



“Improvements in ease of waveform development”

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contents

- the value of understanding ink jetting behavior and using the best waveform
- experimental results showing effect of waveform and ink pressure on drop mass and speed
- measurement tool used and how it can be adapted for different print head types
- appendix: information about The Technology Partnership PLC (TTP) and Meteor™

jetting ink

- jetting ink: second in importance only to whether the ink does the job intended!
- affects reliability (MTBF & maintenance schedule) and print quality
- differentiates the good inkjet systems from the bad inkjet systems



piezo waveform

- drop ejection is caused by a pressure wave in the ink reaching the nozzle
- pressure wave in the ink is caused by a movement of a wall of the ink chamber
- movement of the ink wall is caused by piezoelectric response to an electrical waveform created by the drive electronics

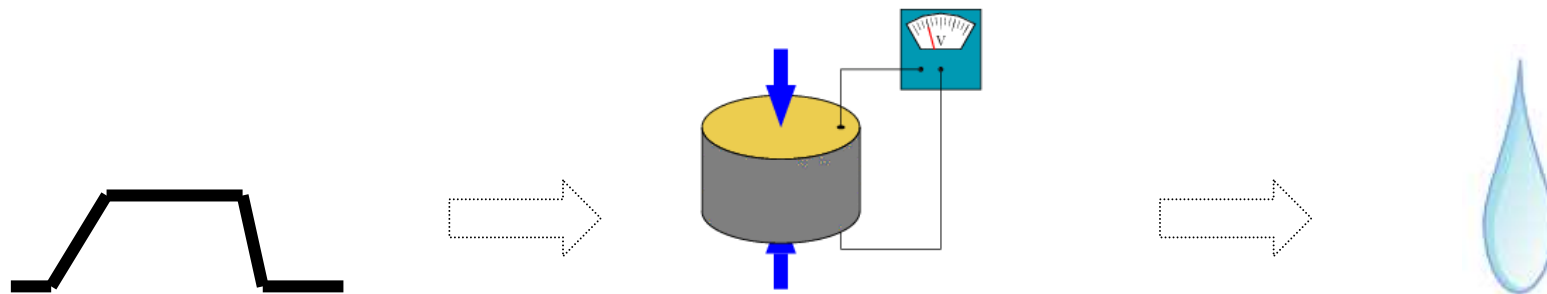


image © wikipedia

piezo waveform source

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



on-head waveform electronics

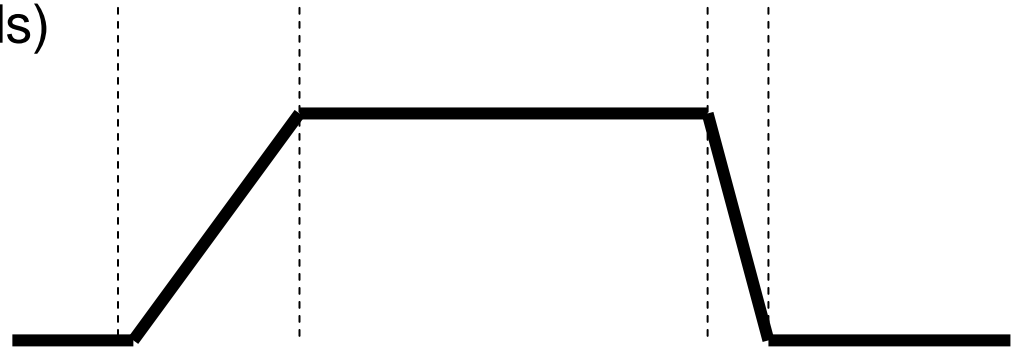
- waveform is defined by a 'waveform file' that tells the printhead's electronics which pulse shape to use
- the waveform file is supplied by the drive electronics used (e.g. TTP's Meteor drive electronics) when the head* is powered up

