



Digital Printing Whitepaper

Applying cutting-edge
technology at industrial
scale

Accelerating the future

**WHITEPAPER BY ROGER PAFFEN
& SHAHZAD KHAN**

Introduction to Digital Printing

Digital Printing is a printing process in which there is no contact between the printing system and substrate in order to deposit ink or a material. By using advanced inkjet technology, very similar to the technology in the inkjet printer at home, Digital Printing not only matches traditional printing in efficiency, it allows for an amazing range of exciting possibilities for both production and customization. NTS has been working at the cutting edge of Digital Printing for 25 years and is now working with clients and partners on applying this technology at an industrial scale.

Digital Printing market segments:

Graphical Printing

By digitally printing on packaging, textiles or any other shape or medium it is possible to create variation and allow for personalisation that was unfathomable only decades ago.

Functional Printing

Printing a material that has a functional property directly onto a substrate that allows for new functionality and even completely new products such as a phone's touch screen or foldable TV-screens.

3D/Additive Manufacturing

Creating a physical object from a digital design by adding one thin layer at a time. This allows for unique shapes and one of a kind production of products of any kind of material most commonly metals or plastics.

“ With Digital Printing, it becomes possible to print solar cells directly in the body of the car, to print conductive wires in the body of the car. But it will also greatly reduce the required inventory a manufacturer needs to stock when you can simply print components on demand. This will undoubtedly contribute to a new standard for production. At NTS, we create the equipment that makes this possible.”
- Shahzad Khan

NTS Digital Printing

NTS works with customers and partners on the (co-)development, manufacturing and assembly of industrial digital printing solutions. Customers use NTS's expertise and proven printer modules in order to overcome challenges concerning development and reliable implementation of the digital printing solution for a specific industrial application. By also providing life cycle management, NTS is truly an all-in-one provider of Digital Printing services.

- **Digital Printing Quality** Read why uptime and yield determine quality on [pag 5](#).
- **Real world example** Applying digital printing to a traditional printing line on [pag 6](#).
- **Future of Digital Printing** Our experts look to the future on [pag 8](#).

