Survey on simulator training in Norwegian oil & gas industry

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1 Introduction

This report presents the results of a survey conducted in the Norwegian petroleum industry during October – December 2011. The main aim of the survey was to quantify the benefits of simulator training in the Norwegian oil & gas industry. The additional goals of the survey were to find out how simulators are used in the Norwegian oil and gas industry, the key factors for successful use of simulators, and users wishes for the simulator development.

The aim of this report is to publish the raw data from the survey, and to enable further use of the survey results by other interested parties. The relevant literature-sources and analysis of the data material is given in the previous publications, in World Oil (Komulainen et al., 2012a) and in Automatisering (Komulainen et al., 2012b). Thus, this report contains only short description of the background to the study, methods, results and discussion.

2 Method

An electronic questionnaire on operator training simulators in the Norwegian oil and gas industry was developed in collaboration with industrial partners. The questionnaire included 42 questions with predefined answer alternatives and an open commentary field, presented in Chapter 3 Results. The questionnaire was tested on a small group of simulator instructors and process operators.

The target group for the questionnaire included all simulator users: operators, instructors and engineers, and all personal involved in simulator projects (system engineers and management). Time estimate for filling in the questionnaire was 15 -25 minutes. The participants were encouraged to base their answers only on their own opinions and experience, I.e. it was not necessary to search for information. The answers are anonymous.

The electronic questionnaire (QuestBack) was sent to approximately 250 simulator users in the Norwegian oil and gas industry. The responses were collected during period October – December 2011. A total of 99 answers were received from 11 different companies including Statoil, Shell, AddEnergy, ConocoPhillips, BP, Petrolink, Gaz de France, ExxonMobil, Marathon Petroleum Company, Talisman, and Sørco.

3 Results

The questions, answer alternatives, answers and answer percentages are given in tabular format. The results are given in numbers and percentages, because all of the questions are not answered by all the respondents, thus enabling further use of the data by other researchers.

The middle columns represent answers from all the participants giving non-blank answer (ALL) and the percentage of the total answers (%). The right most columns, marked with VS and VS%, provide answers and answer percentages for the group of most successful simulator users.

3.1 Background

The first section of the questionnaire was the background of the respondents including profession, education, company, work experience in years, and simulator experience in years.

All the groups related to simulator training were represented in the study; including operators, instructors, process engineers, automation engineers, system engineers and management. Most of the respondents had over 10 years work experience and some experience on simulator use.

Table 1: Background of the respondents.

1 Profession	All	%
Operator	31	31,1%
Instructor	20	20,2%
Automation engineer	17	17,2%
Process engineer	10	10,1%
System engineer	8	8,1%
Manager	5	5,1%
Shift leader	5	5,1%
Operations/ platform manager	3	3,0%
Sum	99	100%
2 Company		
Statoil	76	77%
Shell	7	7%
AddEnergy	3	3%
ConocoPhillips	3	3%
BP	2	2%
Petrolink	2	2%
Gaz de France	1	1%
Exxon Mobile	1	1%
Marathon	1	1%
Talisman	1	1%
Sørco	1	1%
Annet	1	1%
Sum	99	100%
3 Work experience		
0-1 year	1	1%
1-2 years	3	3 %
2-5 years	7	7%
5-10 years	11	12%
over 10 years	74	77%
Sum	96	100%

Table 2: Background of the respondents (table continues).

4 Simulator experience	All	%
Not a simulator user	16	17%
Little experience	5	5%
Couple of training sessions	12	12%
Several training sessions, able to use simulator independently	34	35%
Experienced/ Instructor	30	31%
Sum	97	100%
5 Education		
Technician (apprenticeship)	39	40%
Technician (vocational school)	20	20%
Engineer BSc	13	13%
Engineer MSc	24	25%
Other education (such as economics)	2	2%
Sum	98	100%

3.2 Simulator type and use

The second section of the questionnaire includes details of the operator training simulator and the use of the simulator for other purposes than operator training. Almost all of the respondents (97%) had plant/platform specific process simulator, 78% with integrated control system and 60% with utility systems. Almost all of the plants (99%) had one or more simulators for operator training, and 90% of the plants had simulator available also for engineers. On average simulators were used for 6 other purposes than operator training.

Table 3: Simulator type and use.

6 Simulator type/Process model	All	%	VS	VS%
Generic	3	3%	0	0%
Platform specific without utility systems	37	37%	8	24%
Platform specific with utility systems	59	60%	26	76%
Sum	99	100%	34	100%
7 Simulator type/DCS/SAS system				
Control system is not included to the simulator (Emulated simulator)	16	17%	6	18%
Control system is integrated to the process model (Stimulated simulator)	78	83%	27	82%
Sum	94	100%	33	100%
8 Simulators for operator training				
None	1	1%	1	3%
One simulator for operator training	66	69%	20	59%
2-3 simulators for operator training	20	21%	6	18%
4 or more simulators for operator training	9	9%	7	21%
Sum	96	100%	34	101%

Table 4: Simulator type and use (table continues).

9 Simulator for process/automation engineers	All	%	VS	VS%
Engineers do not use simulators	10	11,4%	2	6%
Engineers can use training room simulators	39	44,3%	14	42%
One simulator for engineers	24	27,3%	8	24%
More than one simulator for engineers	14	15,9%	8	24%
Engineers use other software	1	1,1%	1	3%
Sum	88	100%	33	99%
10 Simulator use for other purposes than operator training				
Verification of process/equipment upgrade	68	75%	29	88%
Verification of DCS/SAS system upgrade	68	75%	26	79%
Verification and testing of new DCS screens and HMI functionality	56	62%	25	76%
Production optimization and debottlenecking	56	62%	23	70%
Dynamic simulation studies on “worst case scenarios”	55	60%	24	73%
Pre-operational & operational support	52	57%	24	73%
Control strategy development and testing	51	56%	25	76%
Verification of new procedures	50	55%	23	70%
Design verification & technical integrity assessment	41	45%	16	48%
FEED and detailed design support	19	21%	12	36%
Flow assurance studies	17	19%	9	27%
Feasibility or conceptual studies	14	15%	8	24%
HAZOP studies	14	15%	6	18%
Real time leak detection and pipeline monitoring	3	3%	0	0%
Amount non-blank answers	91	-	33	-
Average number of options	6,2		7,6	

3.3 Simulator maintenance

Simulator maintenance includes updating of the simulator configuration after process and DCS system modifications and updating of the simulator initial conditions that correspond to the process values on the platform/plant. One fifth of the respondents answered that they did not have a maintenance plan and one third did not know if such plan exists. Nevertheless, 99% of the plants had updated the simulator during the past 5 years. Over half of the respondents report that the simulator model is updated after each significant change, and 11% update the simulator before the changes are commissioned on the plant. 48% of the respondents update the simulator initial condition to match with the plant once a year or more often.