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



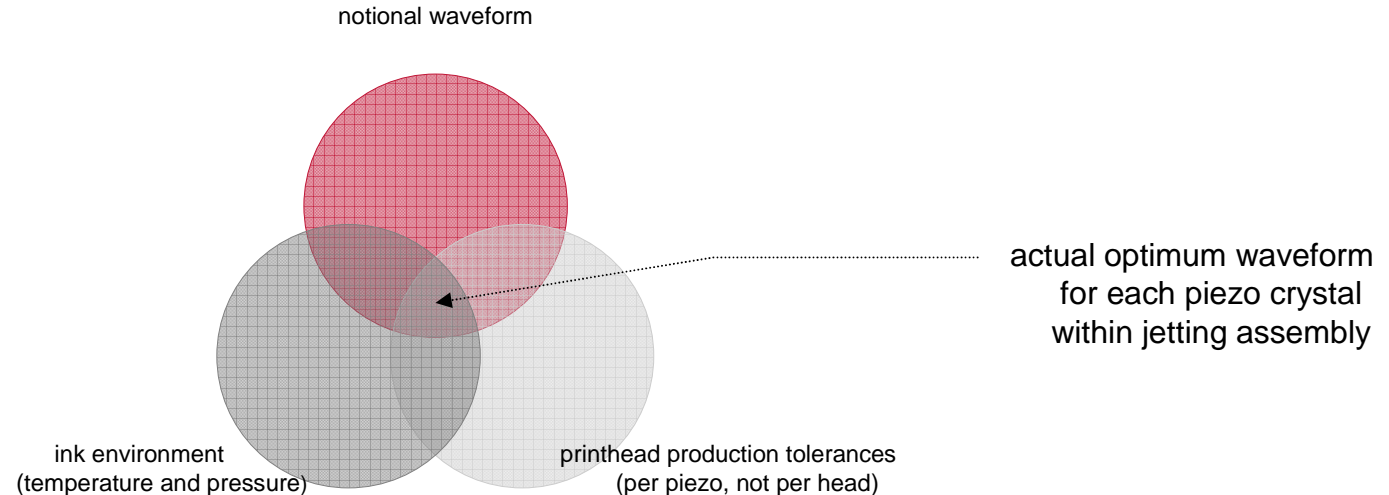
off-head waveform electronics

- 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 (μ seconds)
 - sustain time (μ seconds)
 - ramp down time (μ seconds)



off-head waveform electronics (2 of 2)

- 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 ink viscosity changes



importance of optimum waveform

- avoids satellites
 - prevents build up of ink on nozzle plate
 - improves print quality
- fine tune print quality
 - right drop size for image resolution
 - consistent drop speed across inks and heads used
- can help prevent use of pirate inks
 - tuned for acceptable performance on OEM ink but detuned for pirate ink

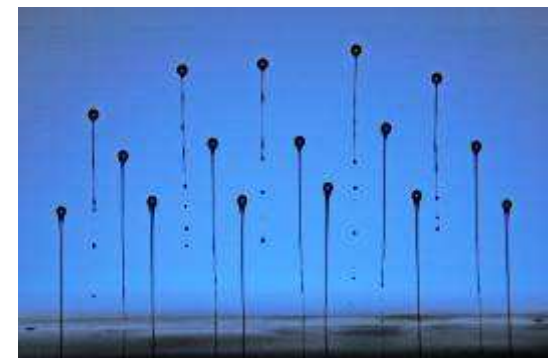
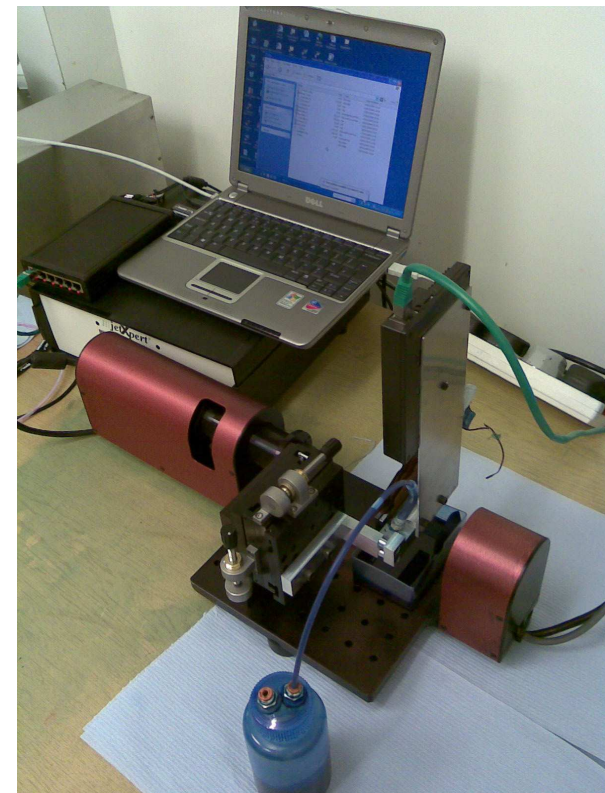


image ©Steve Hoath

experimental results

- conducted by TTP, 15-16 January 2009
- oil-based ink
- Spectra® Galaxy 256/30 printhead
- JetXpert™ jet analysis system (strobe, camera and software)
- Meteor™ driver electronics with Meteor drop control software



test configuration

- room temperature
- nominal values of parameters as used in tests:
 - 87V drive volts
 - 2.5 μ s ramp up
 - 10 μ s sustain
 - 4 μ s ramp down
 - -36 mm pressure