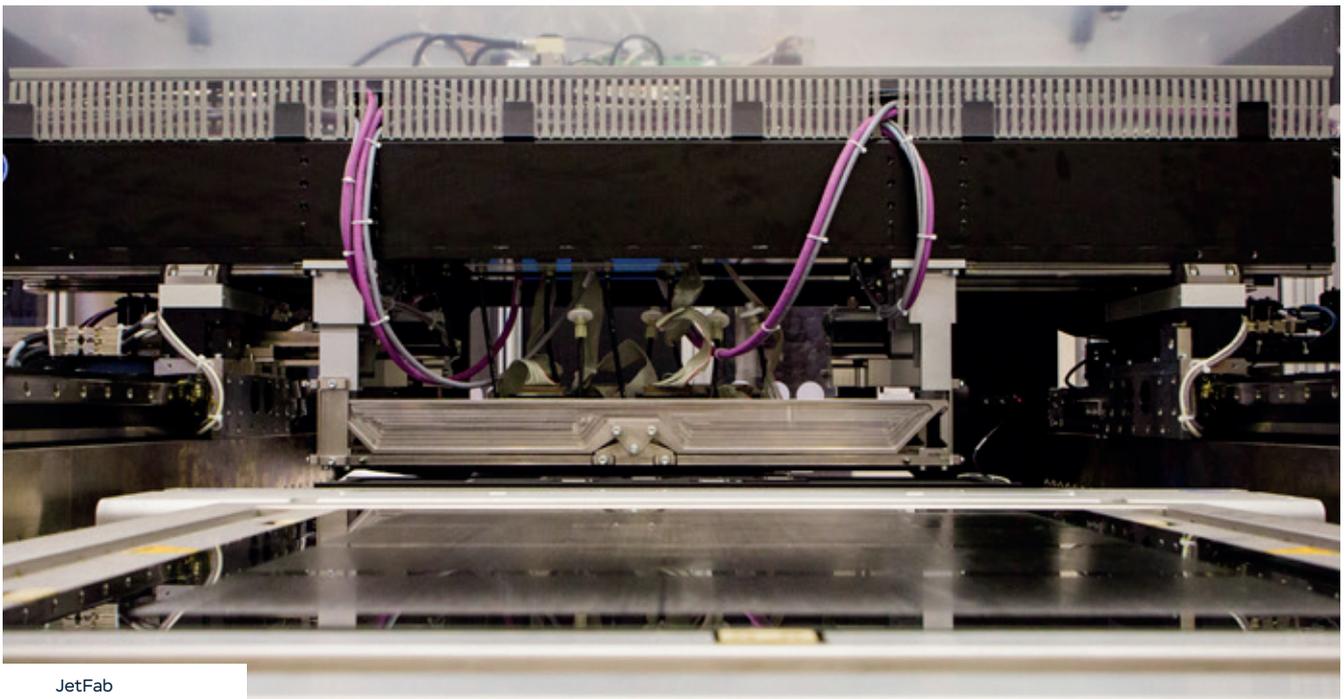
Functional Printing

In recent years, functional printing has taken flight. Advances in inks and printing technology now allow for the application of functional printing in nearly every industry. Not simply because of increased cost-efficiency but also as the result of R&D teams including the latest advances in their product development processes. Examples range from touch screens and integrated RFID chips to heartrate measuring T-shirts and lenses with integrated displays. By printing functional properties directly to a substrate, it is possible to create entirely new products.

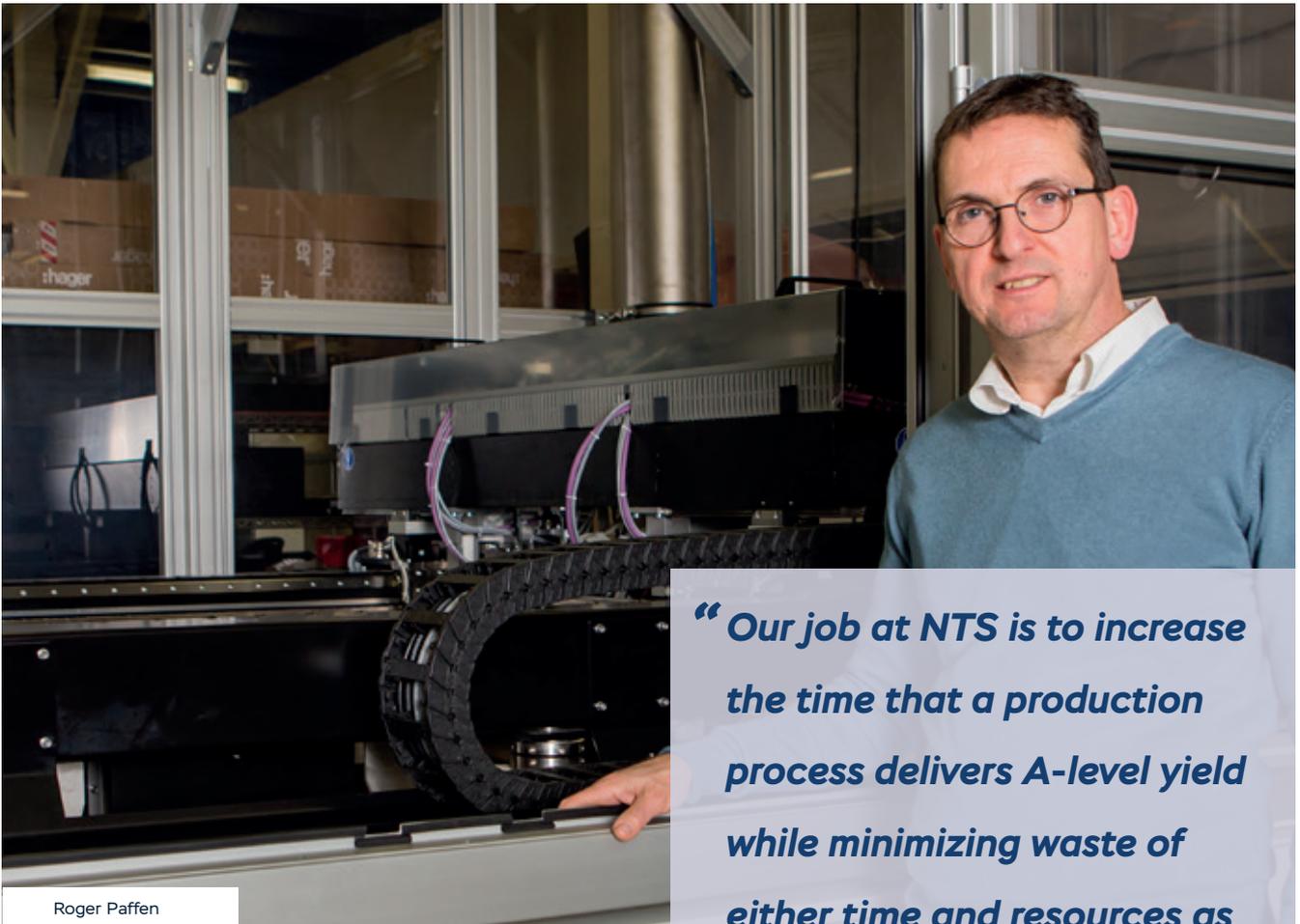
Examples of Functional Printing applications

