
CLEARWATER CONSULTING PARTNERS

PROCESS SIMULATION

PROCESS MODELLING, SIMULATION, OPTIMISATION &
MODEL PREDICTIVE CONTROL USING

VR-SIM™



WHY ?

The complex and inter-active nature of many continuous processes makes it very difficult to achieve optimum design and to maintain best ongoing performance continuously

Common characteristics:

- Capital intensive industries
- Complex and highly interactive variables
- Non-linear relationships
- Non-Newtonian fluids
- High risk

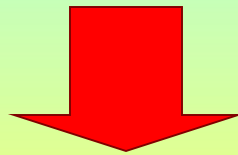
Common risks:

- Under-performance
- Higher operating costs
- Capex over-spending
- Excess effluent discharges
- Lack of flexibility
- Long learning curves

Dynamic process simulation offers the means to get it **right first time** for new investments and to identify and evaluate every real opportunity to improve & **optimise** existing processes – **all with ZERO risk**

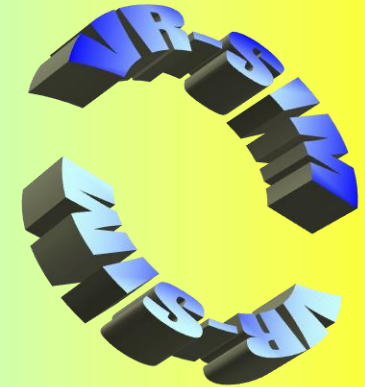
CONCEPTS

- Goal is high fidelity mathematical modelling of all process systems
- Accurate calculation of all process variables
- Precise forecasting of the outcome of all possible operating scenarios
- Real-time forecasting – including true cost per tonne of production for entire process whilst operating



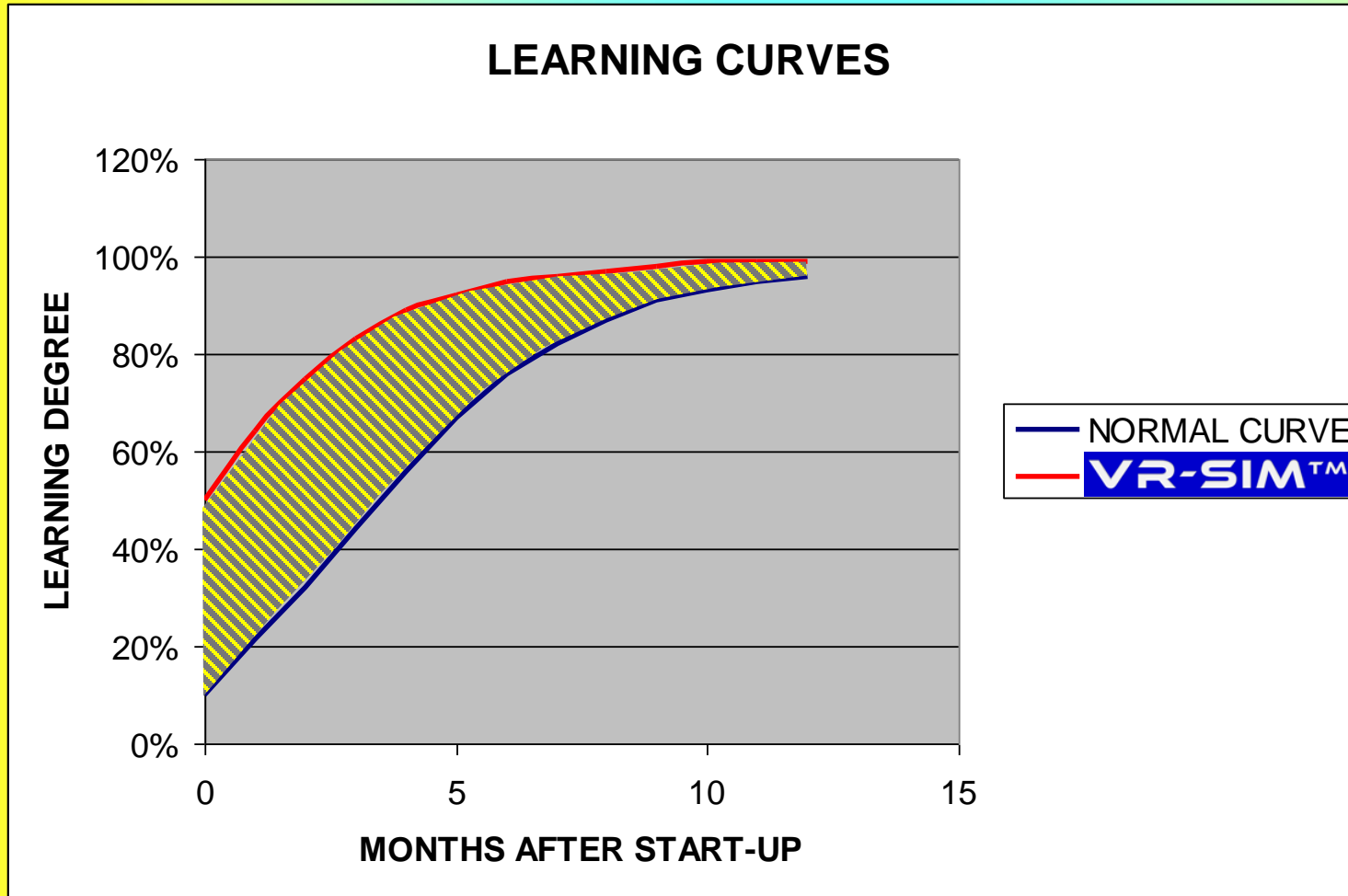
**POWERFUL TOOLS FOR PROCESS ANALYSIS, DESIGN
OPTIMISATION, OPERATION AND CONTROL**

