# BANKNOTE TECHNOLOGY REPORT 2025

## GIVING WINGS TO CASH

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# Beyond Ink: Shaping the Future of Banknotes

At SICPA, we go beyond ink.

We serve as trusted advisors to central banks, guiding them through the complexities of currency creation- from new series and upgrades to commemorative banknotes.

Our mission is to ensure banknotes are secure, efficient, and durable, while meeting the growing demands for public safety and environmental sustainability.

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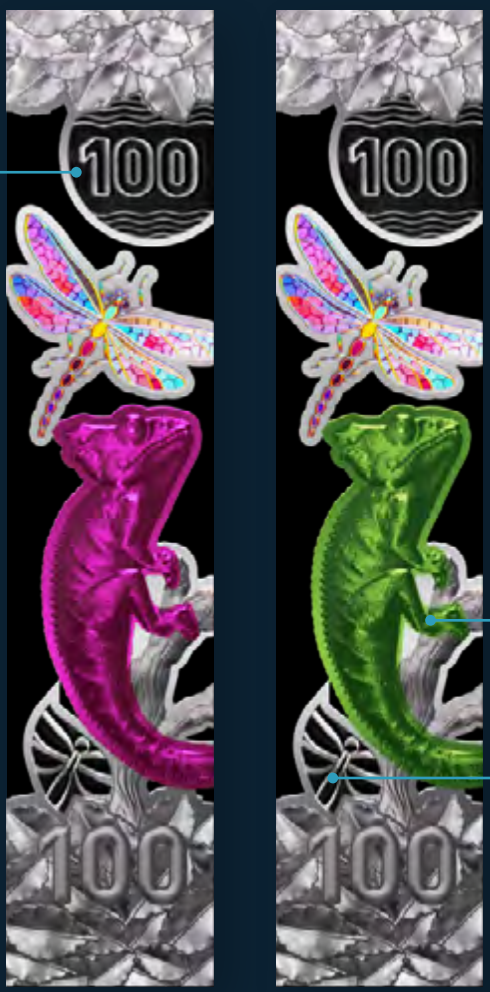


Swap parallax effect

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Hueck Folien

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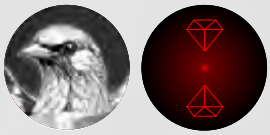

Zoom in on the bird head's micrographic image using a mobile phone.

Observe the nanographic bird head through a forensic microscope.

Detect laser-readable diamond shapes with laser light.

**Watch No. 1 video**


WINNER
IOTA
BEST ORIGINATION
2025

Watch me change colours

On the cover of BTR 2025, you see two images of the number one.
But only one is protected by **nanoengineered optical security features** from IQ Structures, exclusively used by Hueck Folien for the banknote sector.

The difference is clear – and trusted by the world's most demanding issuers.

IQ STRUCTURES

Hueck Folien

More information in Nanovista article


GIVING
WINGS
TO
CASH

Cash is more
than just a means of payment –
it represents freedom, trust and
innovation. *"Giving Wings to Cash"*
sets a clear statement:

We inform, analyze and connect
the industry in order to ensure
a strong future for cash.

Your team from
Banknote Industry News GmbH.