- Flat panel display (e.g. RGB colors, hole injection layers)
- Photovoltaic (e.g. active layer, back plane)
- Printed electronics (e.g. RFID, OLED lighting)
- Back-end semiconductor (e.g. PE)
- Automotive (e.g. Headlamps)

“the A-level in printed electronics is 200.000 square meters per year, with nanometre thickness and micrometre inter-product overlay ” - Roger Paffen, Functional Printing expert



JetFab



Roger Paffen

“Our job at NTS is to increase the time that a production process delivers A-level yield while minimizing waste of either time and resources as much as possible. Our range of Digital Printers and printer modules make that possible.”

Functional Printing Expert: Roger Paffen

Roger Paffen has been working at NTS for four years, making the switch from Philips where he was introduced to printed electronics. Specialized in process, Roger now works on developing functional printing software and equipment that greatly improves the yield of industrial scale production processes. One example of such a project is the JetFab featured in this whitepaper.

By applying his own as well as NTS' experience and technological expertise to the interplay of ink, printhead and substrate positioning he is improving both the speed and accuracy of specific digital printing processes. Roger shares his perspective on functional printing:

Bringing functional printing costs down

“The challenge is often not to think of new products. It's whether you are able to manufacture those products at scale, so that people can actually afford them. And ink generally determines cost, especially with printed electronics where inks are very expensive. The amazing thing about inkjet printing technology is that you control every single droplet of it using DoD (Drop on Demand) print heads.

