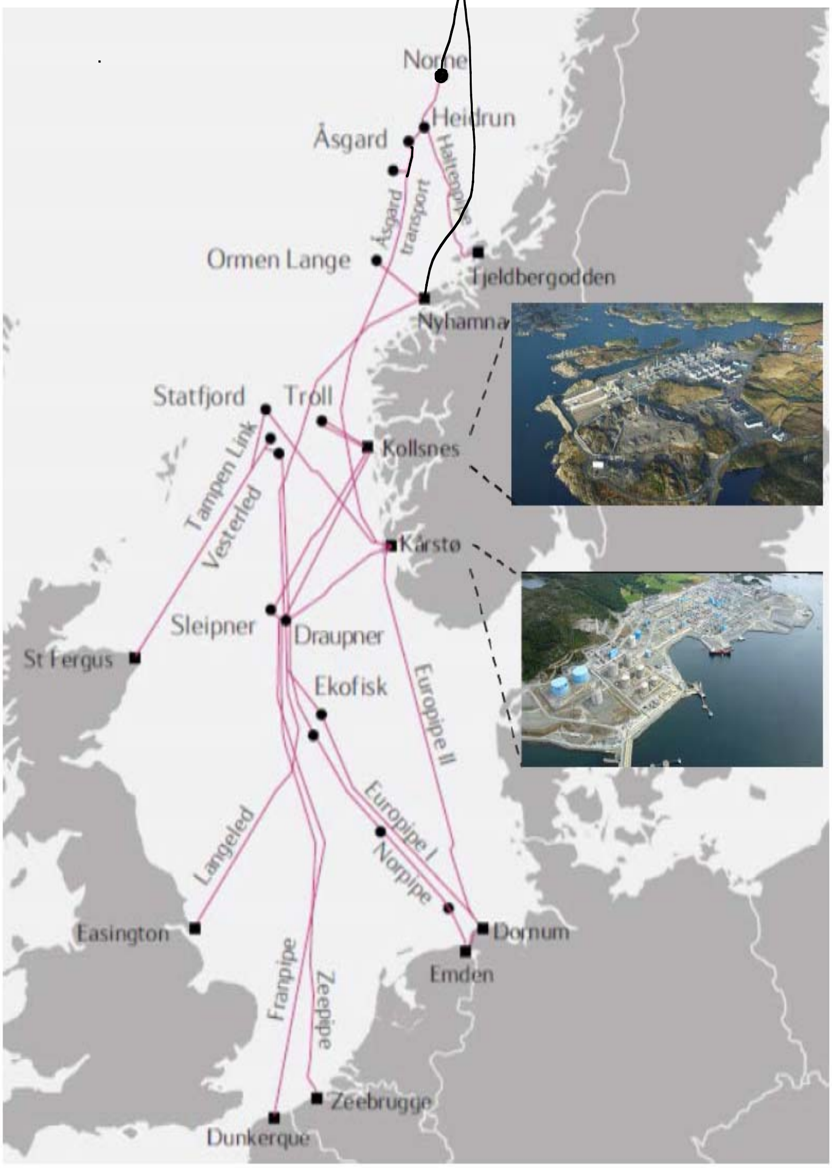
- tentative date for first set of exercises : end of next week.

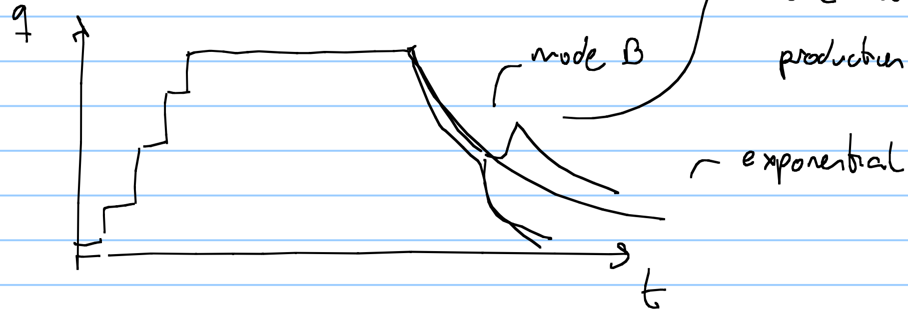
- things that were missing from last class:

for gas developments using a gas distribution network a tariff must be paid (in Norway is Gassco)



in gas contracts one usually has a:
- DCQ (daily contract quantity)
- Swing factor (multiplier to DCQ) 1.2, 1.3
- penalty clause: how much the producer has to pay if doesn't deliver DCQ.

about the production profile



changes in the decline are due to changes in the production system: wellbore collapse, scale in tubing, liquid loading, wax accumulation

