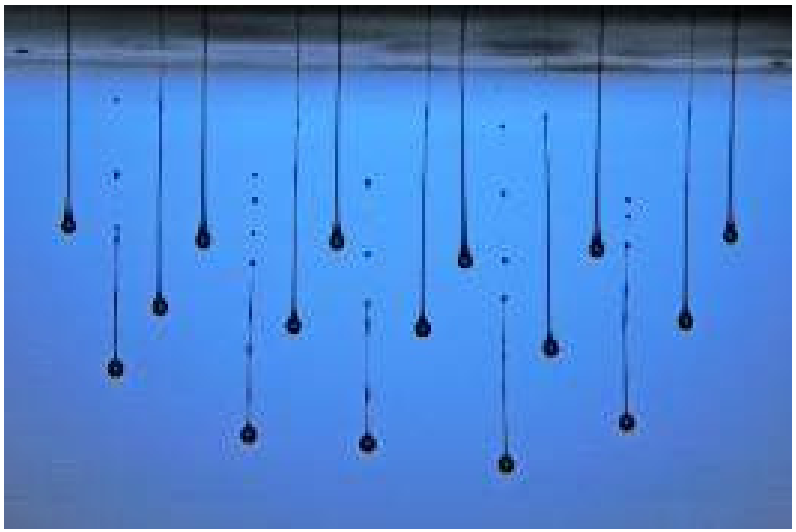
Tool for inkjet drop optimization



Clive Ayling (clive.ayling@ttp.com)
Dr. John Stanton (john.stanton@ttp.com)
www.ttpmeteor.com & www.ttp.com

contents

- the value of understanding fluid jetting behavior and using the best waveform
- experimental results showing effect of waveform and fluid pressure on drop mass and speed
- measurement tool used and how it can be adapted for different print head types

The Technology Partnership plc (TTP)

- Europe's leading technology and product development services company
- 300 engineering and scientific staff based near Cambridge, England
- Leading developer of ink jet technology, products and applications

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The Technology Partnership plc
+44 1763 262626
www.ttp.com

jetting fluids

- how well can you jet your fluid? - second in importance only to whether the fluid does the job intended!
- affects reliability (MTBF & maintenance schedule) and performance
- differentiates the good dispensing systems from the bad dispensing systems

T T P

piezo inkjet ejection

- drop ejection is caused by a positive pressure wave in the fluid reaching the nozzle
- pressure wave in the fluid is caused by a movement of a wall of the fluid chamber
- movement of the fluid wall is caused by piezoelectric response to an electrical waveform created by the drive electronics
- droplet break off is due to drop in pressure and fluid hydrodynamics

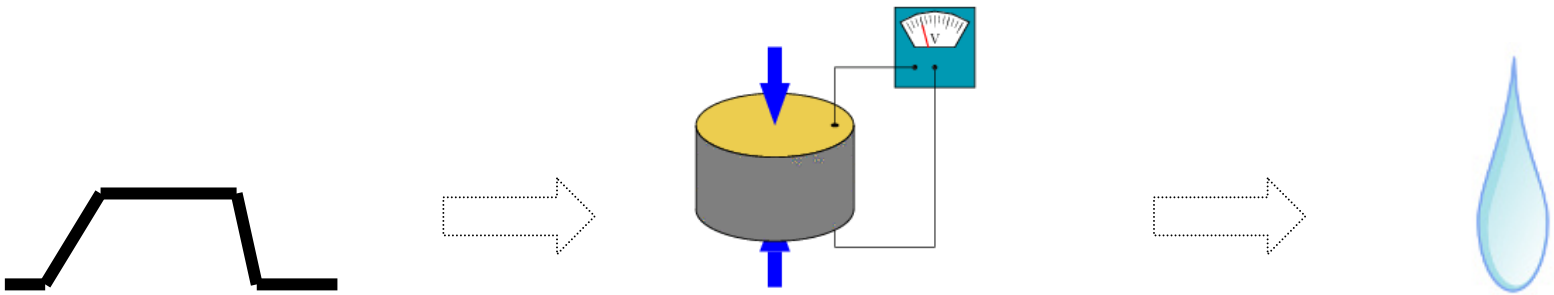
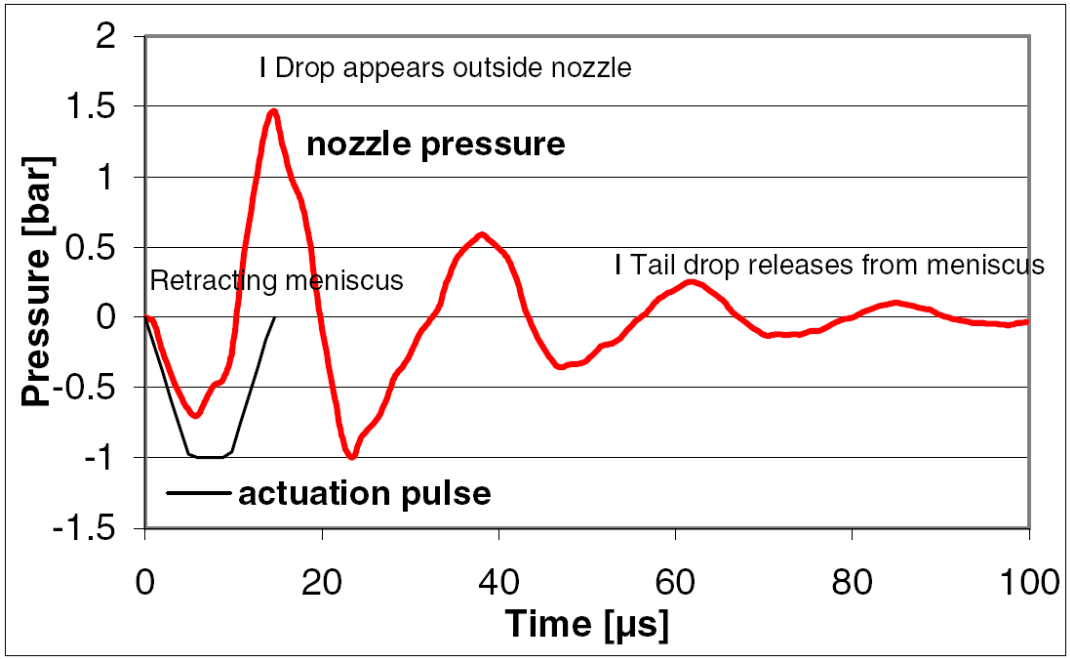


image © wikipedia

piezo waveform

- pressure inside the nozzle is actually more complicated and consequently will depend on the time period between pulses



