

Modelling of Pig Train Dynamics in Natural Gas Lines

Pig Velocity Profiling

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Presentation Content

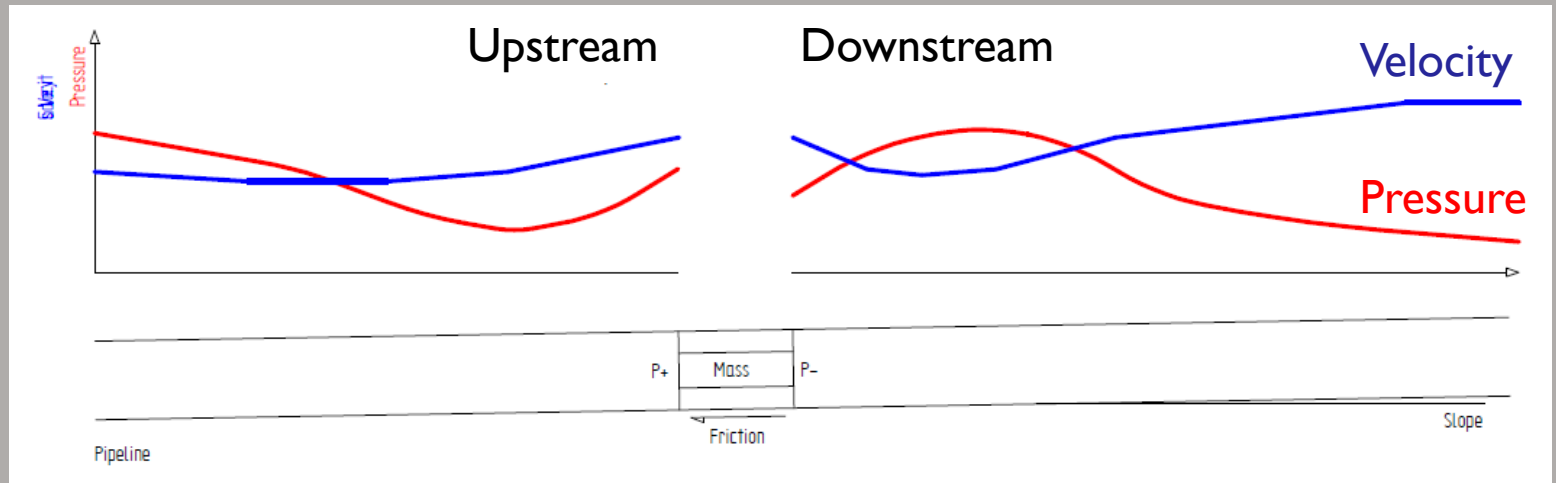
- Motion of single pigs in gas pipelines;
- Motion of pig trains in gas pipelines;
- Research and Development...two-phase gas liquid pigging.

Why model pig velocity?

- Desire to have pigs run in a controlled fashion;
- Loss of inspection data;
- Liquid removal – inefficient at high velocity / acceleration;
- Pig train break up;
- Damage (pig, assets) and possible injury;
- Analysis for investigations;
- Interpretation of data logger output.



Basis of model



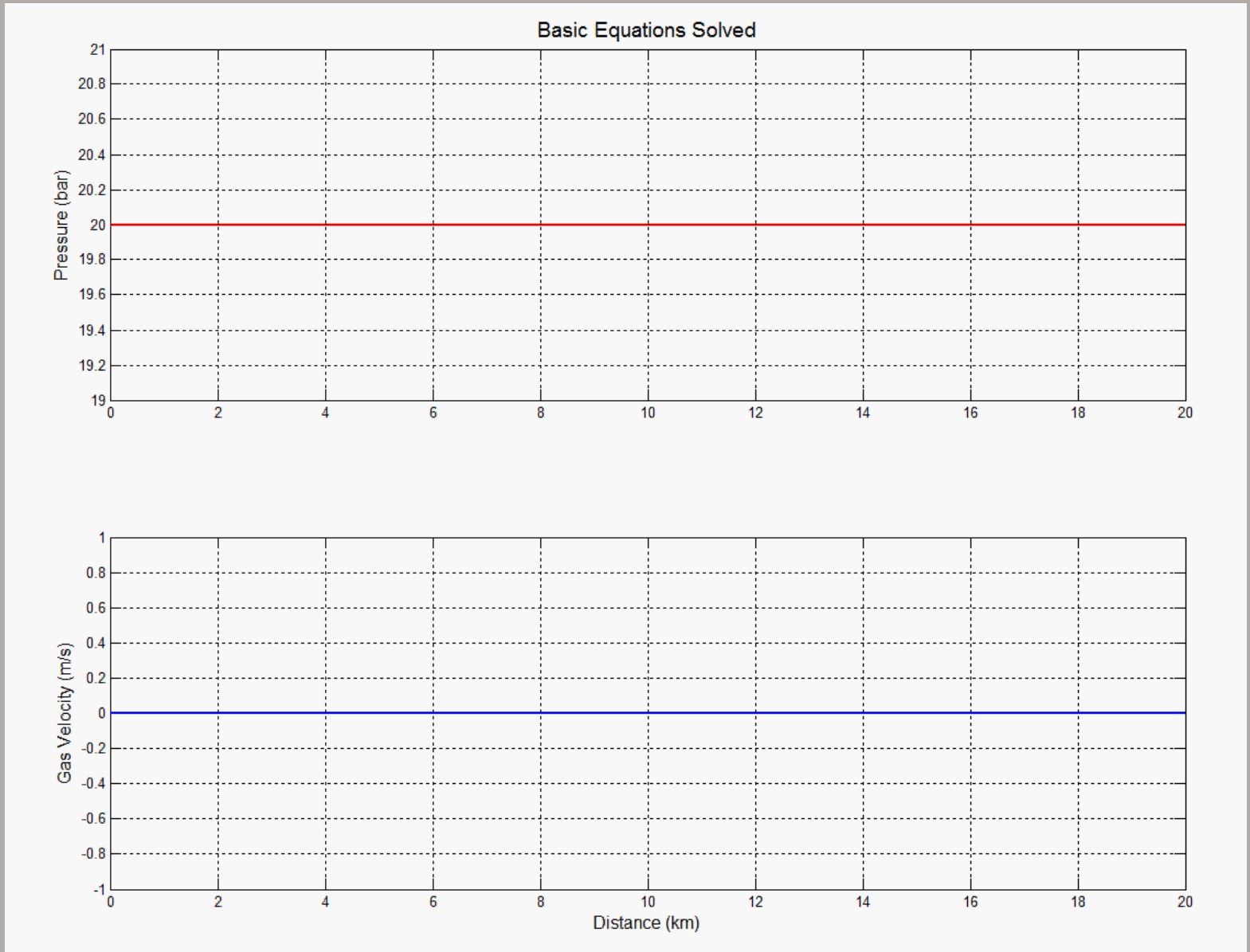
Two simultaneous PDEs: -

- Continuity - $f(\text{Pressure}, \text{Velocity})$;
- Momentum - $f(\text{Pressure}, \text{Velocity})$.