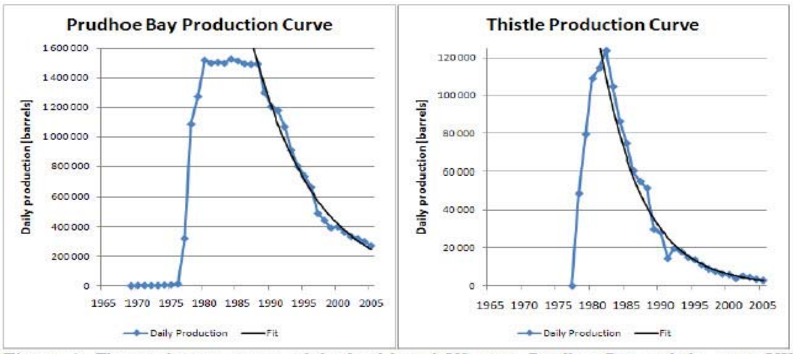
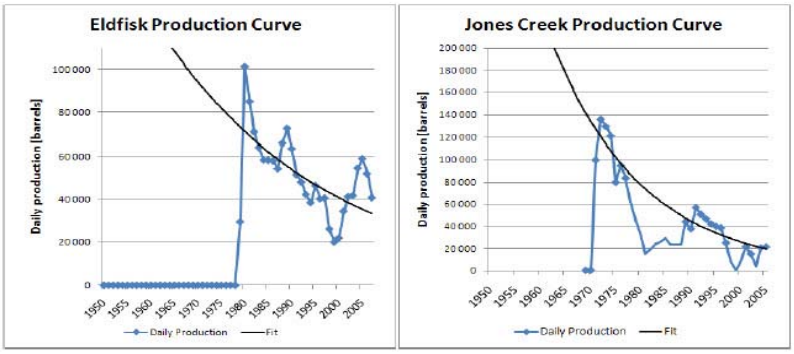
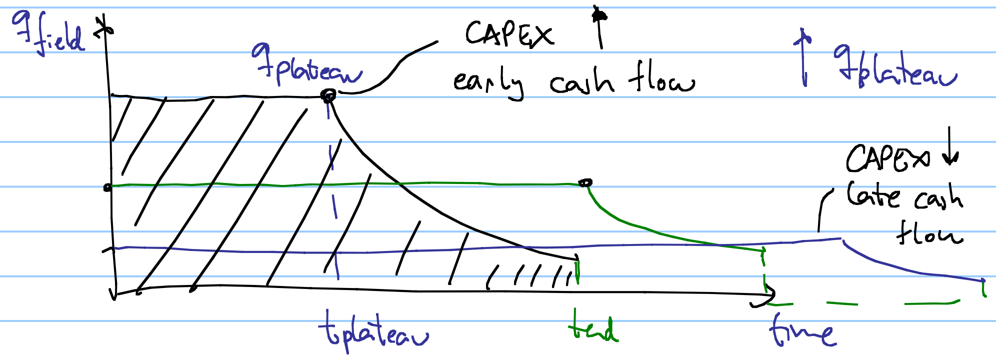


Figure 4: *The production curves of the land-based US giant Prudhoe Bay and the giant UK Thistle offshore field. The approximately exponential average decline rate is clearly seen in these two well-behaved fields.*



https://grandemotte.wordpress.com/oil-and-gas-5-production-decline-rates/

- there is a very close relationship between plateau length and plateau height



↑ $q_{plateau}$ ↓ $t_{plateau}$

$$N_{pu} = \int_0^{t_{end}} q_{field}(t)\, dt$$

l_{orl}

ultimate cumulative production

how do I decide a proper plateau length? { economical analysis, max NPV for a fixed production system.

- height is dictated by physics (engineering)
  - ↳ economics

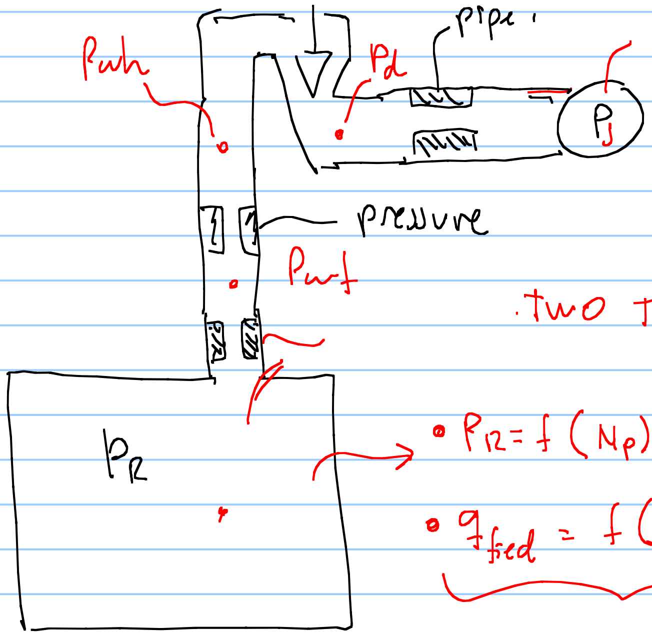
If q is higher:
- produce excessive sand
- erosion
- damage
-