"Manipulating Drop formation in Piezo Acoustic Inkjet"
by Herman Wijshoff, Oce-Technologies B.V., Venlo. Copyright similar.

piezo waveform source

- printheads with on-head waveform electronics:
  - Xaar®
  - Toshiba TEC
  - Konica Minolta
- printheads with no on-head waveform electronics:
  - Dimatix (Spectra®)
  - Ricoh
  - Trident

on-head waveform electronics

- waveform is defined by a ‘waveform file’ that tells the printhead’s electronics which pulse shape to use

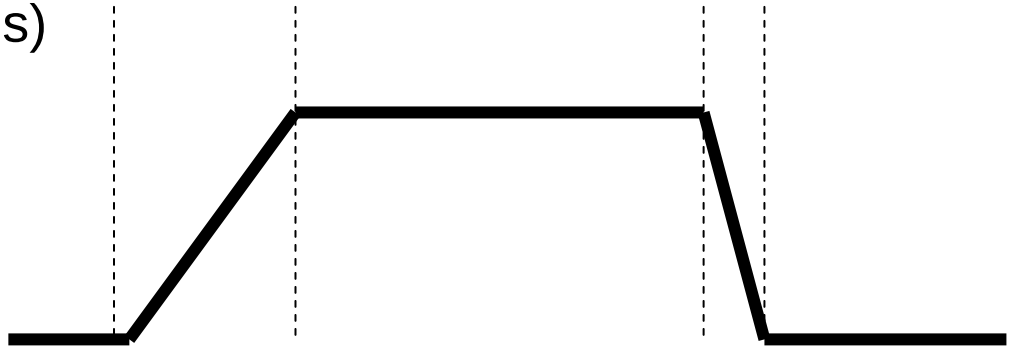
- the waveform file is supplied by the drive electronics used (e.g. TTP’s Meteor drive electronics) when the head* is powered up

*exception to this rule:
Xaar 128 has a fixed waveform

off-head waveform electronics

- waveform is defined by a drive electronics' firmware
  e.g. Meteor drivers have a configuration file where the waveform parameters can be set

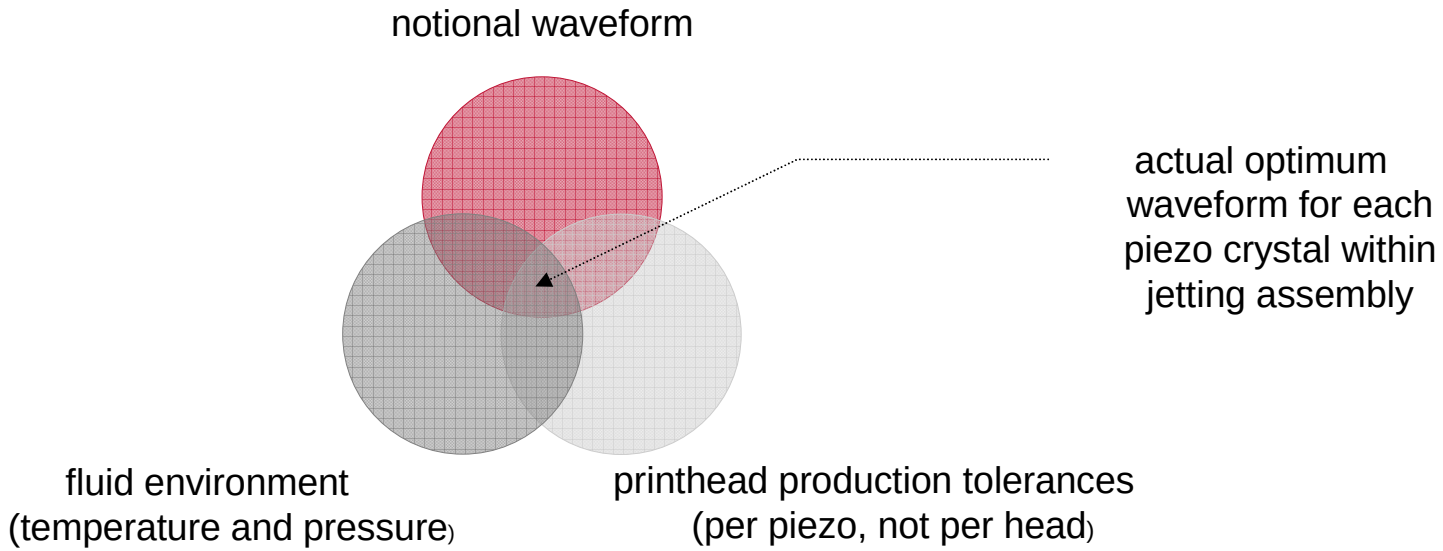
- a simple trapezoidal pulse definition contains
  - pulse height (Volts)
  - ramp up time (µseconds)
  - sustain time (µseconds)
  - ramp down time (µseconds)



off-head waveform electronics

- pulse height required may vary with piezo crystal, jetting assembly and printhead due to production variation in piezoelectric efficiencies

- pulse height required may also vary with temperature to compensate for fluid viscosity changes



importance of optimum waveform

- avoids satellites
  - prevents build up of fluid on nozzle plate
  - improves print quality

- fine tune print quality
  - right drop size for ‘image’ resolution
  - consistent drop speed across fluids and heads used

