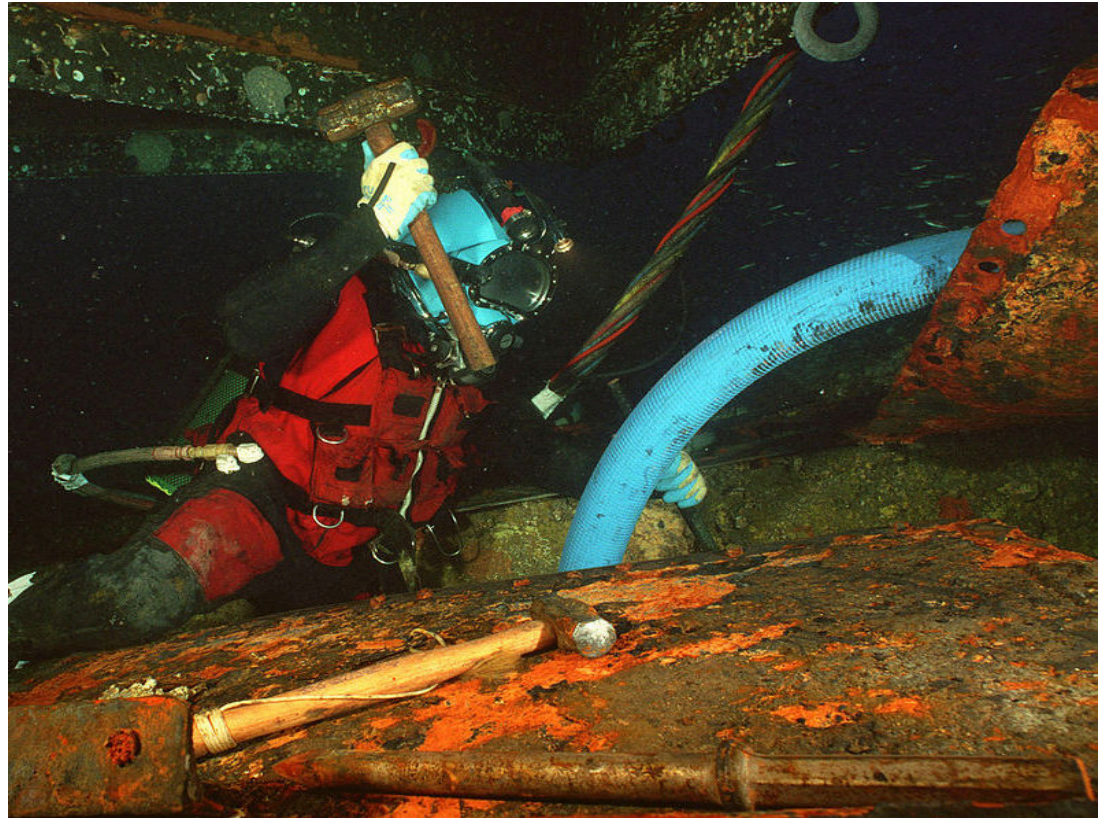


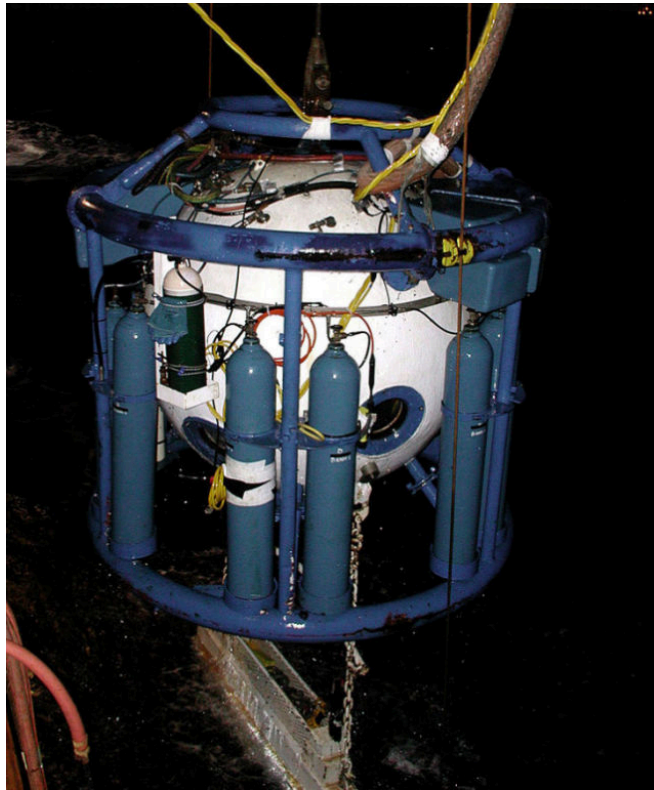
LabVIEW Based Training Simulator: North Sea Diving

Dr Andy Clegg, ISC Ltd



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Soham Banerjee (https://commons.wikimedia.org/wiki/File:Pressurised_Chambers_for_Divers.jpg)
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- Dive Supervisor role is really important
- Adjusts breathing gasses / pressures
- Needs to spot and respond to problems before they turn catastrophic
- Heavily reliant on experience

The Problem

- Dive Supervisors trained on the job shadowing experienced operator
- But difficult to :
 - ❑ Gain exposure to serious / abnormal situations
 - ❑ Transfer to different vessel with different panels / operating procedures
 - ❑ Gain sufficient panel hours to stay certified, especially with shorter dive campaigns
- Training Simulator can address these challenges – needs realism to be effective:
 - ❑ Few simulators currently exist - hardware based with little flexibility and high cost