- length is dictated by physics

PRODUCTION IS THE ONLY SOURCE OF REVENUE IN THE FIELD!

- how to compute production profiles?

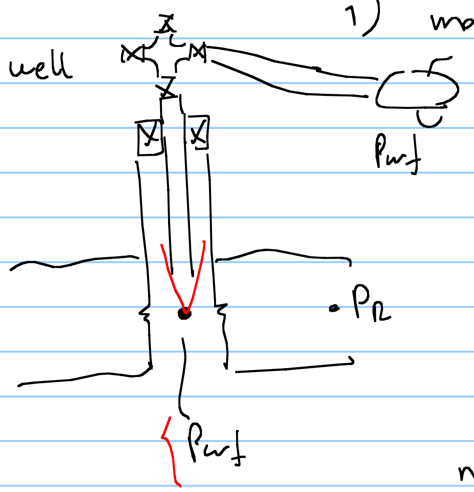
N_p oil
G_p gas
Q_p ~ generic



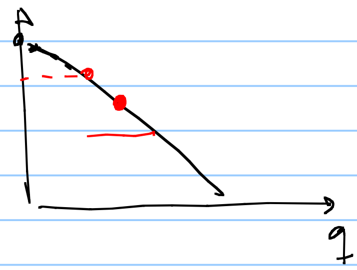
TWO THINGS ARE REQUIRED

- $P_R = f(N_p)$ → static reservoir equation — material balance
- $\underbrace{q_{fed} = f(P_R, P_s, \text{restrictions})}$ → dynamic model

1) material balance + IPR equation
Inflow performance relationship



↳ how much production will I get from the reservoir if I exert certain Pwf



neglects all the system downstream the well bottomhole

? ? It is important to use a Pwf that is realistic and that allows the fluid to flow from bottomhole to separator
(required Pwf)

- a too high P_{wf} will give less production and be too pessimistic
- a too low P_{wf} will give more production and be too optimistic.

required P_{wf} usually changes with time ! . $f(q_{well})$!

2) Reservoir simulator (mass conservation
momentum conservation } !

areal distribution of parameters.

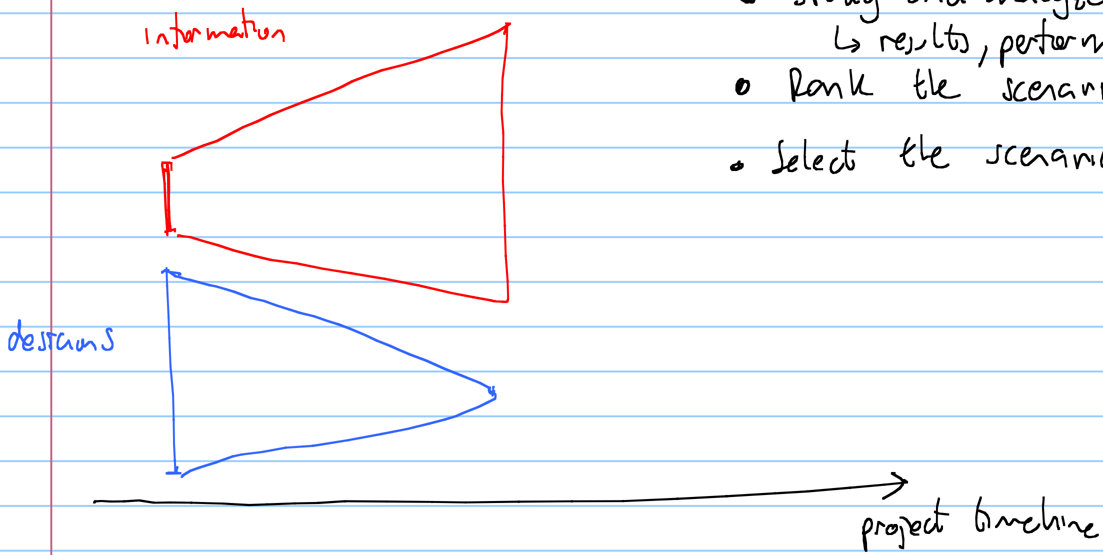
↑ big uncertainty in the input → ↑ big uncertainty in the output

