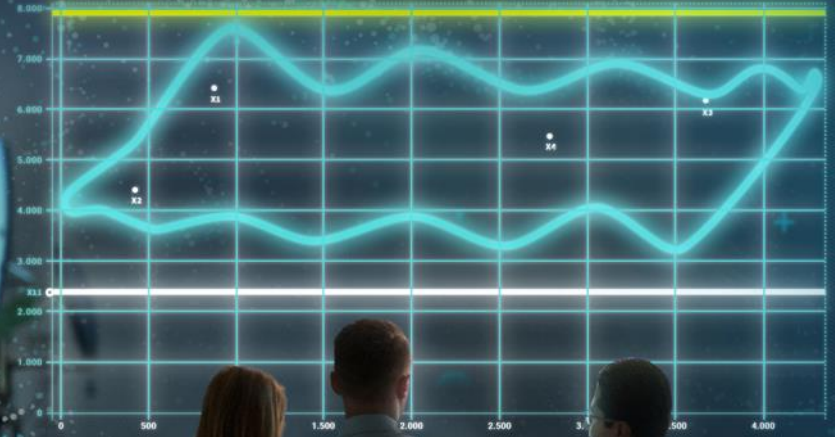


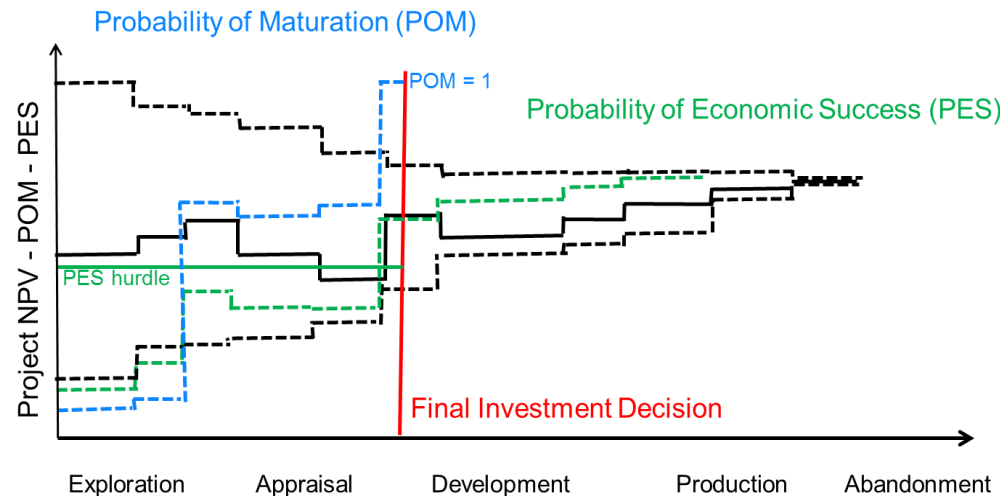
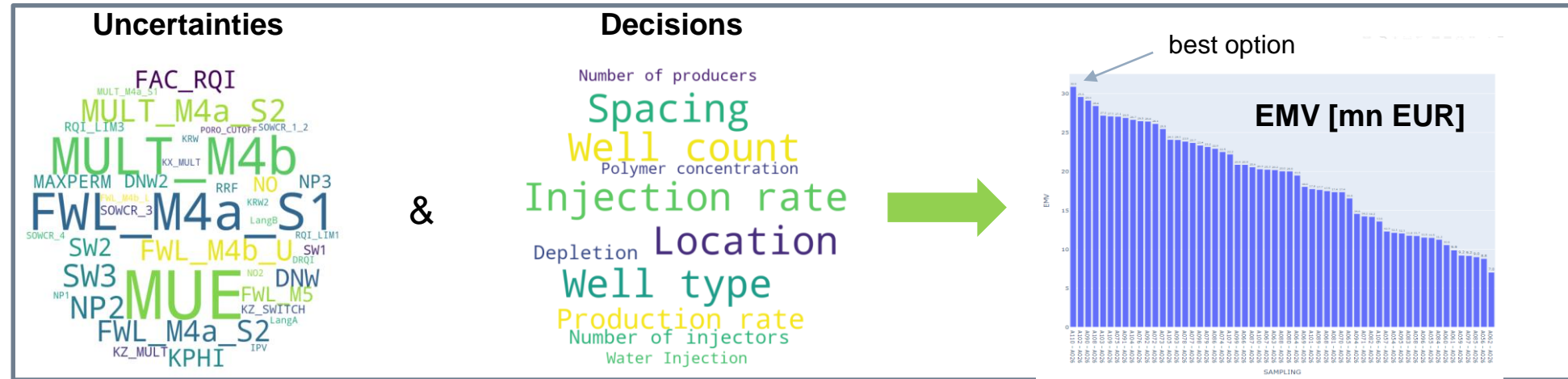
Hydrocarbon Field (Re-)Development as Partially Observable Markov-Decision-Process