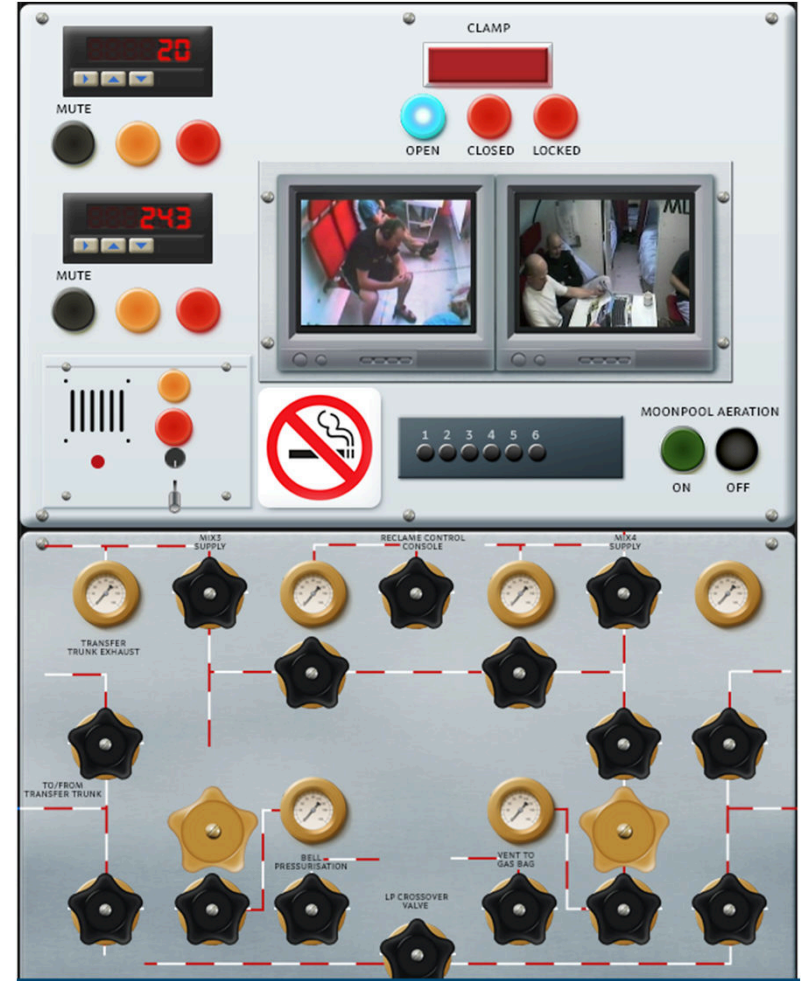
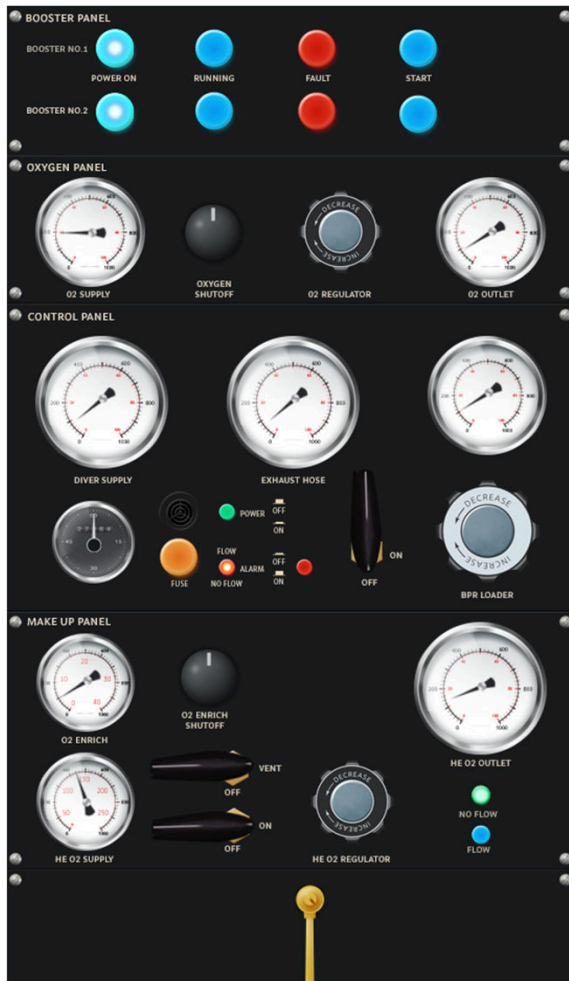
Software-Based Training Simulator



- Involving PaleBlue (Norway), NYD (Norway), ISC (UK)
- Software based training simulator for diving operations:
 - ❑ Highly realistic UI and audio
 - ❑ Pre-recorded real video clips – and potential link to VR Diver
 - ❑ Physics-based math models of breathing gases, vessel pressures / temps and divers
 - ❑ Flexible / Customisable / Cost effective / Portable
- Immersive training scenarios, with ability to create realistic and unlimited faults