—//—

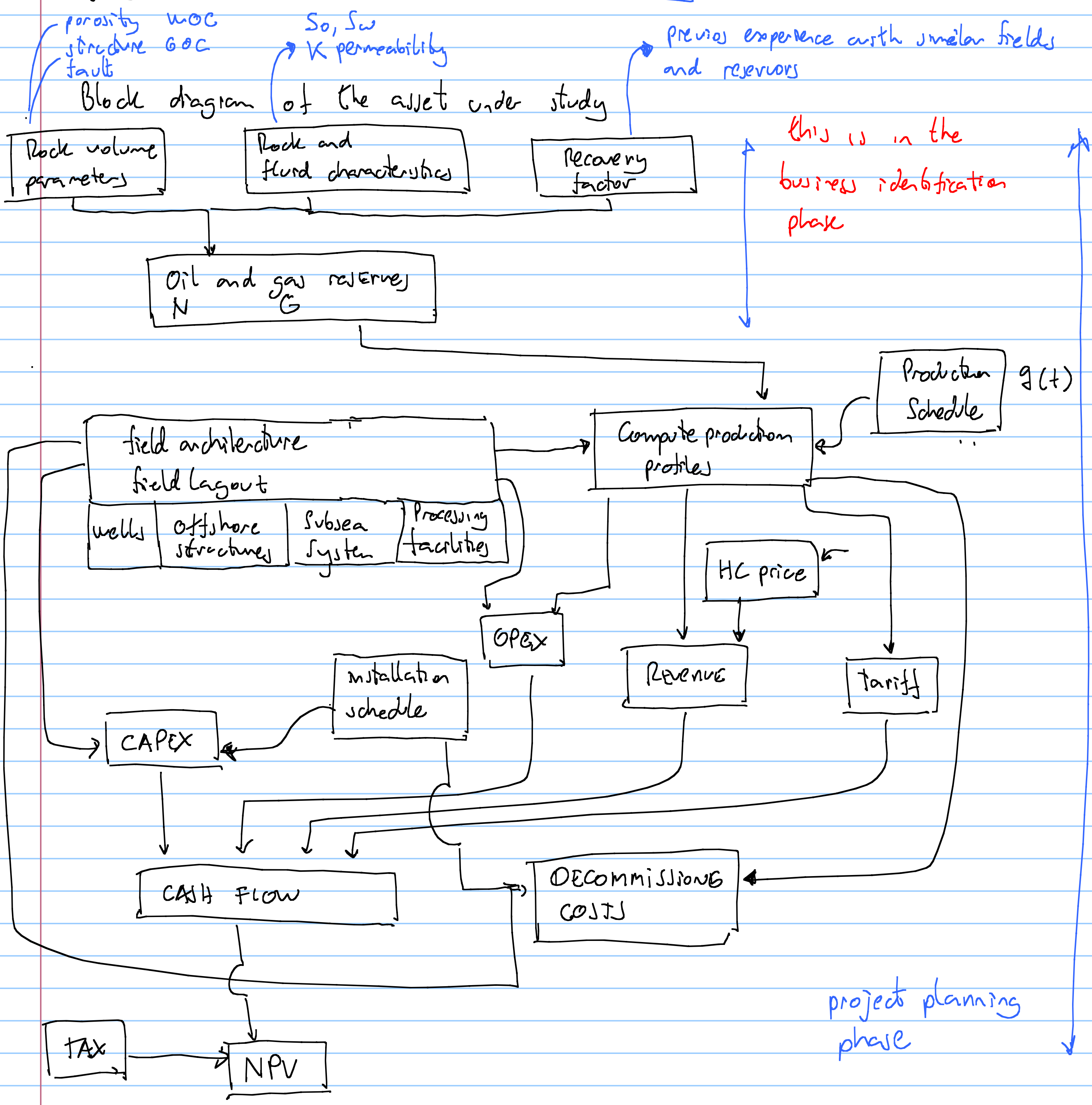
Uncertainty quantification and management in the field planning process

the main tasks of field planning: • Identify field development scenarios

- Perform a pre-design of each scenario
- study and analyze each scenario
  ↳ results, performance
- Rank the scenarios using a criteria
- Select the scenario (Best case)



