



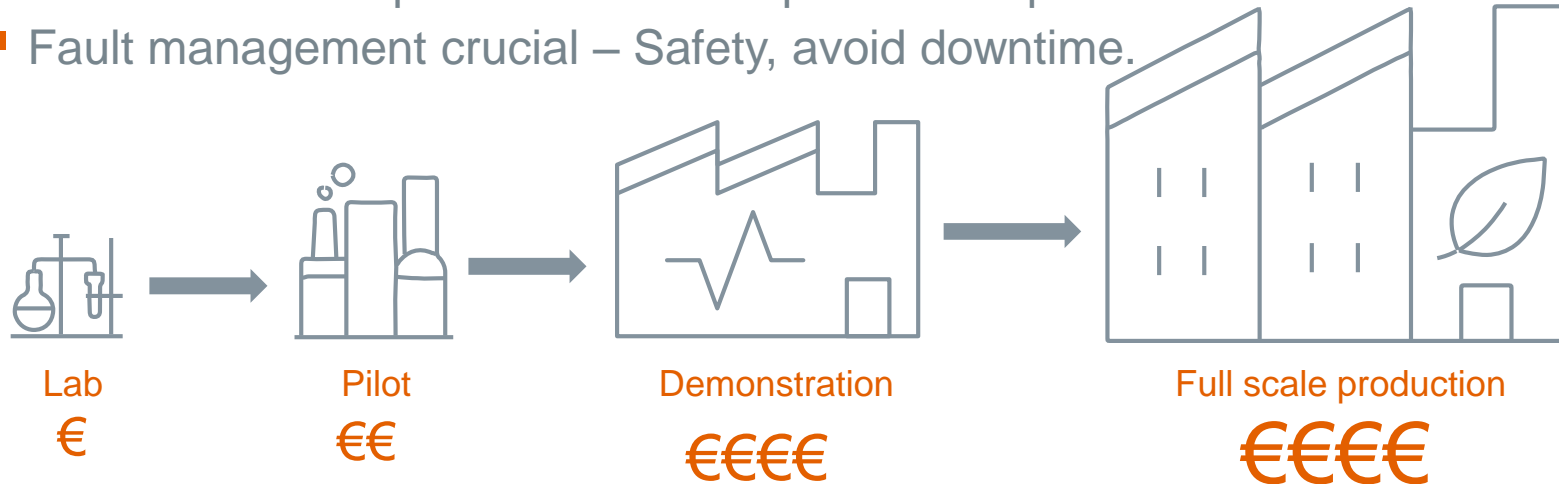
AI Operator - Accelerating the Pilot to Full scale process development

Joonas Linnosmaa

THTH Autumn Seminar
29 October 2020

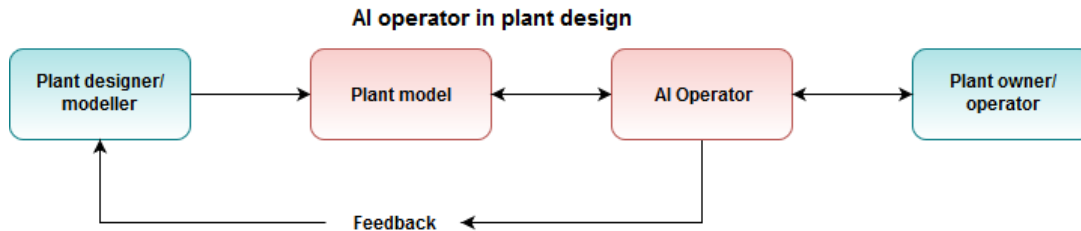
Challenge in process industry - From laboratory to production scale

- Exponential cost increase at each scale-up phase.
- Risks for investors increase – Many projects are cancelled.
- Demand for new products – But no previous experience.
- Fault management crucial – Safety, avoid downtime.