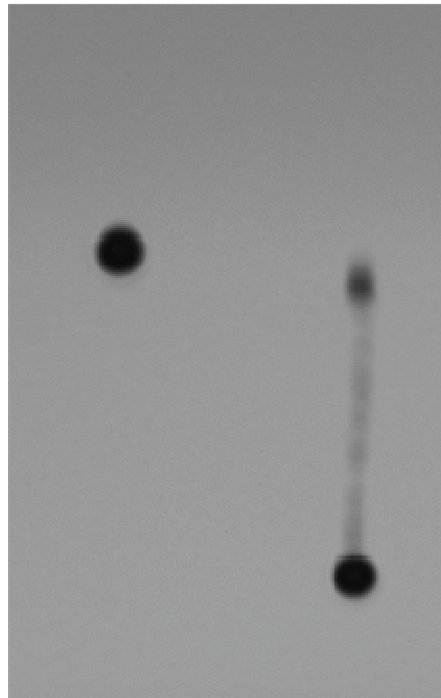


operator involvement

- Meteor Drop Control Software GUI adjusts in real time any printhead parameter:
 - for each piezo crystal: voltage, pulse ramp up time, pulse sustain time, pulse ramp down time
 - temperature (unused in this test)
 - which nozzles are used
 - example: nozzle numbers in range 133-136 inclusive
 - all nozzles, or, alternate nozzle in 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

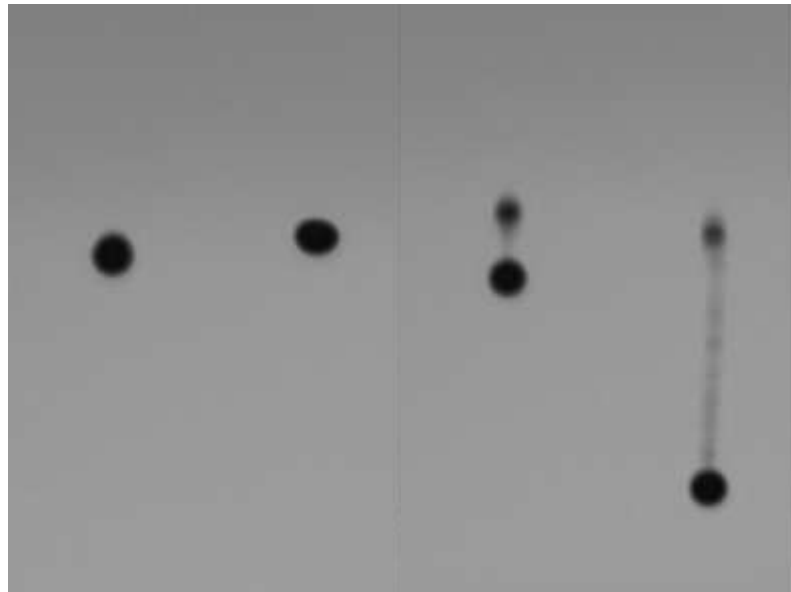
satellites (1 of 3)

- 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



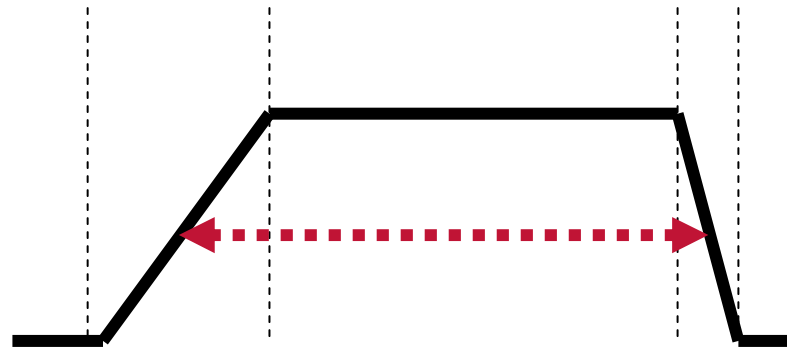
satellites (2 of 3)

- 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)

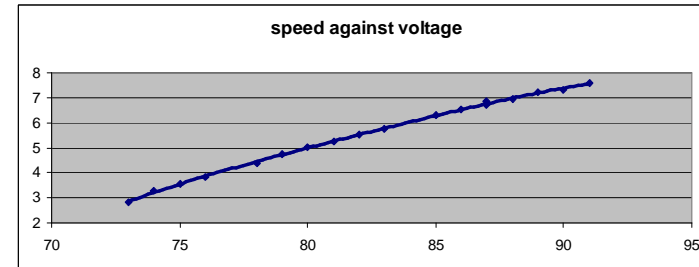
- overall pulse width (sustain + [ramp up +ramp down]/2) seemed important
- an increasing width was required for increasing pulse voltage used



graphs*

- Y-axis as defined in title:

- speed (m/s), or,
- volume (pL)