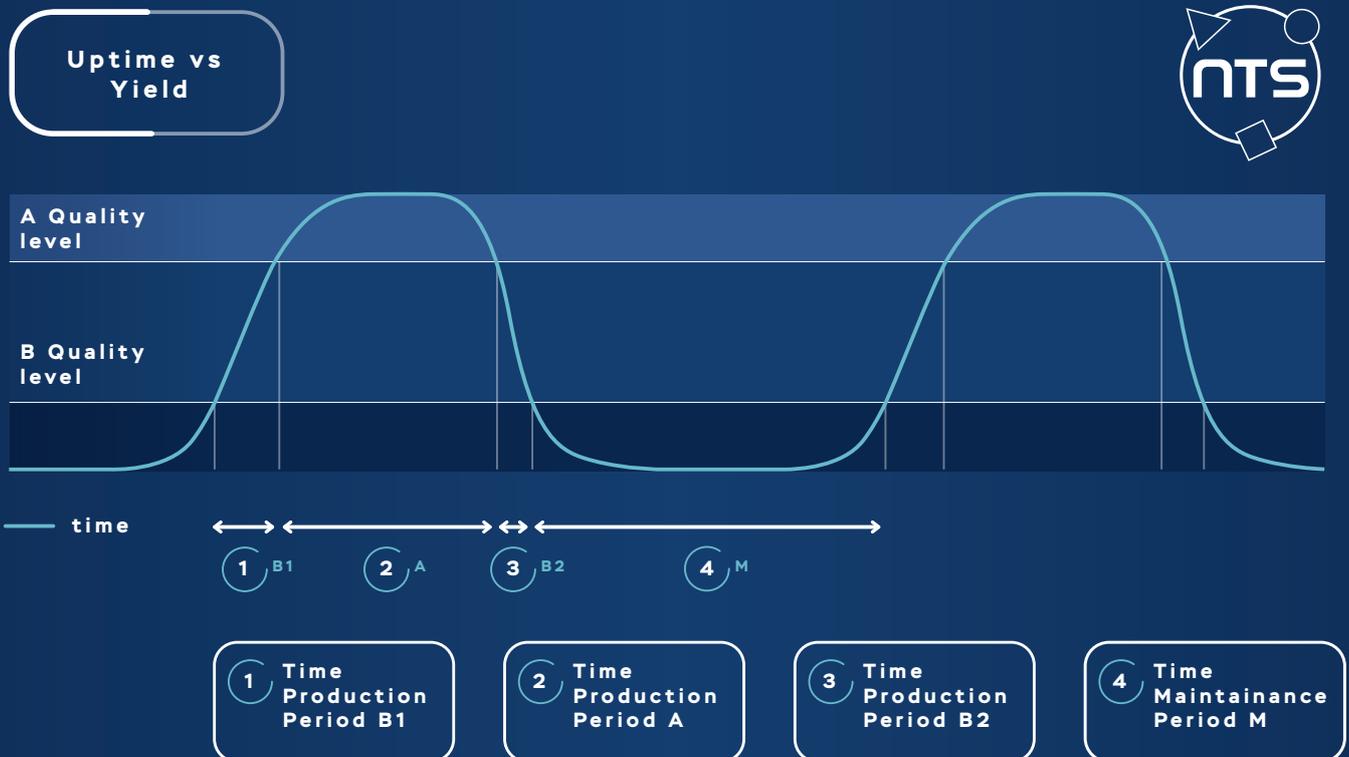
Digital Printing Quality

So, now that we can largely eliminate the waste of ink, what else can we do to improve efficiency? Well, by increasing speed while maintaining accuracy or quality. Currently, for me, the A-level in printed electronics is 200.000 square meters a year, with nanometre thickness and micrometre inter-product overlay. That means it's commercially viable and we already have several manufacturing processes running at that level.

Quality of functional printing is determined by uptime and yield

Personally, I see the core dynamic as a function of time and yield: How many products can we, on average, manufacture in a certain amount of time? I look at it like this (Uptime vs Yield chart below):

Our job at NTS is to increase the time that a production process delivers A-level yield while minimizing waste of either time and resources as much as possible. Our range of Digital Printers and printer modules makes that possible. These proven, reliable building blocks can be tailored or customized to your production process while retaining or even increasing your A-level yield. Methods include for example automated optical inspection, advanced software applications or preventative maintenance routines.”



Cycle time $T = A + B1 + B2 + M$

Yield for Quality level A = A/T

Yield for Quality level B = $(B1+B2)/T$

The JetFab

For any inkjet (scanning) application, it is important to not only develop key process (ink-printhead –substrate compatibility) but also to verify the reliability of the process in an industrial scale and to derive the requirements for the industrial scale printer.

Thus NTS proposes **The JetFab platform** as an advanced R&D and Pre-Production tool for industrial scale inkjet application. An additional substrate handler can enable 24/7 production.

The ideal application area of this high flexible tool is in the flat panel display FPD, photovoltaic, printed electronics, back-end semiconductor, ink/resins development. NTS is able to customize the platform to any requirement for OEMs who want to market industrial printers and can make cost effective re-use of key technologies and/or modules used.