Trainee Environment

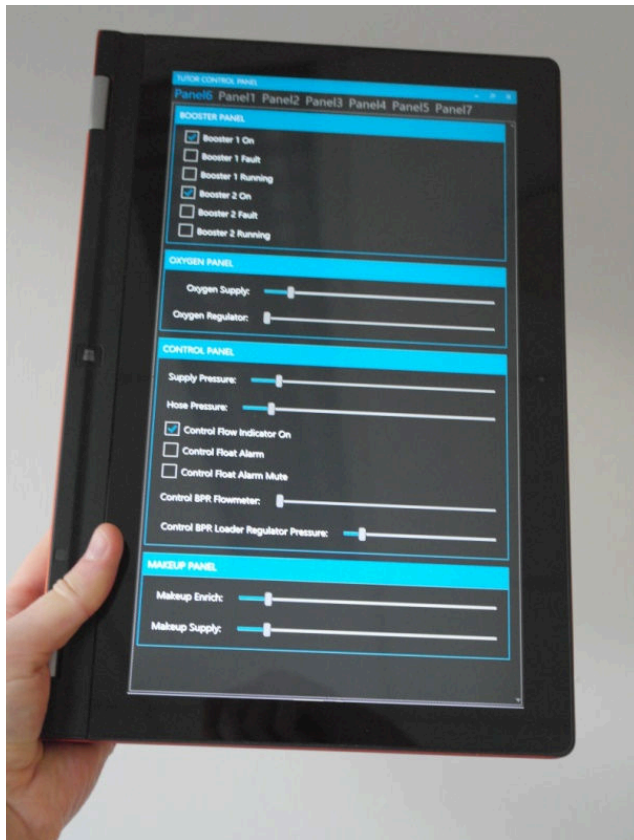


Trainee Environment



- Large, fully interactive touch screens
- Mimic of real supervisor workstation, control panels
- Customisable vessel panels
- Pre-recorded video content
- Multiple communications channels – incl. scrambling

Instructor / Scenario Definition



- Configuration
- Scenario activation
- Normal operational sequences
- Fault introduction – introduced live, so can adapt scenarios from basic to very challenging
- Role playing as divers, bellman, sat control, DP operator ...

Software Architecture



- Main Application developed in C# running on PC (PaleBlue) – handles trainee UI, audio and video, instructor UI and configuration
- But physics-based dynamic models built entirely in LabVIEW (ISC):
 - ❑ C# application drives operation – not true real-time but sufficient for realism
 - ❑ Math models derived from first principles, then coded in LabVIEW
 - ❑ But cast into stateless form – i.e. has no internal memory (states) and all data on C# side
 - ❑ Not so visible, but vital for realism of scenarios, faults and trainee actions

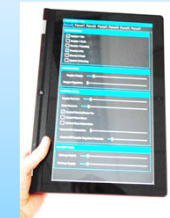
Software Architecture



Trainee
HMI



Visual Studio (C#)



Instructor
HMI

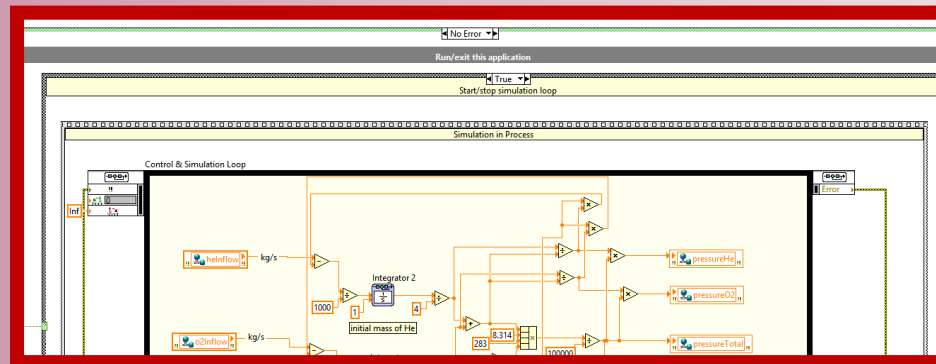
System States

DLL (.NET Interop Assembly)

LabVIEW Dynamic Simulation (CD&SIM)