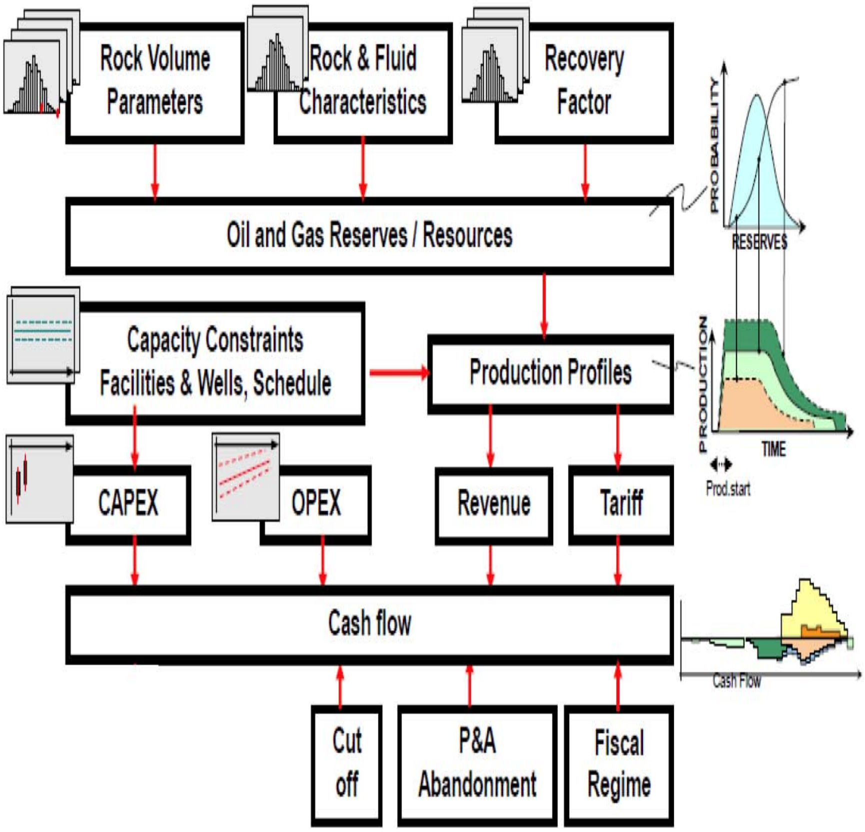
VALUE CHAIN MODEL



- there is a team of experts working constantly in every box.

interdisciplinary : geologist
geophysicists
reservoir engineer
offshore engineer
accountant, economist
drilling engineer

+ non techical - petroleum disciplines
HSE
political advisor


Rock Volume Parameters
Rock & Fluid Characteristics
Recovery Factor
Oil and Gas Reserves / Resources
PROBABILITY
RESERVES
Capacity Constraints Facilities & Wells, Schedule
Production Profiles
PRODUCTION
TIME
Prod.start
CAPEX
OPEX
Revenue
Tariff
Cash flow
Cash Flow
Cut off
P&A Abandonment
Fiscal Regime

Evaluation criteria

① **Economical**
- Cost
- Revenue
- Cash flow investment
- NPV

Schedule
- time line
- resources
- project management

Risk

this is not a deterministic process

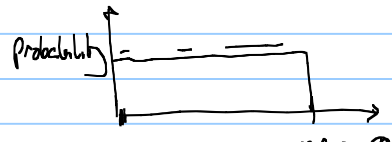
single value → single value

INPUT → f(x) → output

probabilistic : there is a probabilistic distribution for each input

range of values for the input

φ min base low



Probability : chance of ocurrance of an event

Deterministic : discrete outputs (calculated based on min, mean, max)

cannot guarantee that mean case is the base case

It is very unlikely that the maximum or minimum will ocurr simultaneously for all variables

NPV_{min}, NPV_{max}, NPV_{base}

Probabilistic • full range of possible outcomes

NPV

there are several tools to evaluate a project:
- Probability plots
- time plots
- Decision trees
- tornado plots (spider plots)
- summary tables advantages disadvantages
- Qualitative ranking assign grade to a quality