VR-SIM™ BENEFITS

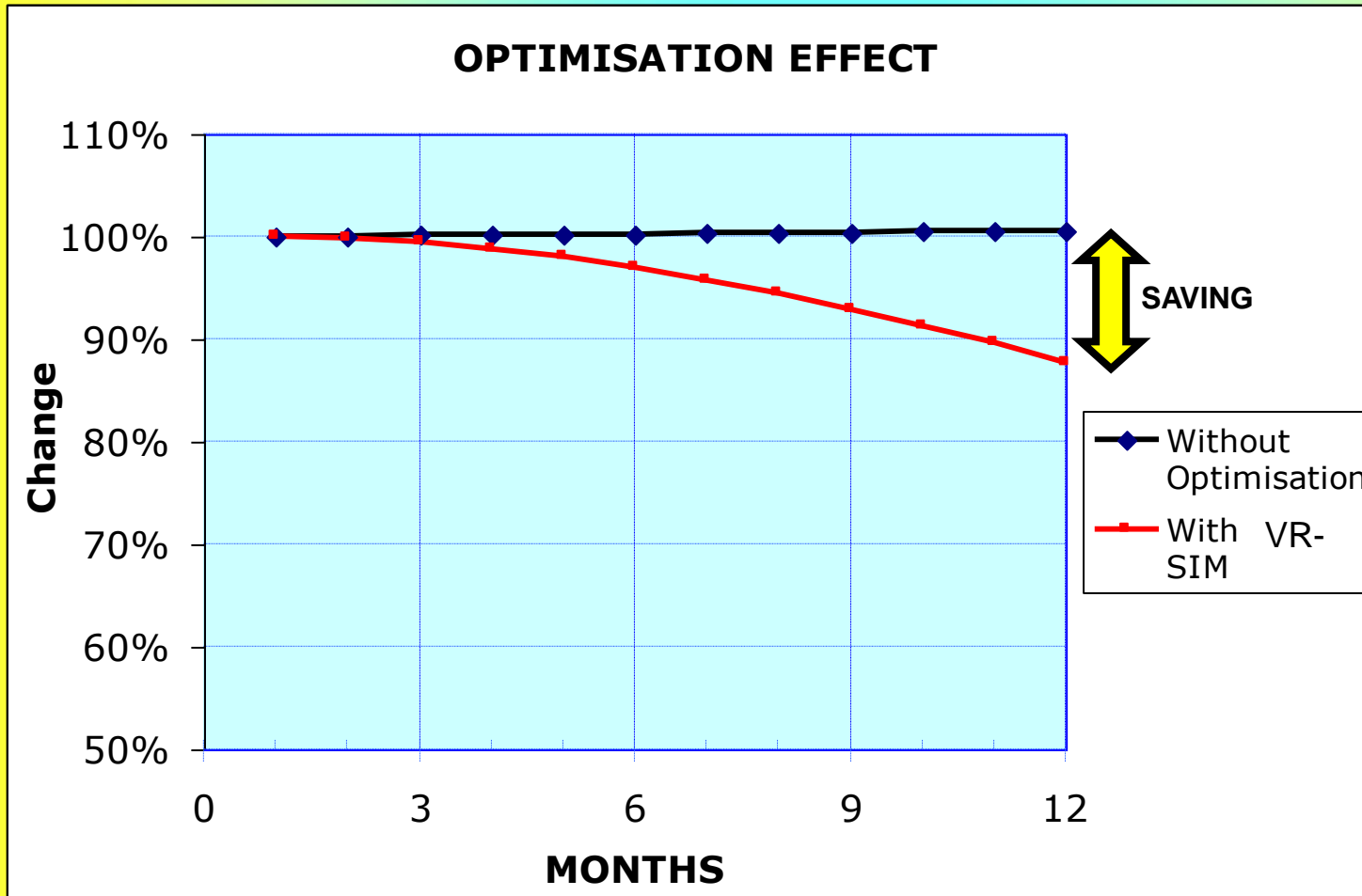


- **Maximise efficiency of existing processes:**
 - **Quantitative & Qualitative benefits:**
 - ❑ Lowest cost/tonne
 - ❑ Highest efficiency
 - ❑ Lowest broke
 - low-hanging fruit / fast ROI
- **Minimise risk in new processes:**
 - Highly accurate specification & design (right first time)
 - Short, exponential, effective learning curves
- **Predict impact of changes accurately and without risk**
- **Model Predictive Control → maximisation of output + quality**
- **Financial forecasting → precise control of cost/tonne production:**
 - ❑ Before construction
 - ❑ After start-up
 - ❑ Ongoing & continuously