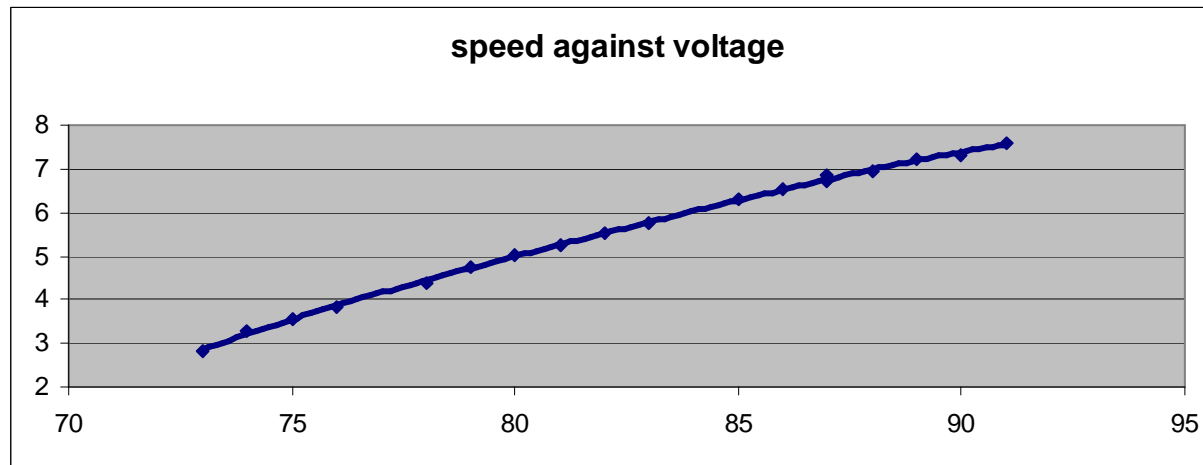
- X-axis as defined in title:

- Volts, or,
- time in μ seconds (microseconds), or,
- pressure in mm (equivalent to 0.1mbar or 10Pa)

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

changing pulse voltage (1 of 2)

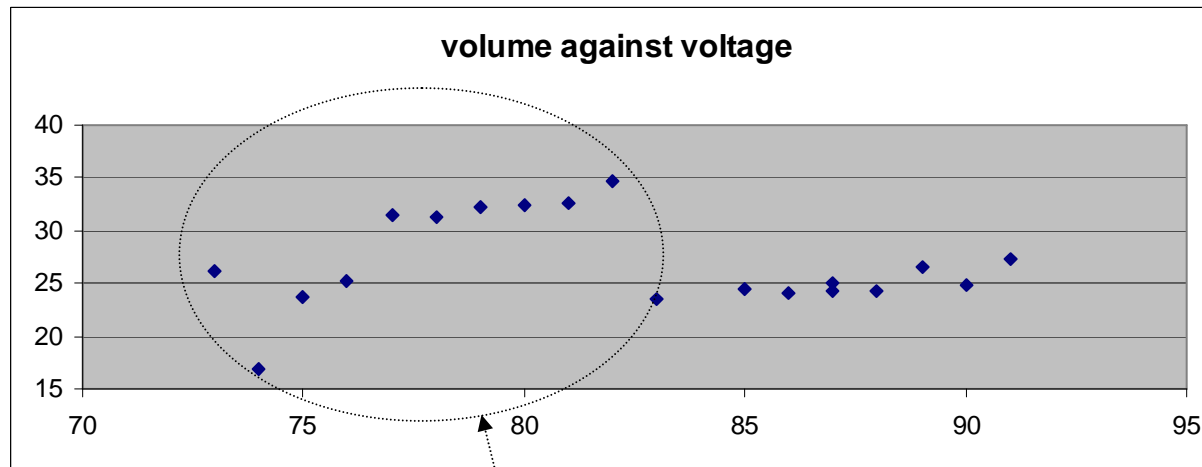
- drop speed is sensitive to drive voltage
rate is +0.26 m/s per volt



- nominal waveform used did not perform well over 92V, so this test stops there; Meteor is actually capable of 130V

changing pulse voltage (2 of 2)

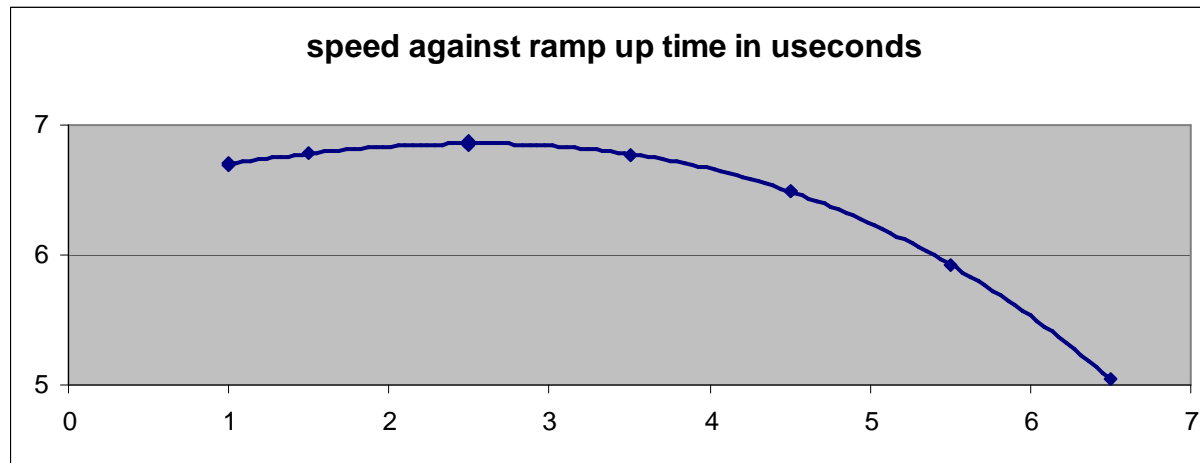
- satellites confuse automatic drop volume calculations