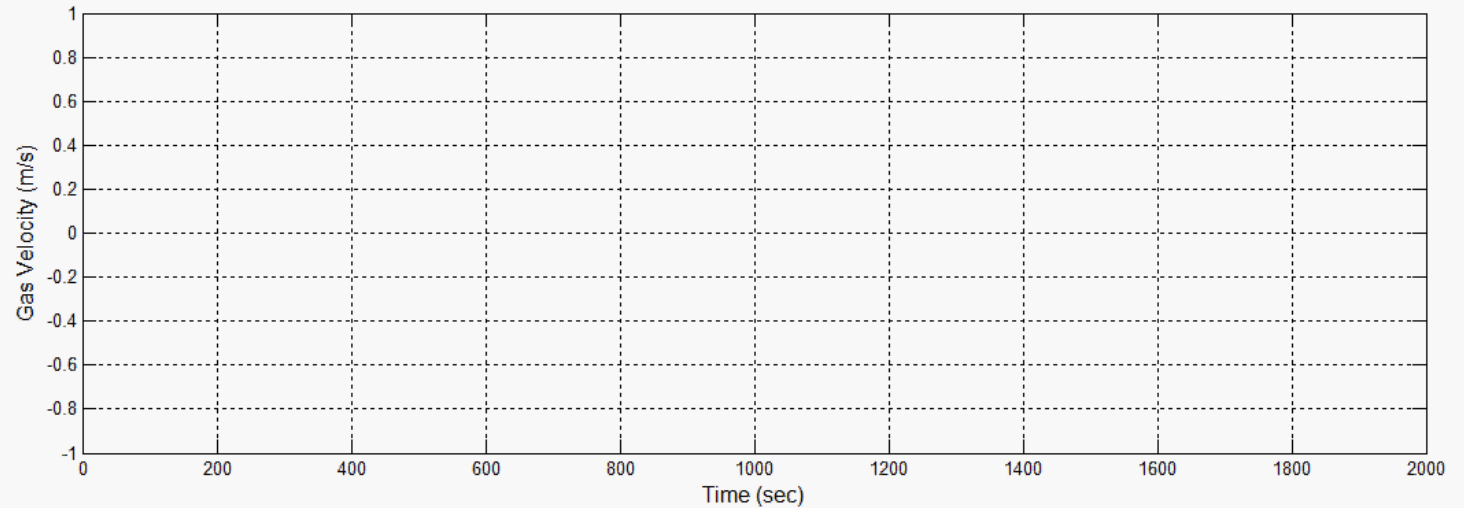
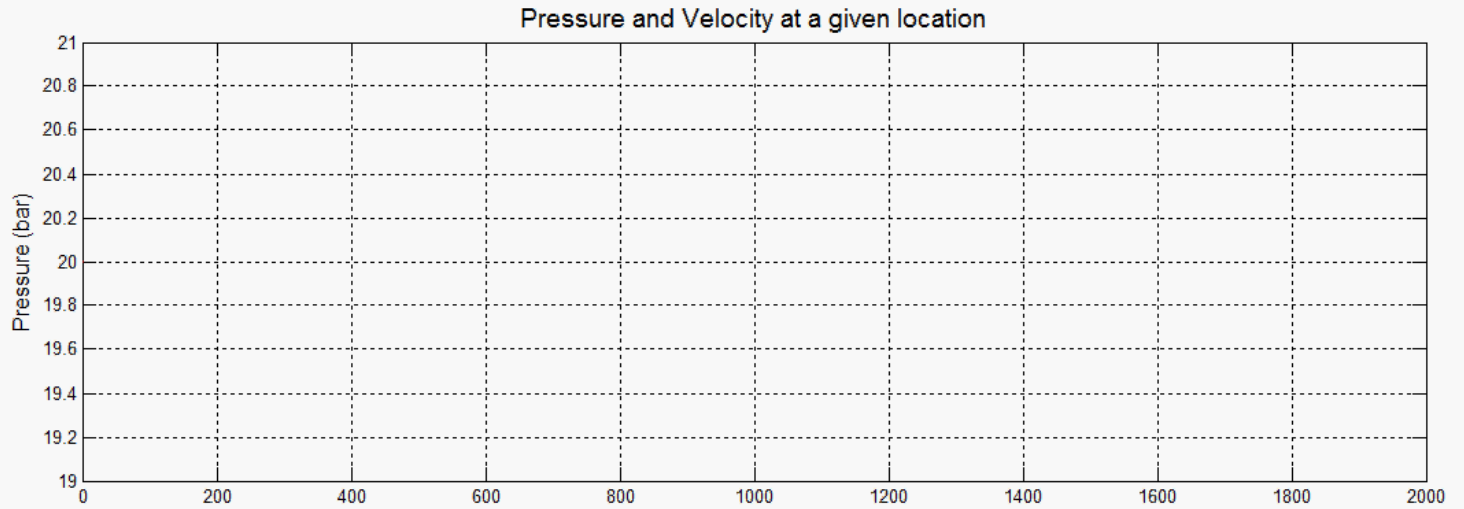
Solve for pressure and velocity against time and distance

Boundary conditions (BC) and initial conditions (IC)