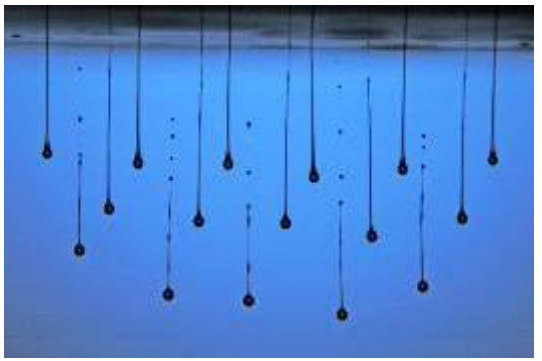


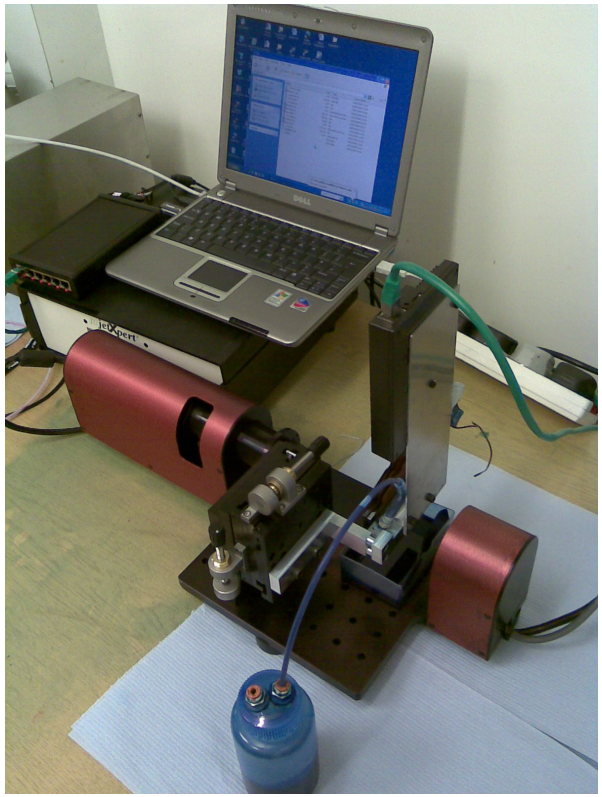
image ©Steve Hoath

targets

- good drop formation (no satellites, stable ejection)
- high speed (less time of flight, windage)
- adjustable drop volume to compensate for fluid spread
- understanding of tolerance on parameters used
- ability to use heads supplied from a single fluid supply with slightly varied meniscus pressures

experimental results

- oil-based fluid
- Spectra® Galaxy 256/30 printhead
- JetXpert™ jet analysis system (strobe, camera and software)
- Meteor™ driver electronics with Meteor Drop Tuner™ software
- nominal values of parameters as used in tests:
  - 87V drive volts
  - 2.5 µs ramp up
  - 10 µs sustain
  - 4 µs ramp down
  - -36 mm pressure



T T P

operator involvement

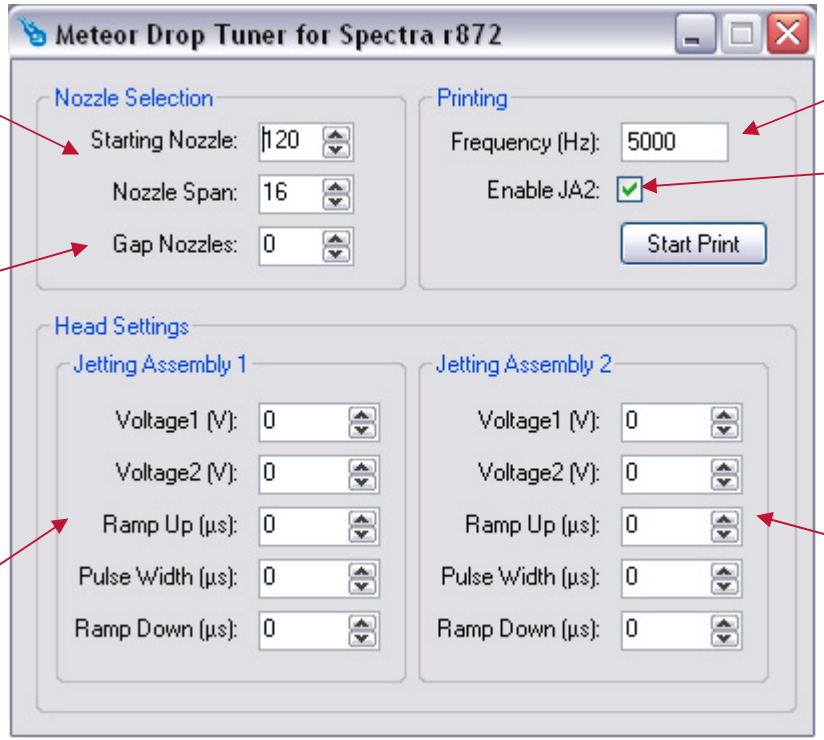
- Meteor Drop Tuner Software can adjust any printhead parameter:
  - for each piezo crystal: voltage, pulse ramp up time, pulse sustain time, pulse ramp down time
  - which nozzles are used
    example:
    - nozzle numbers in range 133-136 inclusive
    - all nozzles in the range, or, alternate nozzle in the range, or, every third nozzle in range
- JetXpert needs pre-configuring for drop visualisation calculations and data logging parameters
- operator must also occasionally alter the vertical micrometer adjustment to match position of drops when their speed changes so that they remain in the field of view of the microscope

operator involvement

restricts nozzles in use to those being viewed

permits examination of cross-talk

on a Fujifilm Dimatix Spectra Galaxy jetting assembly these parameters apply to even-numbered nozzles



sets the frequency of jetting

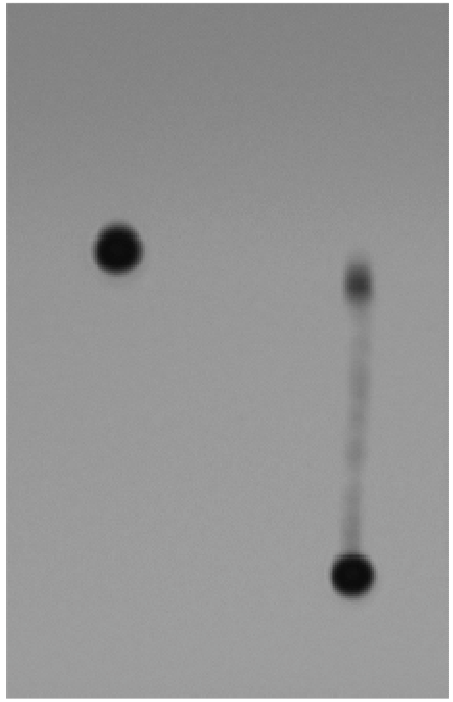
on a Fujifilm Dimatix jetting assembly this defines whether it has 256 nozzles or 128 nozzles

on a Fujifilm Dimatix Spectra Galaxy jetting assembly these parameters apply to odd-numbered nozzles