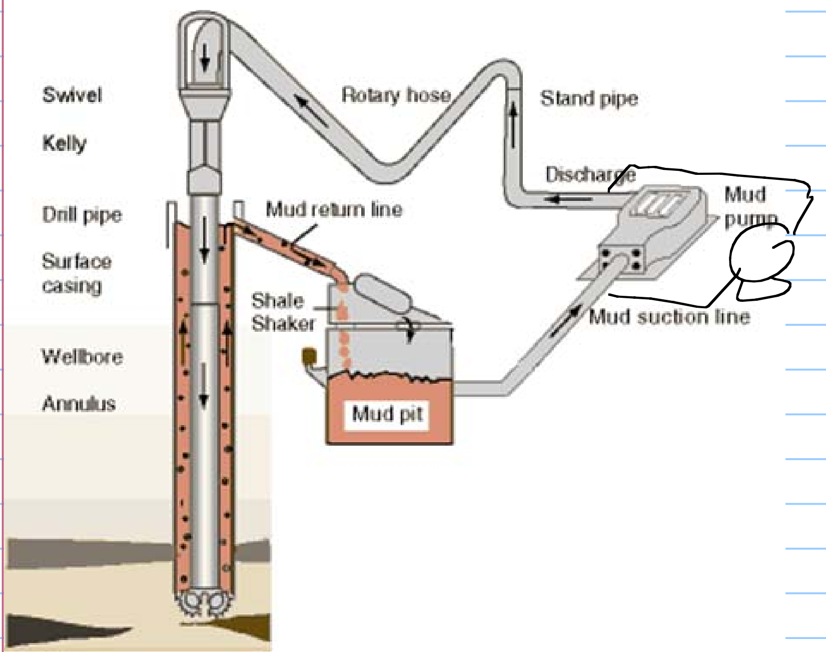
Probability → reserve estimation → probability distribution
→ MONTE CARLO

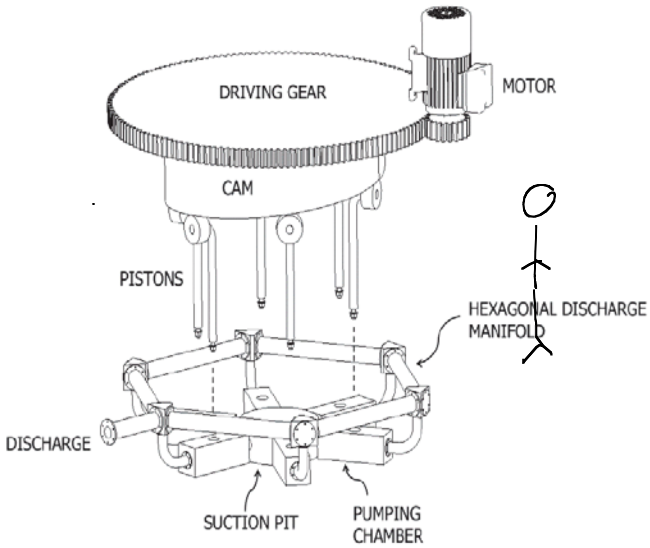
start with an example in excel.