Main advantages

- Dot landing accuracy < 10µm
- Max print size 650 mm x 550 mm/s
- Print speed 20 to 500 mm/s
- Unidirectional and bi-directional printing
- Free choice of print pattern combined with high accuracy and repeatability
- Ingenious non contact cleaning of print heads
- System provides clean room class below ISO 2 above substrate position
- All doors are interlocked and all process related exhausts flow to plant exhaust
- The systems performs in a 24/7 operation due to reliable system architecture
- Easy maintenance: Additional maintenance features ensure the printer is ready to print in a short time after shutdown
- The JetFab is suitable for research environments and as a prototype production line

Economical benefits

- Low operating costs
- Low maintenance costs
- Short down times
- Lower energy consumption

Digital Printing Partner

One of the biggest drivers for the increased application of Digital Printing solutions is the need for personalization and customization. Industrial scale application of traditional techniques has driven costs down while print quality has improved. For many companies, the only way to distinguishing themselves in the marketplace is to offer individual personalization options to their customers. And that is only possible with Digital Printing. By combining personalized graphical printing and functional printing whole new product and service categories take form.

NTS – a unique partner for all stages of your digital printing project

NTS is proactively researching and developing Digital Printing applications that target specific trends or developments in anticipation of future client demand. We are cross-pollinating our learnings from semiconductor equipment technologies to printing technologies, creating an unrivalled service offering. Application of our technology and knowhow is driving change in both consumer and business to business oriented markets.

Digital Printing Expert: Shahzad Khan

Senior Business Developer Shahzad Khan has been with NTS for over 8 years and is working with new and existing customers on the development, manufacturing and life cycle management of digital printing applications. Originally from India, Shahzad has lived in the Netherlands for 13 years and has worked for the Technical Universities of Delft and Eindhoven, Canon Production Printing (formerly Océ Technologies) as well as VDL Automotive before joining NTS. At NTS, he works with customers that have completed the pilot-phase and are ready to take the next steps toward industrial scale manufacturing.

“NTS has worked with digital printing from the get-go and we have been an integral part of its development into the mature technology that it is today. We have already developed the core modules that are the



Shahzad Khan

basis of any advanced digital printing application and tailor these to our customer's unique application and requirements. That means that we allow for our customer's ground-breaking process invention to flow through customized developed (and manufactured) industrial printers.

Apply Digital Printing capabilities to traditional printing line

One great example is a customer who prints with a traditional roll-to-roll system with eight colours with more than 100 meters per second. They needed a solution that could add variable, flexible printing to this line while maintaining the great cost-efficiency the traditional components allow. We had a proven,

digital printing solution that we had to adapt to the available space and line speed. That's where our unique knowledge and expertise comes in.