T T P

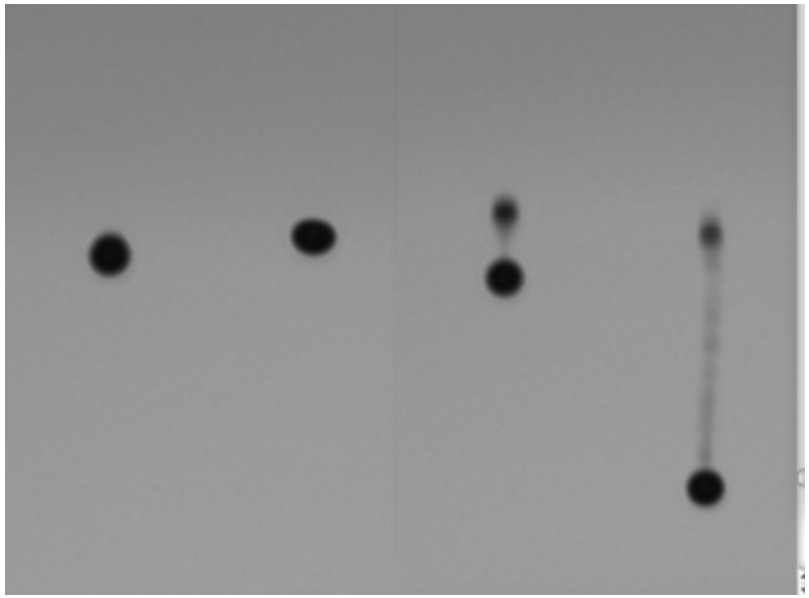
satellites (1 of 3)

- left drop and right drop are from same printhead but are from piezo crystals that are driven with different waveforms by Meteor™ to illustrate satellites



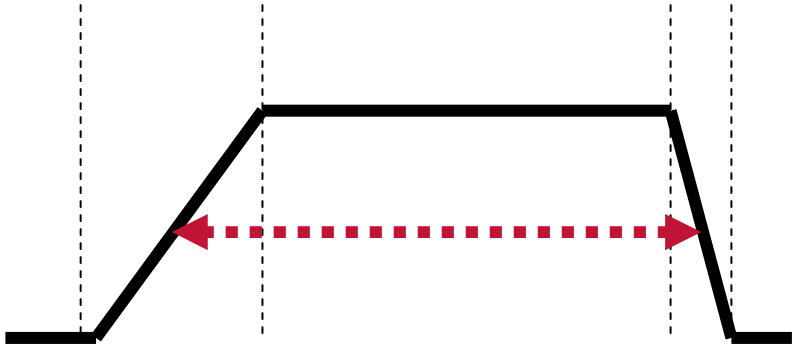
satellites (2 of 3)

- it’s easy to set by eye all parameters (voltage, ramp up, sustain, ramp down) for each of the 4 piezo crystals in a Spectra head to get all drops satellite-free, at same speed



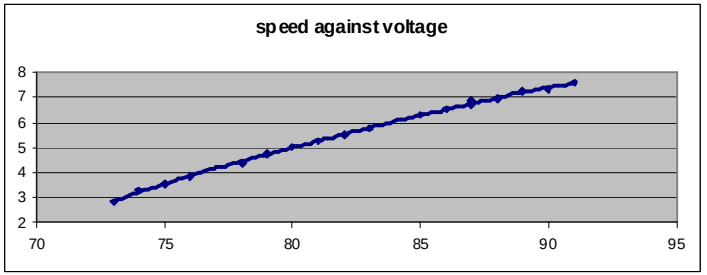
satellites (2 of 3)

- overall pulse width (sustain + [ramp up +ramp down]/2) seemed important
- an increasing width was required for increasing pulse voltage used



graphs*

- Y-axis as defined in title:
  - speed (m/s), or,
  - volume (pL)

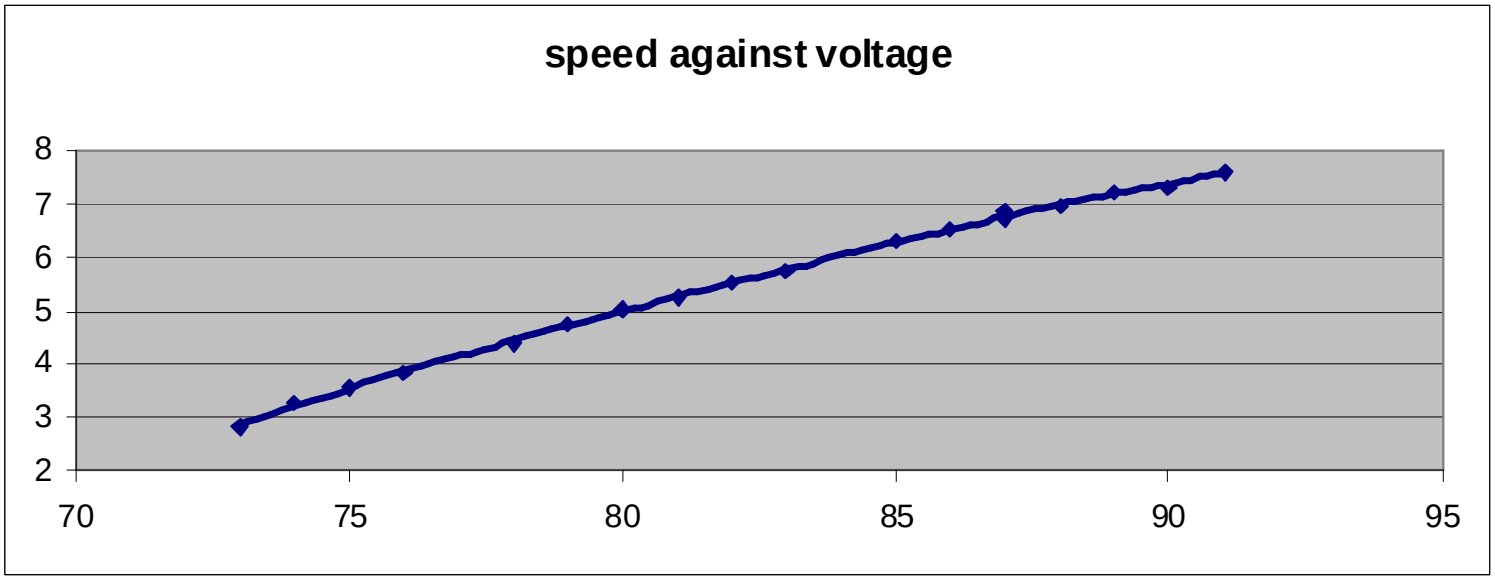


- X-axis as defined in title:
  - Volts, or,
  - time in µseconds (microseconds), or,
  - pressure in mm (equivalent to 0.1mbar or 10Pa)