Torsten Clemens
October 2021



OMV Exploration & Production

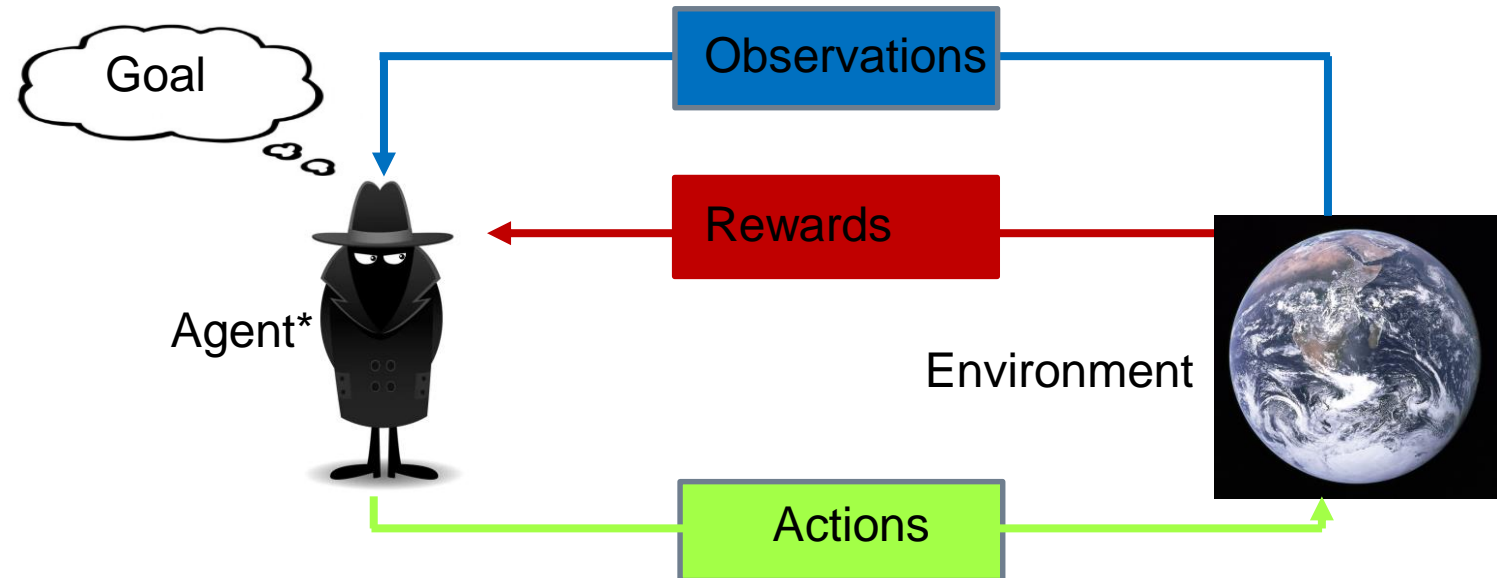
Key aspects of hydrocarbon field (re-)developments