Philipp Greulich  Donald Scholz

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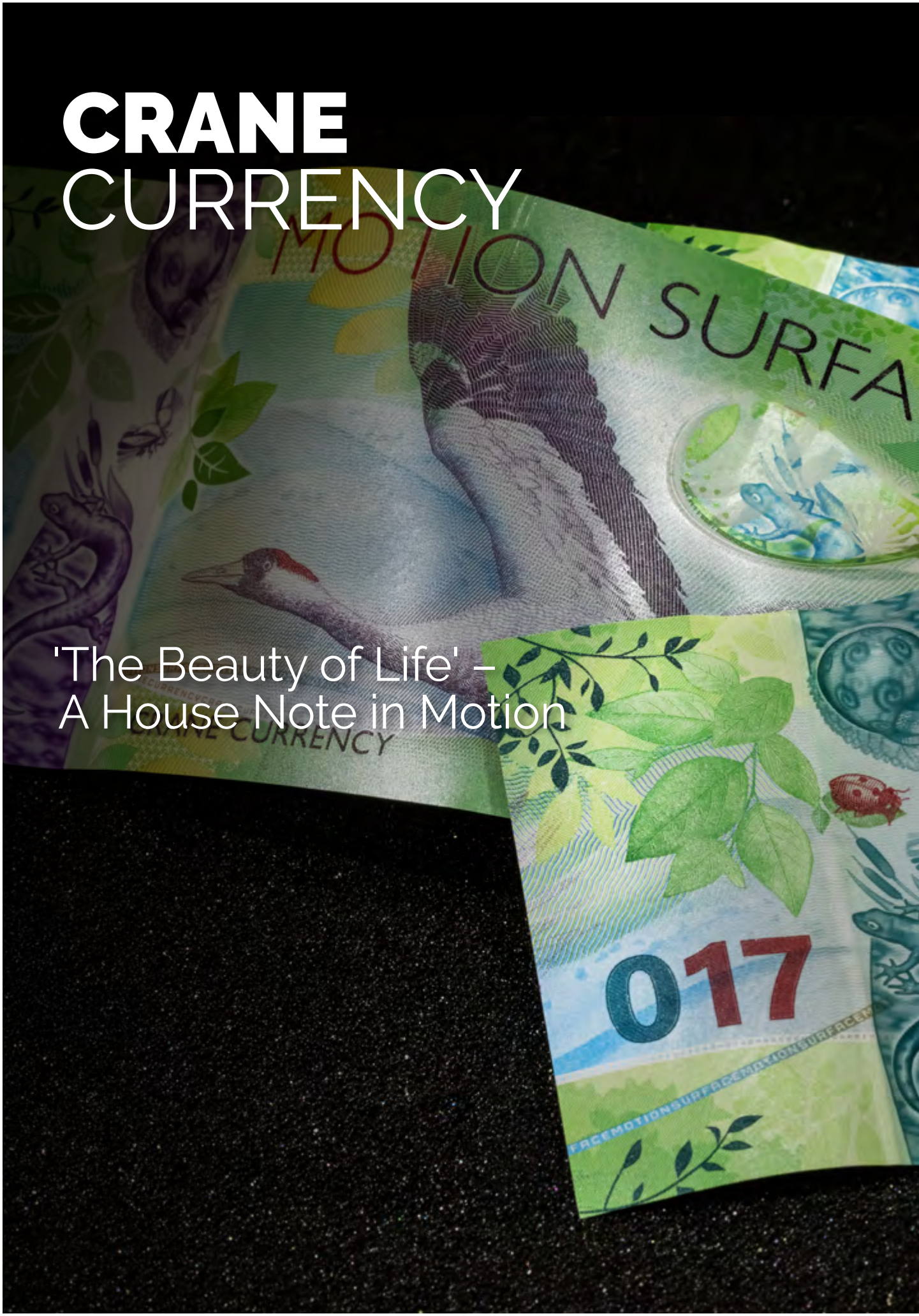
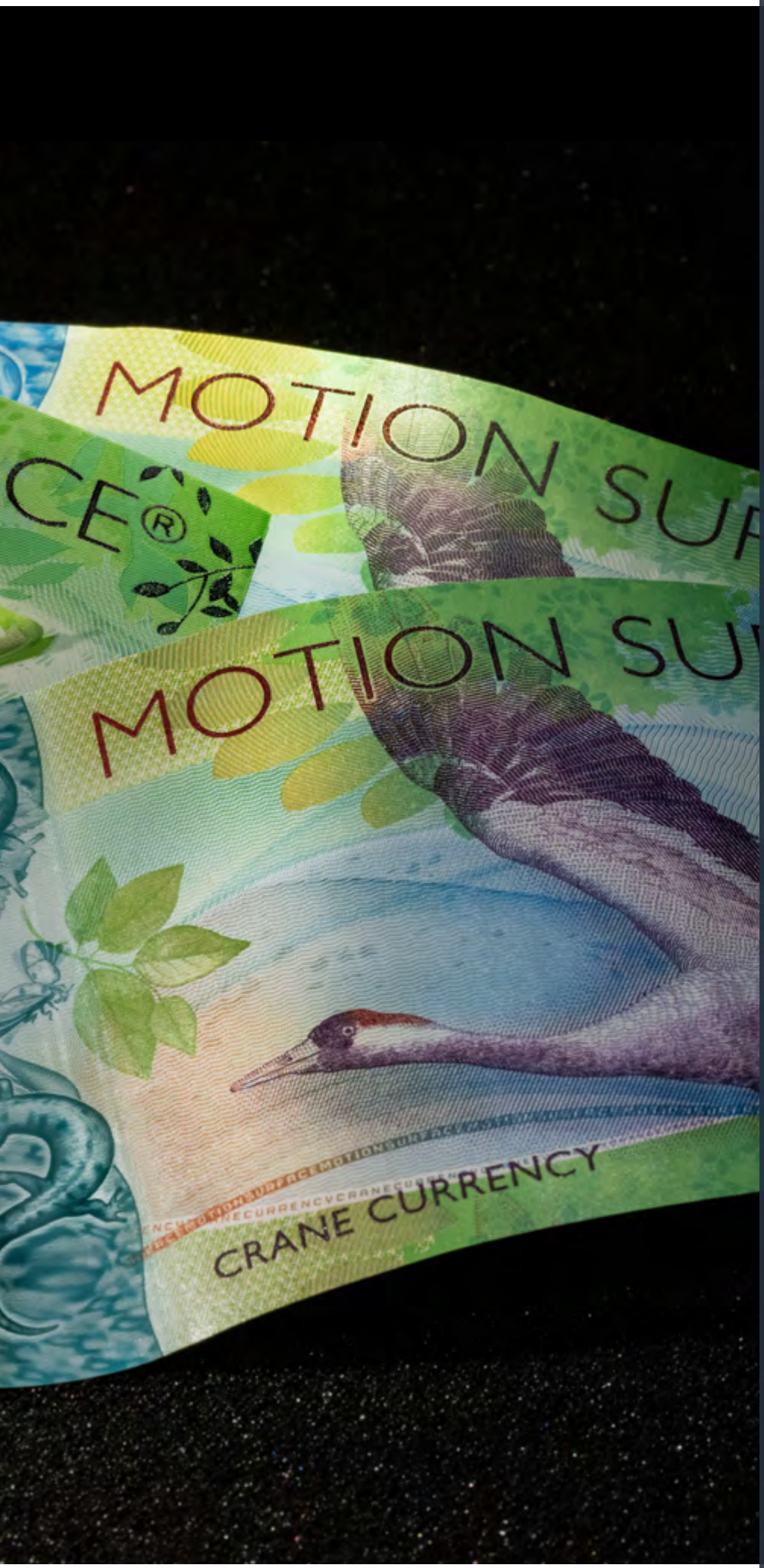
# GIVING WINGS TO SECURITY