NEW PROJECT LEARNING CURVE



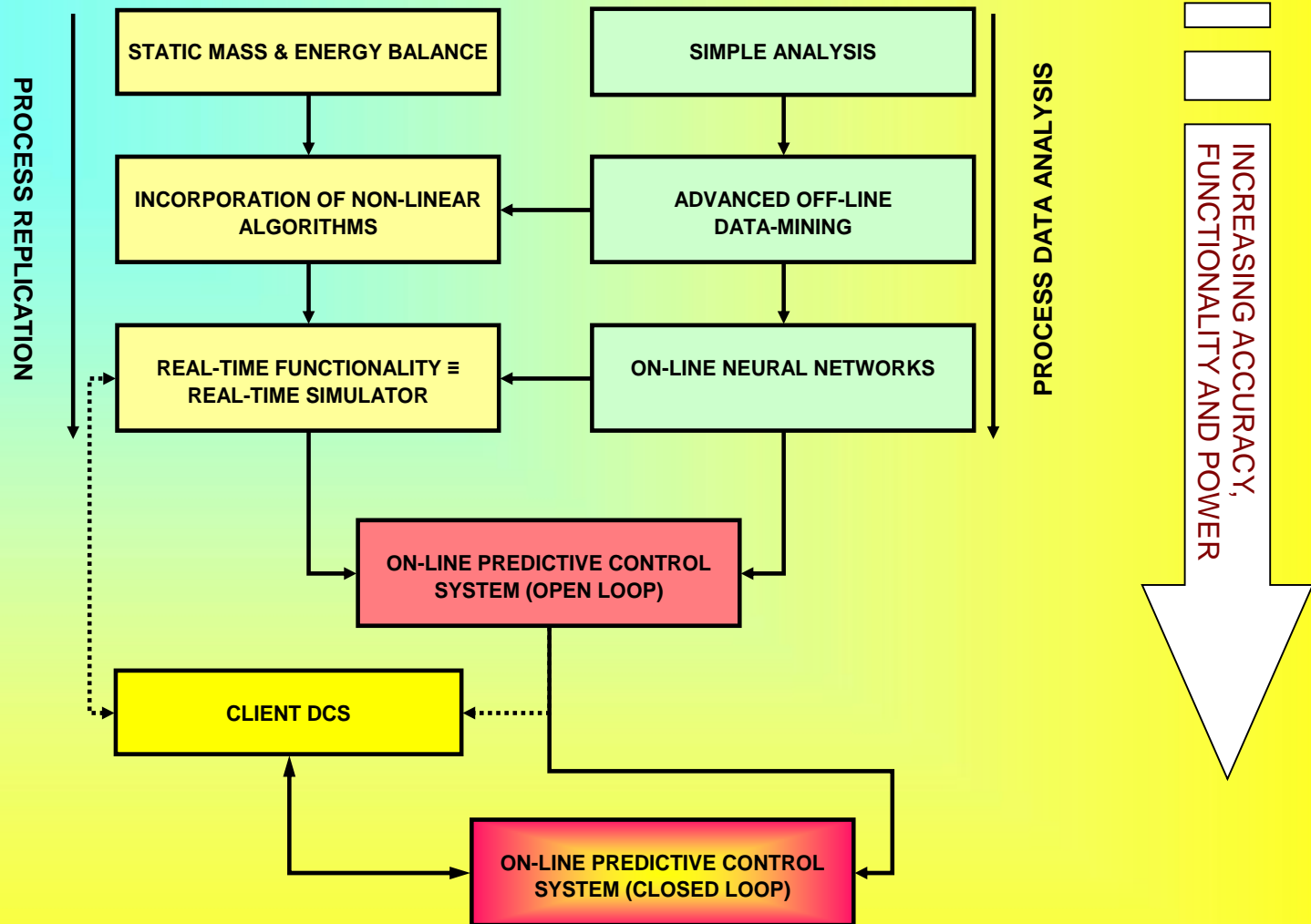
COST OF PRODUCTION



CONVERGENCE OF PROCESS SIMULATION TECHNOLOGY

Convergent technologies:

- Mathematical modelling & simulation
- Data-mining & neural networks
- Distributed Control Systems



VR-SIM™ PARAMETERS

➤ Multi-dimensional predictive values:

- mass
- flow
- consistency
- energy / enthalpy / temperature
- economic / financial
- product qualities
- ash & minerals
- chemicals
- fibre fractions
- dissolved solids → COD, BOD, TOD, TSS
- ink – fractionated by speck size
- dirt specks
- stickies
- flake / grit
- exact qualities
- precise specific cost / Te production



VR-SIM™ MODEL

- Dynamic & Steady State
- Interactive – client operable.
- Iterative – zero error.
- Equilibrium – for discreet elements & total process.
- Forward-driven – process replication.
- Specific & generic process algorithms.
- Specific “quality” algorithms
- Predictive control capabilities

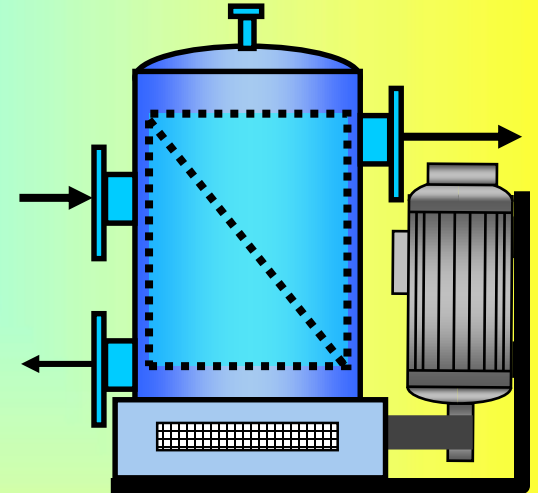
CLEARWATER PAPER TECHNOLOGY										
Client: DEMO		Task: Mass & Flow Balance				REVISION: 2.0				
Date: 04-Jun-02										
Block	Note	Pump m³/hr	A/O	dia.mm	l/min	m³/hr	cons %	bdtpH	kg/min	BDTpD
Broke Pulper Head Tank										
Spray heat exchanger water				69	667	40.000	0.05%	0.022	0.37	0.527
Mill water inlet				0	-	-	0.00%	-	-	0.000
TOTAL IN				69	667	40.000	0.05%	0.022	0.37	0.527
Broke pulper dilution demand				54	413	24.797	0.05%	0.014	0.23	0.327
OVERFLOW to main pulper head tank				42	253	15.203	0.05%	0.008	0.14	0.200
Main Pulper Head Tank										
Spray heat exchanger water inlet				0	-	-	0.05%	-	-	0.000
Overflow from broke pulper head tank				42	253	15.203	0.05%	0.008	0.14	0.200
Inlet from broke pulper head tank overflow				42	253	15.203	0.05%	0.008	0.14	0.200
Mill water inlet				0	-	-	0.00%	-	-	0.000