Steineder & Clemens, SPE-205227

Characteristics of a Markov-Decision-Process

- ▶ States
- ▶ Actions
- ▶ Transitions
- ▶ Rewards
- ▶ Observations
(Partially Observable MDP)



Sieberer & Clemens, SPE-206041

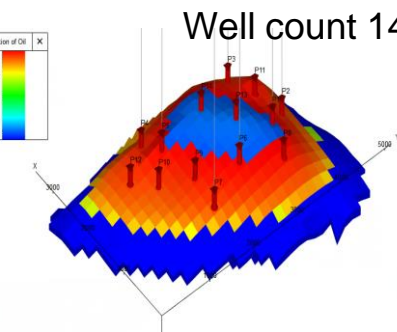
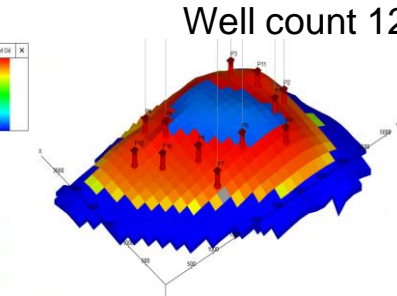
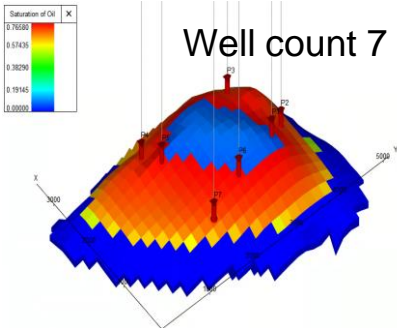
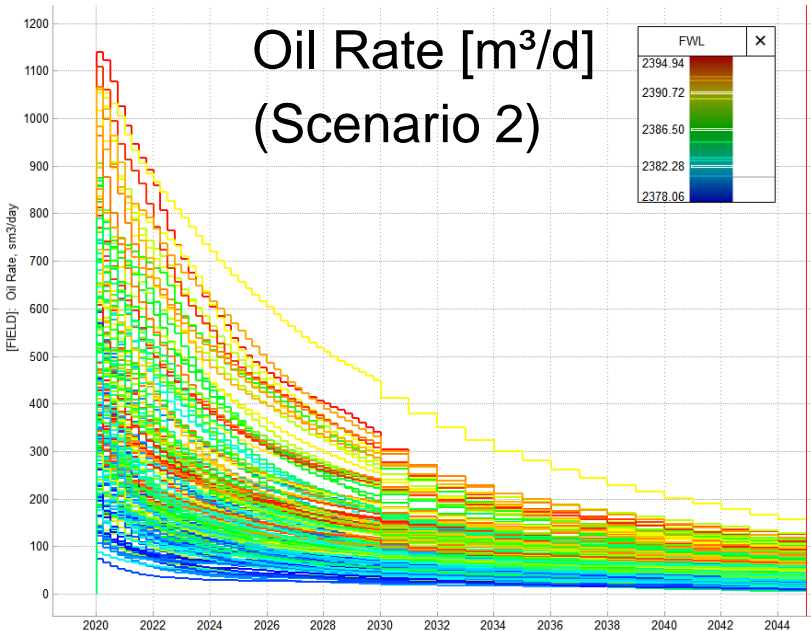
Example case reservoir

Parametrization Table:

Parameter	Type	Range	Ranges change with scenario?	Measurement cost [mn EUR]	Possible outcomes
MUE	Integer	U[1,10]	no	0.5	{1-3, 4-7, 8-10}
FWL	Real	U[2378,2395]	no	4	{2378 - 2387, 2387 - 2395}
GOC	Real	U[2340,2360]	no	4	{2340 - 2350, 2350 - 2360}
PERM_MULT	Real	U[0.5,2.0]	no		
KV_MULT	Real	U[0.01,0.3]	no		
PORO_MULT	Real	U[0.7,1.3]	no		
SW1	Real	U[0.1,0.3]	no	0.5	{0.1 - 0.2, 0.2 - 0.3}
KRW	Real	U[0.45,0.8]	no	0.5	{0.45 - 0.62, 0.62 - 0.8}
NO	Real	U[1.3,4.0]	no	0.5	{1.3 - 2.0, 2.0 - 4.0}
DNW	Real	U[0.0,3.0]	no		
NP1	Real	U[8.0,15.0]	no		
SOWCR	Real	U[0.1,0.4]	no	0.5	{0.1 - 0.25, 0.25 - 0.4}
Oil Price	Real	U[30.0,60.0]	no		
Gas Price	Real	U[5.0, 8.0]	no		
CAPEX per well	Real	U[3.0,5.0]	no	0.5	{3.0 - 4.0, 4.0 - 5.0}
CAPEX facility	Real	Scenario 1,2,3: U[16, 28] Scenario 4: U[2,3]	yes		
Unit OPEX oil	Real	Scenario 1,2,3: U[0.119, 0.221] Scenario 4: U[0.199, 0.243]	yes		
Unit OPEX gas	Real	Scenario 1,2,3: U[0.7, 1.3] Scenario 4: U[1.17, 1.43]	yes	0.5	{lower third, middle third, upper third}
Unit OPEX water	Real	Scenario 1,2,3: U[0.14, 0.26] Scenario 4: U[0.23, 0.29]	yes		
Unit OPEX Liquid	Real	Scenario 1,2,3: U[0.5, 0.94] Scenario 4: U[0.84, 1.03]	yes	0.5	{lower third, middle third, upper third}
Unit OPEX Producer	Real	U[0.019, 0.035]	no		