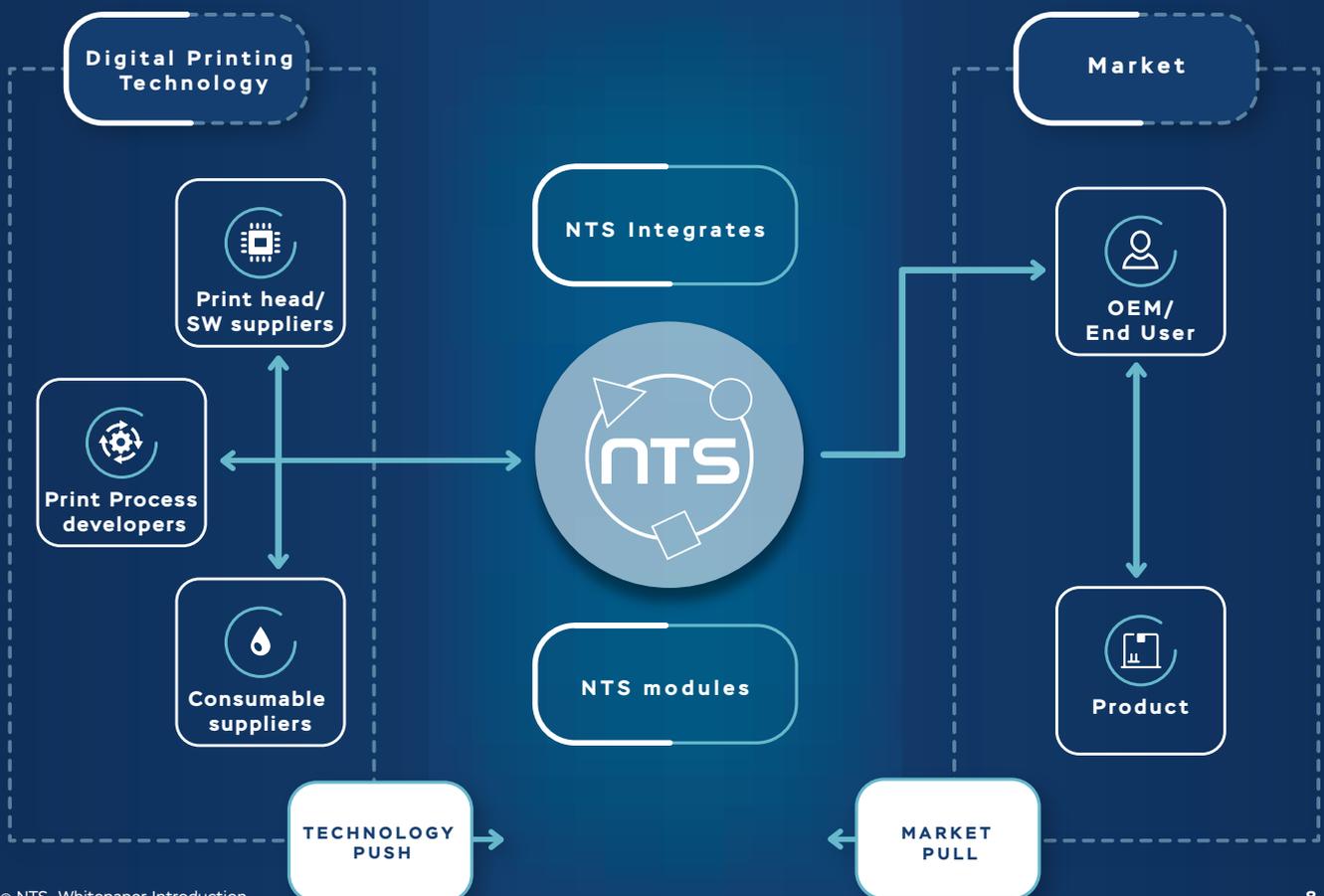
In this case we supersized our print bar, realizing 18 print heads per colour, and fitting it within the one meter build size that is required. After the pilot was a success we had to manufacture a large number of print bars and integrate our software, including the automated quality control measures, with their systems. But the technical realization is only one side of the coin, during this process we are also working with this customer to grow their knowledge of digital printing and training first and second line of support staff to maintain the production line after its up-and-running. NTS is the premier, all-in-one partner for such a process.”