possibly erroneous
readings due to
presence of satellites

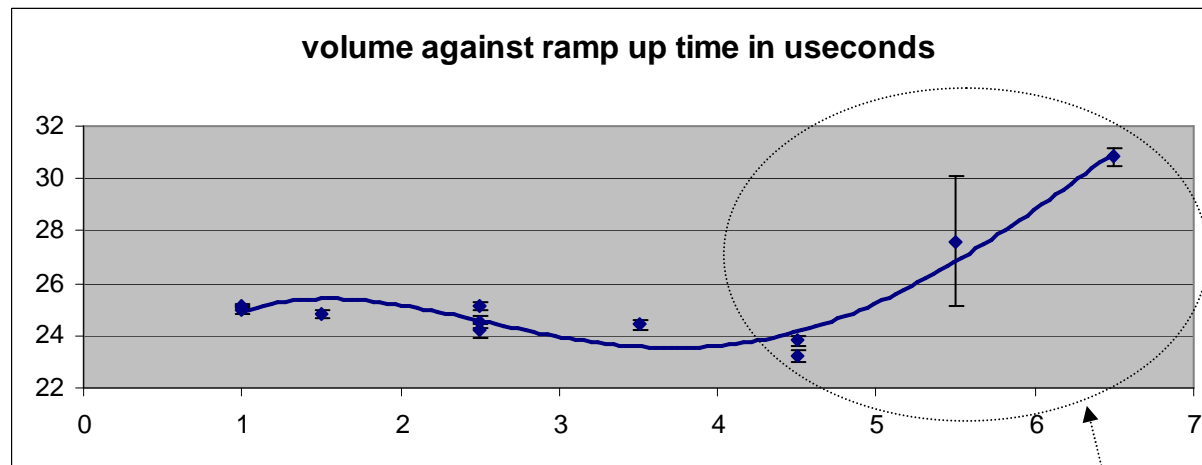
changing ramp up time (1 of 2)

- speed is little affected by ramp up time if $<4 \mu\text{seconds}$



changing ramp up time (2 of 2)

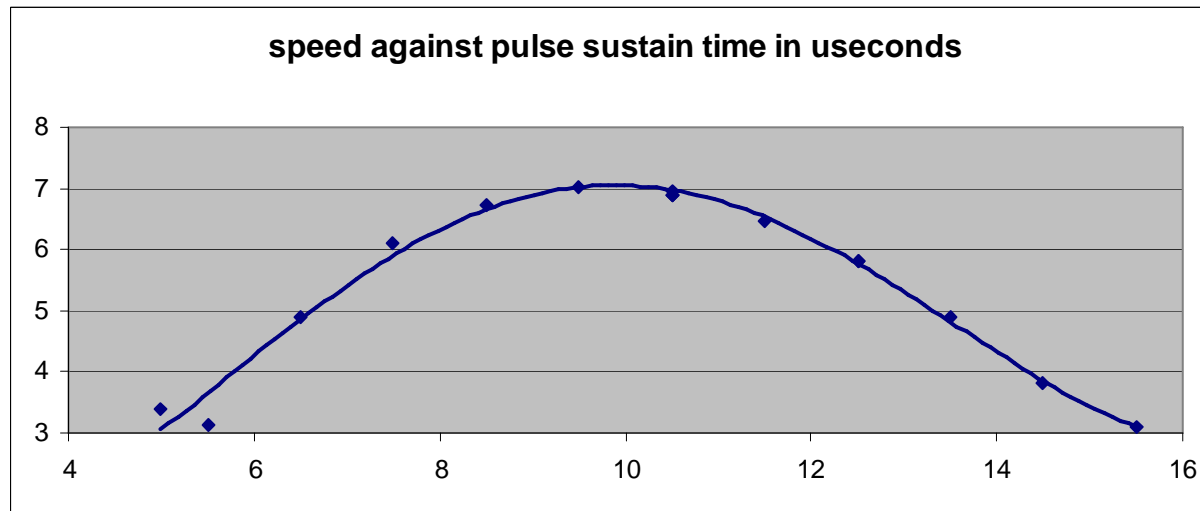
- small changes in volume (excluding satellites)