# CRANE CURRENCY




## 'The Beauty of Life' – A House Note in Motion




# FACT BOX

Facts about the "The Beauty of Life" house note:

- Security Platform: Crane Currency designed and produced with new MOTION SURFACE®.
- Level 1 Feature Highlight: Super-wide MOTION SURFACE® stripe with multidimensional, synchronized movement effects.
- Level 2 Feature Highlight: Vivid™ (polymer version only); GSI mouveINK polar, and Information Carrier Screen (ICS), JURA Security Printing
- Inks & Varnish: GSI Inc. and SICPA, five color intaglio
- Substrate: ENDURANCE™ high durability cotton paper and Guardian™ polymer.
- Software: Internally developed tools for design simulation and animation modeling.
- Production: Precision-engineered and produced within Crane Currency's secure production facilities; quality tested to industry standards.

What does the future of currency look like? For Crane Currency, it moves with light, tells a story, and earns trust at a glance. "The Beauty of Life," our latest house note, brings this vision to life with narrative-rich design and a bold new use of micro-optic technology – the first-ever super wide variant of MOTION SURFACE®.

"The Beauty of Life" raises the bar not only for design and innovation but for what public authentication can feel like. This is not a passive experience – it is one that comes to life in the hands of the public.

## NARRATIVE-RICH BANKNOTE SECURITY

At the heart of "The Beauty of Life" is a narrative that unfolds visually, showcasing the rich biotope of a wetland and its flora and fauna. Layers of movement mimic the activity common to vernal pools and the arrival of spring.