*results will vary by fluid, temperature etc. so values shown in this presentation are for comparison purposes only

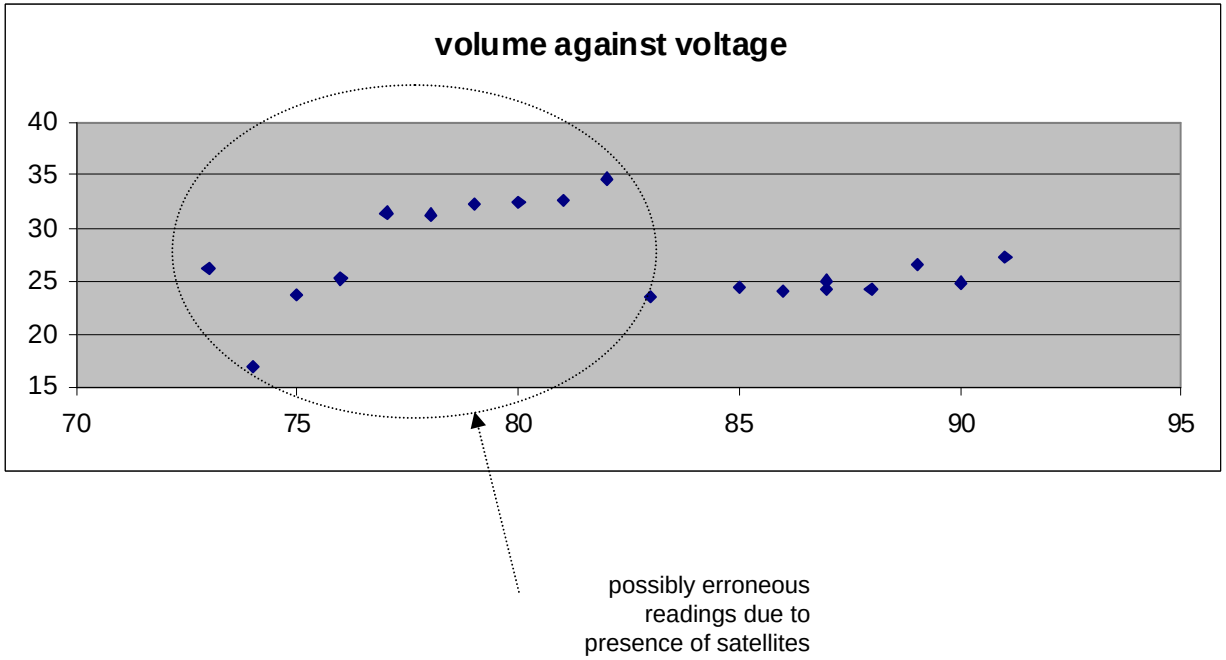
changing pulse voltage

- drop speed is sensitive to drive voltage
  rate is +0.26 m/s per volt



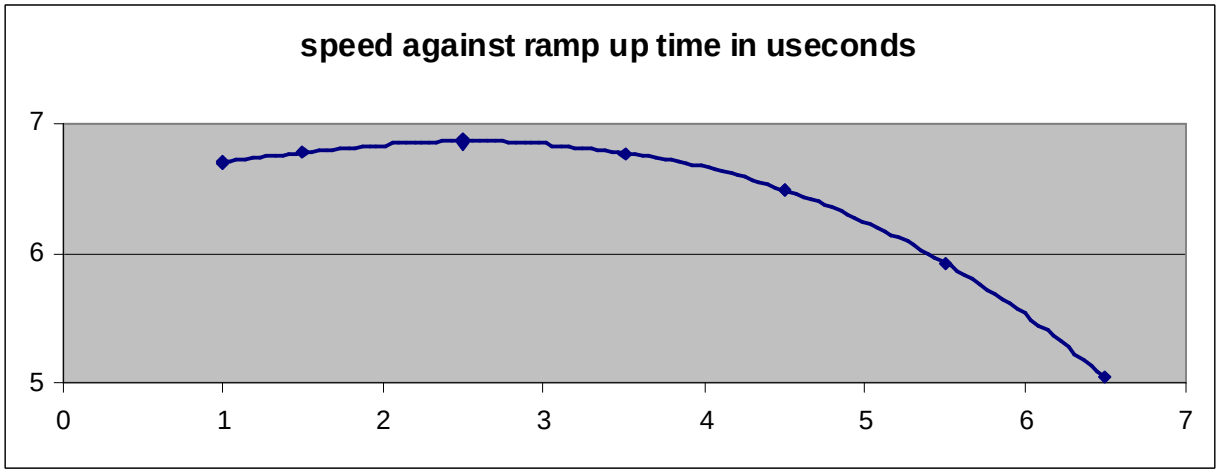
changing pulse voltage (2 of 2)

- satellites confuse automatic drop volume calculations



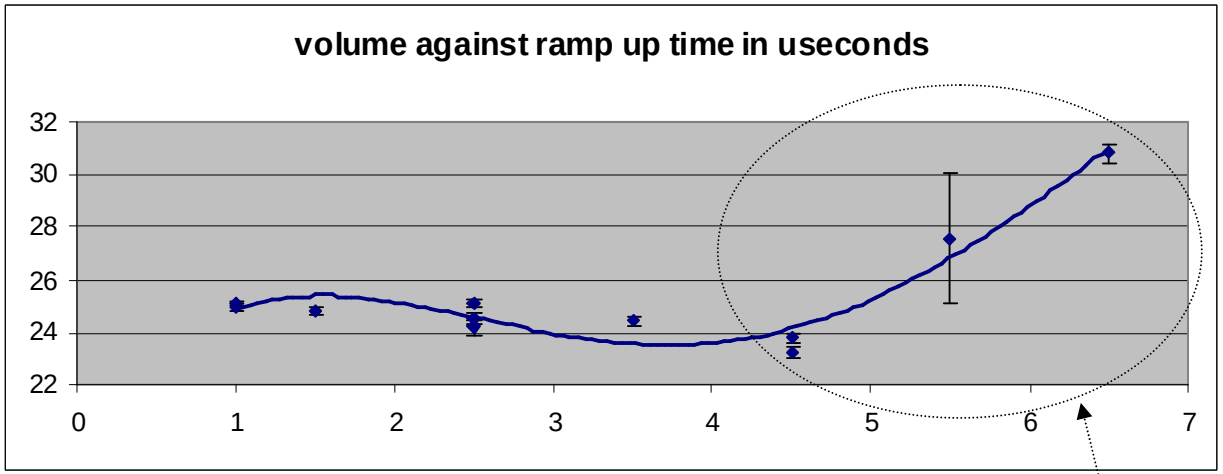
changing ramp up time (1 of 2)