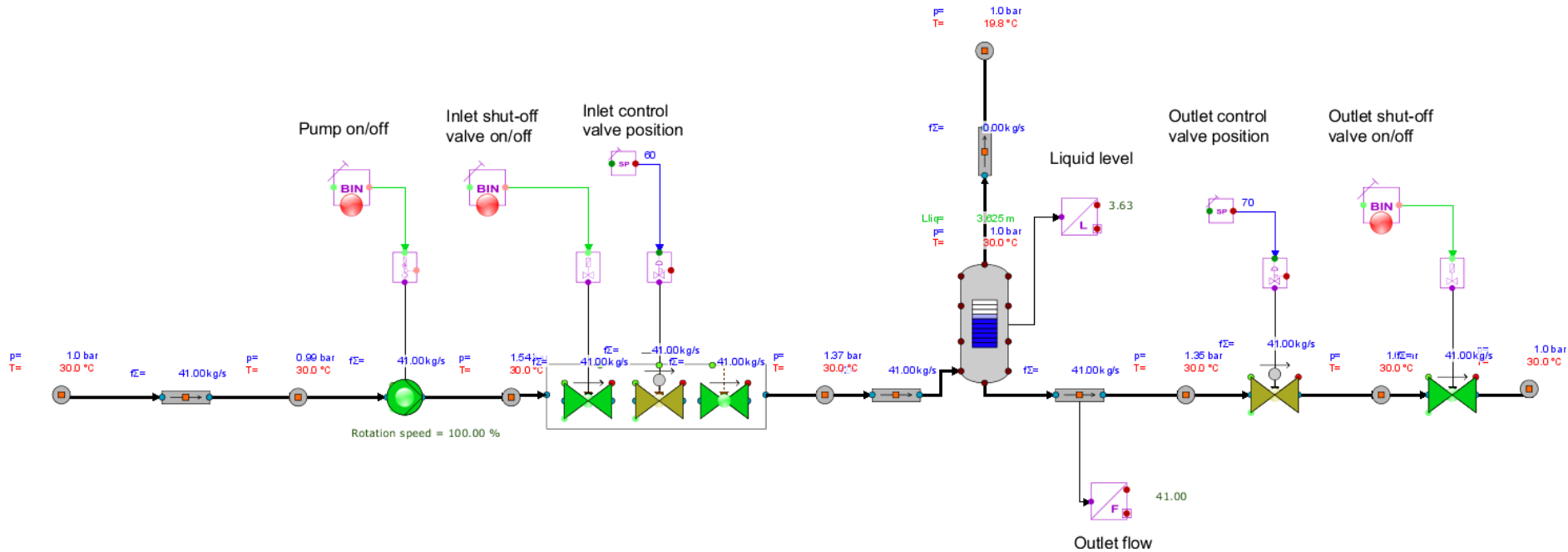


AI Operator: Key idea

- AI is a key element in **Industry 5.0**, enabled by plant **digitalization**.
- AI has novel potential as a design and operation support tool and in handling fault situations on plant level.
- **Exhaustive simulation → Learning how to act**
 - The AI Operator tries to learn how to control the simulation model in each fault situation.
 - If learning is possible in all fault situations, the plant design is sound → proceed.
 - If not, a safety risk is found early → much cheaper to fix.

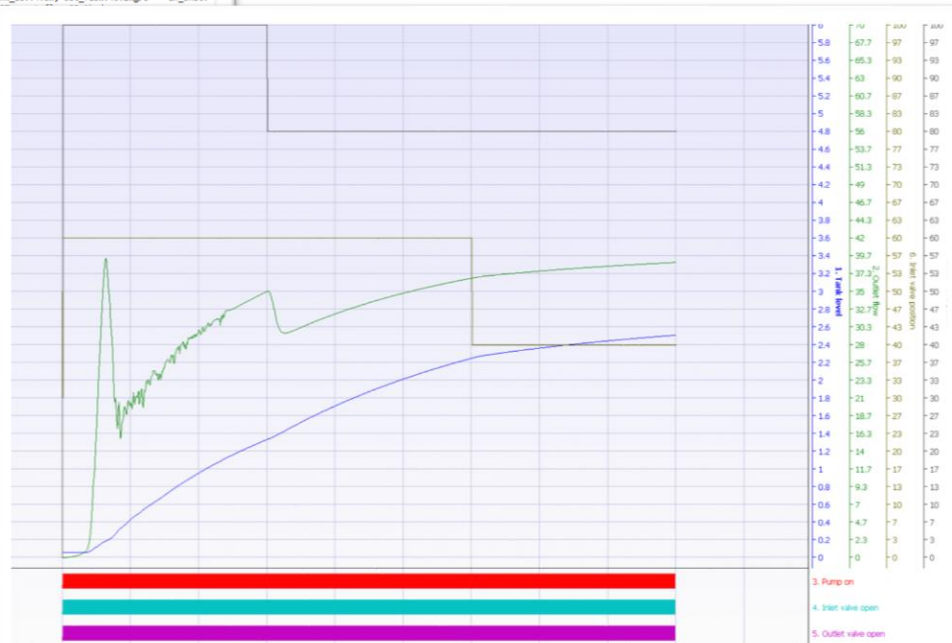
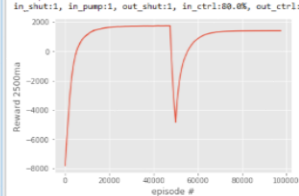