This is the elegance of a modern banknote's advanced public security. It is narrative-based security technology and world-class design combining to communicate authenticity and value intuitively. Put more simply, it is a feature technology that can combine any number of visual effects and unite them into a coherent whole. When done well, what would otherwise be complex is simple, even enjoyable, turning a banknote into a multidimensional storybook of movement.

Achieving this means the union of feature customization and integration is critical. The experience, skills and tools, including Crane's micro-optic design software, guide the modern design process behind "The Beauty of Life". The bright, flowing vegetation, intricacy of the central motif and array of Level 1 and 2 security features are the assemblage of multiple printing steps each integrated in accordance with specific operational tolerances. These produce

textures and movements that work in unison to create new, never seen qualities that instill confidence and trust.

Yadira Sierra, VP Global Design at Crane Currency, explains: "Modern banknotes must do more to deter forgery. They must engage, inform and resonate with the public. For those who are tasked with evaluating technology, the features that can communicate authenticity intuitively will be strongly considered. The more intuitive the feature, the stronger the trust."

## CRANE MICRO-OPTICS – PRECISION IN MOTION

Crane house notes are made for central bank education and evaluation. House notes like "The Beauty of Life" offer something no white paper or technical specification ever can – a way to see, experience and evaluate the full integration of cutting-edge security as an actual banknote. Crane produced these house notes to industry durability standards, and at production speed and scale – meaning the features and print quality reflect true production realities, not just prototype conditions. They are a bridge between vision and execution and provide central banks with a clear benchmark of physical performance, and a trusted starting point to initiate the planning of their new banknotes.

The centerpiece of the note's security is its most daring use of Crane micro-optics to date. MOTION SURFACE®, presented in a groundbreaking super-wide format to deliver vibrant, synchronized, multi-directional animation. This feature doesn't merely shimmer – it performs.

Sam Cape, Director of Innovation and Technical Design at Crane and a key architect behind this unique technology, describes it as a realization of a decades-old promise.

"These are visual effects that first attracted me to the company," says Cape, "but back then we didn't have the technical means to produce the features that the theory described."

More than a decade later, it is Crane's years of experience innovating both its micro-optic production equipment, and its design software that are delivering movement effects that range from gentle and fluid to bold and dynamic, all with consistent, stable coloration that is easily perceived by users across different lighting conditions and viewing angles.

Behind this fluidity lies a world of technical rigor. Custom-built software powers the animation designs, the modeling of lens arrays, ultra-microprinted icons, and motion parallax. Each movement, whether a slow drift or a sharp switch, is calculated, simulated and tested.

## WHERE ENGINEERING MEETS IMAGINATION

Sam Cape explains: "This technology isn't just about beautiful movement. It's about making counterfeiting mathematically implausible. In many ways, the true innovation is in our thinking. It's how our computation harmonizes our capabilities in production with our design goals and imagination – it's very exciting."

This fresh, new approach is similar to what Sam and colleagues pioneered two decades ago. It relies on a two-layer approach: a micro-lens array rests on an optical spacer above an image array. It is the precise interplay between these layers that creates fluid movement. However, today the visual wonder of MOTION SURFACE® on The Beauty of Life house note is based on an encrypted image layer in which each icon is unique. Without precision microlenses to make sense of it, these icons are undecipherable.

Before production, every animation sequence is rigorously modeled and tested, in controlled light conditions and real-world simulations. This ensures the motion effects are not just spectacular, but consistently reliable under varied conditions of use.

The production process is equally complex, relying on purpose-built machines maintained to meticulous calibration. Every step, from material and chemical selections to equipment operation and maintenance is executed with the goal of delivering the micron-level accuracy required by the final product.

## HOW DESIGN MEETS THE PUBLIC

While the technology is complex, the experience is not. "The Beauty of Life" is intuitive to authenticate, offering a public-friendly and emotionally resonant interaction. It eliminates the need for instruction, relying instead on clear, integrated storytelling and instantly recognizable movement couched in realistic imagery.