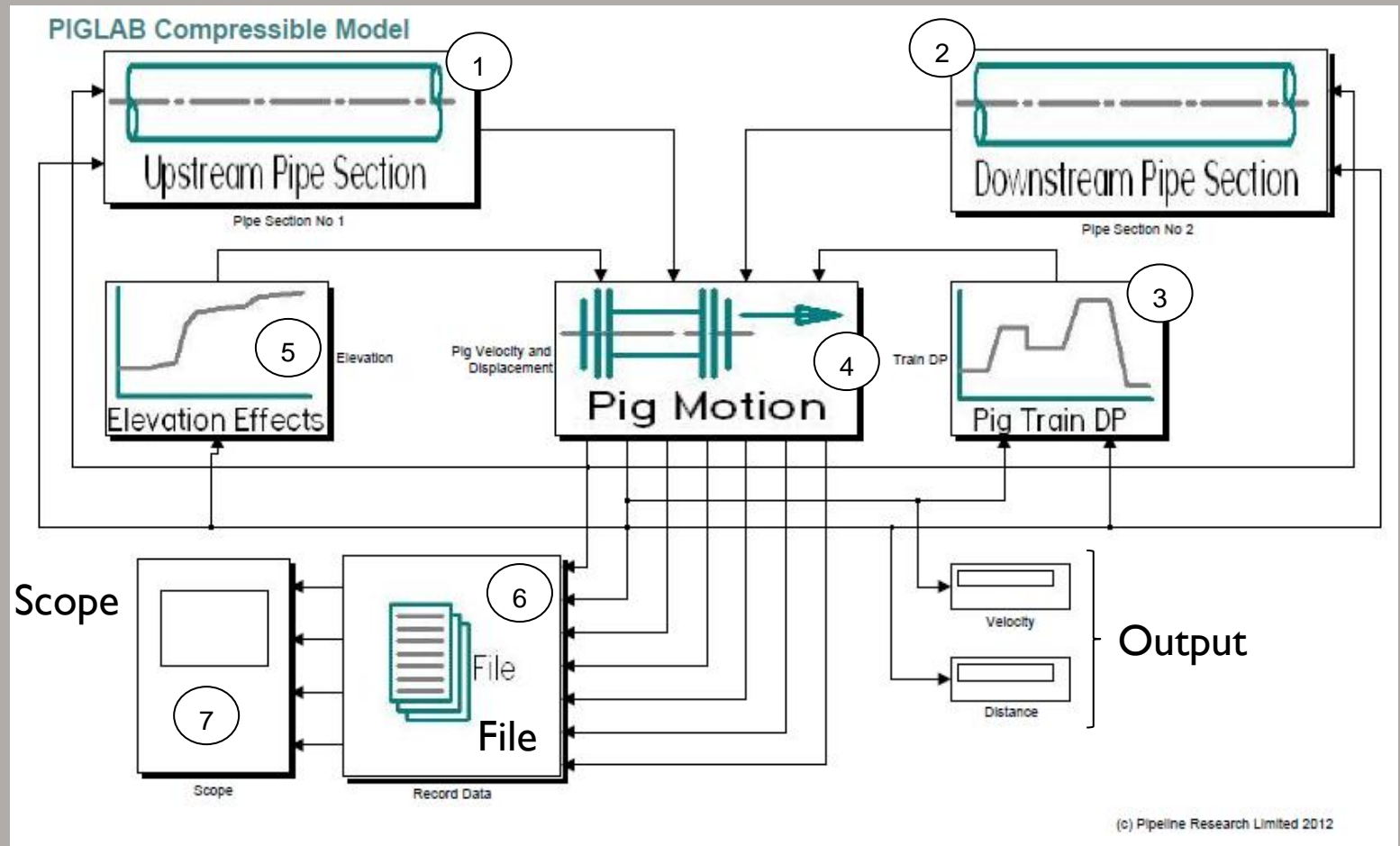
Animation of Basic Equations



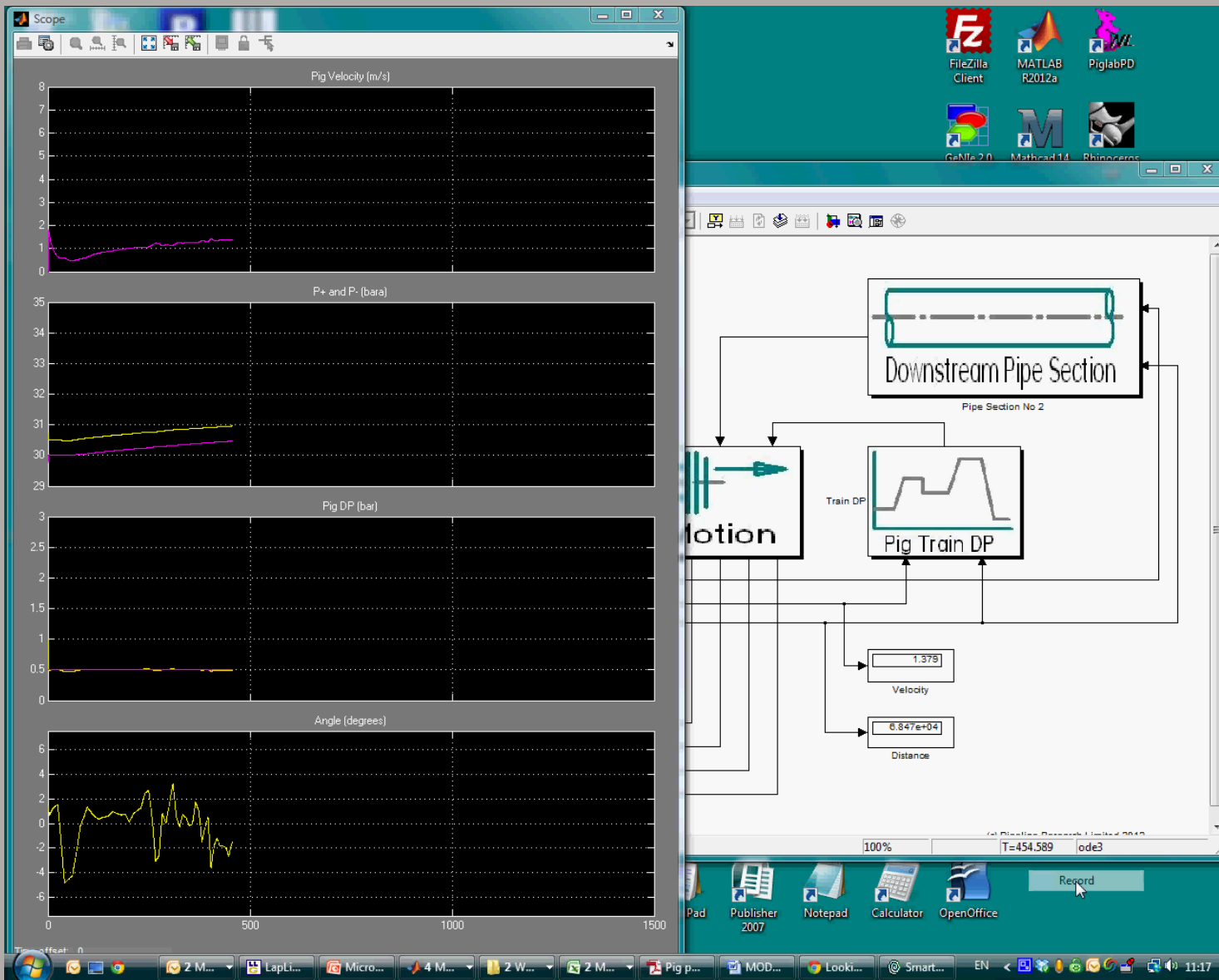
Pressure at location in the line against time



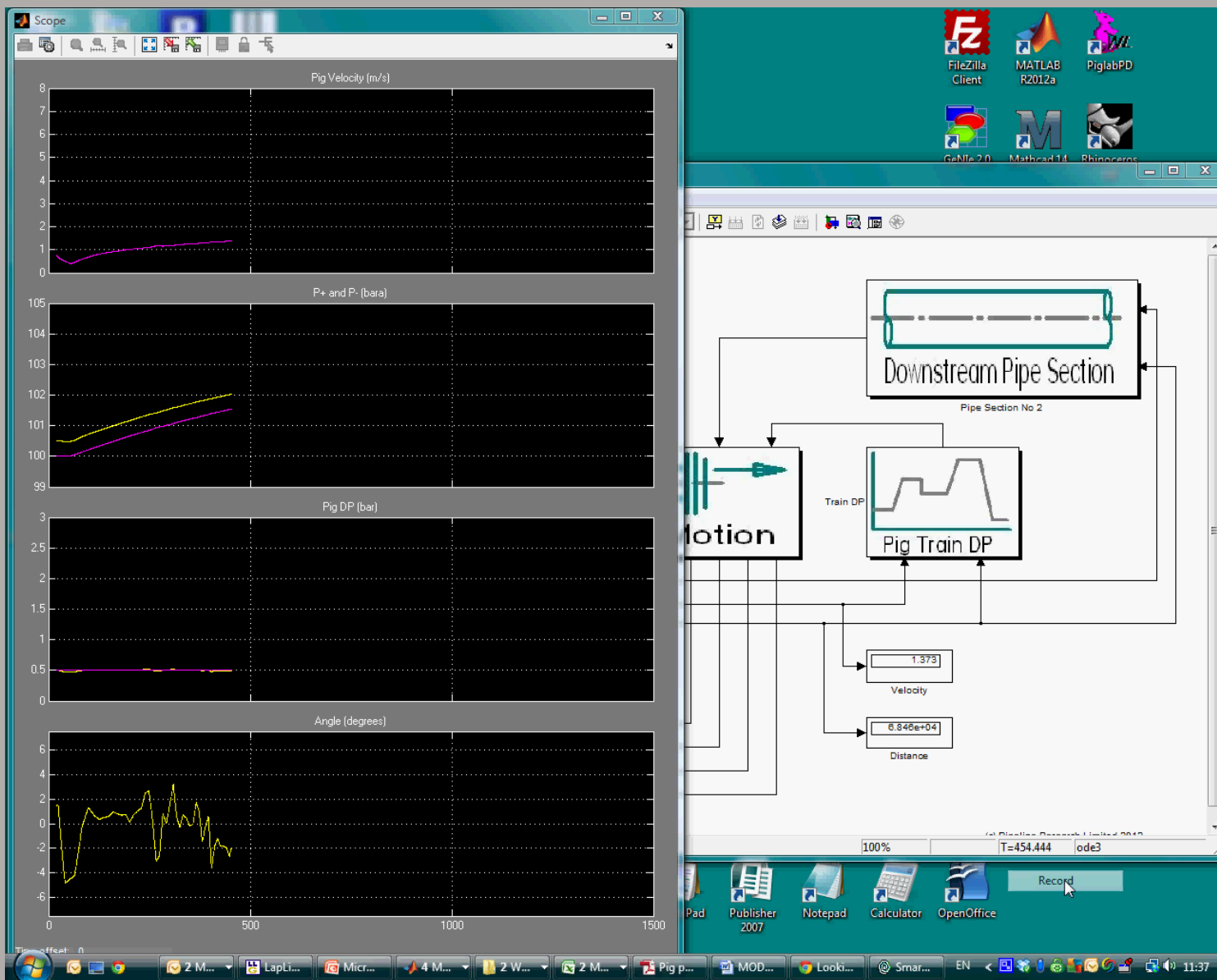
Simulink™ Model for Pig Velocity



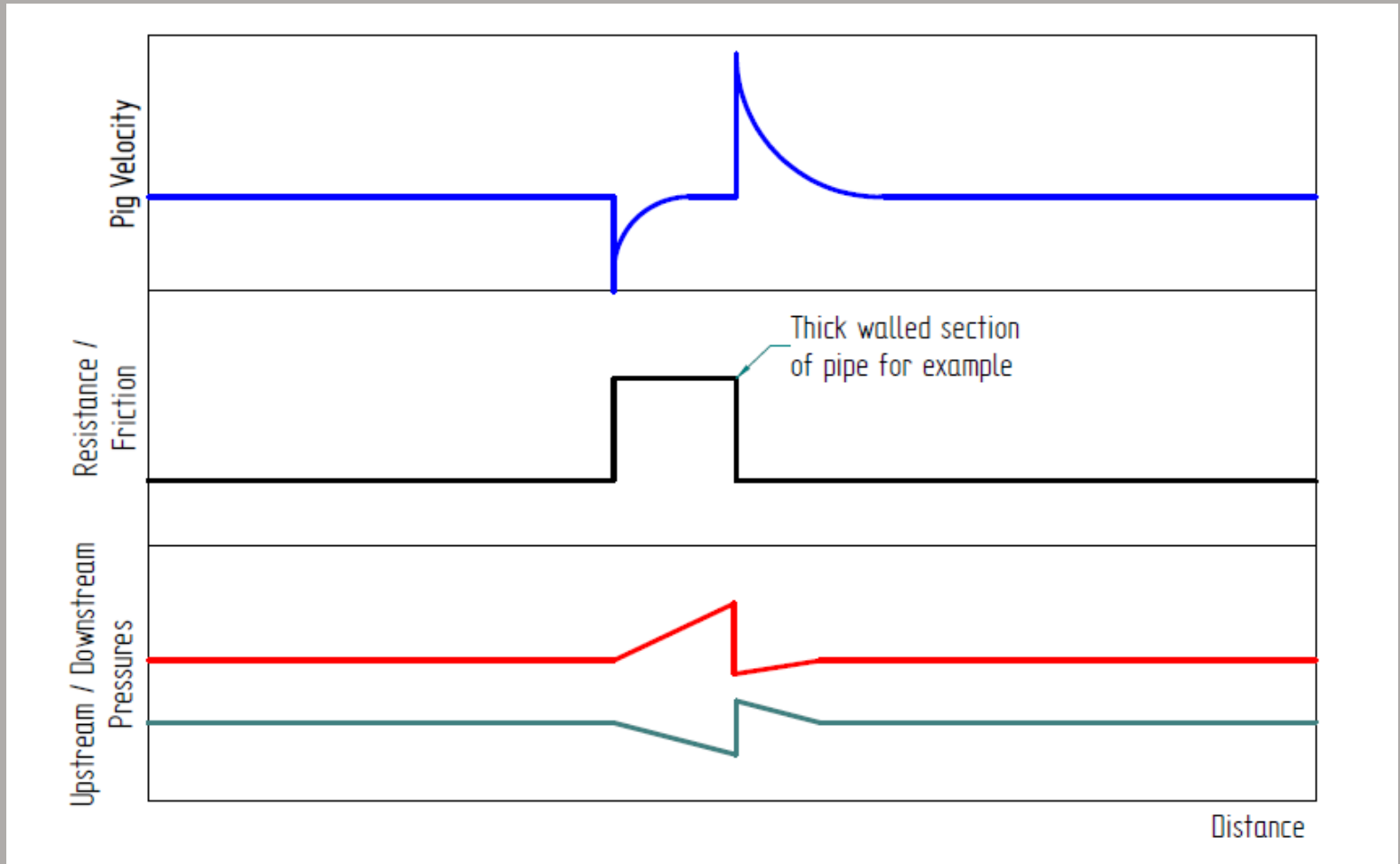
Pig in 30 bars line with tight section of pipe