Table 5: Simulator maintenance plan and frequency for updating.

11 Does your plant/platform have a simulator maintenance plan?	All	%	VS	VS%
We have a plan	35	35,4%	19	56%
I don't know	34	34,3%	8	24%
We do not have a plan	18	18,2%	3	9%
We are currently working on a plan	7	7,1%	2	6%
Other	5	5,1%	2	6%
Total	99	100%	34	101%
12 How often is the simulator configuration updated (not simulator software)?				
Maintenance is done after each significant change (process equipment/DCS system change)	31	42%	13	45%
Maintenance is done if it's allocated in the budget	10	14%	1	3%
Maintenance is done based on an annual evaluation	9	12%	4	14%
The simulator is updated before the changes in the platform/plant	8	11%	3	10%
Maintenance is done after each smaller change (field device/instruments /piping/DCS system/ DCS picture change)	7	10%	4	14%
Based on needs	3	4%	2	7%
Random	2	3%	0	0%
Other	2	3%	2	7%
Simulator has not been updated during the past 5 years	1	1%	0	0%
Amount non-blank answers	73	100%	29	100%
13 How often is the initial condition of the simulators updated, i.e. how often the simulator initial condition is matched with the process values in the platform /plant?				
Seldom	26	45%	7	32%
Once a year	10	17%	1	5%
Once every three months	6	10%	2	9%
Once every 6 months	4	7%	1	5%
Once a month	4	7%	3	14%
Weekly or more often	4	7%	2	9%
Never	4	7%	3	14%
Amount non-blank answers	58	100%	22	101%

Plants included in this study have on average 2 responsible parties for the simulator maintenance, typically the system engineers and instructors. However, many of the respondents wished for more involvement from the process engineers and management. The main challenges for maintenance are priorities in the organization and availability of qualified personal.

Table 6: Simulator maintenance.

14 Who is/are responsible to keep the simulator up to date with process/automation system changes?	All	%	VS	VS%
System engineers	40	46%	14	44%
Instructors	41	37%	14	44%
Vendor (process model or DCS/SAS system)	24	28%	9	28%
Automation engineers	23	26%	11	34%
Training center	22	25%	7	22%
Process engineers	14	16%	6	19%
Management	9	10%	2	6%
Other third party	3	3%	2	6%
Amount non-blank answers	87	-	32	-
Number of responsible parties/plant, on average	2,0		2,0	
15 Who should be responsible/more involved in the simulator maintenance?				
Current maintenance organization is good	24	25%	14	44%
System engineers	44	46%	10	31%
Instructors	43	45%	13	41%
Process engineers	28	29%	7	22%
Training center	25	26%	6	19%
Vendor (process model or DCS/SAS system)	20	21%	3	9%
Automation engineers	18	19%	6	19%
Management	17	18%	3	9%
Other third party	2	2%	1	3%
Amount non-blank answers	95	-	32	
Desired number of responsible parties/plant, on average	2,3		2,0	
16 What are the main challenges of the simulator maintenance?				
Priorities in the organization	62	66%	19	63%
Availability of qualified personal	34	36%	10	33%
Costs	26	28%	7	23%
Work load related to simulator modifications/changes is too large	24	26%	9	30%
There are no procedures on simulator maintenance	20	21%	6	20%
Amount non-blank answers	94	-	30	
Amount of main challenges/plant, on average	1,7		1,7	

3.4 Operator training in your platform/simulator training center

The fourth section of the questionnaire is only open for respondents who have first-hand experience on simulator training, which was 61% of the respondents.

Table 7: Participants of simulator training courses.

17 Have you participated simulator training course? Are you simulator instructor? Or have you participated planning of the operator training courses?	All	%	VS	VS%
Yes (opens this section 0 of questions about operator training)	60	61%	23	68%
No (passes this section and leads to next section 3.5 of questions)	39	39%	11	32%
Total	99	100%	34	100%

3.4.1 Simulator training organization

This section of the survey includes the simulator training plan and frequency and length of the simulator courses for trainees and experienced operators.

Most of the respondents did have a training plan (70%), at some plants/platforms the plan was dependent on the availability of the instructors and simulator room (16%) and some plants/platforms did not have a plan (14%). The three most common factors restricting simulator training are availability of the training simulator (48%), availability of the simulator instructors (36%) and lack planning (24%).

Table 8: Simulator training plan.

18 Does your platform/plant have a simulator training plan?	All	%	VS	VS%
We have a plan	40	70%	15	71%
Depends on capacity (simulator room/instructors)	9	16%	4	19%
We do not have a plan	8	14%	2	10%
Amount non-blank answers	57	100%	21	100%
19 Which factors restrict the utilization of the training simulator?				
Availability of the training simulator (too few)	20	48%	9	45%
Availability of the instructors (too few)	15	36%	7	35%
No plan for simulator training	10	24%	3	15%
Simulator is outdated (large difference between simulator and plant/platform)	9	21%	1	5%
Operators lacks interest in simulator training	8	19%	3	15%
Cost/budget	8	19%	2	10%
Management lacks interest in simulator training	7	17%	2	10%
Engineers lacks interest in simulator training	2	5%	1	5%
Availability of model support from vendors	2	5%	1	5%
Amount non-blank answers	42	-	20	-
Number of restricting factors, on average	1,4		1,8	

During the initial operator training period the trainees are using simulator on average 9 days, 39% of the plants are arranging more than 2 week of simulator training for the new operators, and 8% are not arranging any simulator training for the new operators.

