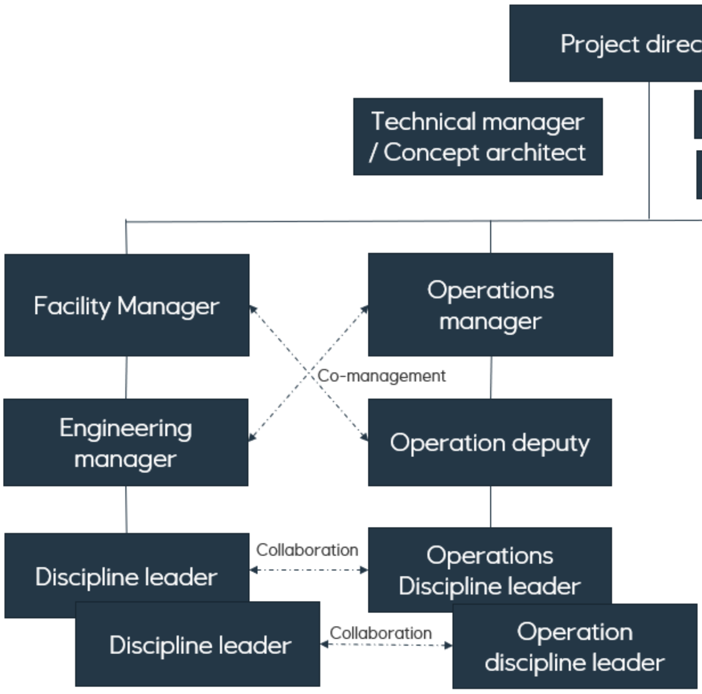

Figure 5-8 - Organization of PMT with comanager model

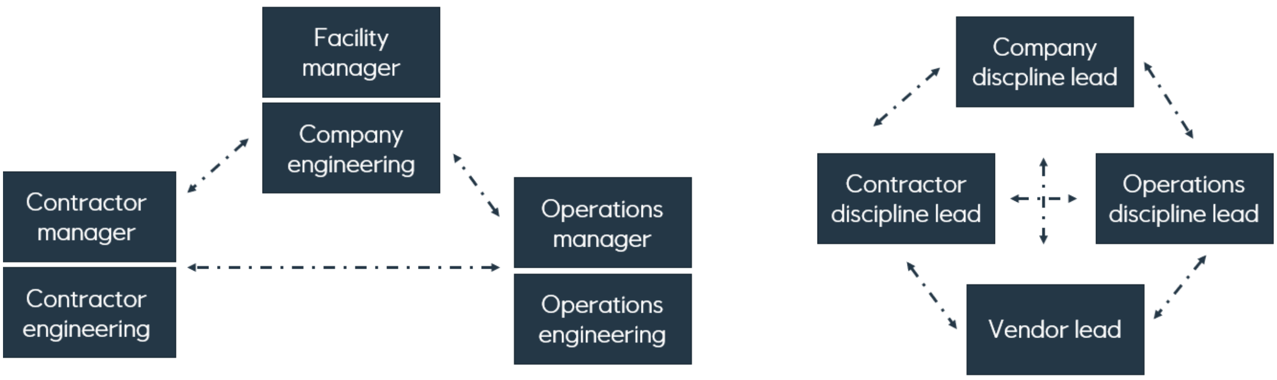

Figure 5-9 - Illustration of communication lines and integration between operations, facility, contractor and vendor.

In order to handle change and interface there must be established communication channels with use of digital tools and efficient meeting structures. The discipline leads must be responsible for changes within their area without direct influence or need for approval from management. Changes influencing other areas or disciplines will be handled in weekly status meetings at the lowest possible level where those from impacted areas can meet. Conceptual changes or changes of a larger magnitude are stored in the "idea bank register" and decided upon at iteration close-out. The Design-2-Operate (D2O) workflow was developed in the last two years while working with unmanned concepts at Equinor. The workflow illustrates the close collaboration needed between facility engineering and operations (see Figure 5-10). In principle it is a methodology that ensures an integrated and systematic approach to designing oil and gas facilities with a minimum of maintenance hours and maximum availability. An iterative design thinking approach integrates the end user and designer with user verifications of the design at the end of each iteration.

The workflow is carried out for each iteration, where the level of detail increases per iteration and on additional systems. This ensures that the total concept can be optimized from a maintenance perspective earlier than a typical approach where the maintenance estimate would be the last delivery with limited possibility for redesign based on results from maintenance assessments. The first iteration would typically be to establish the main process system and functionality, gather data for the equipment needed and establish the preliminary layout – then maintenance assessments must be performed. Suggested improvements from the maintenance reviews are worked into the next iteration based on a prioritization of items performed at iteration startup. As systems, once layout and maintenance philosophies are agreed upon, they will be marked as ready. This will make for a seamless handover from contractor to engineering and then to operations, without the need for later quality checks or formal reviews.
In order to maintain the overall schedule and deliver the required documentation on time, it will be important to establish a list of end deliverables early and to stop iterations on respective tasks if needed. Therefore, prioritization of the most critical items at any given time is vital, and the team must focus on quality delivery of the most important items first and not try to deliver everything at once.