Pig in 100 bars line with tight section of pipe



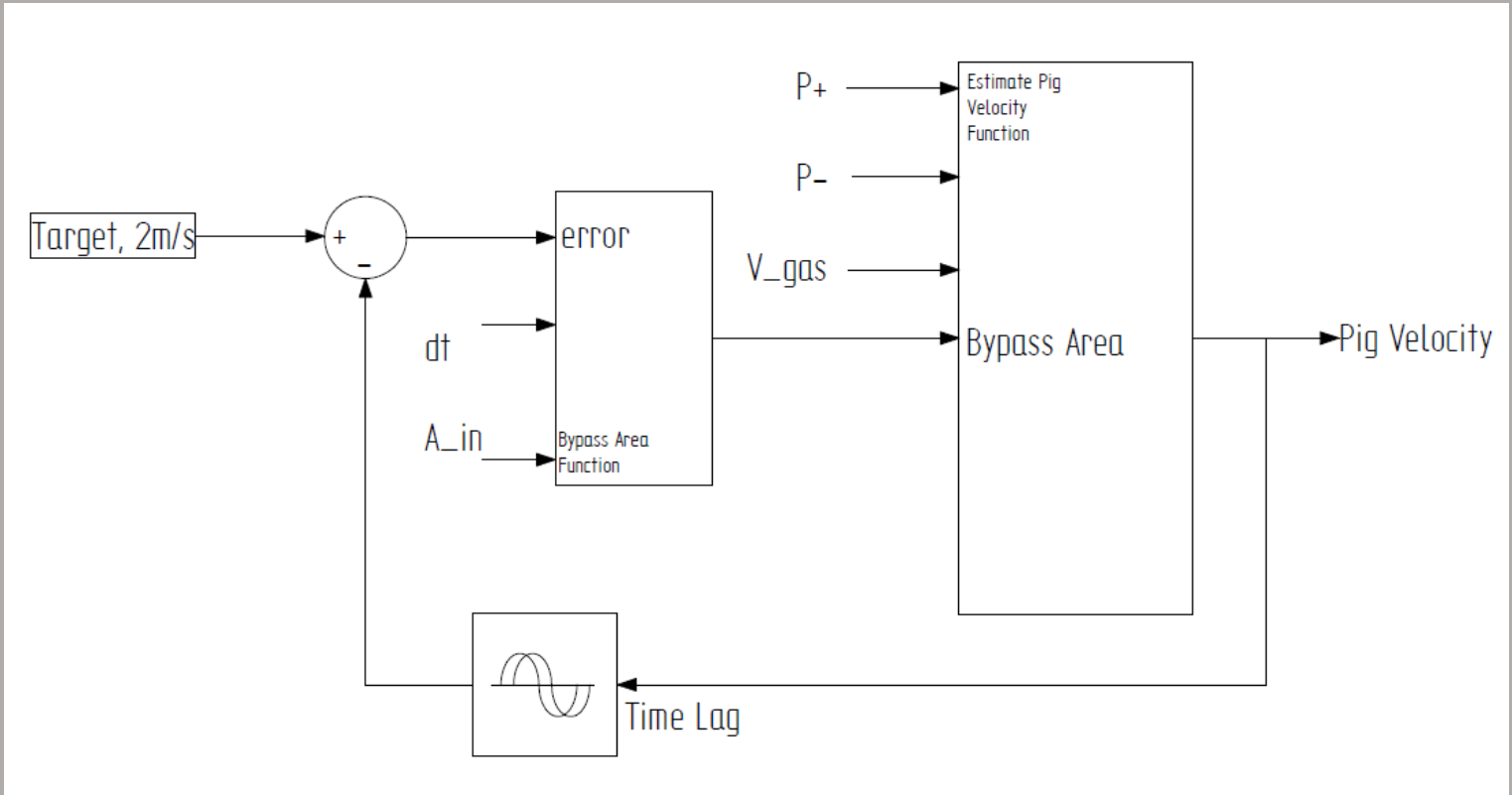
Excess Pressure converted to Kinetic Energy



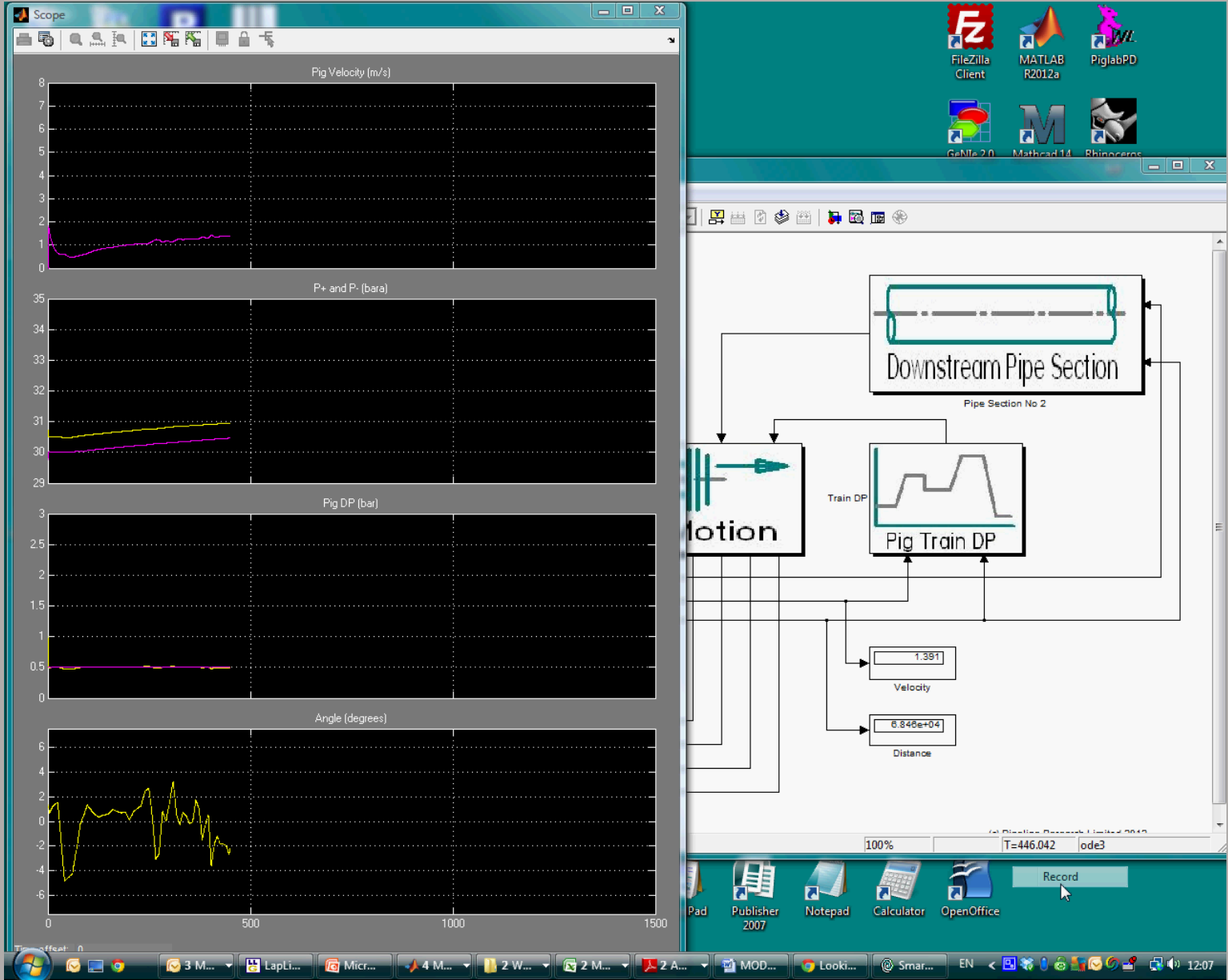
Excess pressure is translated into high velocity
High acceleration due to low mass

How can we control the velocity?