Half of the plants/platforms require the experienced operators to re-train with simulator, whereas 10% are not able arrange re-training capacity restrictions. 70% of the plants/platforms arrange simulator training for the experienced operators at least once a year.

Table 9: Simulator training for new and experienced operators.

20 How much time is spent on simulator training during the initial operator training period?	All	%	VS	VS%
None	4	8%	1	5%
2 days	1	2%	0	0%
3-5 days	14	27%	3	16%
1 – 1,5 weeks	12	24%	7	37%
2-3 weeks	15	29%	5	26%
4-5 weeks	4	8%	2	11%
6-7 weeks	1	2%	1	5%
8 weeks or more	0	0%	0	0%
Amount non-blank answers	51	100%	19	100%
Days simulator training for new operators, on average	8,9		10,5	
21 Annual re-training with simulator for experienced operators is?				
Mandatory (certain number of days a year must be spend on simulator training)	25	50%	12	55%
Voluntary (other courses can be chosen instead)	11	22%	4	18%
Before offshore trips	6	12%	3	14%
Not possible due to capacity restrictions on the simulator	5	10%	2	9%
Mandatory (other frequency than 1/year)	2	4%	1	5%
Other (little used)	1	2%	0	0%
Amount non-blank answers	50	100%	22	101%
22 How often are simulator re-training courses arranged for experiences operators?				
More than twice a year	15	31,9%	8	45%
Twice a year	6	12,8%	4	21%
Once a year	12	25,5%	4	21%
Every other year	5	10,6%	1	5%
Every three years or more seldom	4	8,5%	0	0%
Never	5	10,6%	2	11%
Amount non-blank answers	47	100%	19	100%

3.4.2 The learning program and objectives (didactic model)

Majority (84%) of the respondents reported on clear presentation of the learning goals of the simulator training courses. The training sessions consisted of simulation scenarios in normal operating conditions with use of procedures (83%), simulation scenarios with unknown failure (69%) and failure scenario with use of procedures (69%). About 40% were using theory/power point presentations in addition. The six most common scenarios were: Start-up and shut-down operations (91%), system familiarization and work flow studies (78%), safety training (74%), emergency response management (72%), operating procedures (67%) and process upsets and hardware/software failures (67%).

Table 10: Simulator training program learning goals, contents, methods and tools.

23 Learning goals	All	%	VS	VS%
Presented very clearly at the beginning of each simulation session	21	37,5%	12	55%
Presented only in the beginning of the course	26	46,4%	9	41%
I know some of the goals of the simulator training course	3	5,4%	0	0%
The goals of the simulator training course are unclear/do not exist/I have not heard about	3	5,4%	0	0%
Other	3	5,4%	1	5%
Amount non-blank answers	56	100%	22	101%
24 Contents/elements in the simulator training program				
Start-up and shut-down operations	49	91%	19	86%
System familiarization and work flow studies	42	78%	17	77%
Safety training	40	74%	17	77%
Emergency response management	39	72%	19	86%
Operating procedures	36	67%	14	64%
Process upsets and hardware/software failures	36	67%	16	73%
Operations optimization (max production, etc)	19	35%	9	41%
Preparation for modification campaigns (process/DCS)	19	35%	9	41%
Amount non-blank answers	54	-	22	-
Number of training elements, on average	4,6		5,5	
25 Teaching methods and tools				
PowerPoint presentations (theory)	22	42%	11	50%
Simulation demos (instructor presents)	20	38%	9	41%
Traditional classroom exercises (pen & paper)	12	23%	6	27%
Simulator scenario in normal operating state, use of procedures	43	83%	20	91%
Simulation scenarios, failure scenario is known, use of procedures	36	69%	15	68%
Simulation scenarios, failure scenario is not known	37	71%	14	64%
Other	2	4%	2	9%
Amount non-blank answers	52	-	22	-
Number of methods, on average	3,3		3,5	

The instructors observe the operator/operator team on: communication (72%), stress suppression and tolerance (63%), handling of complexity and simultaneous changes (61%), organized behavior (41%) and coordination/leadership (28%). Most of the instructors (72%) are giving continuously feedback during the simulator scenarios. The feedback is given mainly on positive behavior with other possible ways to solve the task (69%), positive behavior with right actions and good team work (67%), wrong actions with instructor explanation (59%), achieved learning goals (57%) and good team work (47%). Only 29% of the platforms/plants arrange exam/participant evaluation after the simulator course, whereas most of the plants/platforms (71%) do not arranged official tests/participant evaluations after the simulator training but rely on instructor evaluation (31%) or no evaluation (40%).

Table 11: Simulator training program: observation methods, feedback during the scenarios and final evaluation.

26 Observations	All	%	VS	VS%
Communication	33	72%	13	68%
Stress suppression and stress tolerance	29	63%	12	63%
Handling of complexity and simultaneous changes	28	61%	13	68%
Organized behavior	19	41%	8	42%
Leadership/coordination	13	28%	5	26%
Amount non-blank answers	46	-	19	
Number of methods, on average	2,7		2,7	
27 How often feedback is given during the course				
Continuously during the scenarios	39	72%	16	76%
After completed scenarios	20	37%	11	52%
After course	16	30%	6	29%
After course day	10	19%	7	33%
Never	0	0%	0	0%
Amount non-blank answers	54	-	21	-
Number of options, on average	1,6		1,9	
28 Feedback is given on				
Positive behavior, other possible ways to solve the task (learning from other training sessions/teams)	35	69%	12	60%
Positive behavior (right actions, good team work)	34	67%	13	65%
Wrong actions, instructor explains how are the task should have been done differently	30	59%	15	75%
Achieved learning goals	29	57%	13	65%
Good team work	24	47%	8	40%
Not-achieved learning goals	15	29%	6	30%
Wrong actions, team explains how things should have been done differently	15	29%	6	30%
Unsuccessful team work	13	25%	4	20%
Wrong actions	10	20%	4	20%
Amount non-blank answers	51	-	20	-