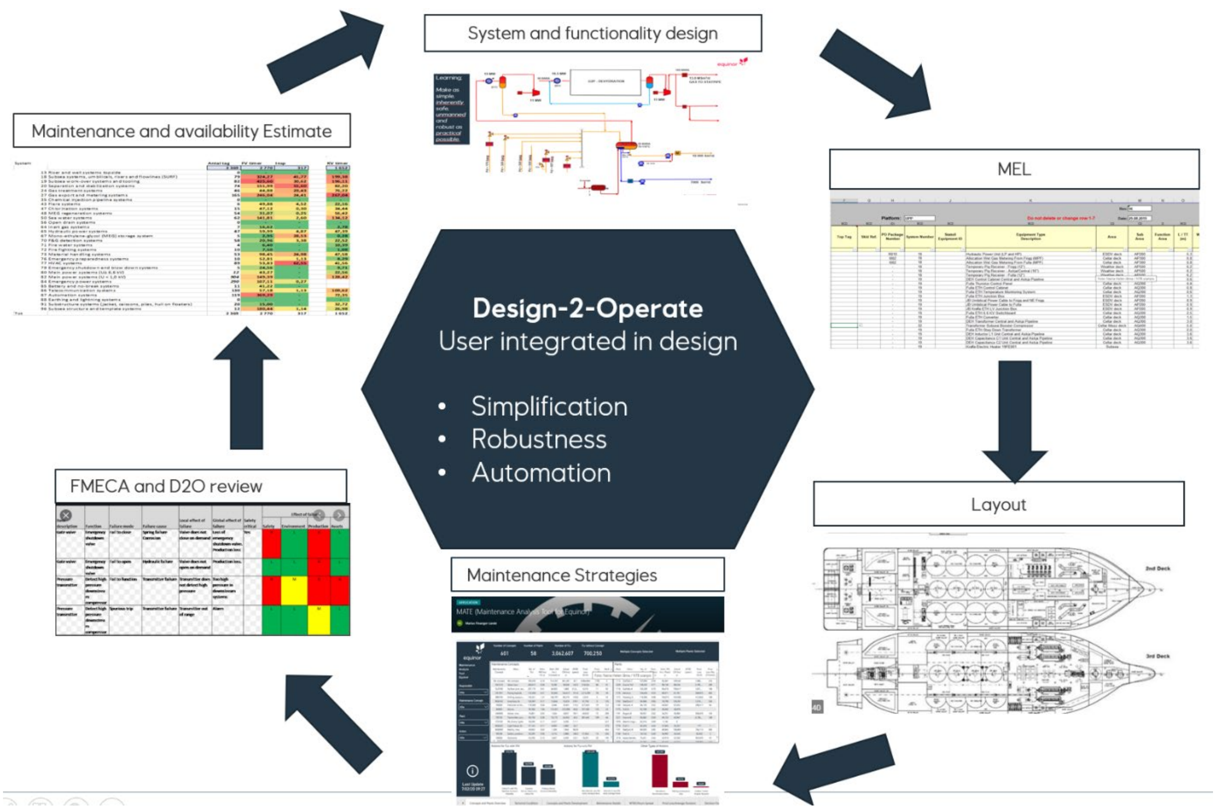

Figure 5-10 - Design-2-Operate iterative and user integrated design approach.

Documenting actions and requirements developed during each iteration and tracking implementation during later project phases will be vital. Early establishment of the Requirement Breakdown Structure (RBS) is therefore important in order to document everything continuously during the iterations. This process will minimize the work to be done when updating final deliverables or requirement documents. Requirement documents should be written so that they can be transformed to checklists in later phases to perform quality control and verification that designs and equipment are delivered accordingly.

6 Conclusion

This thesis has outlined a new way of working with early phase field developments based on agile principles. The proposed PMLC model is based on personal experience, discussions with experienced project managers and major studies in the literature. The goal of the agile PMLC model developed in this thesis is to find a way to handle changes more effectively, delivering higher-quality concepts at the concept select milestone. Finding the optimum concept is critical in achieving economic robustness and delivering on company strategies in a global economy characterized by lower oil prices and an increasing emphasis on sustainability.

Based on the nature of early phase field developments with high fuzziness and unknown solutions, the literature strongly favors agile PMLC models (if executed correctly) to deliver the best result. This also coincides with my own personal experience with several projects that struggled in the early phase due to a high rate of change, resulting in reduced quality, suboptimal concepts and significant team-member frustration and reworking. It is likely that a successful implementation of the agile PMLC model described will improve concept development and deliver better concepts at a lower cost and more aligned with company strategy.

It is not possible to test the PMLC model as part of this thesis: The scope and magnitude of such a task is significantly outside the ambit of a master's thesis. Testing and verification of the PMLC model must be made by an operating company as part of a field development project. Therefore, the only possibly way of verifying the benefits and feasibility of the model at this stage will be to discuss the likelihood of success and possible pitfalls with senior project managers at Equinor and through personal experience.