- speed is little affected by ramp up time if <4 µseconds



changing ramp up time (2 of 2)

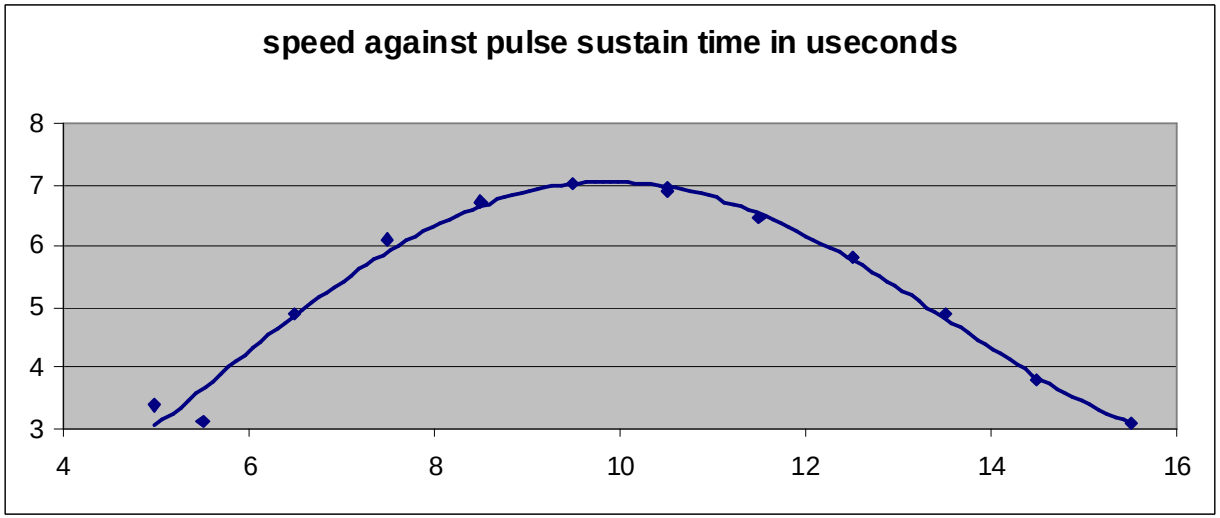
- small changes in volume (excluding satellites)