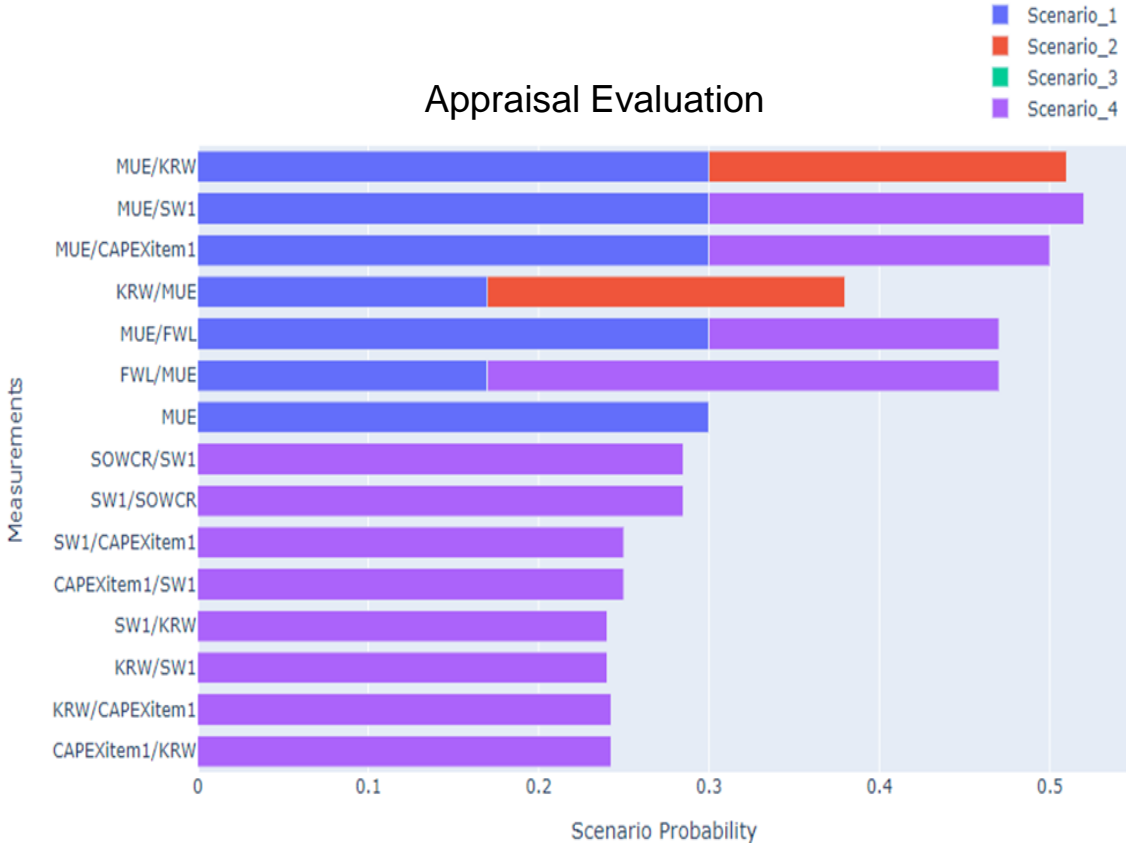
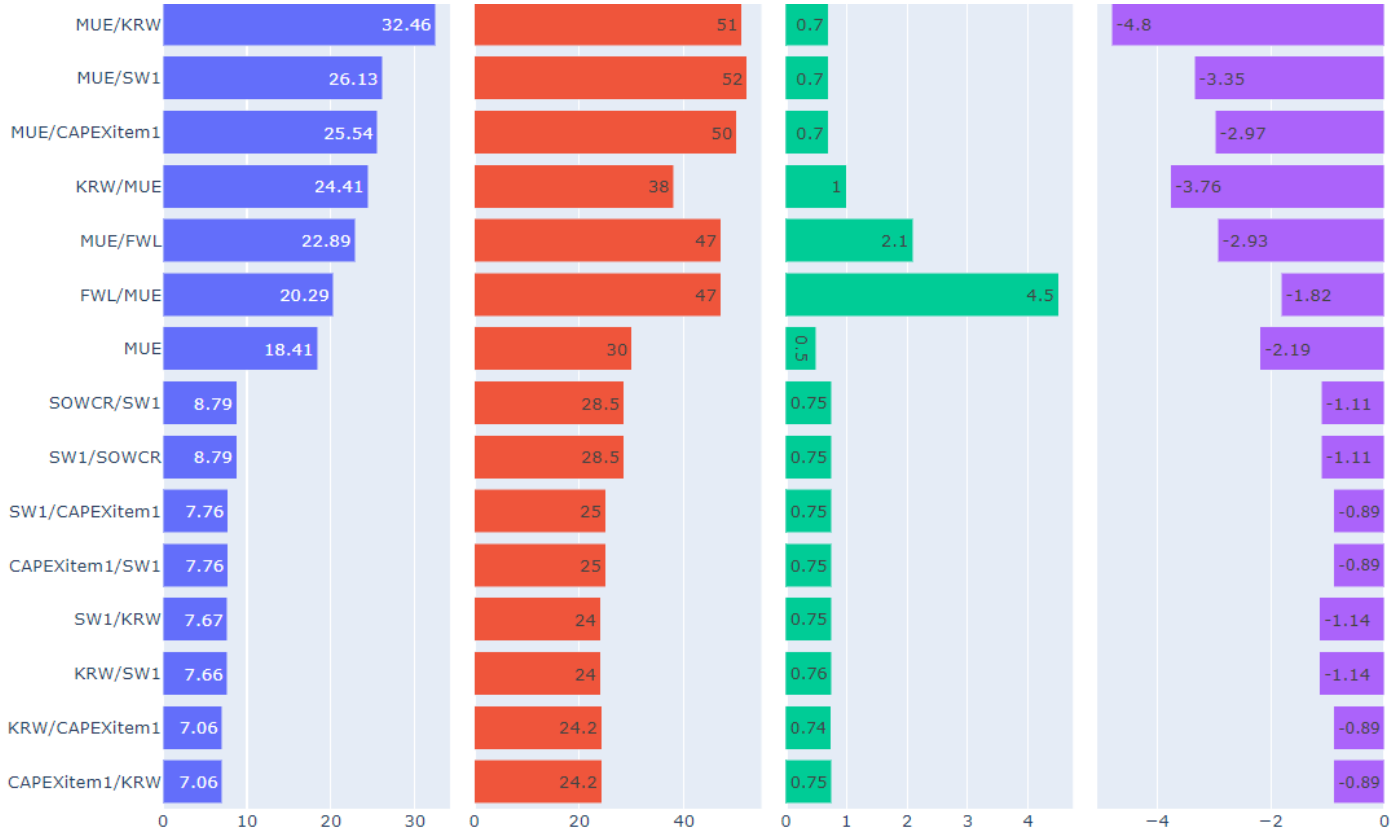
Development Option Table:

Scenario	Facility constraint [m³/d]	Well count
1	1400	7
2	1400	12
3	1400	14
4	350	7

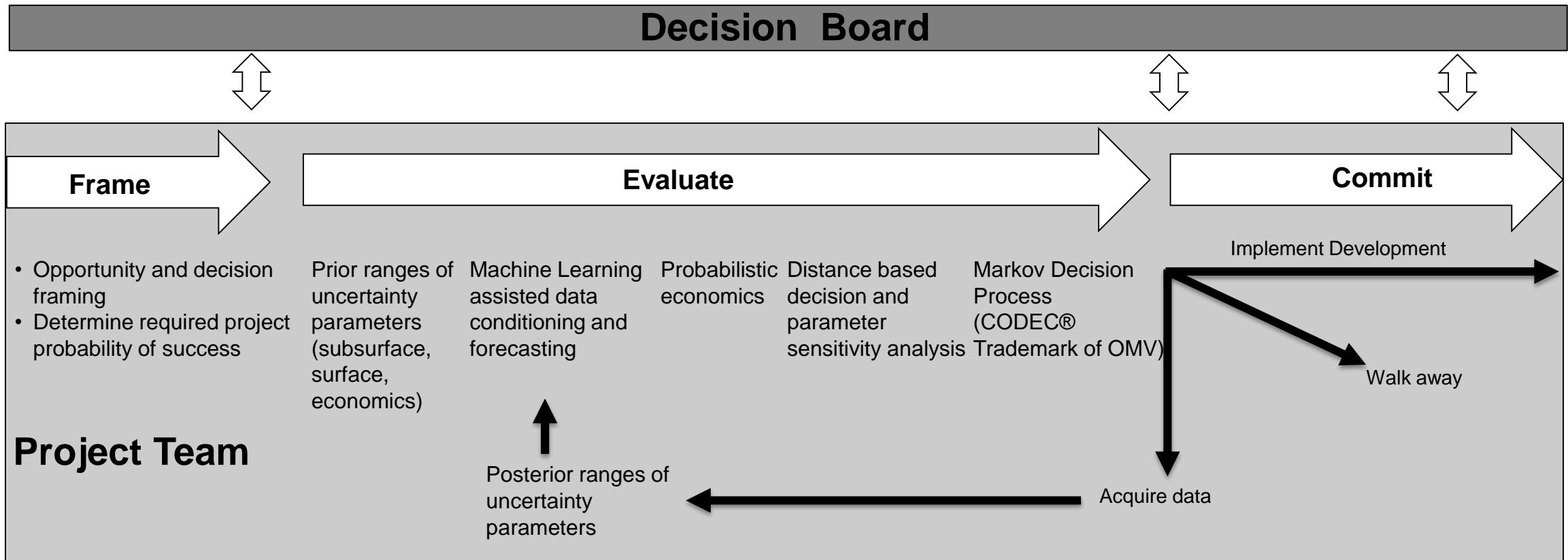


Results of the solving the Partially Observable Markov-Decision-Process

Expected Monetary Value Probability of Maturation Expected Costs Excepted Loss



OMV's Bayesian DEvelopment Process (BDEV® - Trademark of OMV)



Further reading, OMV Journal Papers: SPE-205188-PA, SPE-203384-PA, SPE-200540-PA, SPE-195499-PA, SPE-190233-PA, SPE-179546-PA

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