Function Calls
from C# to
compiled
LV stateless
model

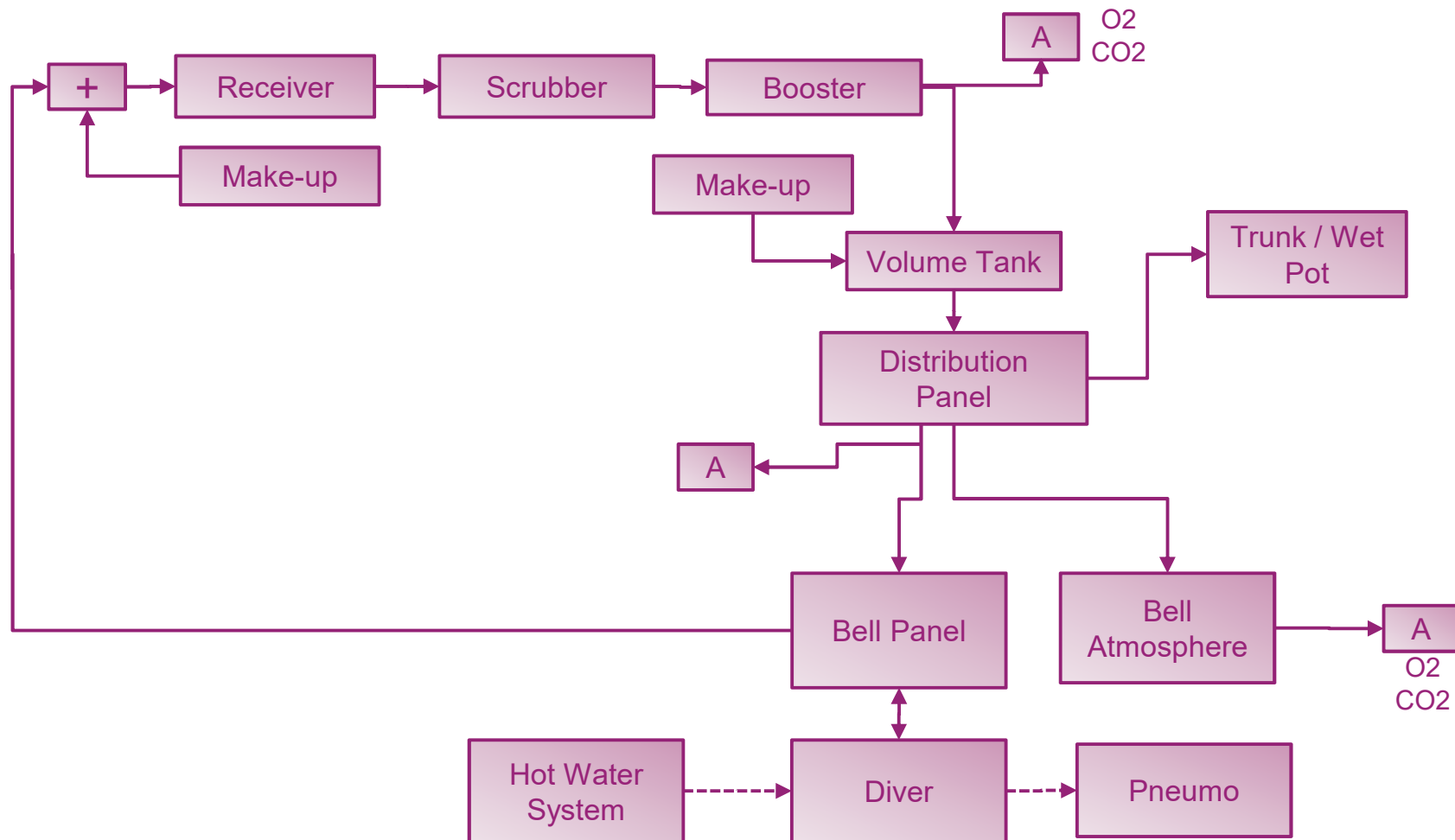
Config
Params
(SVE Lib)