Incoming flow from water pit				122	2,108	126.492	0.05%	0.063	1.05	1.514
TOTAL IN				136	2,615	156.897	0.05%	0.080	1.33	1.915
Main pulper dilution demand				85	1,022	61.326	0.05%	0.031	0.52	0.748
OVERFLOW				106	1,593	95.572	0.05%	0.049	0.81	1.166
Main Pulper										
FURNISH:	53.8	cu.m.								
Cons:	3.302	T/batch								
Pulp	90.0	75.0%		36	63	3.750	90.00%	3.375	56.25	81.000
DIP	25.0	20.8%		19	17	1.042	45.00%	0.469	7.81	11.250
Broke	5.0	4.2%		9	3	0.208	94.00%	0.196	3.26	4.700
Furnish	120.0	BDT/24 hrs		42	83	5.000	80.79%	4.040	67.33	96.950
Pulper dilution				85	1,022	61.326	0.05%	0.031	0.52	0.748
Heating steam	temp rise (deg C)=	0		0	-	0.000	0.00%	0.000	-	0.000
Pulper dump					1,105	66.326	6.14%	4.071	67.85	97.698
	Pulper fill time required (mins) =	5								
	Pulping time required (mins) =	20								
	Pulper discharge time (mins) =	5.01								
	MAX theoretical throughput=	6.602	BDT/hr							
		158.439	BDT/24 hrs							
	Pump flow rating =	PMP128	13,236	lpm						
	DUMP CHEST A? (Y OR N)	Y								
	DUMP CHEST B? (Y OR N)	N								
Wet-End Broke Pulper										
FURNISH:	38.94	cu.m								
Cons:	2.385									
Pulp	10.8	20.4%				0.448	90.00%	0.403	6.72	9.675
Unifibre	20.0	37.9%				0.833	45.00%	0.375	6.25	9.000
Broke	22.0	41.7%				0.917	94.00%	0.862	14.36	20.680
Furnish	52.75	BDT per 24 hrs				2.198	74.61%	1.640	27.33	39.355
Pulper dilution				54	413	24.797	0.05%	0.014	0.23	0.327
Heating steam	temp rise (deg C)=	0		0	-	0.000	0.00%	0.000	-	0.000
Pulper dump					98	450	26.995	6.12%	1.653	27.56
	Pulper fill time required (mins) =	3				242	8.266	495.943	0.05%	
	Pulping time required (mins) =	60				0				
	Pulper discharge time (mins) =	2.11				521	12.858	767.185	6.12%	
	MAX theoretical throughput=	2.198	BDT/hr							
		52.747	BDT/24 hrs							
	Pump flow rating =	PMP121	12,858	lpm						