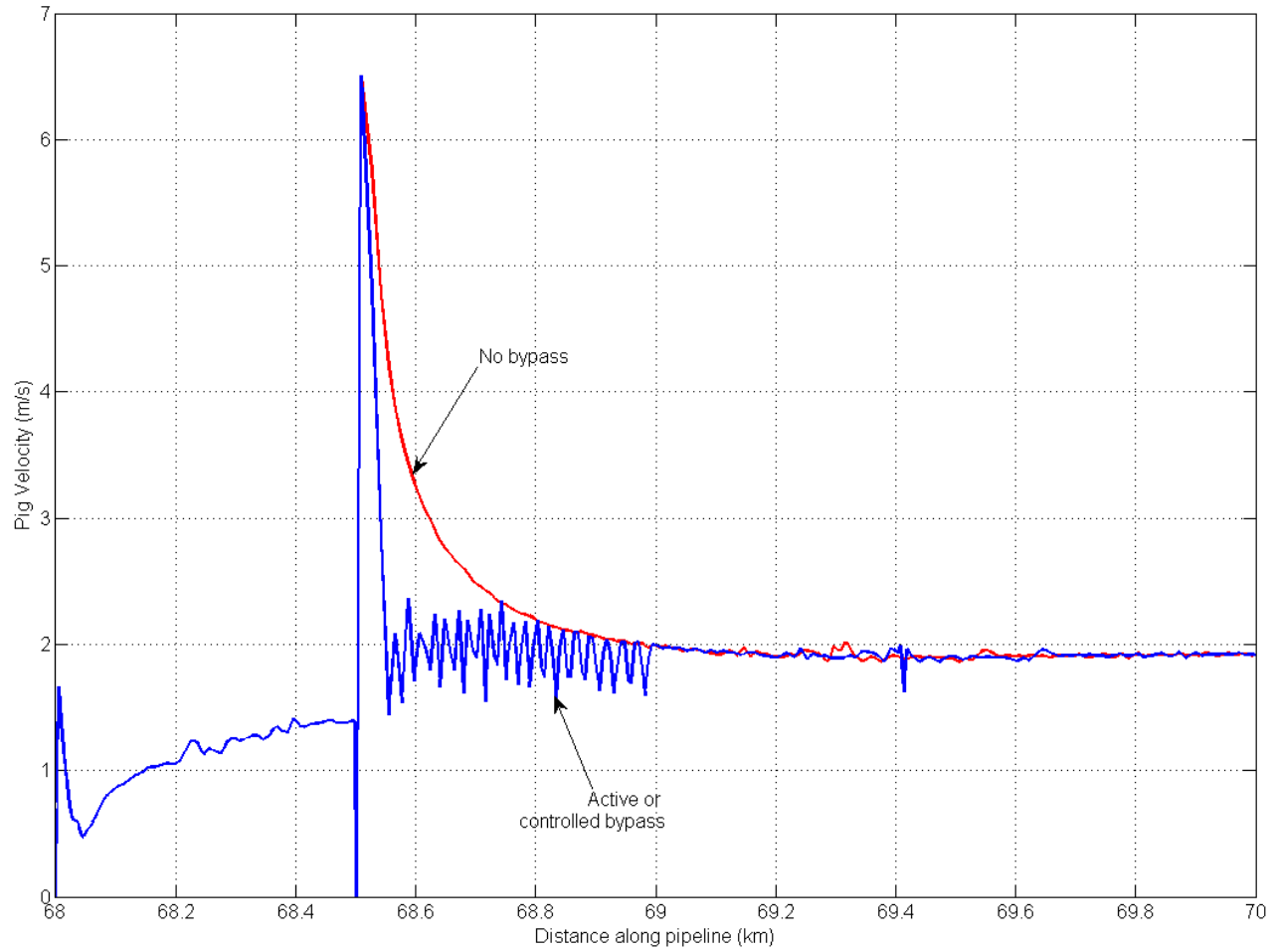
- Simple fixed bypass port;
- Control system with variable bypass.