The visual effects – shapes that shift, colors that deepen and reflect, and forms that animate – are so decorative they nearly belie their true purpose, subconscious validators that guide users toward recognition and trust. This alignment of art and science is the cornerstone of Crane Currency's vision. As Yadira Sierra puts it, "We design banknotes

not just for security but for human connection. Design that is intuitive becomes design that is trusted. Crucially, Crane's proprietary design software – developed entirely in-house – enables designers and engineers to model micro-optic animations and simulate their effects in astonishing detail. This closed-loop capability enhances both innovation and control and allows us to iterate central bank design ideas quickly."

These animations which are a direct part of the design and production process hold positive, significant implications for central banks. The burden of connecting and engaging with the public through education campaigns is greatly lessened. The bold three-dimensionality of the feature and its digital twin project a story securely.

This aligns with an era in which much public learning is powered by smartphone viewing. The banknote feature and its animated replica, created as part of the feature design process, offer their own instruction. Responding in ways we understand instinctively, these animations are captivating and lend themselves to viewing via social media.

## THE POWER OF CHOICE – A SUBSTRATE-AGNOSTIC SOLUTION

As demonstrated by "The Beauty of Life" house note, MOTION SURFACE® stripes deliver maximum value when integrated optimally. How this potential is achieved differs greatly depending on the central bank's choice of substrate.

It is for this reason that Crane has produced "The Beauty of Life" house note using its ENDURANCE™ high-durability cotton paper and Guardian™ polymer substrate by CCL Secure. It was a significant effort that

demonstrates Crane Currency's commitment to addressing a range of customer needs. Scale production of the two variants showcases the company's expertise in designing and integrating micro-optics with different substrates. This ensures that central banks can evaluate Crane's latest security and design solutions in a relevant context, one that fits their unique currency strategy.

## IN SERVICE TO DECISION MAKERS

House notes from Crane Currency are produced to industry standards and serve as valuable tools for decision-makers across the currency ecosystem – mostly the central bank but also security experts and central bank designers. This allows decision-makers to see and work firsthand with innovation.

"The Beauty of Life" house note is an engineering marvel of secure storytelling, and a glimpse into the future of currency design. Its design pays tribute to the natural world that inspires and supports us, and with it, reaffirms Crane Currency as a leader in banknote innovation and central bank engagement.

CRANE CURRENCY

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# ORELL FÜSSLI
# SECURITY PRINTING


## JAGUAR
## Digital security for banknotes

# FACT BOX

- Digital security features add a versatile and flexible security layer to banknotes, combining traditional high-security printing technologies with digital advancements.
- JAGUAR is a new-generation digital security feature for banknotes. Created using offset security printing and standard inks, JAGUAR enables authentication through a smartphone app.
- JAGUAR employs a copy detection pattern based on the principle of information loss. This means that when the pattern is printed or copied, it loses some information, ensuring that counterfeits will always contain less information than the original banknotes.
- The authentication assessment employs advanced deep learning and machine learning algorithms, enabling precise differentiation between genuine banknotes and sophisticated counterfeits.
- When integrating JAGUAR, Central banks do not require additional investments in plate-making equipment or printing presses, ensuring a cost-effective transition.

## MEGATREND DIGITALIZATION

Digitalization has emerged as a key mega-trend over the past 40 years, significantly impacting society and the economy. As a result, digital is redefining products and transforming industries. With the accelerated digital developments of the last 20 years, smartphones have become almost ubiquitous, serving as the primary gateway to the digital world for many people.

For the security printing industry, ignoring these developments is not an option. As a result, efforts have been made to integrate digital solutions into traditional practices. One innovative response is the use of digital security features, which connect high-security printing with the digital realm.