Number of options, on average	4,0		4,1	
29 Participant evaluation/final exam after the course				
No official test, no participant evaluation from the instructor	16	30,8%	5	26%
No official test, participant evaluation from the instructor	21	40,4%	5	26%
Traditional written exam or multiple choice exam	5	9,6%	3	16%
Simulation scenario based exam	4	7,7%	2	11%
Both written exam and simulation scenario based exam	6	11,5%	4	21%
Amount non-blank answers	52	100%	19	100%

3.5 Benefits of simulator use at plants/platforms

Approximately 90% of the respondents considered simulator utilization at their plant/platform as successful and none considered it as waste of time. The key factors for successful simulator use were:

1. Simulator model is up-to-date
2. Good instructors
3. Proper organization around simulator training and facilitation of participation

Table 12: Successful simulator use.

30 How successful simulator utilization in your platform has been?	All	%	VS	VS%
Very successful	34	37%	34	100%
Quite successful	49	53%	-	
Not successful, but not harmful either	9	10%	-	
Simulation is waste of time	0	0%	-	
Amount non-blank answers	92	100%	34	100%
31 Key to success in simulator utilization (prioritize 3)				
Simulator model is up-to-date	62	63%	21	62%
Good instructors	58	59%	21	62%
Proper organization around simulator training and facilitation of participation	35	35%	8	24%
Support from management	22	22%	10	29%
Main process and the utility systems are included in the simulator	22	22%	8	24%
Well planned and executed training sessions	20	20%	9	26%
Other	18	18%	7	21%
Both operators and engineers use simulators	17	17%	5	15%
Active utilization of simulators	17	17%	5	15%
Proper training center (design, materials, quality of the simulators)	17	17%	6	18%
Simulator budget	9	9%	2	6%
Amount non-blank answers	99	-	34	

The improvement in operator effectiveness due to simulator training was estimated as noticeable to remarkable by 80% of the participants. The average estimate of operator effectiveness improvement

was 31%. The top three benefits of simulator use for the operators were: better understanding of the complex processes and confidence to operate the plant/platform safely, improved ability to handle process upsets, makes daily work more comfortable. The top three benefits of simulator use for the company were accelerated time to production start-up, reduced operational risk and enhanced facility integrity, and high production performance and production.

Table 13: Benefits of simulator training for the control room operators and for the company.

32 How large is the improvement of operator effectiveness due to simulator training in your platform?	All	%	VS	VS%
None (0 %)	2	4%	0	0%
Small (0-10%)	9	16%	0	0%
Noticeable (10 - 30%)	22	39%	6	29%
Large (30 – 50%)	13	23%	7	33%
Very large (50 – 75 %)	5	9%	3	14%
Remarkable (75% – 100%)	5	9%	5	24%
Amount non-blank answers	56	100%	21	100%
Improvement in effectiveness, on average	31%		49%	
33 Benefits of simulator training (operators)				
Gives better understanding of the complex processes and gives confidence to operate the plant/platform safely.	26	84%	6	100%
Improves my ability to handle process upsets	25	81%	6	100%
Makes me more comfortable in my daily work	22	71%	6	100%
Decreases the amount of fail responses	19	61%	5	83%
Reduces my stress level in my daily work	18	58%	6	100%
Helps my team to cope with complex and stressful alarm situations	16	52%	5	83%
Reduces the stress in my team	12	39%	6	100%
Improves co-operation in my team	12	39%	5	83%
My team has avoided one or more trip-situations due to the experience from simulator training	12	39%	5	83%
Amount non-blank answers	31	-	6	-
Number of operator benefits, on average	5,6		8,2	
34 Benefits of simulator use (other groups than operators)				
Accelerate time to production start-up	54	79%	22	79%
Reduce operational risk and enhance facility integrity	49	72%	20	71%
Maintain high production performance and production	42	62%	19	68%
Improve safety and environmental performance	41	60%	20	71%
Optimize production and improve recovery rates	33	49%	15	54%
Optimize procedures (collaboration between operators and engineers)	33	49%	18	64%
Increase collaboration between operator, engineer, contractors and vendors	29	43%	12	43%
Speed up information sharing and decision making	19	28%	9	32%
Reduce capital and operating expenses	19	28%	10	36%
Amount non-blank answers	68	-	28	-
Number of benefits, on average	4,7		5,2	

Due to simulator training on average 18 days can be saved on commissioning and start-up of a new plant, and on average 53 hours (2,2 days) on commissioning and start-up after major modifications. Operator training with simulator also helps preventing unnecessary downtime of the plant by reduction of unplanned shutdowns, on average 3 per year per plant. Almost 80% of the participants estimated the savings due to simulator training to be over 15 MNOK (2,6M$) and 26% of the participant considered the saving to be over 200 MNOK (38,4M$). On average the total saving was estimated to be 88 MNOK (15,3M$). Over half of the participants assess the payback time to be under 6 months, but the average payback estimate is 14 months. It is worth noticing, that although the profitability estimates are not following normal distribution, the highest estimates are given by participants with different backgrounds. This might be due to more successful utilization of simulators in some platforms than others, also across companies.

Table 14: Economic benefits of simulator training.