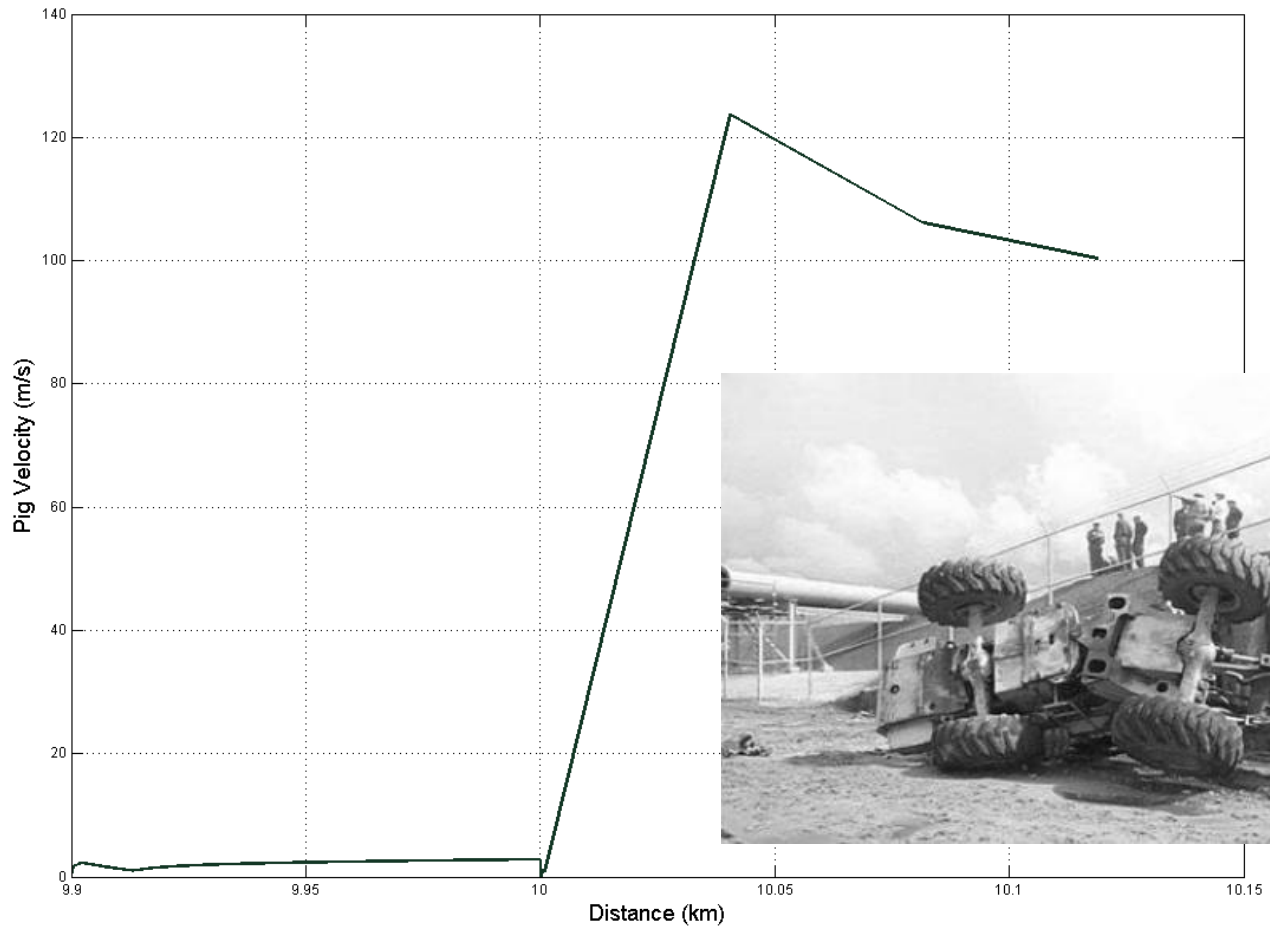
30 bars case with active bypass control



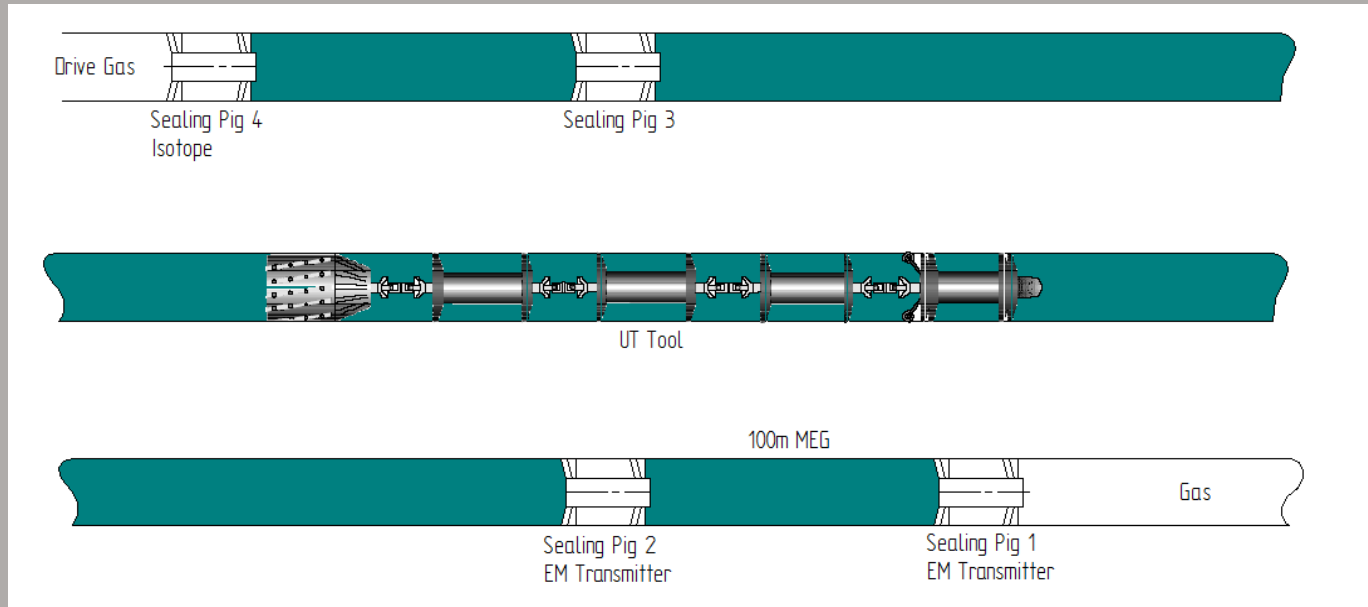
Comparison - Speed control / no speed control



Foam Pig Incident



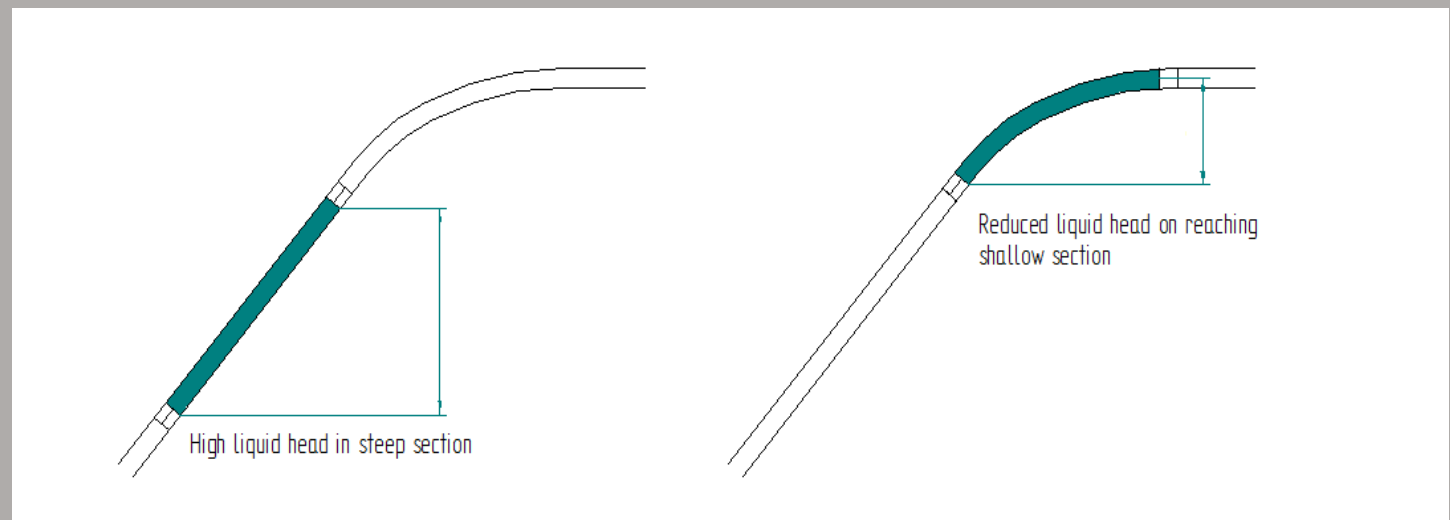
Examples of a pig train



- Ultrasonic Pig Trains in gas lines;
- Start up of Isolation plugs;
- Positioning isolation plugs in a target zone.

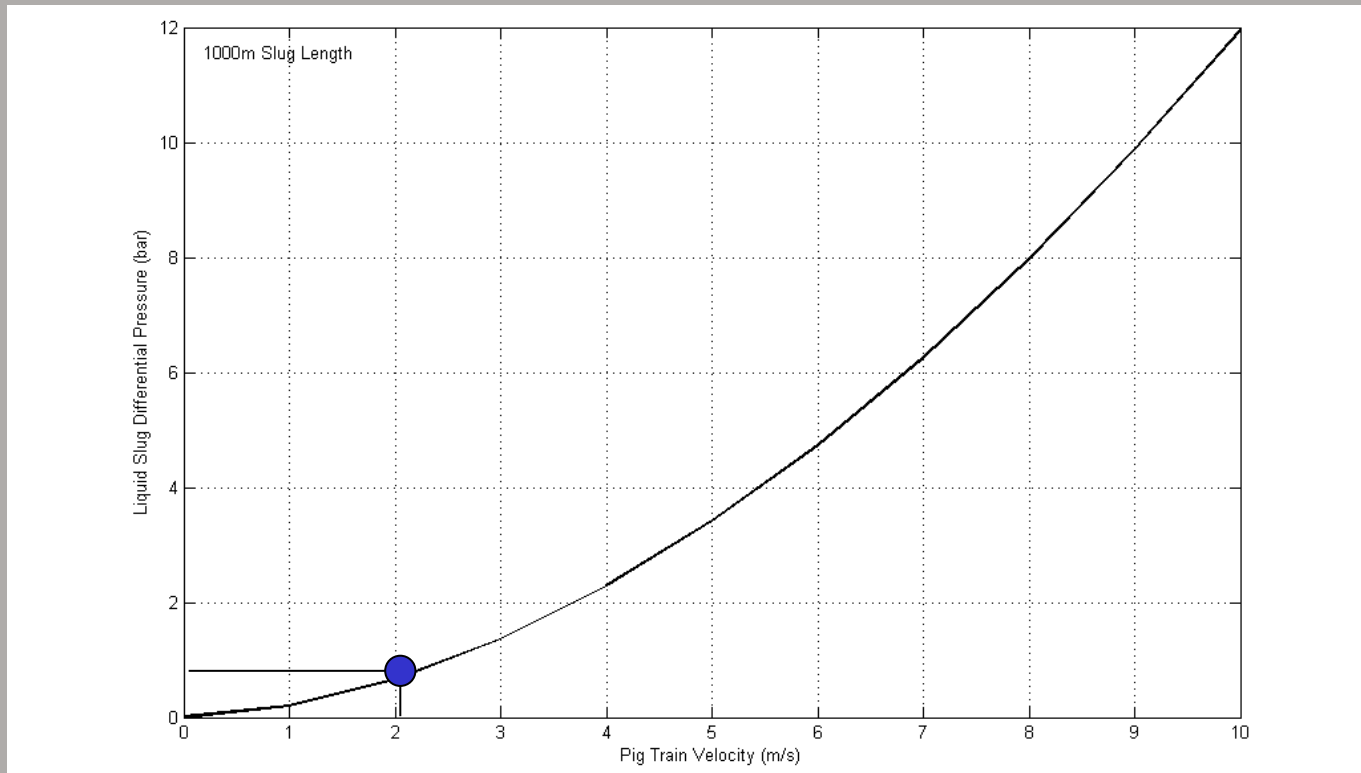
Why is the train velocity unstable

- Multiple pigs mean higher differential pressures;
- More changes in differential pressure;
- High momentum;
- Weight of train in steep sections;
- Change in back pressure during change of elevation...

