Our series of articles on where Sigma's Foveon architecture lies in the wider marketplace, and where the camera bodies really sit, continues - as the surprisingly long lifespan of technology is revealed and the skill of marketing and product designers perpetuates the idea that we can expect improvements on par with Moore's law in all fields of microelectronics. Pentax users may not be delighted to hear that when they pick up their shiny new K-r they're holding essentially six-year old sensor tech, but it's no bad thing if you care about images, rather than specifications.

Sigma's SD9 didn't have it all, despite the stunning gauntlet thrown down. Early models handled by reviewers had high luminance noise (soon rectified in a firmware update, but notably not retrospectively corrected in online reviews, when the PR efforts of many firms saw coverage revised and re-interpreted) and there was the inevitable brand resistance from people already familiar with the compact, CCD-based digital cameras from Nikon, Fuji and Canon. Had Sigma started out with a compact, who knows - the only compact Foveon camera to make it to market during that era was a Polaroid-branded Chinese product, the x530, which was blighted with engineering problems and poor build quality.

Despite the reticence of reviewers to really push the SD9's strengths in dynamic range and sharpness, it soon gained a strong cult following. Sales figures suggest that the initial production run sold out well within the gap between the SD9 and SD10 - a marked difference from the SD14 - and user feedback saw the real drawbacks of the SD9 far removed from the image quality. The dual battery setup and reliance on AAs was not uncommon when the SD9 would have been in the design stage, but by 2002 Li-Ion battery packs were powering the competition. Whilst Sigma got to work evolving the SD9 into the much improved SD10 the DSLR market grew massively: rather than sitting as a $1799 body with only a handful of DSLRs on the market (the competition at the time was the Nikon D100 & related Fuji S2 Pro, and the Canon D60 - all of which cost more); of these four cameras announced in 2002, two of them used a different sensor technology to traditional Bayer GRGB CFA layouts, whilst the two traditional Bayer models used differing silicon technology - Canon sporting the relatively young CMOS, also used by Sigma. The spread of sensors in 2003 included two full-frame 35mm models announced at the end of 2002, the Canon 1Ds at 11Mp and the Kodak DCS 14n at 14Mp, costing £7000 and £14,000 respectively. Contax's N-Digital, a 6Mp full-frame system was announced, and went on sale only to be withdrawn rapidly (Contax themselves disappeared from the market in 2005).

If one thing can be drawn from this period it's the rapid expansion of the DSLR market. From 1999 and the D1 (ignoring the very expensive, specialised and complex solutions from Kodak and others previously), the market had leapt in four years to full-frame, 14Mp systems, cameras

touching the $1000 price point, and essentially doubled the resolution buyers could expect making 6Mp the minimum.

That expansion was not necessarily driven by advances in sensor technology though.

The SD10 was announced near the end of 2003, and launched in 2004 to critical acclaim - with the operational improvements, faster computers to deal with the raw-only image files and an overall refinement of the concept, the SD10 put Sigma firmly on the DSLR map - and with a much lower UK price at £1250 with two lenses.

By that time, the DSLR market had seen new entries from Pentax with the *ist D, Nikon and Canon had brought out entry-level models with last generation sensors - the D100 sensor reappeared in the Nikon D70, the Canon 10D's sensor emerged in the groundbreaking (in price terms) 300D and prices began to creep down. Nikon's D2H brought a third sensor technology to the market - LBCAST, or Lateral Buried Charge Accumulator and Sensing Transistor array - though this would prove to be a dead end as a definition of sensors, lessons learned undoubtedly shaped future CMOS units.