- Algorithms simulate reality →

Eg. Pulp Thickening Factor (TF)

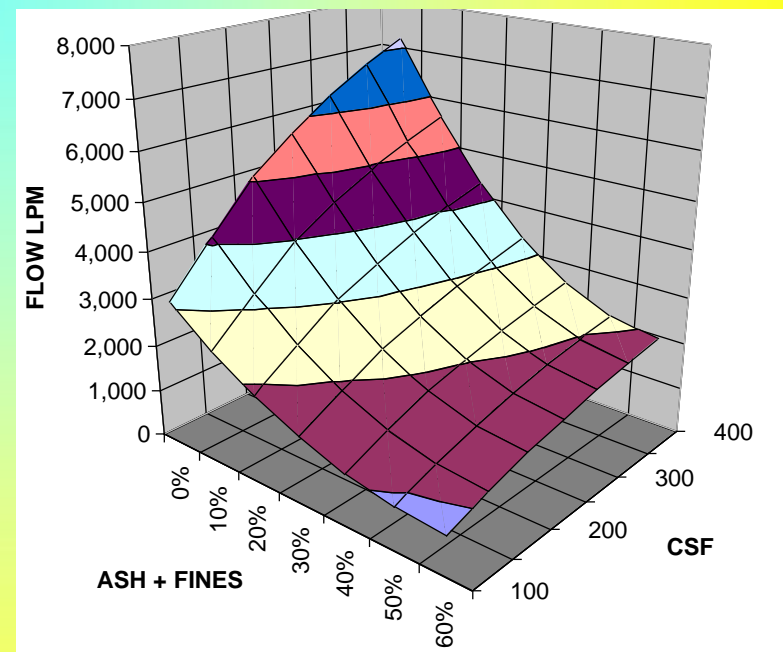
TF is **never** a constant:

TF \propto f($cons_{inlet}$, passing velocity, furnish, etc)



- Incorporate non-linear algorithms for most unit operations → greatly increased accuracy