Example case: A simple Aprosim model



Reinforced Learning – Adaptive agent

```
...
60 gives us 8 total movement options: NO change, change SP01, change SP02, change SP03, inc/dec :
61 ...
62 if choice == 0:
63     pass
64 if choice == 1:
65     self.SP01 = 1 - self.SP01
66 elif choice == 2:
67     self.SP02 = 1 - self.SP02
68 elif choice == 3:
69     self.SP03 = 1 - self.SP03
70 elif choice == 4:
71     self.SP02 += 1 if self.SP02 < CTRL_VALVE_SLOTS else 0
72 elif choice == 5:
73     self.SP02 -= 1 if self.SP02 > 0 else 0
74 elif choice == 6:
75     self.SP03 += 1 if self.SP03 < CTRL_VALVE_SLOTS else 0
76 elif choice == 7:
77     self.SP03 -= 1 if self.SP03 > 0 else 0
78 if not self.have_fault:
79     self.SP02 = 0
80
81 def GetSystemState(self):
82     inflow = 0.0
83     outflow = 0.0
84     isOverflow = False
85     for i in range(EVAL_TIME_STEPS):
86         # for boolean variables (SP01, SP02, SP03): 1 = valve OPEN/pump ON
87         if self.SP01 > 0 and self.SP02 > 0:
88             inflow = 10 * self.SP02 / CTRL_VALVE_SLOTS # inlet valve percent to inflow
89             if self.SP03 > 0 and self.L101 > 0:
90                 outflow = (self.L101 * 0.5) * 0.245 * (10 * self.SP03 / CTRL_VALVE_SLOTS) # outflow depends on
91                 self.L101 += (inflow - outflow) * 0.05
92                 if self.L101 > 0:
93                     isOverflow = True
94                 self.L101 = self.L101 if self.L101 > 0 else 0.0
95                 self.L101 = self.L101 if self.L101 < 0 else 0.0
96
97     self.FI01 = outflow * 6.7
98     # Constants were selected so that SP02=6 (60 K) and SP03=7 (70K) keeps the tank in constant
99     # in this case the outlet flow FI01 is close to the optimum 40 kg/s
100
101 SP02_index = self.SP02
102 SP02_index = SP02_index if SP02_index > 0 else 0
103 SP02_index = SP02_index if SP02_index < CTRL_VALVE_SLOTS else CTRL_VALVE_SLOTS
104 SP03_index = self.SP03
105 SP03_index = SP03_index if SP03_index > 0 else 0
106 SP03_index = SP03_index if SP03_index < CTRL_VALVE_SLOTS else CTRL_VALVE_SLOTS
107
108 Bool1_index = self.SP01 + 2 * self.SP02 + 4 * self.SP03
109
110 if isOverflow:
111     L101_index = 13
112 else:
```



AI Operator: Benefits

- *Scale-up will be a lot faster! Projects are not cancelled because of uncertainty!*
- The additional cost of training an AI Operator is small (w.r.t. plant simulation model).
- However, the insight gained from the AI Operator is invaluable: Either confidence to the current plant design before the scale-up phase, or detecting the safety risks early.
- AI Operator offers early safety assessment, increased confidence.

bey⁰nd

the obvious

Joonas Linnosmaa
joonas.linnosmaa@vtt.fi
+358 40 6796132

@VTTFinland

www.vtt.fi