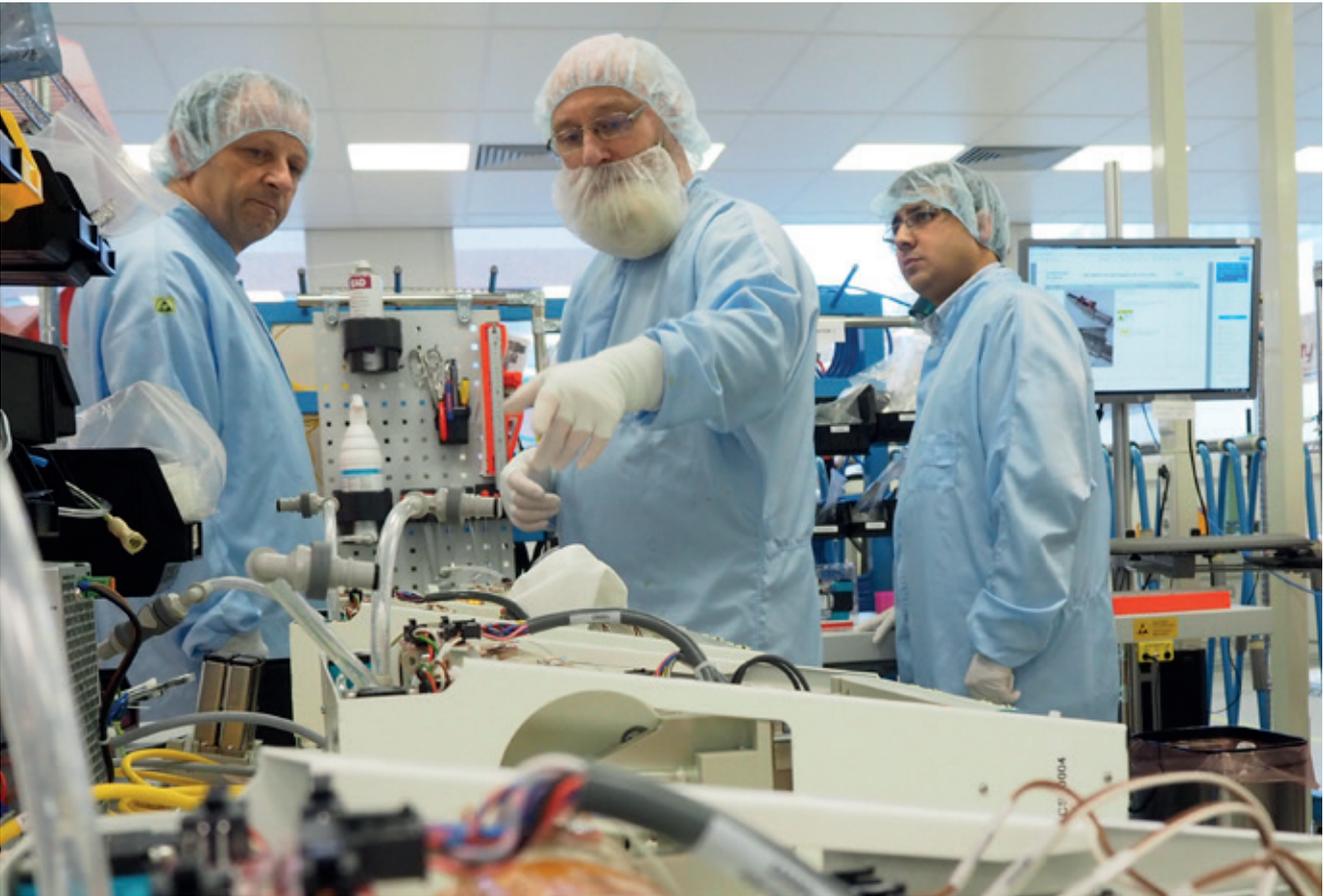
Unique NTS value proposition

NTS Digital Printing has a unique market position that is illustrated by the following graphic.

NTS's dual role in the Digital Printing market is illustrated by the Modules and Integration elements. For customers, NTS is primarily the integrator of Digital Printing technology into solutions that are applicable to their business. This is for a large part driven by the fact that digital printing experts recognize NTS' pivotal role as an equipment manufacturer.

On the one hand, NTS is anticipating demand from the market while on the other we are in close collaboration with ink suppliers, printhead suppliers, process developers and electronics partners in order to develop new, best-in-class equipment that tackles our customer's latest challenges.





Working with NTS

“It’s important to be clear about NTS’ multi-faceted role. We are the primary partner for end-users and OEM for the development, contract manufacturing, assembly, installation and life cycle management of cutting-edge Digital Printing solutions. We:

1. Help our customer’s develop and test a product by leveraging both our proven modules and expertise
2. Provide worldwide contract manufacturing services to quickly scale-up into full production
3. Assemble and install
4. Provide life cycle management solutions, including 1st and 2nd line of support training for our customer’s staff

And each phase is adapted to the customer’s changing needs. For example, our development and testing is done in our European facilities while our contract manufacturing is completed in NTS facilities in China or Singapore to drive down costs. We are truly an all-in-one partner.”

Interested to get to know more about our printing solutions? Contact Shahzad Khan.