Process Modelling

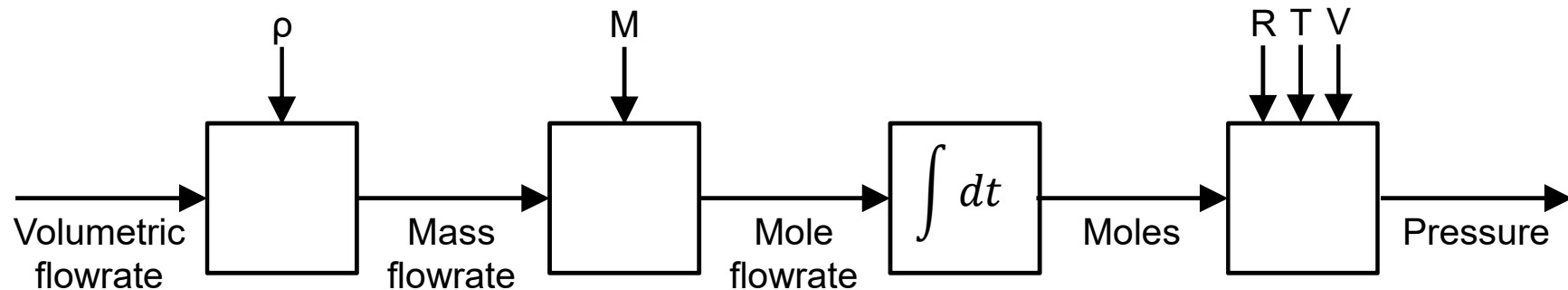
- System boundaries / assumptions are defined by functionality want to replicate
- Split into sub-models – but still need high level functionality
- For each sub-model define inputs, outputs, maths to match physics and operations
 - Assumptions – to simplify, but need to make sure appropriate
 - Constraints on usage – math model may only be valid for restricted range of input
 - Define both normal and abnormal features
 - Validation of model very important here

Process Sub-Models



Process Modelling

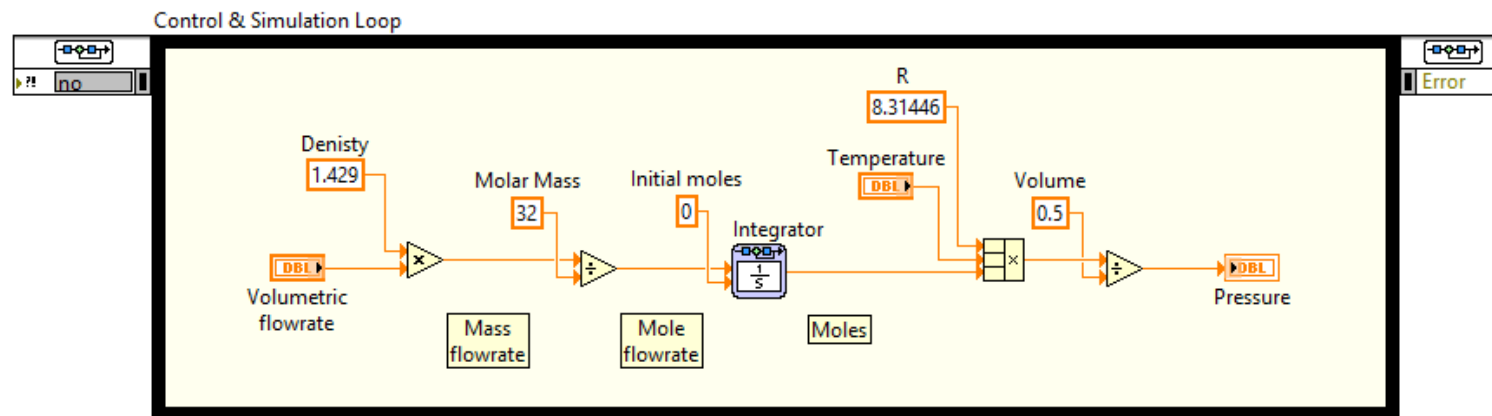
- Example, flow of gas into a chamber to increase the pressure:



- Important to define all features needed, e.g.:
 - ❑ Gas removal (e.g. leakage, flow-out) easy to add: *net flow = flow in – flow out*
 - ❑ Gas mixture: define each gas component separately to give overall pressure, but also get concentrations as ratio of moles (e.g. for CO_2 build-up)
 - ❑ Doors between chambers: can only be opened when pressure difference $< 0.1\text{bar}$