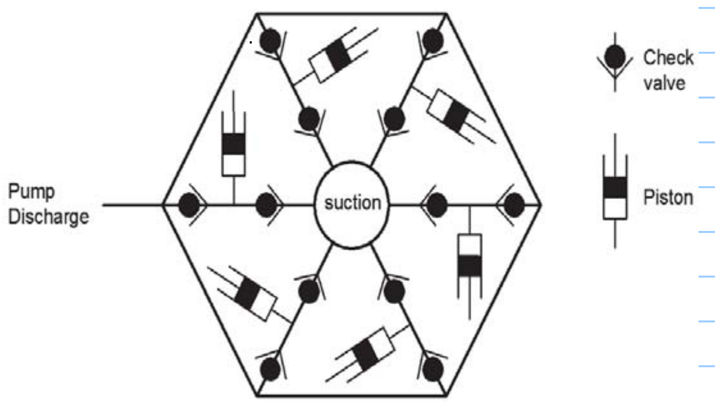
tripexo

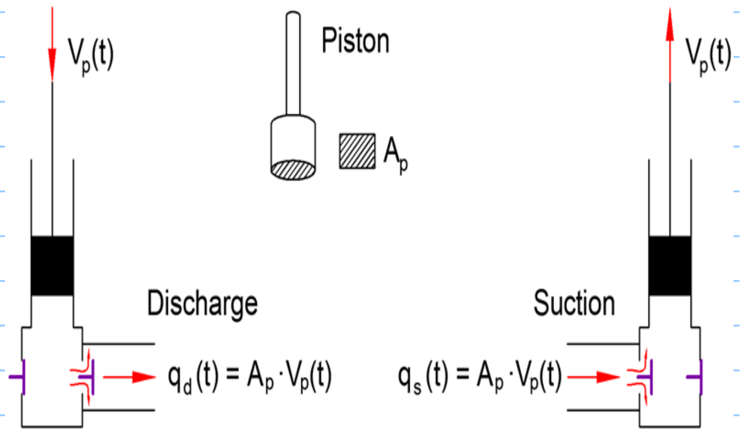
Oseberg Øst

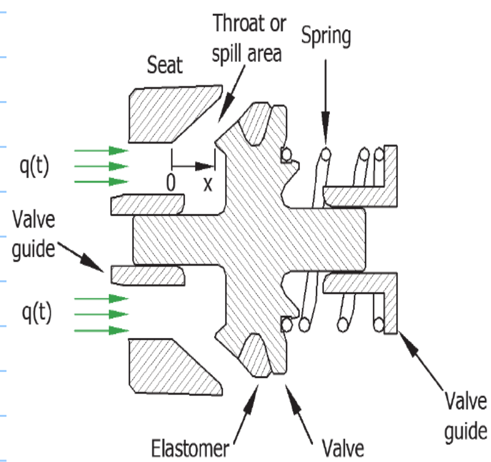
200 rpm

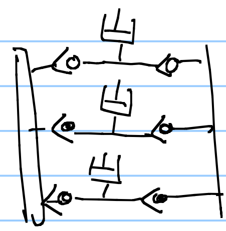








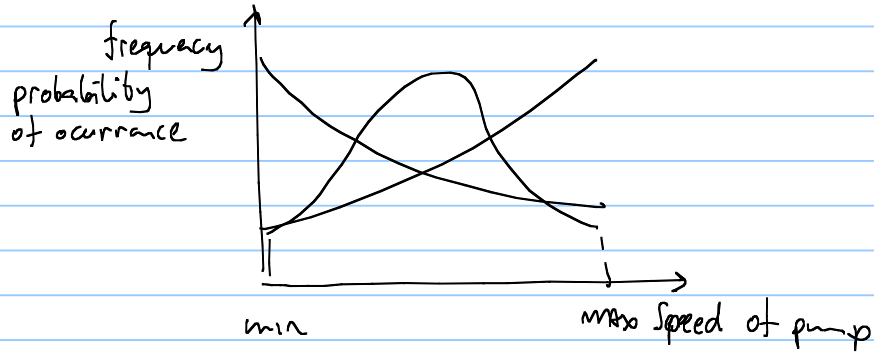




120 rpm

high pump ~~speed~~ speed ⇝ high valve failure ?