At the upper end of the market, Kodak's DCS Pro models evolved with a Canon-compatible version based on the Sigma SA-9 (it looks remarkably similar to an SD from above, and it's widely held that Sigma assembled the Kodak DCS SLR Pro/c) and a 12Mp sensor appeared in Nikon's D2X - a 2004 announcement that would set the template for Nikon's APS-C sensors until 2010.

in fact, the expansion of the market saw each new introduction migrate into newly created levels of camera. That first 10.2Mp sensor in the D1 was refined with new CFA layers to first fully utilise the resolution (from 2.7, to 5.3, then the full 10.2) before heading into mid range, then entry level cameras; the last camera released with the 10.2Mp CCD was the 2009 D3000, which shared ISO sensitivity and dynamic range with the first full 10.2 implementation in the 2005 D200; meanwhile Sony and Pentax launched models based on that sensor.

The same pattern exists with the 6.1Mp CCD sensor introduced in the D100 (2003, sensor current until the 2009 Nikon D40) - with the ground breaking camera retailing at nearly 10x the cost of the last, closeout prices of the entry-level model.

Canon is unusual in that nearly every generation of their cameras has seen small, incremental and tailored changes to the sensor architecture until recently - when their new APS-C 18Mp sensor has appeared in three different tiers of camera. Almost inevitably, the late 2009 (and still current) 7D suffers by comparison with the entry-level 550D whilst the almost apologetic gap-filler 60D sells purely on the strengths of not being an 'entry level' DSLR - there's so little between the 550D and 60D as imaging devices.

Whilst Sigma's pattern of development has seen sensors valid for about four years (though no hard-and-fast rules can be drawn at this early stage), the multi-tiered strategy allows Nikon and the other manufacturers to gradually increment their product ranges with a minimal genuine advances. Sigma's perceived slow pace of development is actually a series of leapfrog moves; if the sensors were otherwise identical Bayer tech, Sigma would have been shifting 9.9Mp when 6.1Mp was pretty high, 14.1Mp when 10Mp was very current - and now, approaching 2011, Sigma has announced the ground-breaking 46Mp sensor of the SD1.

With four years, roughly, for each model (SD9/10 - 2002-2006/7, SD14/15 2006/7-2010/11) Sigma's sensor lifespan compares remarkably well as a "current" technology with the CMOS 12Mp (2004-2010 and counting), the CCD 10.2 (albeit with CFA upgrades, 1999-2009 - 2005-2009 as a 10.2Mp unit) and CCD 6.1Mp (2002-2009). Even Fuji's unusual SuperCCD sensor - seemingly a blip on the horizon now development appears to have ceased - managed 2002-2009, with the initial S2 Pro release being refined to the S5 Pro and IS Pro. As with Sigma, Fuji's release schedule focused on the middle ground, affordable professional bodies, leaving no entry level and really pushing high-end imaging without the more specialised features like high-speed capture or extreme body engineering - had Fuji produced, 18 months after the S2 Pro, an S3 (D100) equivalent in a D80 body would they have had more success in the marketplace?

The biggest changes in the market have been live view (which requires CMOS technology, and was mooted as one of the benefits of the Foveon chip initially) and video, first seen on Nikon's D90 of 2008 using the Sony-manufactured 12Mp CMOS sensor; since that point 18 months Nikon has released four more APS-C video capable models, two of which use the same sensor.

With the DP1x/DP2s and SD15 models suggesting the X3 14.1Mp sensor has not been allowed to stagnate since first release, it's possible that the SD15 will finally find a niche in the marketplace for another 3 years as an entry level counter to the high-end, high quality SD1. Sigma will never effectively market the facts of their development, as people buy so heavily on

numbers and only see the specifications as compared - nowhere do reviews and comparisons make it clear that even if the output file is 4.5Mp, the sensor and processors are, were, handling 14.1Mp of data - but throughout the development of the Foveon-based cameras, the cutting edge development and high-end work that has gone into the system is apparent once you look beyond that output size.

As the other manufacturers release a new generation of cameras, a new era of sensors has dawned - and Sigma is right there, with a sensor delivering 3x the base number of pixels available in the latest models. What does the future really hold for the SA-mount, Foveon, and Sigma's camera range?