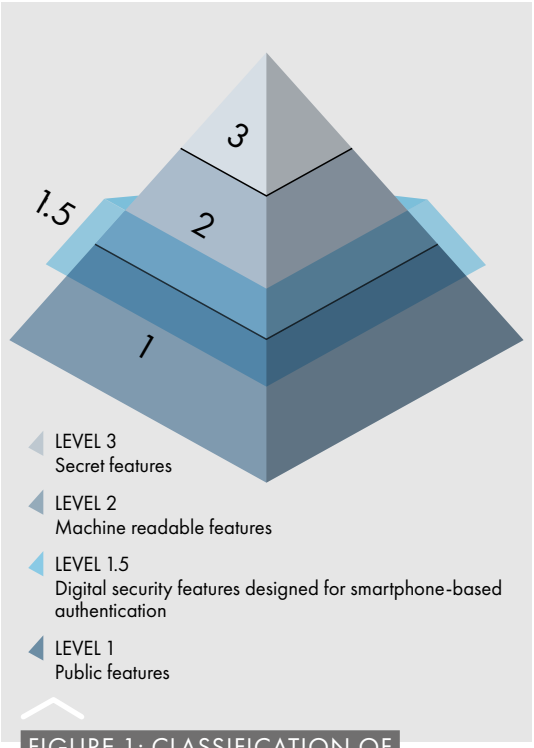


FIGURE 1: CLASSIFICATION OF DIGITAL SECURITY FEATURES INTO THE ESTABLISHED SECURITY SCHEME FOR BANKNOTES

## DIGITAL SECURITY FEATURES

Digital security features are physical features on banknotes or security documents that can be authenticated using a smart device application (app). These features leverage advanced technology to provide an additional layer of security and authentication. This type of machine-aided authentication, which is highly accessible to the public, can be classified as level 1.5 (see Figure 1).

Compared to the existing security layers, this new security layer is highly versatile and flexible. The digital setup and architecture of these features can be customized to meet the needs of a Central Bank, (integration in an existing platform or standalone, authenticity calculation in the cloud or on premise). In terms of adaptability, digital security features allow for significant control over the app version and its circulation. This enables dynamic modification of authentication criteria in the field based on the current threat level.

In addition to enhancing security, digital features boost public engagement, especially among younger generations. By integrating smartphone authentication, central banks can increase awareness and interaction with physical banknotes and so reinforce trust in cash. From the perspective of a citizen, digital security features offer an intuitive and accessible way to verify banknotes. No expert knowledge or specialized equipment is required – only a smartphone application. This democratization of authentication strengthens confidence in the integrity of physical currency.

Regarding implementation, one of the key advantages of digital security features is their seamless integration. There is no need