possibly erroneous
readings due to
presence of satellites

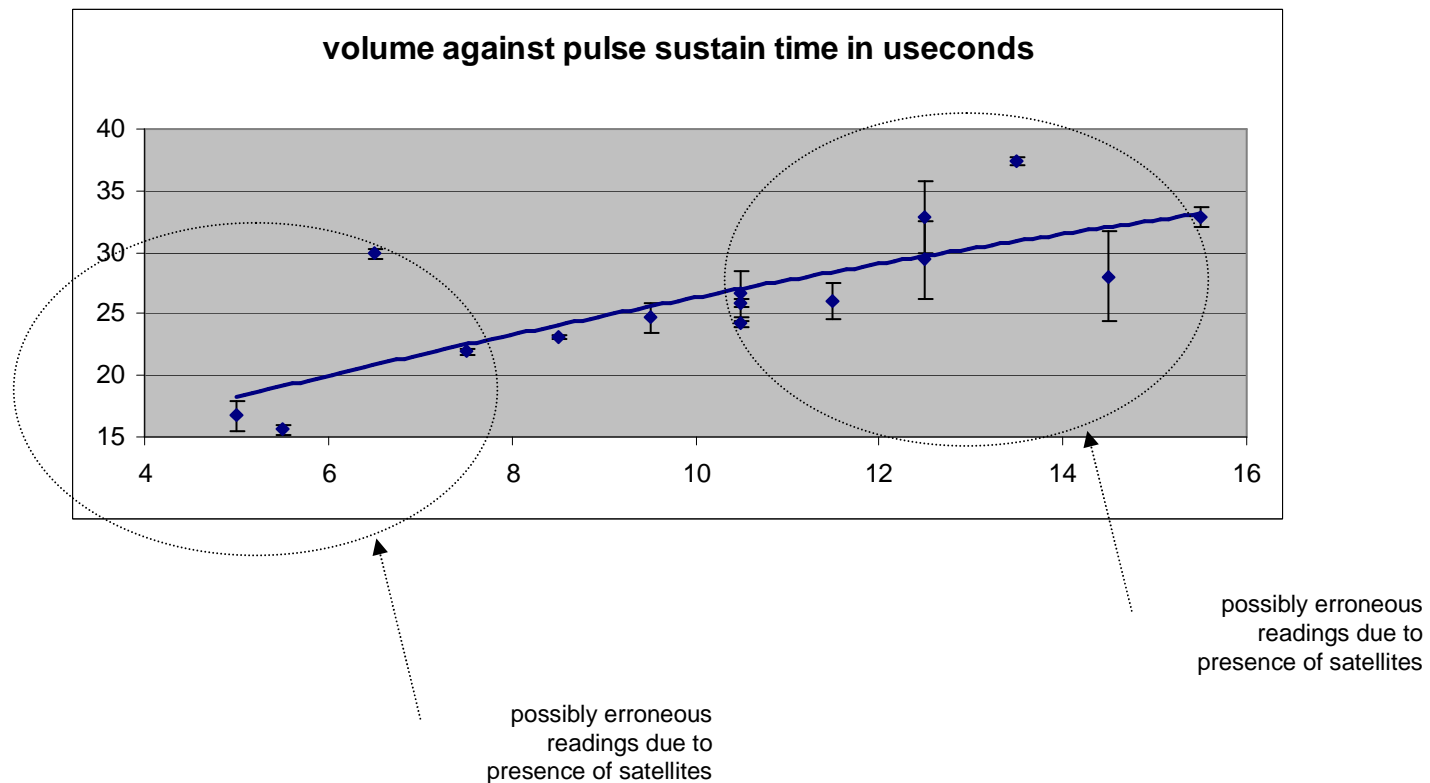
changing pulse sustain time (1 of 2)

- speed has a peak around 10usecs sustain time



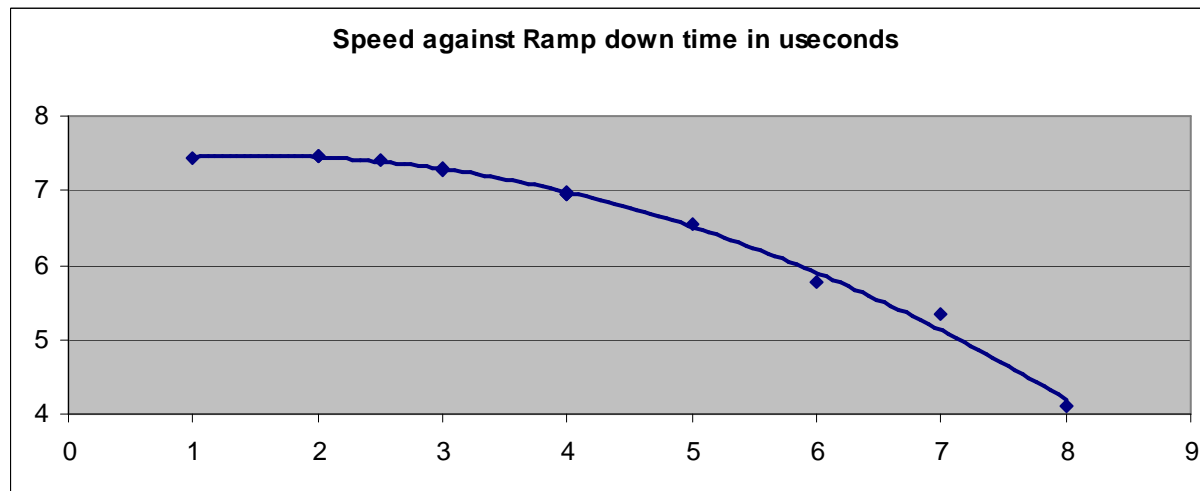
changing pulse sustain time (2 of 2)