possibly erroneous readings due to presence of satellites

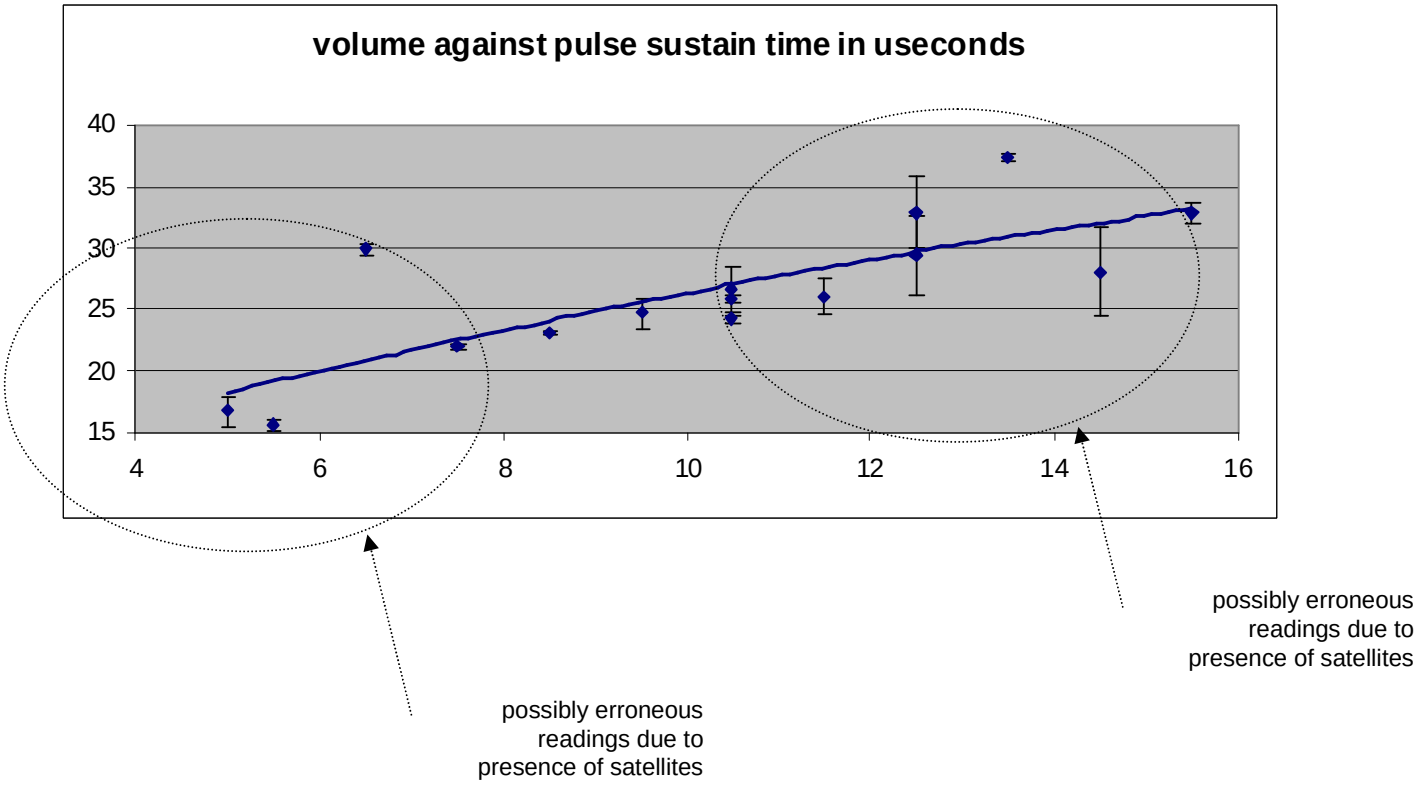
changing pulse sustain time

- speed has a peak around 10usecs sustain time



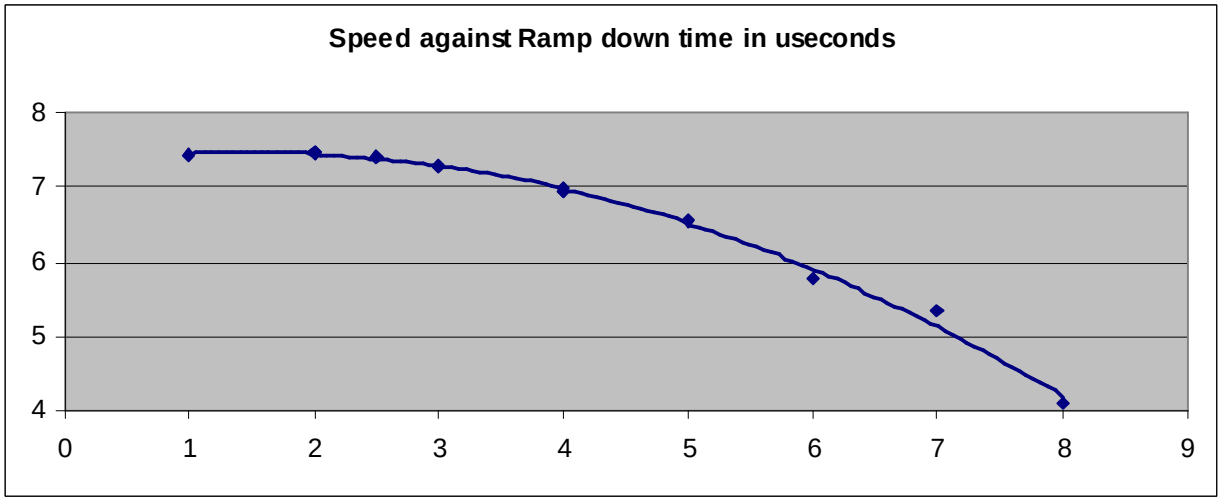
changing pulse sustain time (2 of 2)

- trend is increasing volume with sustain time, however results possibly erroneous due to satellites



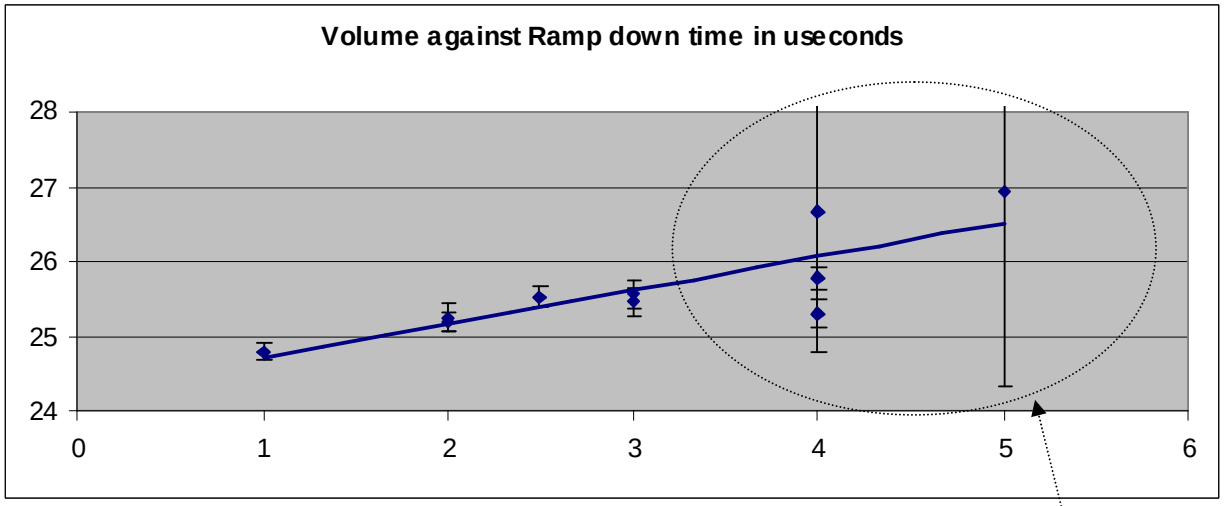
changing ramp down time (1 of 2)

- speed is sensitive to ramp down time
- need <2.5 µseconds



changing ramp down time (2 of 2)

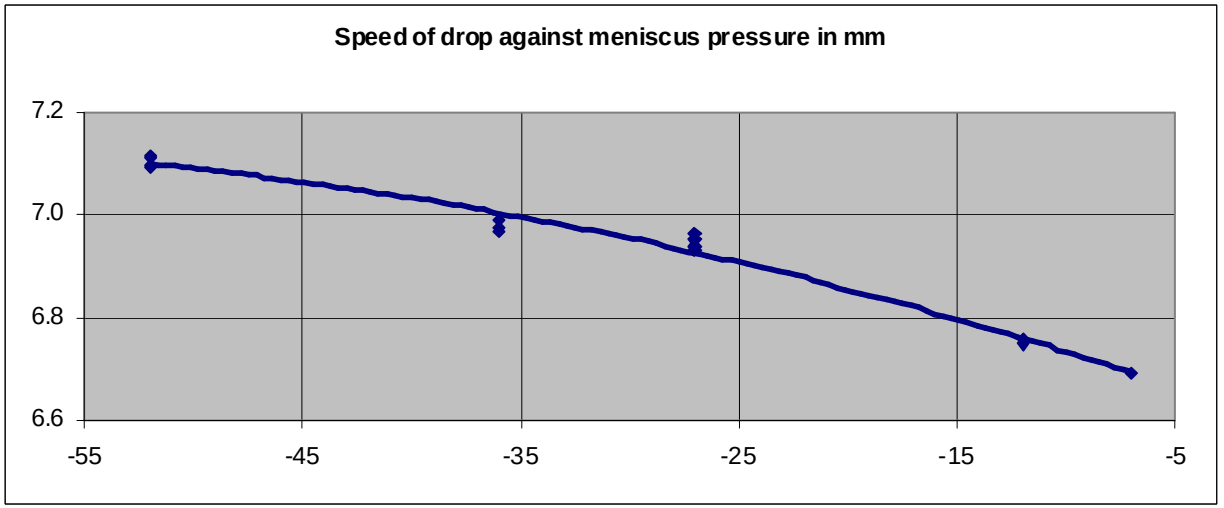
- small increase (2%/µsec) in drop volume as ramp down time increases