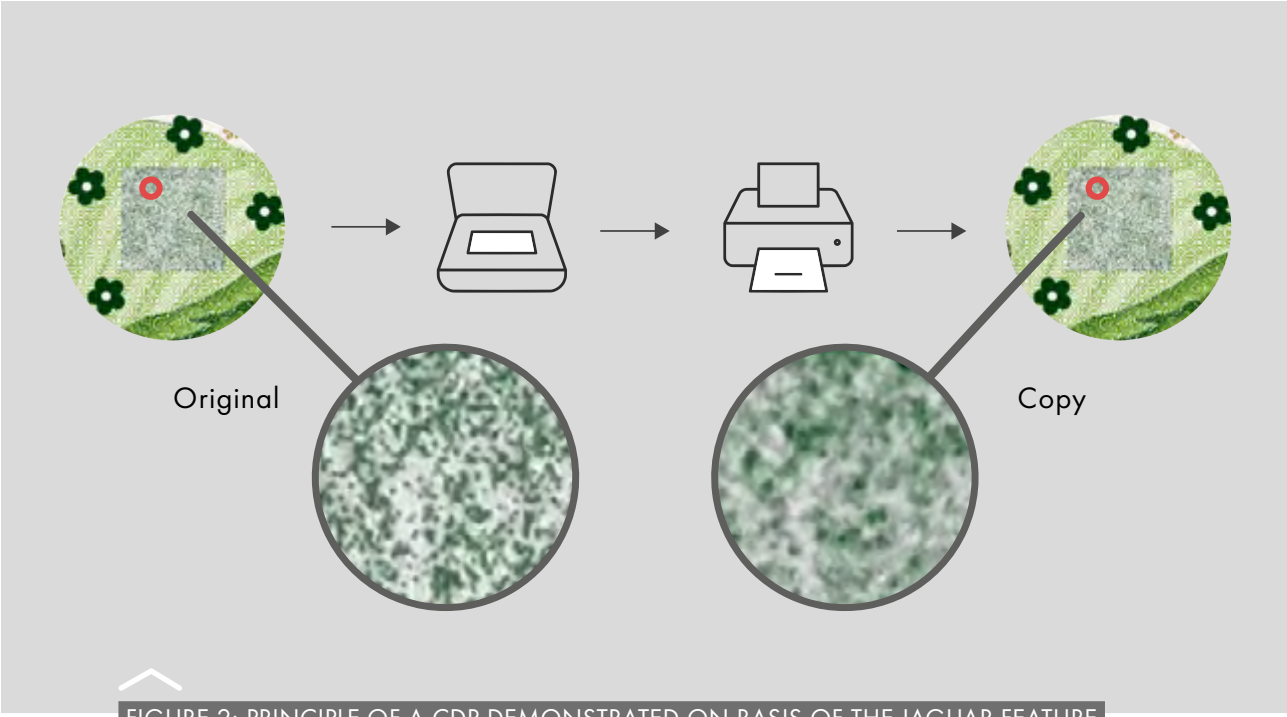


FIGURE 2: PRINCIPLE OF A CDP DEMONSTRATED ON BASIS OF THE JAGUAR FEATURE

for additional investments in plate-making equipment or printing presses. These features can be implemented using standard inks and existing printing technology, ensuring a cost-effective transition.

## JAGUAR – AUTHENTICATION IN YOUR POCKET

JAGUAR is a next-generation digital security feature designed for banknotes developed collaboratively by Orell Füssli Ltd. Security Printing and Scantrust SA. It is created using standard offset security printing and standard offset security inks, allowing for authentication through a smartphone application. At the core of this feature is the patent-pending improvement of secure graphic technology, an invention by Scantrust SA, which has been ported to the domain of banknotes by leveraging Orell Füssli's expertise and competence in the security printing field.

The secure graphic technology is based on Copy Detection Patterns (CDPs) embedded within the banknote design. The concept of CDPs was initially introduced by the co-founders of Scantrust and has since been recognized as an effective anti-counterfeiting technology. It is referenced by the European Union Intellectual Property Office, and its security properties have been examined in various academic studies and articles.

CDPs are engineered to amplify the inherent information loss induced during the printing process. This is achieved by exploiting naturally occurring phenomena like ink smearing and dot gain, collectively referred to as 'information loss'. Such information loss is inevitable when printing under conditions similar to those used for the original secure graphics. Consequently, counterfeiters cannot successfully create a one-to-one copy.

As counterfeit prints undergo an additional print cycle, the secure graphic in the copy contains less information than the original prints, which allows detection of these copies with a scan via a smartphone. This principle is illustrated in Figure 2.

## DESIGN INTEGRATION OF THE SECURITY PATTERN

The CDP is embedded within a discrete region of the banknote according to the design requirements. The app provides real-time visual guidance to the user, aiding in the precise localization and capture of the secure graphic area. Secure graphic localization is supported via the detection of design elements.

To accommodate various types of designs, a deep-learning algorithm was selected for training on large amounts of synthetic images. This model learns to localize the secure graphic area in the input camera stream using synthetically generated images. The deep learning detection algorithm searches for the area with CDP in each input frame. The flexibility of this algorithm has been validated on real banknote prints with various designs.

The JAGUAR house note in Figure 3 shows an example of four different implementations of secure graphics that have been integrated into the banknote design. In general, the technology allows for endless variations in shape, appearance and integration of the security pattern into the banknote design.