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



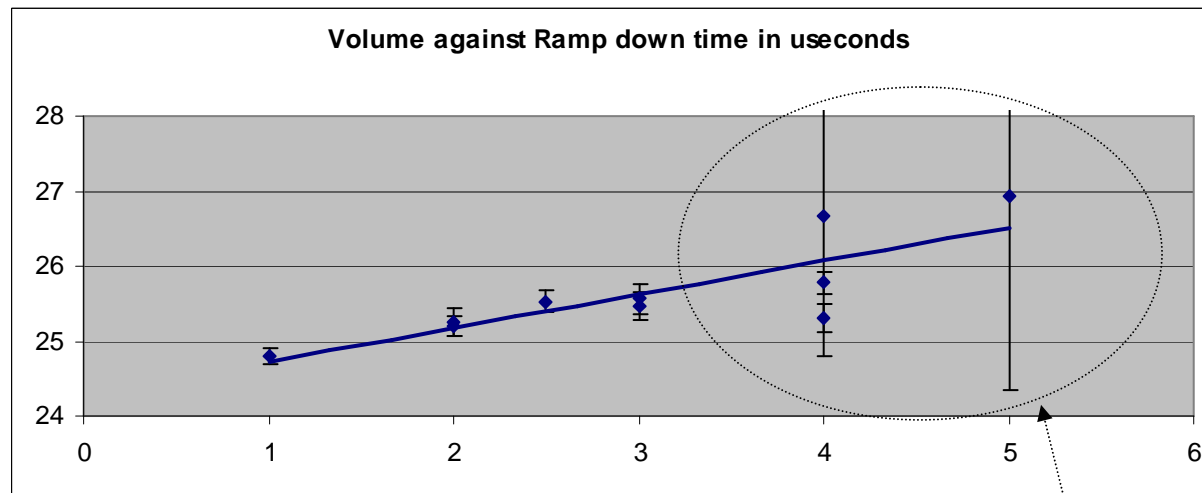
changing ramp down time (1 of 2)

- speed is sensitive to ramp down time
- need $<2.5 \mu\text{seconds}$



changing ramp down time (2 of 2)

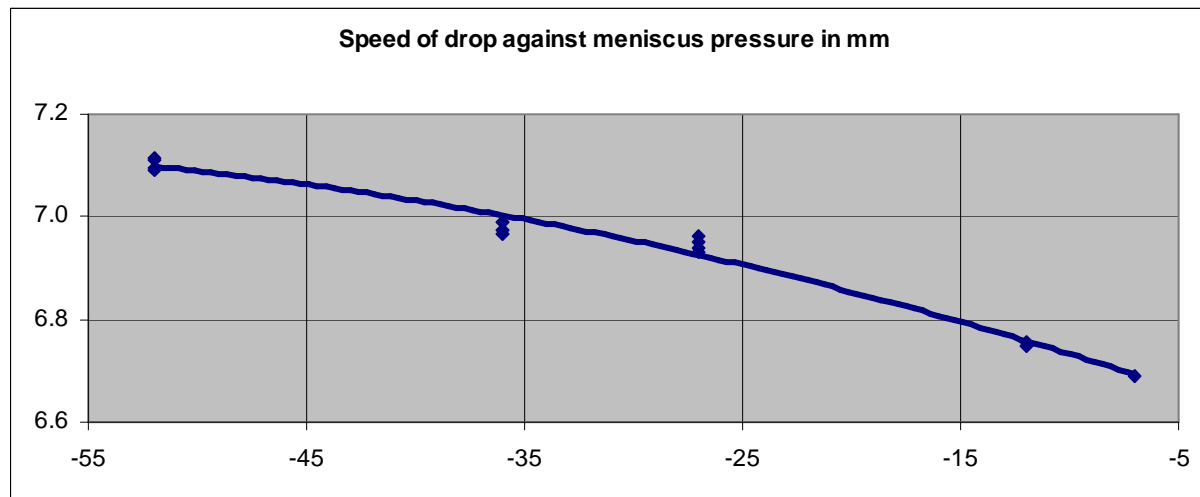
- small increase (2%/μsec) in drop volume as ramp down time increases