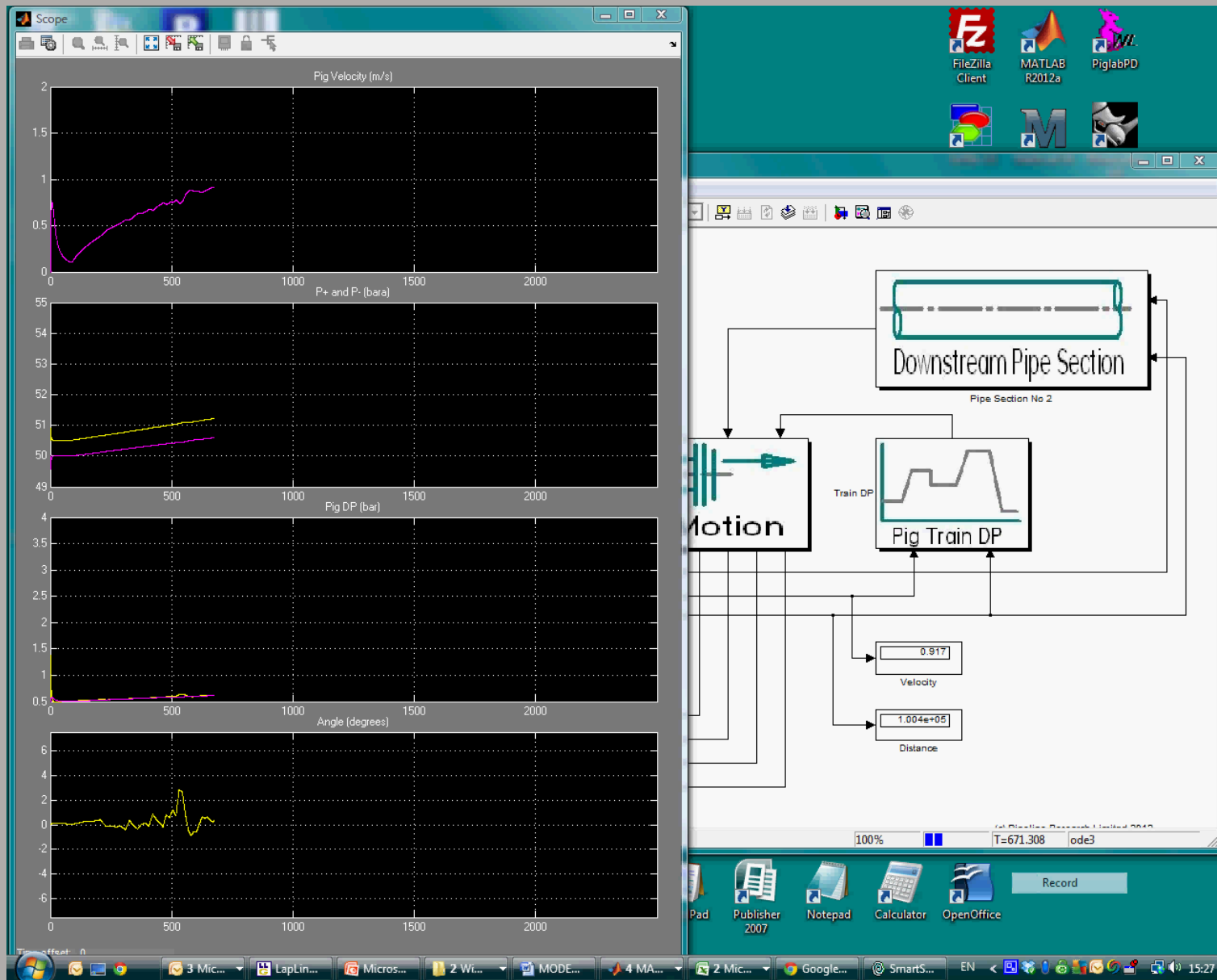


Options for speed control

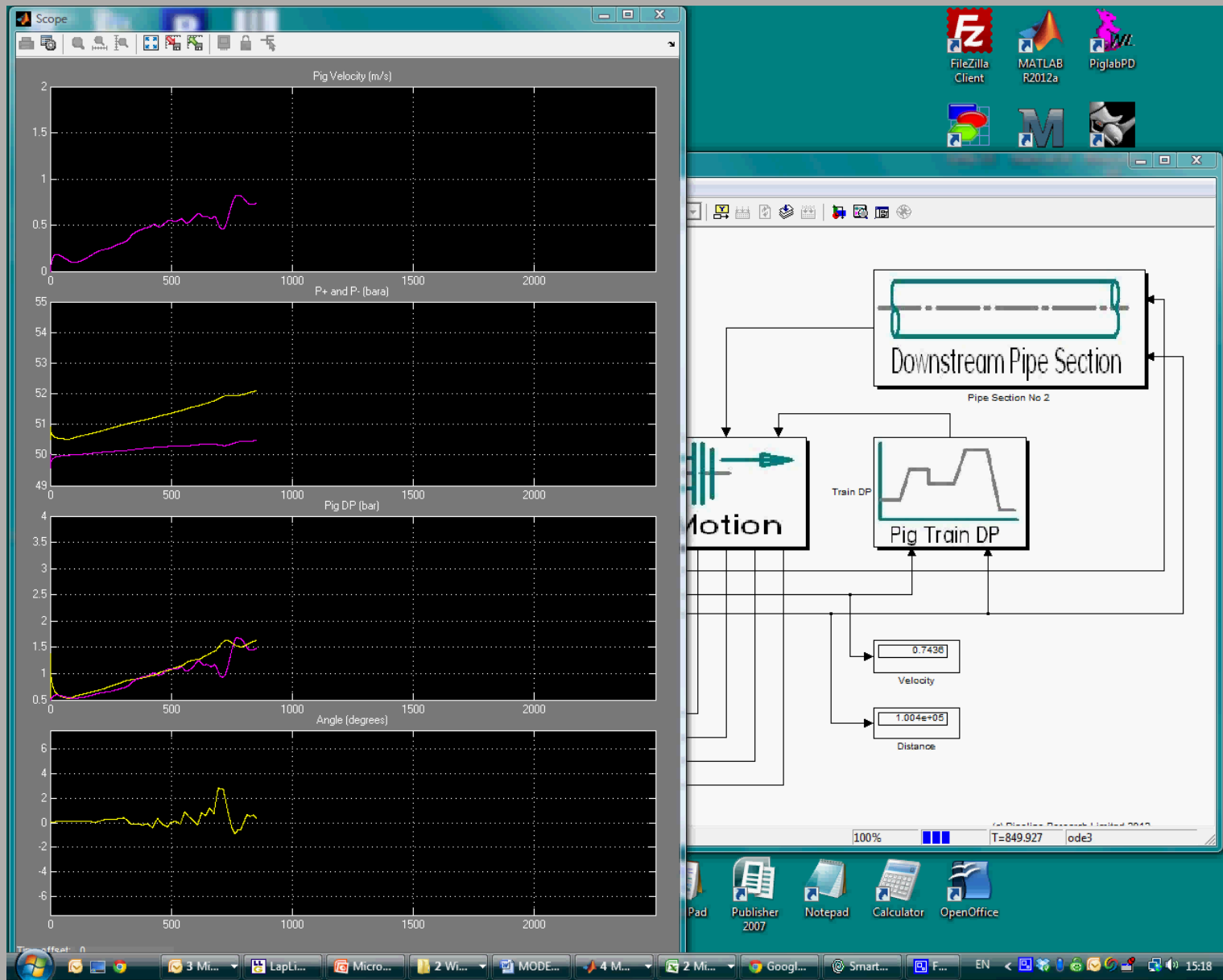
- Optimise pig design, low DP changes;
- Length of train – increased momentum ;
- Length of train – increasing DP with increasing velocity...