35 How many days can be saved on commissioning and start-up of a new platform due to simulator use?	All	%	VS	VS%
0 days	1	2%	0	0%
1-2 days	9	17%	4	20%
3-5 days	1	2%	0	0%
6-8 days	6	11%	0	0%
2 weeks	6	11%	0	0%
3 weeks	3	6%	0	0%
4 weeks or more	28	52%	16	80%
Amount non-blank answers	54	100%	20	100%
Days saved, on average	18,3		22,7	
36 How many days can be saved on commissioning and start-up after major modifications due to simulator use in your plant?				
Nothing	2	4%	0	0%
1-6 hours	3	5%	0	0%
6-12 hours	9	16%	3	14%
12-24 hours	3	5%	2	9%
1-2 days	13	23%	5	23%
2-4 days	7	12%	3	14%
over 4 days	20	35%	9	41%
Amount non-blank answers	57	-	22	-
Days saved, on average	2,2		2,5	

Table 15: Economic benefits (table continues).

37 How many unplanned shutdowns per year can be avoided in your plant due to operator training with simulator?				
0	4	7%	1	5%
1	8	13%	3	14%
2	15	25%	4	18%
3	11	18%	4	18%
4	5	8%	2	9%
5 or more	17	28%	8	36%
Amount non-blank answers	60	100%	22	
Avoided unplanned shutdowns per year, on average	2,9		3,2	
38 How much can be earned or saved per year by the utilization of a training simulator? (your platform/plant)				
Nothing	0	0%	0	0%
under 1 MNOK	1	2%	0	0%
1 – 5 MNOK	2	4%	0	0%
5 – 15 MNOK	8	15%	4	19%
15 – 50 MNOK	15	28%	5	24%
50 – 100 MNOK	9	17%	2	10%
100 – 200 MNOK	4	8%	3	14%
More than 200 MNOK	14	26%	7	33%
Amount non-blank answers	53	100%	21	100%
Annual savings in MNOK, on average	88		105	
39 What is the payback time of a simulator in your platform/plant? (including operator training, DCS verification, training on procedures, simulation studies, etc.)				
0-6 months	20	54%	11	69%
6 -12 months	4	11%	0	0%
1-2 years	5	14%	3	19%
2-3 years	5	14%	1	6%
3-4 years	0	0%	0	0%
4-5 years	1	3%	1	6%
Longer than 5 years	2	5%	0	0%
Amount non-blank answers	37	100%	16	100%
Payback time in months, on average	13,8		10,7	

3.6 How the simulator should be

In the sixth section of the survey, the respondents were asked about how the simulators should be developed.

Over 90% of the respondents agreed that the process model should represent the real process exactly and ¾ considered identical DCS replica as an important for part of the simulator. Most of the respondents (86%) did not consider identical simulator room and control room as a necessary feature for simulator training in the future. Also addition of all the utility systems to the simulator was not that important to half of the respondents (53%). The wishes for the simulator use for other purposes than simulator training were similar to the current use.

The top-most requests for the simulator improvements at the respondents' workplaces were:

1. Model should be updated more often, so that it represents the plant more accurately (57%)
2. More utility systems should be included in the model (55%)
3. Online-simulator, possibility to use real-time data from the platform/plant (51%)

Table 16: Requests for the future simulator.

40 Simulator and simulator training facilities should be as follows:	Answers	%
The process model should represent the real process exactly	91	93%
All utility systems should be modeled	46	47%
The DCS part of the simulator should include all the functionalities of the real control system	75	77%
The simulator console should be exact replica of the operator console (all ESD/PSD functionalities/CAP panel must be included)	47	48%
The whole simulator room should be exact replica of the control room	14	14%
Amount non-blank answers	98	-
Number of options, on average	2,8	
41 Wishes for the operator training center in my plant		
Model should be updated more often, so that it represents the plant more accurately	50	57%
More utility systems should be included in the model	48	55%
Possibility to use real-time data from the platform/plant (online simulator)	44	51%
Possibility to present numerous upset situations from past months	33	38%
Possibility to use recent operation data from past days/weeks (online simulator)	32	37%
More interactive simulations scenarios	17	20%
Broader spectrum of initial conditions (IC)	17	20%
More simulators	16	18%
More support from vendors	6	7%
Emulated system should be converted to stimulated system	6	7%
Stimulated system should be converted to emulated system	1	1%
Amount non-blank answers		
Number of options, on average	2,7	

42 Wishes for the simulation use for other purposes than operator training in your platform/plant? (We would like to use the simulator for:)		
Verification of process/equipment upgrade	73	78%
Production optimization and debottlenecking	72	77%
Dynamic simulation studies on “worst case scenarios”	69	73%
Verification of DCS/SAS system upgrade	66	70%
Verification of new procedures	58	62%
Pre-operational & operational support	59	63%
Verification and testing of new DCS screens and HMI functionality	53	56%
Control strategy development and testing	52	55%
Design verification & technical integrity assessment	52	55%
FEED and detailed design support	33	35%
HAZOP studies	30	32%
Flow assurance studies	23	24%
Feasibility or conceptual studies	23	24%
Real time leak detection and pipeline monitoring	9	10%
Amount non-blank answers	94	-
Number of options, on average	6,8	

3.7 Comments from the respondents

Respondents comments was the last part of the survey, question 43. The original version in Norwegian is given in italics. Details added by the authors of this document are marked with CAPITAL LETTERS. These details were removed in order to keep the respondents’ identity and workplace anonymous.

The comments are grouped in the following subcategories: simulator as collaboration tool, successful simulator training, successful simulator maintenance, organizational barriers, and technical barriers.

Table 17: Simulator as collaboration tool between different work groups, use of simulator for other purposes than operator training.

	Comments
Instructor	*Vi er i en omleggingsfase til nytt kontrollsystem, og er blitt lovet fult oppdatert simulator… (DETAILS)… vi håper å få en simulator til som kan brukes sammen med ingeniørstaben.*
	We are changing the control system at the plant, and have been promised a fully updated simulator… (DETAILS)… we hope to get a simulator we can use together with the engineering stab.
Automation engineer	*Jobber som automasjonsingeniør og er opptatt av at det skal være mest mulig likt på treningssimulator/ingeniørsimulator å gjøre logikkendringer, slik at man kan bruke simulator til denne type opplæring også, samt uttesting av logikk.*
	I work as automation engineer. My priority is that the training simulator and engineering simulator has to be as similar as possible, especially to implementation of CONTROL SYSTEM logic changes. This enables such type of scenario at simulator training, and testing of the CONTROL SYSTEM logic AHEAD.