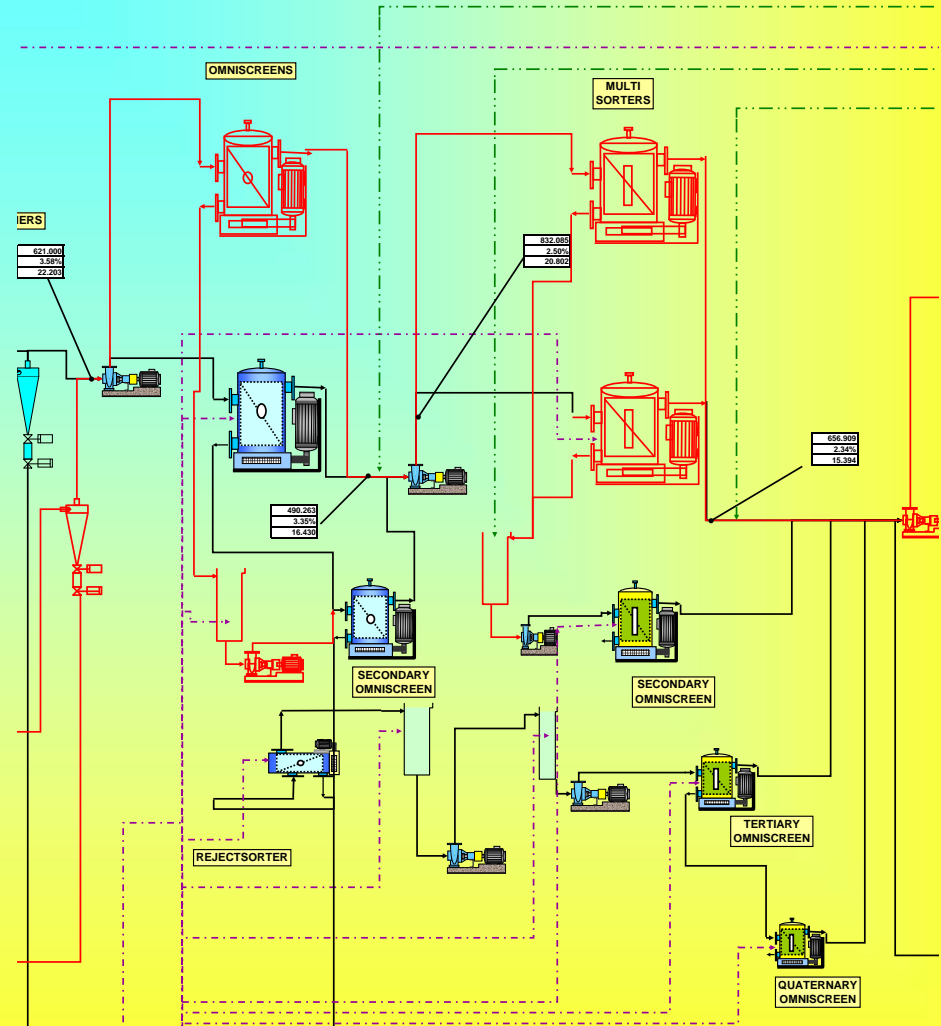
- Unique, highly specific algorithms of complex, multi-variable processes.
- Infinite database size and complexity (only limited by processing power & time)
- High degree of forecasting accuracy.
- Embedded in Pro-SIM model to create true virtual reality simulation of entire process.
- Off-line application → accurate forecasting of hitherto “impossible” variables.
- Real-time application → true predictive control capability



SPECIFICATION

Also provides:

- Product quality parameters
- Variable cost forecasting
- Pipe sizing
- Tank/chest sizing
- Pump curves (head/capacity)
- Delta P data
- Power consumption
- Evaporation rates
- Steam & condensate system design



OPTIONS

➤ **BASE SIMULATOR**

- **Mass & flow balance**
- **Additional elements – eg energy**
- **Flow diagram**
- **Cost module**