The following key areas have been developed in this thesis:

- new ways of working in early phase field development projects based on an agile PMLC model
- outline of the digital Business Case Simulator tool enabling agile PMLC models for field developments
- an agile PMLC model for unmanned facility engineering – Design-2-Operate

The potential to improve concept development and quality in early phase field development projects by applying agile methodology is confirmed through the literature and from applications in other industries. However, the main challenge is how to successfully implement and execute such a model for greenfield oil and gas field developments. Oil and gas projects are complex undertakings, with significant interfaces, complicated technical concepts/issues and large project sizes even in the early phases. This makes it impossible to keep number of team members at a typical level where today agile methodology is applied and challenging to perform fast iterations.

The agile PMLC model developed have identified three critical areas in order to successfully implement an agile work methodology:

- use of small integrated teams with top-tier competence
- establish the main building blocks of the concept as early as possible and iterate with an increasing level of detail
- develop a software tool to improve information flow and manage interfaces and changes

A crucial measure for success is keeping team size as small as possible by using highly skilled multidisciplinary personnel, combined with excellent change management and communication. A small team makes it significantly easier to ensure the whole project is working towards the same goal based on a consistent basis and mindset. Note that a small integrated team in the context of a field development project is likely 50 persons or more and even a small team will be outside the typical envelope where agile PMLC models are used today. Team size and task complexity in a field development project is perhaps the most important argument against implementation of agile PMLC models for the full field development. Typical application of agile PMLC models are for small teams preferably co-located due to the need for communication and management of change. This obstacle must be overcome in order to successfully implement agile PMLC models for early phase oil and gas field development projects. The development within digitalization over the last years and improved communication methods (as exemplified by the wide spread implementation of IT communication tools during the Corona outbreak) are likely to push the envelope of where agile PMLC can be applied effectively. Successful implementation of agile models in large and complex field development project will require tools that effectively manage interfaces, communication and change management for a large team located on multiple sites. This thesis developed and outlined the digital software tool "Business Case Simulator" to mitigate the effect of larger team size by ensuring effective change management and communication for a multilocation and multiteam project. The tool will enable all team members to have access to the most recent information about the design basis and any related changes, together with live information on project drivers / KPIs. This tool, or a similar one, is seen as critical to the successful implementation of agile work methodologies for large oil and gas field developments.

A major change to a standard project management life-cycle model is that a Minimum Viable Product (total business case) is developed as early as possible and subject to later optimization and detailing based on project maturation. Similar to an IT project where software is realized and subject for later optimization and added functionality. Traditionally work is carried out in sequence with the product being developed at the end. In order to apply agile methodologies, a concept must be fully developed as early as possible and then later optimized in iterations or cycles. Key KPIs must be monitored and tracked for each iteration, ensuring that everything works towards a common goal of optimizing the total business case. There must be a game changer in how project KPI's are produced, today a typical period for developing cost, revenue and schedule input and performing economical analysis is around 1 month. This period must be drastically reduced in order to effectively work with iterations governed by KPI's. The Business Case Simulator tool is introduced as a tool to reduce estimation period by removing manual copy&past work and reduce time needed for coordination of input. This is essential in order to ensure that estimation of KPIs are reduced from a month to one week.

Both integrated teams and changing design approach to an MVP as described above will require new ways of working with contractors, along with new internal procedures and workflows. This is not easily achieved as it will require a significant change agenda both in external and internal organizations. Changing contract terms and altering ways of working with both are challenging tasks that are filled with potential pitfalls and have not been covered by this thesis. It is recommended as further work based on the outlines in this thesis.

A stepwise approach to implementation of a agile PMLC for field development projects is suggested to manage the risk related to new ways of working and gradual as well a developing the agile model further. The first step for implementation in Equinor should be test on a small project where the number of team members is manageable and limited external studies is recommended in order to keep team size, scope and risk at a tolerable level. Based on findings from that project, the PMLC model should be updated and, if successful, form the basis for a broad company implementation.

A new agile PMLC model to Facility design, Design-2-Operate, has been developed for unmanned facilities requiring a high degree of user collaboration and influence in design. The model is based on an iterative approach where the end user is part of the design cycle, guiding and setting prioritize at end of each cycle in order to achieve an optimum unmanned facility design. An agile PMLC model for facility design sets similar requirements as for an agile field development project as Facility is a part of the field development project. The discussion above is therefore also applicable on this topic. The difference being that KPI's are different, changing from economical to operational, such as facility yearly availability and maintenance hours. The integrated and iterative process designed to optimize operability is key in order to optimize unmanned facilities.

The maturation of the Design-2-Operate process have been performed over several years in Equinor. Note that the work presented and process as presented in this thesis is my work, but based on work, input and discussions from projects and team members in Equinor.

7 Further work

The following is recommended as further work in order to build on this thesis and to successfully implement agile PMLC models in early phase oil and gas field developments:

- test proposed agile work method on a smaller field development project
- continue developing the digital tool Business Case Simulator (or similar)
- develop contract models that allow and encourage agile work methods

Agile Facility PMLC model, Design-2-Operate, is ready for implementation in a project studying an unmanned concept to DG2 milestone.

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9 Abbreviations