Operator	*Tror vi kan spare en god del, ved å lage simulerte modeller av prosjekter og så testkjøring på simulator i prosjekteringsfasen. Da kan vi få samkjørt det hele både nytt og gammelt og på den måte oppdage uforutsette konflikter før man bygger. Hjelpeutstyr må også med, har selv opplevd at kapasitets tester ikke holder mål pga manglende hjelpeutstyr som i utgangspunktet virker ubetydelig og derfor var utelatt.*
	I think that one can save quite a lot by making PARTIAL-models of the MODIFICATION projects and then test run the MODIFICATIONS with the WHOLE simulators during the project phase. Like this it is possible to run both new and existing parts of the PLANT, and to find out the unforeseen conflicts/problems before the MODIFICATION is built. Utility systems should be included in the SIMULATOR. I have myself experienced that capacity tests are not good enough when utility systems are missing, even if these to start with seems less important, and therefore were not included in the SIMULATOR MODEL.
Shift leader	*Simulatoren er et fleksibelt verktøy som kan brukes i mange situasjoner. Tror bruken av den til detaljerte prosess modeller for utvikling av nytt utstyr etc kan bli for omfattende og ikke passe helt til det jeg ser for meg. Men uttesting av nye reguleringer, nedstengings/sikkerhets funksjoner etc er en viktig del av simulatoren. Det er også viktig at den er ofte oppdatert og har realistiske oppsett basert på plattformens situasjon i nåtid. Alle nye regulerings sløyfer bør innom simulatoren og testes av operator der før idriftsettelse på plattform.*
	Simulator is a flexible tool that can be used in many situations. I think that use of the simulator for detailed process models/development of new equipment can be too extensive and does not quite fit in for my purposes. But testing of new control loops, shut-down and safety functionalities, etc, are an important part of the simulator. It is also important that the simulator is frequently updated and has realistic PROCESS CONDITION based on the platforms current situation. All new control loops should be IMPLEMENTED in simulator and tested by the process operators before commissioning on the platform.
Manager	*Denne undersøkelsen kunne tatt med seg prosjekt dimensjonen i større grad. men eller var den bra :-)*
	This survey should have included the project-dimension better. But otherwise good.
Shift leader	*Det som uansett må ligge i bunn for en vellykket organisasjon mtp bruk av simulator er at vi evner å legge til rette, planlegge for bruk, ha en god struktur på bruk. (Gode IC'er, involvering av flere instruktører, skape engasjement).*
	Basis for a successful simulator organization is facilitation of the simulator use, planning of the simulator use, and a good structure for the users. (Good INITIAL CONDITIONS FOR THE MODEL, involvement of many instructors, and engagement in the organization.)

Table 18: Successful simulator training.

	Comments
System engineer	*Det er noen år siden jeg var system ingeniør, men det er klinkende klart at simulator er helt nødvendig for alle anlegg.*
	It is a couple of years ago I worked as system engineer, but it is crystal clear that simulator is essential TOOL for all plants/platforms.
Operator	*Vanskelig å si hvor mye bedriften kan spare på å gjennomføre simulatortreninger. Men oppkjøringstidene kan reduseres kraftig med å ha trent mye på simulator. Uansett hvor "store" simulatorutgifter man har, så er det billigere enn tapet på senere oppkjøring.*
	It is difficult to say how much the company can save due to simulator training. But start-up time can be reduced significantly due to adequate simulator training. No matter how "large" the simulator costs are, these are much less costly than mistakes made in drift.
System engineer	*Treningssimulatorer er viktige både for operatorenes trygghetsfølelse og bedre kjøring av anlegg.*
	Training simulators are important for both the operators feeling of safety and better steering of the process.
Instructor	*Simulator er et essensielt verktøy for å kunne gi en tilfredsstillende opplæring til kontrollromspersonell i større prosessanlegg.*
	Simulator is an essential tool enabling adequate training for control room operators.
Operator	*Ved trening på simulator bør man kun være 2 personer sammen på simulatoren, der man opererer på hver vår operatørstasjon. På den måten blir det likt som på plattformen, og det blir også mer effektiv trening. Opplever også at det brukes tid på møter og diverse andre saker når man har satt av tid til å trene på simulatoren. Dette bør unngås slik at vi får mer utbytte av treningen. I tillegg ønsker jeg mer stresstrening på simulatoren, f.eks. ved at man får inn brann og gass alarmer og raskt ta hånd om dette. Mer trening på DFU'er.(DEFINERTE FARE- OG ULYKKESSITUASJONER)*
	During simulator training session there should be 2 persons running the simulator, each operating their own operator station. In this way it will be just like it is at the platform, and therefore more effective training. Too much of the allocated simulator training time is used for meetings and other things. This should be avoided in order to get more out of the training. In addition I would like to have more stress-training on the simulator, for example by adding fire & gas alarms AS EXTRA TRIGGERS and ask the operators to handle the situation as fast as possible. More training on defined danger and accident situations.
Operator	*Veldig viktig simulatortrening både for gamle og ikke minst nye operatorer. Har selv vært involvert og laget scenarier, har lærling som også får god nytte av verktøyet. Det må tilstrebes å brukes mye mere.*
	Simulator training is very important for both experienced and new operators. I have been involved IN SIMULATOR TRAINING and made scenarios. I supervise a trainee who benefits a lot of the simulator. One should put more effort to use the simulator much more.
Instructor	*Simulatoren har blitt brukt mye pga forsinkelser i prosjektet. Erfaringen så langt har vært veldig positive. Simulator bruken skaper mange gode diskusjoner og Operatorene får hele tiden utviklet en bedre forståelse til prosessen og de kan prøve og feile. (DETAILS)*
	The simulator has been used a lot due to delays in the project. Experiences so far have been very positive. The use of simulator creates many good discussions. The operators get to widen their understanding of the process, they can test and fail.