possibly erroneous
readings due to
presence of satellites

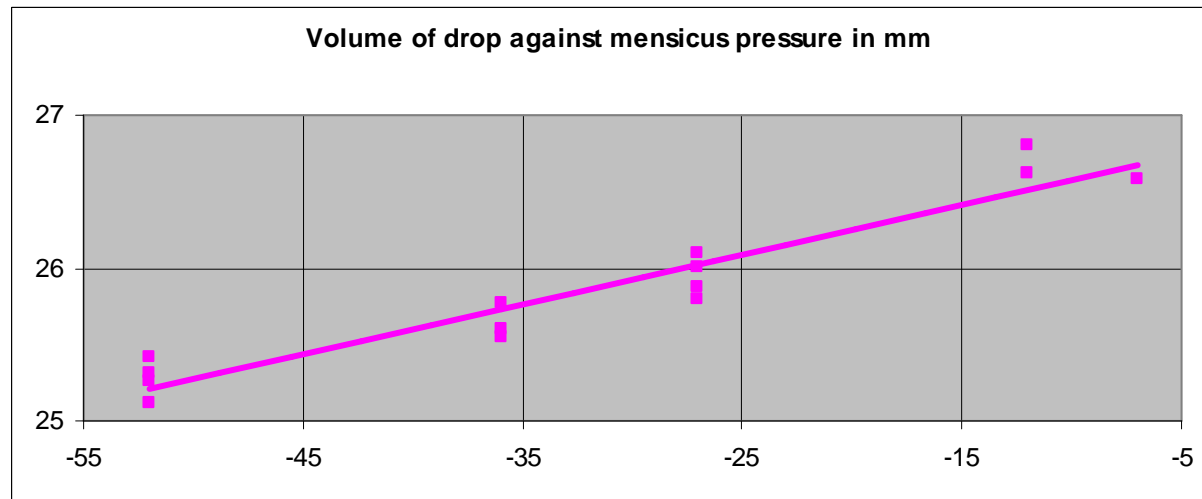
changing meniscus pressure (1 of 2)

- 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



targets

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

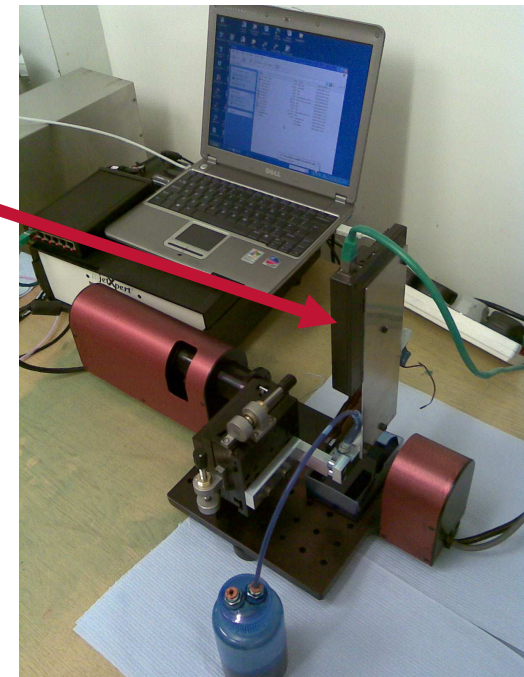
summary of experimental results

- for no satellites:
 - pulse width of 18 μ seconds for $72V < \text{voltage} < 90V$
 - pulse width of 20 μ seconds for $90V < \text{voltage} < 110V$
 - comprising
 - 4-5 μ s ramp up
 - 10-14 μ s 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 2)



- Meteor and JetXpert are both printhead-agnostic, however some differences exist when using different printheads:
 - the options in Meteor Drop Control 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 2)



- Meteor Head Driver Cards do not yet exist for all printhead types. As off February 2009 the heads supported are:
 - Spectra Galaxy
 - Spectra Nova
 - Spectra S-class
 - Spectra Skywalker
 - Toshiba TEC CA3
 - Toshiba TEC CA4
 - Toshiba TEC CE2
 - Xaar 1001
 - Xaar 500
 - Xaar 318
- the range will continue to expand in 2009 and beyond



take-aways

- drop control and visualisation is a powerful tool for developing and optimising an inkjet product (ink, head or print engine) and can affect business success
- some test results given for future reference of trends and sensitivities (actual results on different heads or inks will vary)
- a simple flexible tool has been demonstrated: “JetXpert Plus Meteor”
- the Meteor system supports an expanding range of heads for integration into OEM printers and/or for drop visualisation tools

The Technology Partnership PLC (TTP)

- Europe's leading technology and product development services company
- 300 engineering and scientific staff based near Cambridge, England
- 33% of TTP's business is developing products and technologies for leading companies based in USA, 15% for companies based in Japan, the rest is for companies based in Europe.
- A 20 year track record in bringing innovation to the digital print industry



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Meteor™

- a leading brand of printhead driver electronics and software
- 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
- quality British sub-contract manufacture
- developed and supplied exclusively by TTP



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