Shahzad Khan

Senior Business Developer – Digital Printing

shahzad.khan@nts-group.nl

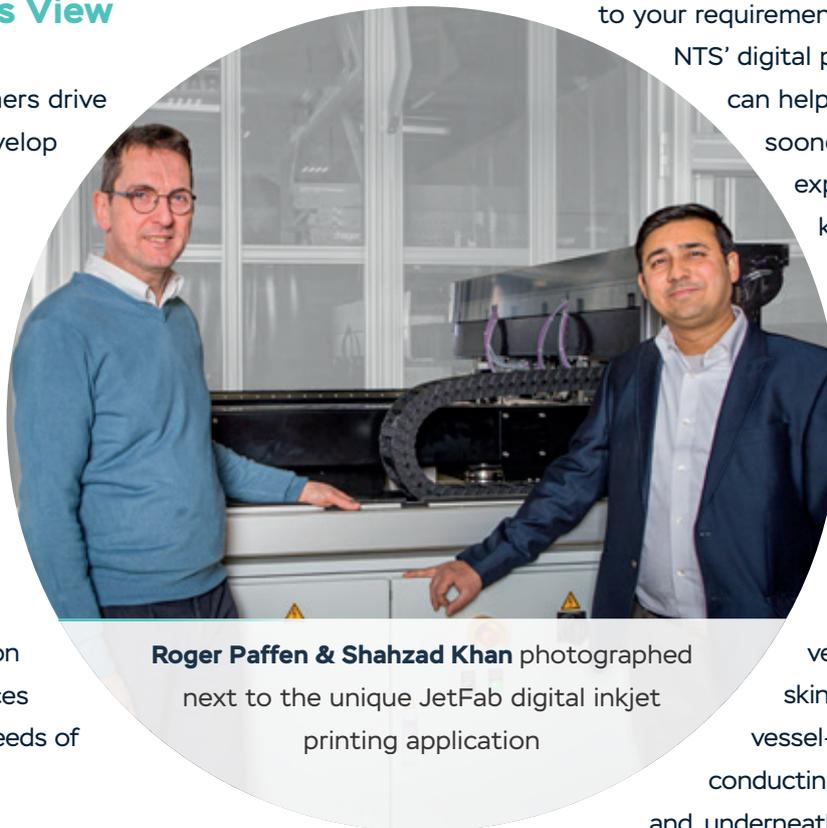
T +31 (0)40 4027490 / M +31 (0)612170446

Future of Digital Printing: Industrial application

Industrial printing is a fast growing industry that is leveraging digital printing technology to extend far beyond graphical applications. Inkjet printing is the fastest growing digital printing technology and examples of successful applications can be found in virtually every market. The turnover of the industrial printing industry is forecasted to grow to as much as €95 billion by 2022. For this whitepaper, NTS asked its Digital Printing experts what developments they are most excited about:

Roger Paffen's View to the future

“At NTS, our customers drive innovation. They develop new production technologies or products and we are responsible for providing them with the equipment that enables commercial production. That means that we need to keep a close eye on technological advances and anticipate the needs of our customers.



Roger Paffen & Shahzad Khan photographed next to the unique JetFab digital inkjet printing application

Shahzad Khan's View to the future

“To my mind, the Industry 4.0 evolution is at the heart of what we do here at NTS. Instead of importing products from all over the world you have one local or regional facility that can manufacture on-demand. Add to that the opportunities for customization that digital printing offers and you get the best of both worlds: access to anything you might need, which is always tailored specifically

to your requirements or needs.

NTS' digital printing solutions can help make this a reality sooner than anyone expects.”One area I'm keeping a close eye on is how digital printing is instrumental in the development of soft robotics. By printing various inks and polymers together we will be able to create a 'bionic skin' that is very similar to regular skin. It contains a blood vessel-like structure of conducting ink, a surface layer and, underneath all that, various sensors that will for example allow robots to

feel as we do. Or we can even combine it with our own organic tissue for a wide variety of applications and purposes, not just reconstructive but also to expand our individual capabilities.

Our work at NTS helps us take further steps toward making this a reality and enable the at scale production that would allow us all to enjoy these opportunities.”

Accelerating the future



Dillenburgstraat 9
5652 AM Eindhoven
PO Box 7093
5605 JB Eindhoven
The Netherlands

[nts-group.nl](https://www.nts-group.nl)