Table 19: Successful maintenance and updating of the simulator.

	Comments
Automation engineer	*En simulator må alltid være oppdatert for at man skal ha nytte av den. Dette krever gode rutiner og prosedyrer for hvordan dette skal gjøres!*
	A simulator must be up-to-date at all times to get most out of it. This requires good routines and procedures on how-to-do updating.
Automation engineer	*Etter IAT på nye software-pakker, bør disse legges inn på simulatoren, og fat og commissioning prosedyren kjøres på simulator. Dette bør bli en rutine. Da sparer alle mye tid i havet . Stor suksess på PLATTFORM, arbeid som jeg har ledet.*
	After the INTERNAL ACCEPTANCE TEST on new software packages, these should be implemented in the simulator. FACTORY ACCEPTANCE TEST and commissioning procedures should be run through the simulator. This should be a routine that would save a lot of time offshore. The work I have been leading at MY PLATFORM has been a great success.
Automation engineer	*Simulatorer bør i større grad integreres med offshore anlegg og eventuelle avvik mellom anleggene vil kunne minimeres.*
	Simulators should be integrated more tightly with the offshore platforms. This way the discrepancies between the process and the simulators could be minimized.

Table 20: Organizational barriers for successful simulator use.

	Comment
Operator	*Har aldri brukt simulator tilhørende min installasjon, da mine ledere ikke legger vekt på slik trening. Føler meg utrygg og ukomfortabel i mange situasjoner, mye på grunn av null simulator trening.*
	I have never used simulator that is specific for my PLANT/PLATFORM, because management does not prioritize such training. I feel unsecure and uncomfortable in many situations, mainly due to lack of simulator training.
Operator	*Simulatoren som vi kan disponere er i alt for liten grad benyttet. Det skyldes dårlig drifting og vedlikehold av simulatoren, somt lav prioritering av simulatortrening fra ledelsen ombord på installasjonen.*
	Simulator that is available for us is used far too little. The reason for this is poor operations and maintenance of the simulator, combined with little prioritization of simulator training from the management at the installation.
Operator	*Min erfaring med simulator er basert på da den var i drift, vi har nå en simulator som står brakk pga manglende prioritering i organisasjonen. Dessverre.*
	My experience on simulators is based on the past when it was in drift/actively used. Now it is broken/unused due to lack of prioritization in the organization. Unfortunately.
Instructor	*Det er utfordrende å svare helt optimalt på alle spørsmålene deres. Jeg mangler spørsmål som går på metoder for bruk av simulatoren.* *Det er mye her det svikter når det gjelder opplæring. Instruktør ender som regel opp med å kjøre simulator bare etter prosedyre, og har ikke kunnskap til å sette opp et manus og en ramme for selve opplæringen. Derfor utnyttes ikke simulatoren optimalt. Pedagogisk sett er oljeindustrien på steinaldernivå når det gjelder dette tema. Eller sagt på en annen måte = det er bare prosessteknikk som gjelder, hvordan mennesket skal lære å beherske det er underordnet. Etter mitt syn bør oljeindustrien snu på denne formelen.*

	It is challenging to answer all the questions optimally. I would have liked questions on methods for simulator use. When it comes to learning there are lots of things that fail. Generally instructors end up running the simulator only according to procedures. The instructors do not have the knowledge required to set up a manuscript FOR THE SIMULATION SCENARIO, and a framework for the learning process itself. Therefore the simulator is not used optimally. From the pedagogic point of view, oil industry is stuck in the stone age. Eller said in another way = it is only process knowledge that is in focus. How people learn is secondary. In my opinion, the oil industry should change/turn over its priorities.
Instructor	*Det er for liten forståelse vedrørende trening på simulator fra D&V-ledere.*
	Operations and maintenance management have too little knowledge about simulator training.
Operator	*Viktig å prioritere nok midler til drift av simulator og trening.*
	It is important to prioritize some assets for the drift of the simulator and simulator training.
Process engineer	*Simulator brukes i stor grad til å dele læring fra hendelser eller neste hendelser. Disse kan være sikkerhetsrelaterte eller produksjonsrelaterte. Dette krever ressurser og bruk av ingeniører med direkte kunnskap til den spesifikke prosessen (typisk prosess ingeniør). Utfordring er å få ledelse til å erkjenne dette.*
	Simulator is used frequently to share lessons learned from incidents or close-by-incidents. These can be related to safety or production. It requires resources and use of engineers who have first-hand knowledge on the specific process (typically a process engineer). The challenge is to get the management to understand/acknowledge this.

Table 21: Technical barriers for simulator use.

	Comment
Instructor	*Vi har en simulator i simulator senter. Den kan tas opp enten der eller på PC via COMPANY_NETWORK_TOOL. Ønsker at vi hadde muligheter begge plasser samtidig.*
	We have one simulator in the simulator center. The simulator can either be used there or through the COMPANY_NETWORK_TOOL at desktop PC. I wish it would be possible to use the simulator in both places simultaneously.
Operator	*Vi holder på å bytte ut kontrollsystemet på PLATTFORM. Men jeg tviler på at det planlagt en ny simulator likt det nye systemet.*
	We are changing the control system on MY PLATFORM. But I doubt that the planned new simulator will be alike the new system.
Operator	*Vi på PLATFORM har hatt cirka 3 oppgraderinger/nye simulatorer uten at de har vært noe særlig i bruk.* *Det er veldig viktig å tilrettelegge for bruk.* *Da er mulighet for fjernstyring/fjernpålogging veldig viktig.* *Kan en logge seg på f.eks. fra offshore, hadde simulatoren vært mye oftere i bruk.* *Dette brukes allerede i dag og er en enkel tilrettelegging data teknisk som ikke har hatt stor nok fokus.*
	In my PLATFORM we have had about 3 upgrades/new simulator, but the simulators have not been used that much. It is very important to facilitate the use of simulator. Possibility to remotely log on the simulator and use it is very important ENABLING FACTOR.