Process Modelling

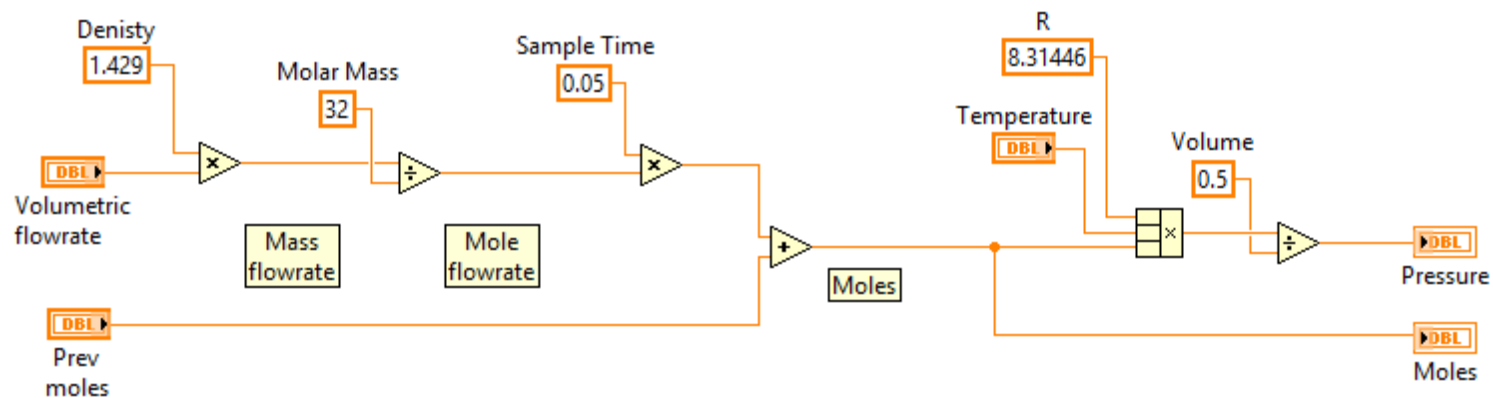
- Can build model exactly in this format in LabVIEW CD&SIM:



- Important to be rigorous:
 - ❑ Care with units (e.g. temperature in Kelvin)
 - ❑ Integrator – initialisation, limits important to keep model valid, reset (?)
 - ❑ Assumptions – temperature fixed or variable ? pressure changes density ?

Process Modelling

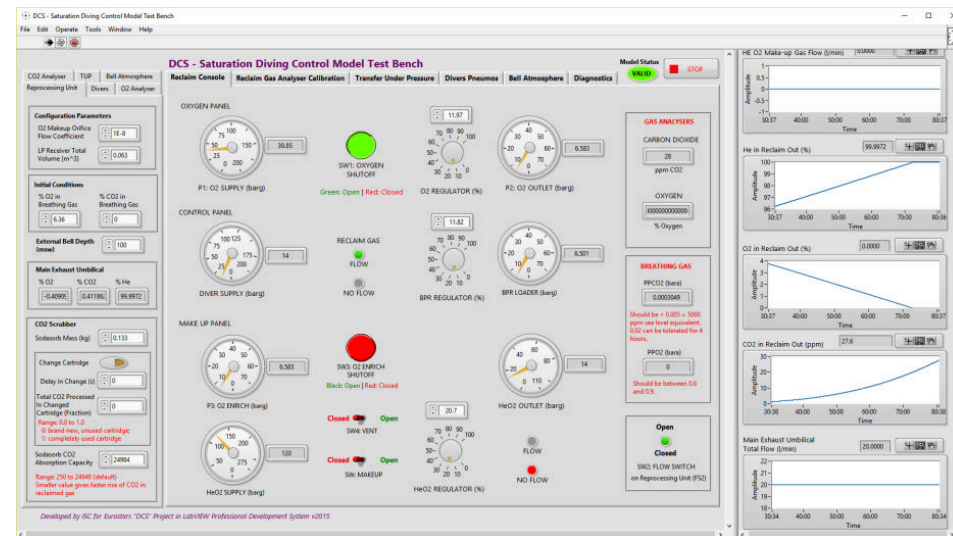
- But final implementation in a stateless form:



- Integrator replaced by discrete equivalent (summation) and state (input/output):
 - ❑ Sample time now important to include correctly – might vary with non-RT operating system
 - ❑ Initialisation handled by initial value of state
 - ❑ Limits on integration would need to be included

Model Testing and Validation

- Sub-models initially developed using LabVIEW CD&SIM
- Converted to stateless form and tested in Test Bench built in LabVIEW, using same input/outputs/states as used by the main application
- Test Bench allows testing of the overall system model without having to use full simulator
 - ❑ Also provides test cases / debugging for integration into C# application
- Final model validation done by experienced dive supervisors using full simulator



Outcomes

- Has generated a lot of interest in industry – operators, training, certification bodies
 - Now approved as a Class B simulator by IMCA
- Could also be used for incident investigation, equipment development, equipment testing and certification
- Training simulators have been widely used in many safety critical industries – oil and gas, nuclear, aircraft – but often very expensive to give realism.
- LabVIEW's flexibility and interfacing is enabling new applications

Thank you. Any questions ?



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Background to ISC



- Control engineering consultancy based in Glasgow
 - Founded 1987 - as a spin-out from Strathclyde University
- Works across many sectors:
 - Oil/Gas; Power Generation; Automotive; Marine; Process
- Small – 5 full time, 4 part time employees
- However we work with some very large companies:
 - BP; Shell; General Motors; Toyota; Boeing; BAE Systems; Rolls Royce Marine; SSE;
Scottish Power; Alstom; EDF ... and GSK

ISC Core Capabilities

- Dynamic Systems Modelling:
 - high fidelity first principles models or data-driven identification
- Control Strategy Design – both new and improvements
 - full software development – NI LabVIEW / CompactRio
- Troubleshooting Control Problems
- Optimisation
- Technology Reviews
- Training – standard and bespoke courses

ISC is typically involved in novel or challenging control studies.

Close working with clients to get best solution and ensure full transfer.

ISC's use of Simulation in the V-Model



Front End Engineering Design

Engineering Support

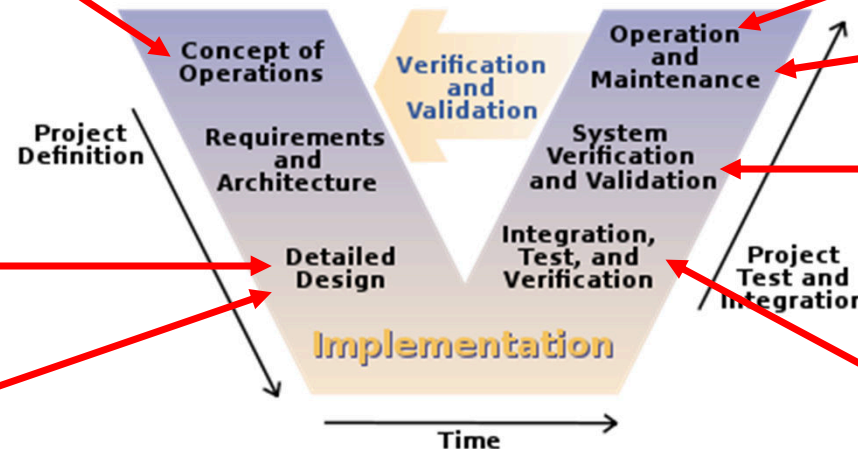
Training simulators

Minimise commissioning time

Model based control

Optimisation of design

Hardware-in-the-loop testing



- ISC use both Matlab/Simulink and LabVIEW for dynamic simulation, and have experience with model conversion as well as other simulation packages.
- LabVIEW CD&SIM is can be used at all stages with minimal transition required when moving from pure simulation to HIL environments to final realisation.