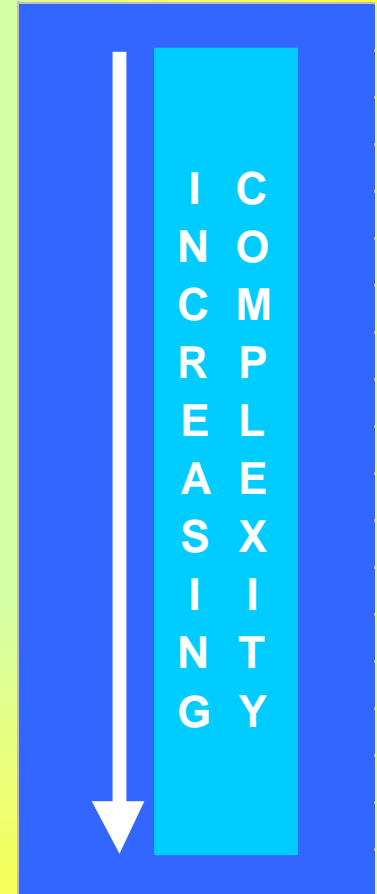
➤ **GRAPHICAL SIMULATOR**

➤ **VIRTUAL REALITY SIMULATION**

VR-SIM™

- **Process Control System / DCS**
+
- **VR-SIM Simulation**

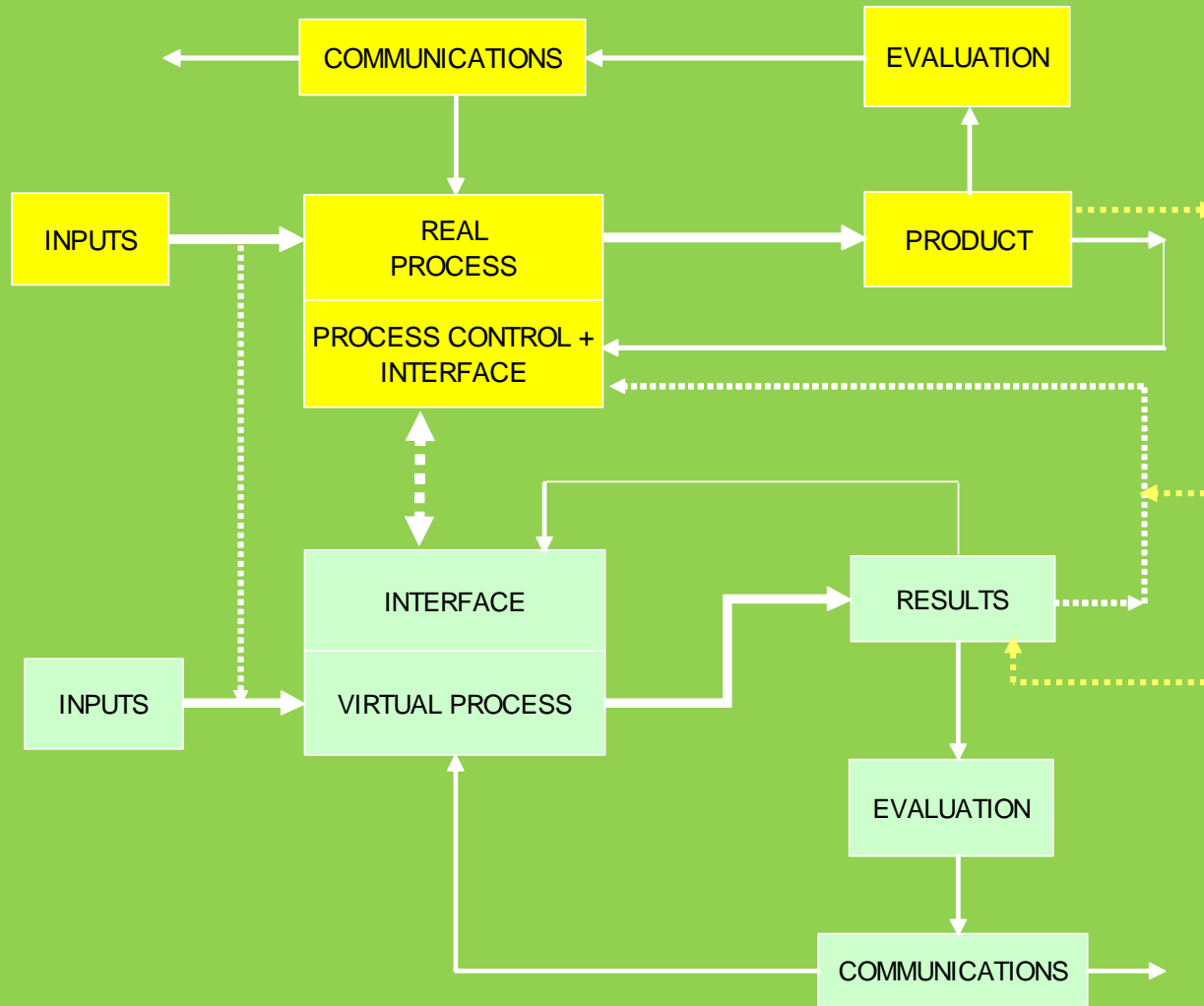
➤ **MODEL PREDICTIVE CONTROL**



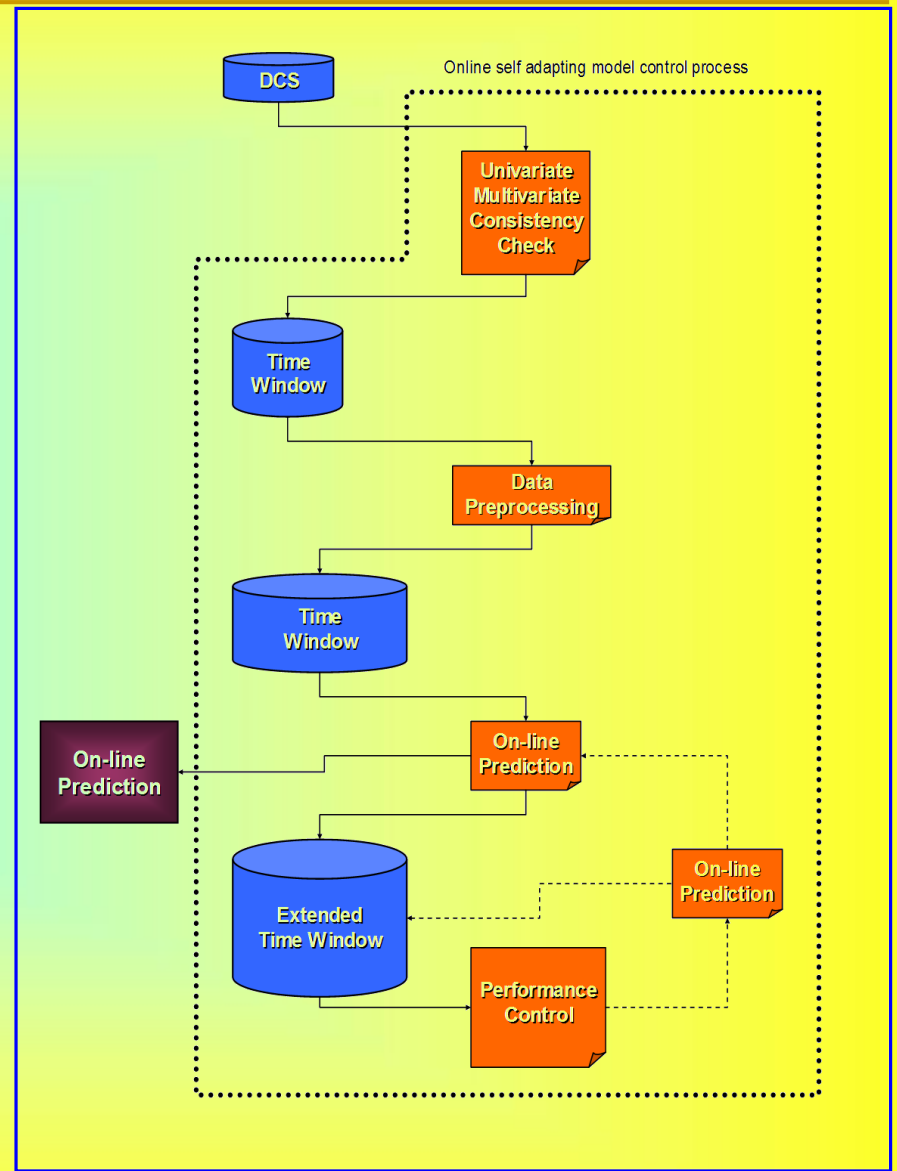
"Data-PRO"™

- Integrates dynamic model with neural network technology
- Advanced data mining techniques create complex (novel / unique) algorithms for specific systems (machines)
- Data-mining nuggets are built into the process model
- Process model linked (real-time) to process control (PLC, SCADA, DCS)
- Provides accurate & powerful feed forward (predictive) process control & optimisation opportunities with self adaptive tuning

PREDICTIVE CONTROL



SELF-ADAPTING NEURAL NETWORK FOR REAL-TIME AUTOMATIC PREDICTIVE CONTROL




VR-SIM™ SUMMARY

➤ **Benefits include some or all of:**

- Increased output
- Improved quality & consistency of attainment
- Better asset utilisation
- Increased efficiency
- Reduced energy / tonne production.
- Reduced process maintenance.
- Accurate forecasting
- Short paybacks (typically within weeks)



EXAMPLE

MONDI STETI MILL		
PM5		
SIMULATION & LIMITATION STUDY		
TO IDENTIFY CONSTRAINTS AND LIMITS ON THE ACHIEVEMENT OF AN INCREASE IN PM SPEED		

CONCLUSION

- **VR-SIM™** is a very powerful and truly **unique** tool
- But, like any other tool – its what you do with it that counts!!
- **CLEARWATER** is **not** a software business → our interest is in using our technology combined with know-how and experience

That's where the skill, experience and knowledge of the **CLEARWATER CONSULTING** team working in partnership with our clients creates lasting and effective results