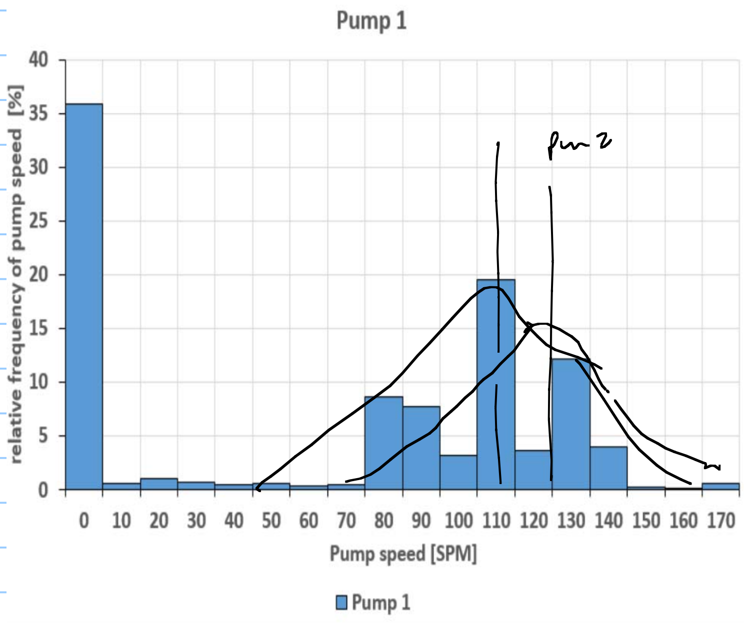
mud logging data every 10 s, for

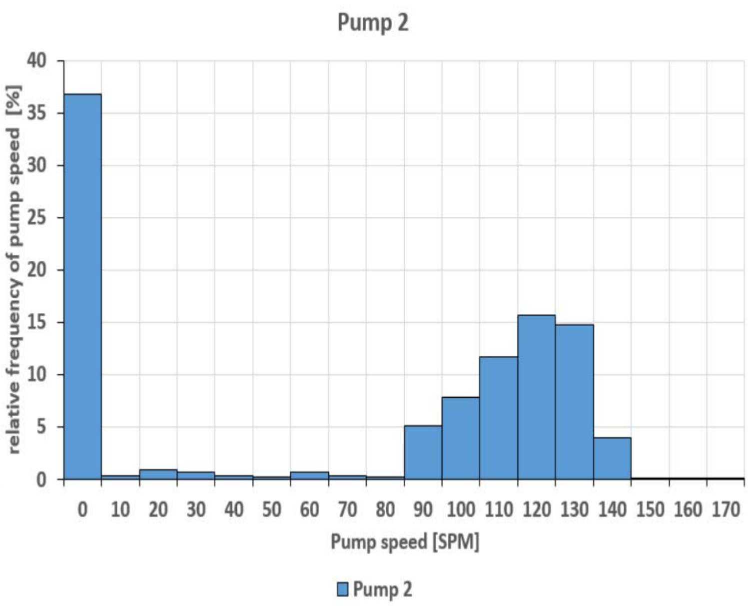


tricks in Excels

0	-5
	<5
10	5.1 ≤
	14.999
20	
30	

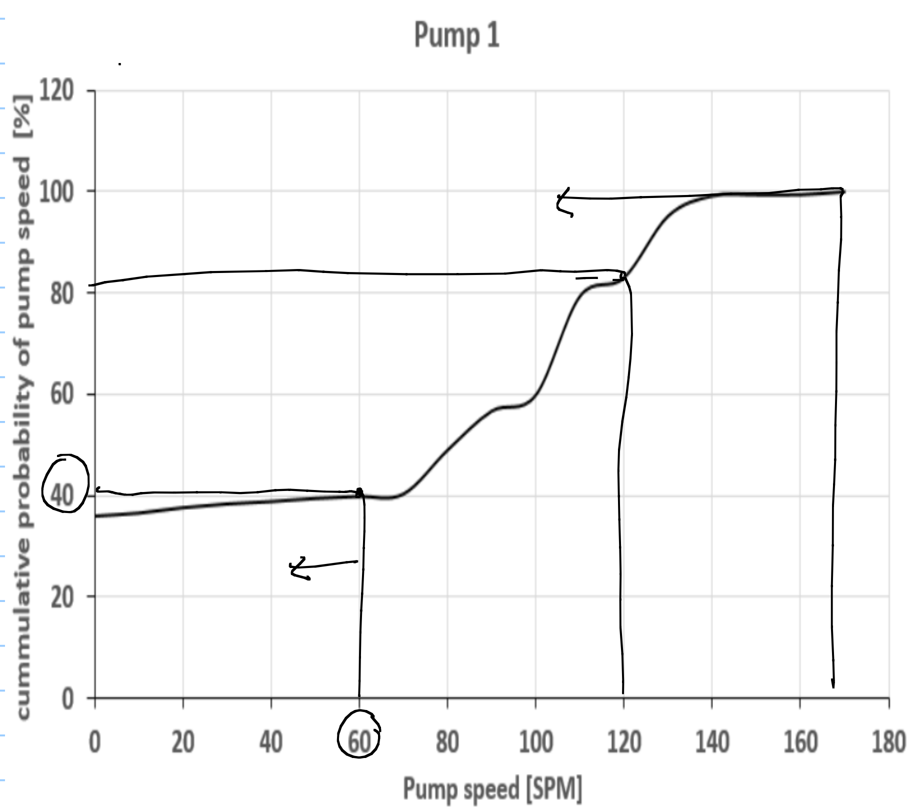
- to send the selection all the way to the end press sequentially ctrl + shift + down
- to apply a matricial function (takes vector and returns vector)
  instead of pressing "enter" press ctrl + shift + enter sequentially

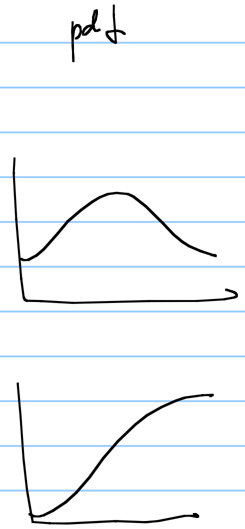




relative frequency plot. probability density function pdf

cummulative probability:

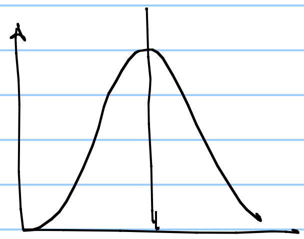




We have worked so far with a discrete distribution. It is possible to use continuous dist. using analytical equation x variable of interest

pdf

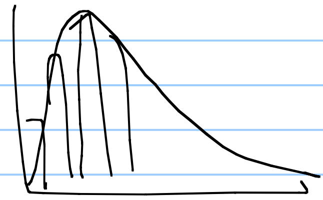
$$f_\zeta(\zeta) = \frac{1}{\sigma_\zeta\sqrt{2\pi}} exp\left[-\left(\frac{\zeta}{\sigma_\zeta\sqrt{2}}\right)^2\right]$$ ~ Gaussian



x variable of interest

$$f_H(H) = \frac{H}{4\sigma_\zeta^2} exp\left[-\left(\frac{H}{\sigma_\zeta\sqrt{8}}\right)^2\right]$$ ~ Raleigh distribution

standard deviation



it is possible with discrete data to tune to a analytical probability expression