	If you can log on the simulator for example from offshore, the simulator could be used much more frequently. Such technology is already used today (IN OTHER PLACES) and it is a simple technological set up that has not had enough focus.
Automation engineer	*Bruk av simulator i migreringsprosjekter hvor noder leveres over lengre tid (år) er en utfordring da plattformen vil bestå av gammel/nytt i en lengre periode.*
	Use of simulators in migration-projects where control system nodes are delivered/replaced over longer time (year) is a challenge when the platform will contain old and new CONTROL SYSTEM PARTS over longer time.
Operator	*Jeg er svært fornøyd med simulatoren på min arbeidsplass.* *Men har hørt at hjelpesystemene ikke er helt optimale.*
	I'm very satisfied with the simulator at my workplace. But I have heard that the utility systems in the model are not quite optimal.

4 Discussion

What makes some simulator users evaluate the simulator training as very successful where as others consider it quite successful or are neutral on simulator use? In this discussion section the answers to questions 6 – 29 are compared between the most successful group and the average of all the respondents.

The results for the simulator type, including the process model (q6) and DCS system (q7), were similar between the two groups. The most successful group had more simulators for operator training (q8), 21% in the most successful group had more than 4 simulators, and more simulators for engineers (q9), 24% had more than one simulator for engineers. Thereby, the most successful group was also using the simulators for many other purposes besides operator training (q10), on average over 7 different purposes.

The responsible parties for the simulator maintenance (q11) were similar between the groups, mainly system engineers, instructors, vendors and automation engineers update the simulator. The most successful group was more satisfied with the current maintenance organization (q12), 44% gave good remarks for the maintenance organization. Not surprisingly, the 56% of most successful group had also a simulator maintenance plan (q13).The difference between the frequency of the updates (q14, q 15) however was not that large between the groups, majority of the most successful respondents updated the simulator configuration after each significant process change (45%), each small change (14%) or based on annual evaluation (14%). Only 10% of both groups were updating the simulator before the changes in the plant/platform. Based on the comments in section 3.7, testing of the modifications with the simulator before commissioning saves a lot of time and resources. The reason for this might be given in the answers for question 16; the main challenge of the simulator maintenance are priorities in the organization, availability of qualified personal, work load and costs.

Approximately 70% of the most successful simulator users answered to the questions in section 0 about the operator training with simulator. There was almost no difference between the groups in question 18 on existence of simulator training plan, about 70% had a plan. However, the most successful group spend more time simulator training (q19), on average 10,5 days for new operators. In the most

successful group retraining was more often mandatory (question 20, 55%) and retraining courses were arranged more frequently for the experienced operators (87% once a year or more often). The top two factors restricting simulator use were the same for both groups: availability of simulators and instructors. However, the most successful group suffered less for non-existing training plan (15%) and outdated simulator model (5%).

Over 90% of the most successful respondents considered that the learning goals were clearly presented (23). The simulator training program in the most successful simulator training centers included more elements than for the other groups, on average 5,5 elements (q24). The most successful group trained more on emergency response management (86%), safety training (77%) and process upsets and hardware/software failures (73%). Theory (50%) and simulation scenarios in normal operating state (91%) were more common in the most successful group (q25). The observation methods (q26) were similar for both groups. The most successful group gave feedback more often (q27), continuously during the scenario (76%), after completed scenario (52%) and after the course day (33%). The most common situations for feedback in the most successful group (q28) were wrong actions where the instructors explains how the task should have been done differently (75%), positive behavior, right actions and good team work (65%) and achieved learning goals (65%). Almost half of the most successful respondents reported that the participants were evaluated using exam in (47%), which was less common for the average group (29%, question29).

The key factors to successful simulator use (q30) according to the most successful group were up-to-date simulator model (62%), good instructors (62%) and support from management (29%); the last factor being slightly less important for the average group. The most successful simulator users consider the benefits of the simulator use to be larger than the average group (q32-q39). The most successful group listed more benefits for simulator use (q32) than the average group, giving improved safety and environmental performance (71%) as the second most common benefit. The most successful group of operators evaluated almost all the benefit options to apply for their work (q33). The improvement for operator effectiveness was 49% for the most successful group, whereas it was 31% for the average group. The most successful group estimates over 23 days that can be saved on commissioning and start-up of a new platform and over 2,5 days on a major modification, whereas the average group estimates over 18 days for new platform and over 2,2 days for a major modification. The most successful group suggest that they can avoid 3,2 unplanned shutdowns per year per plant, the average group 2,9 unplanned shutdowns per year per plant. The savings (q38) and payback time (q39) are over 105 MNOK and under 10,7 months for the most successful group, and over 88MNOK and under 13,8 months for the average group.

5 Conclusions

According to the survey results, simulator training in the Norwegian oil and gas industry is successful. The main success factors are up-to-date high-fidelity simulator model tailor-made for the plant/platform, good instructors, proper organization around simulator training and facilitation of participation. The main benefits of the simulator training for the process operators is confidence to operate the plant/platform safety, and for the company reduced operational risk , enhanced facility integrity, and

high production performance. The economic benefits of simulator training are significant due to rapid start-ups, avoidance of shut-downs, and improved effectiveness.

The simulator training programs are well planned, and both new and experienced operators participate simulator training. The instructors give continuous follow up for the participants during the simulation sessions, where the scenarios are based on typical process operations on normal and abnormal situations, for safety training and emergency response management.

The respondents who evaluated their simulator use most successful had the following advantages compared to the whole respondent group on average: they had more simulators, were using the simulators for many other purposes than simulator training, had more organized structure around simulators including plan for simulator maintenance, training, learning and evaluation. Not surprisingly, the most successful group considered the benefits of the simulator use to be larger than the average group.

The participants wish for more frequent simulator model/model condition updates, more extensive simulator model and possibility to use real-time data from the platform/plant.

The solid simulator training programs and the high-fidelity simulator technology in the Norwegian oil and gas industry provide great possibilities for technology transfer to other process industries where simulator technology is not widely used.

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