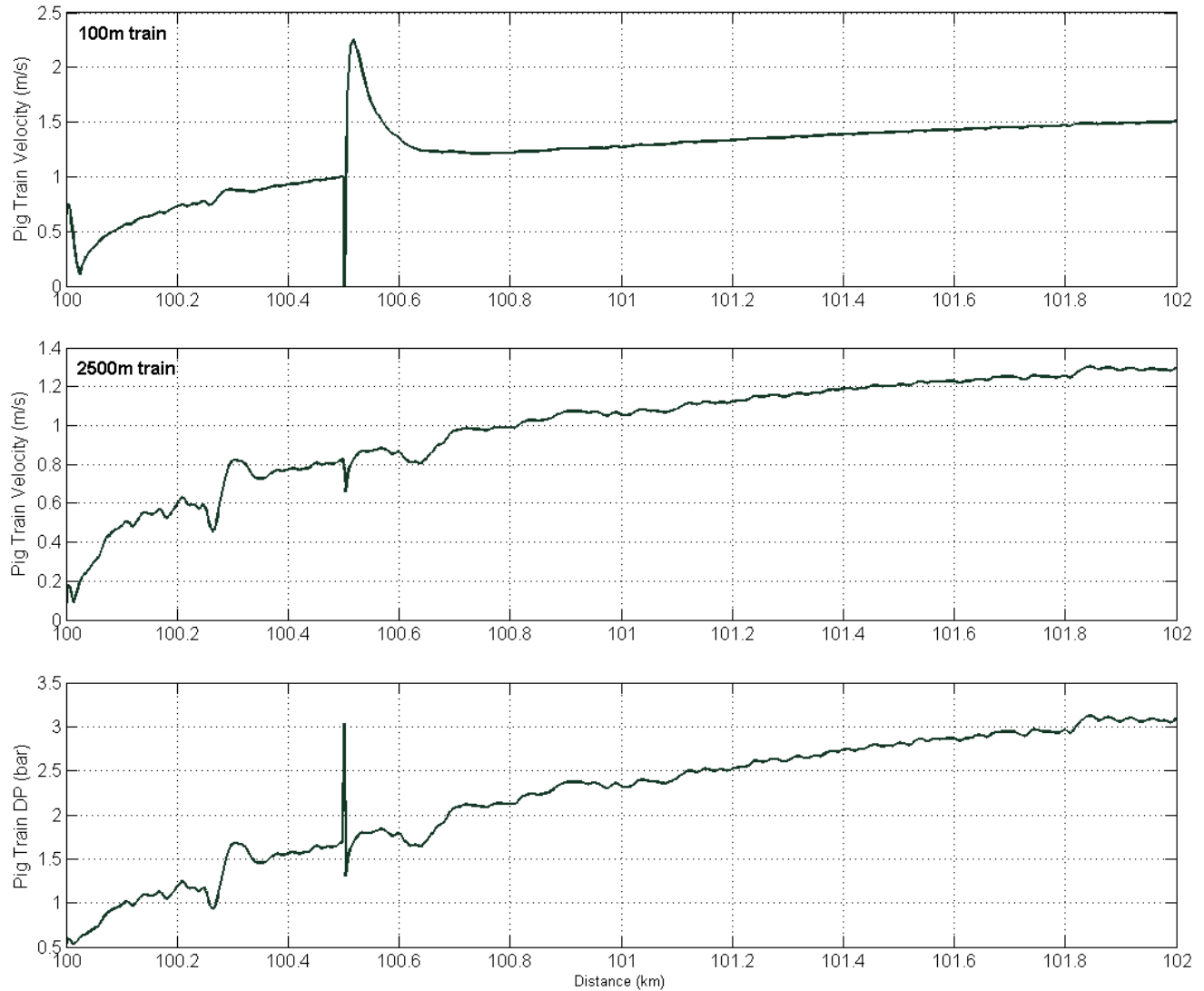
Velocity Profile for short 200m pig train



Velocity Profile for long 2500m pig train



Comparison – Short and long pig train

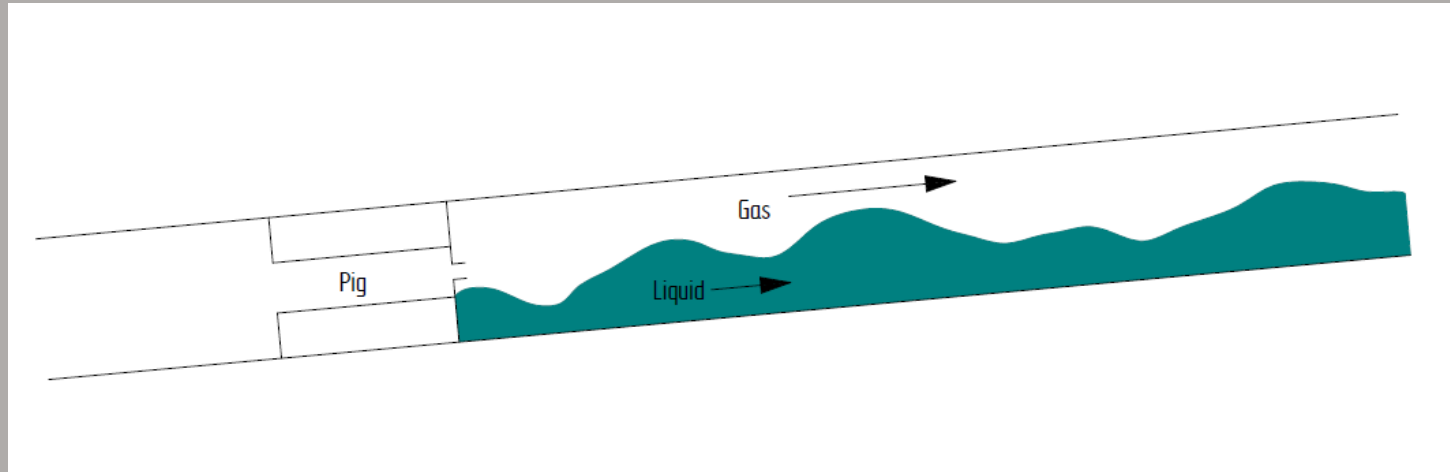


Projects where the model has been used

- Woodside Browse Project;
- ConocoPhillips BI I and H7 Bypass Project;
- Gorgon Jansz Development;
- BP CATS 36" Line;
- Woodside Pluto Gas Export;
- Statoil Kvitebjørn Repair;
- BP Ethylene line inspection.

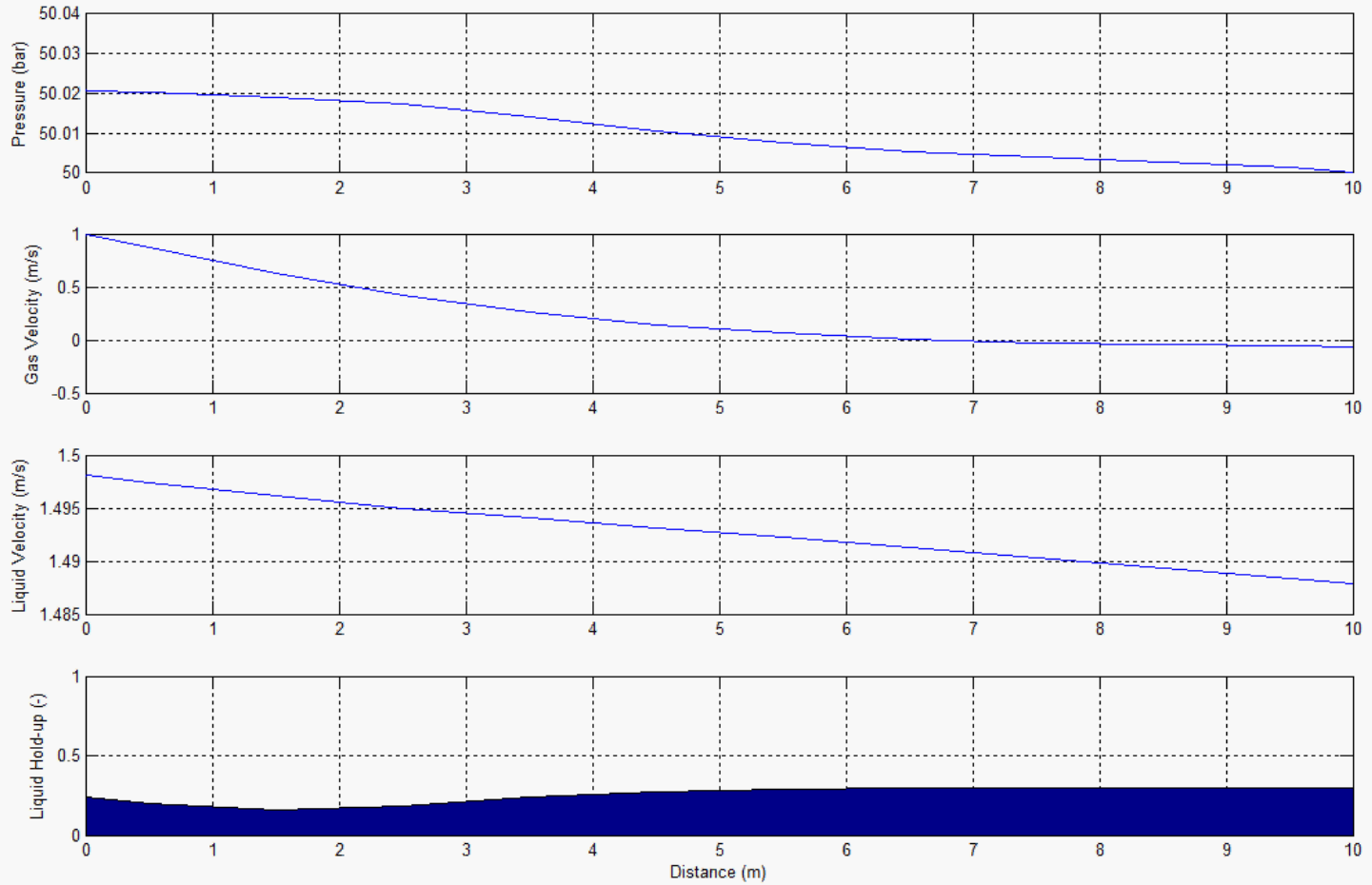
Also for various investigations and enquiries into problem pigging jobs.

Two Phase, gas-liquid flow with pigging



- Now four equations: -
 - Gas Continuity and Momentum;
 - Liquid Continuity and Momentum;
- Closure relationships;
- Boundary and initial conditions.

Initial Output from this analysis



Thank You.