possibly erroneous readings due to presence of satellites

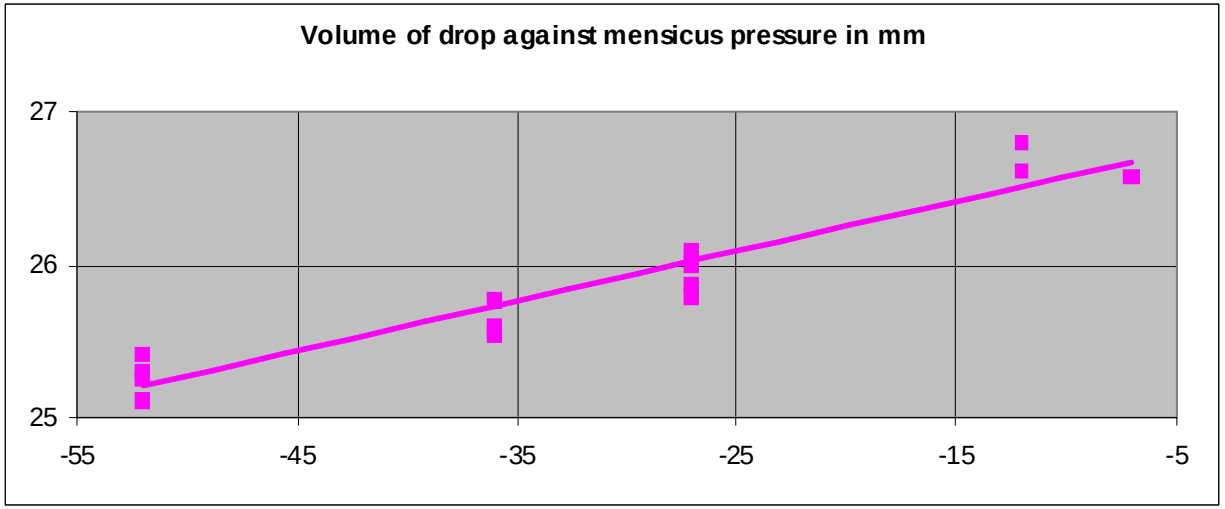
changing meniscus pressure (1 of 2)

- meniscus pressure range seen: -55mm to -5mm
- small decrease in speed seen as negative pressure is reduced



changing meniscus pressure (2 of 2)

- small increase in drop volume seen as negative pressure is reduced



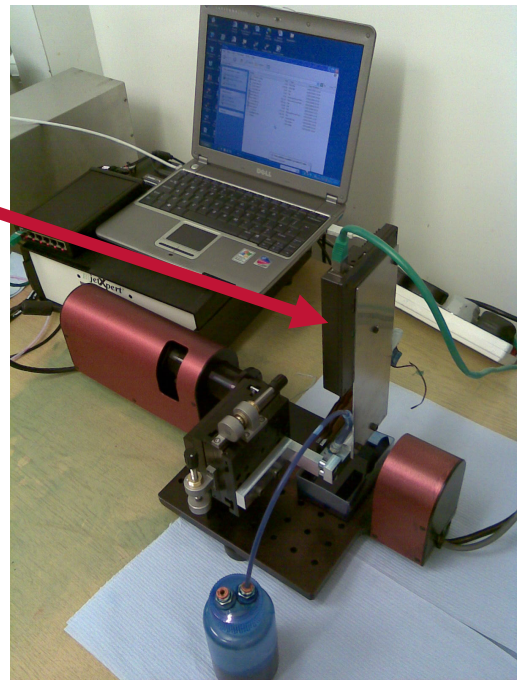
summary of experimental results

- for no satellites:
  - pulse width of 18 µseconds for 72V < voltage < 90V
  - pulse width of 20 µseconds for 90V < voltage < 110V
  - comprising
    - 4-5µs ramp up
    - 10-14µs sustain
    - 2.5-6.5 ramp down

- a greater negative meniscus pressure gave (slightly) faster, smaller drops, but these effects could be compensated if desired by small changes in waveform parameters

different printheads (1 of 3)

- Meteor and JetXpert are both printhead-agnostic, however some differences exist when using different printheads:
  - the options in Meteor Drop Tuner Software vary to reflect on-head / off-head printhead waveform creation (see slides 5-7)
  - an appropriate Meteor Head Driver Card is required



different printheads (2 of 3)

- Meteor Head Driver Cards do not yet exist for all printhead types. As off May 2009 the heads supported are:

- Fujifilm Dimatix:
  - Spectra Galaxy
  - Spectra Nova
  - Spectra S-class
  - Spectra Sapphire
- Toshiba TEC:
  - CA3
  - CA4
  - CE2
  - CF1
- Xaar:
  - Xaar 1001
  - Xaar 500
  - Proton
  - Xaar 318

- the range will continue to expand in 2009 and beyond

different printheads (3 of 3)

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- particular interest to dispensing applications due to small drop size (6pL - 25pL):

- Fujifilm Dimatix:
  - -Spectra Galaxy
  - -Spectra Nova
  - -Spectra S-class
  - -Spectra Sapphire

- Toshiba TEC:
  - -CA3
  - -CA4
  - -CE2
  - -CF1

- Xaar:
  - -Xaar 1001
  - -Xaar 500
  - -Proton
  - -Xaar 318

more capable with conductive inks

more capable with unstable inks

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take-aways

- drop control and visualisation is a powerful tool for developing and optimising a fluid deposition system (fluid, head or print engine)
- a simple flexible tool has been demonstrated: “JetXpert Plus Meteor”
- the Meteor system supports an expanding range of heads for integration into laboratory dispensing systems, production-line dispensing systems and/or for drop visualisation tools

Meteor™

- integrated by OEMs in USA, EU and ROW to drive
    - large digital presses
    - grand format printers
    - industrial inkjet print engines
    - **inkjet deposition systems**
    - **drop visualisation systems**
- developed and supplied exclusively by TTP

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