FIGURE 3: JAGUAR HOUSE NOTE WITH FOUR DIFFERENT IMPLEMENTATIONS OF SECURE GRAPHICS

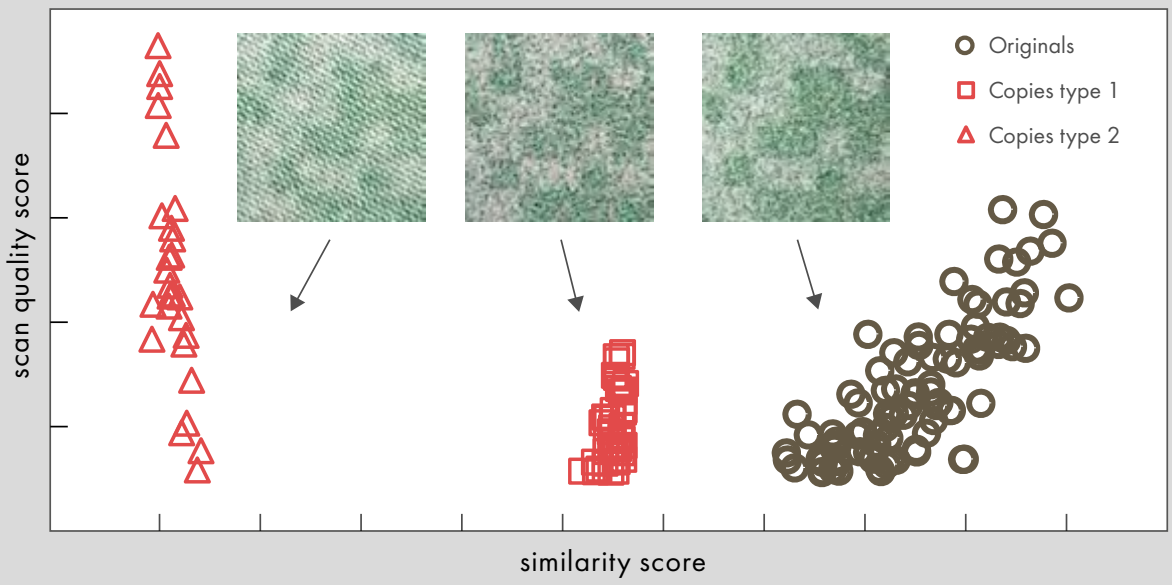


FIGURE 4: PLOT OF THE SCAN QUALITY SCORE VERSUS THE SIMILARITY SCORE OBTAINED DURING FIELD MEASUREMENTS ON ORIGINALS AND DIFFERENT TYPES OF COPIES

During the scanning process, real-time image quality metrics are calculated to optimize frame selection and mitigate the impact of environmental factors such as camera shake and variable illumination, thus reducing the likelihood of utilizing suboptimal image data for reliable authentication. Once authentication conditions are met, the relevant information is transmitted to a secure server for complete authentication.

## AUTHENTICATION OF THE SECURITY PATTERN

Authentication is conducted by the server once it receives the necessary information from the mobile app. Due to the varying camera optics across different smartphone types and varying capturing conditions, the input image invariably exhibits geometric distortions, which need to be corrected before authentication can take place. Authentication is therefore performed after a step of image registration, in which the scan is aligned with the digital image of the CDP prior to printing

.

The corresponding authentication model is retrieved, and a decision on authenticity is made by using deep-learning based localization models. The key quantity that is extracted through applying the authentication algorithms is the so-called similarity score. It is a measure of the degree of similarity between the captured image of the security pattern and the original data file used for printing. In addition to the authentication metrics,

the technology is capable of extraction the metrics for the quality of the captured picture.

An illustrative way to demonstrate the capabilities of the technology are plots of the measured scan quality score against the measured similarity score. Figure 4 shows an example of the results obtained in field measurements on originals and two types of copies using a fixed smartphone model. The plot depicts a clear separation between copies type 1 (push button copies of a high-quality office laserjet printer – lowest similarity scores) and copies type 2 (high-resolution scans printed at high-end press proof inkjet printers – medium similarity scores) and original prints.

The main challenge in developing this feature is ensuring reliable authentication in edge cases, such as when aged banknotes are scanned. For those cases, the technology has to provide a sufficient separation to high-quality copies of mint condition. To address this challenge, Orell Füssli conducted validation measurements on aged banknotes that were prepared according to the UGRA standard for lifetime testing. The results show that there is a sufficient distinction between aged notes and reference copies under medium ageing conditions, which are expected to occur during the lifespan of banknotes in moderate climatic conditions and in industrialized countries.

## BUILD TO EXPAND

The JAGUAR feature was introduced into the market at Intergraf 2025. The market response during the introduction phase will be used to make decisions on further refinements of the feature. Further optimization of the capturing process, as well as the investigation of implementation strategies towards a more subtle and discrete embedding, are already parts of the roadmap. While development continues, JAGUAR is already transforming the way the public is able to authenticate banknotes by empowering them with a user-friendly yet sophisticated tool.

ORELL FÜSSLI LTD. SECURITY PRINTING

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Senior Scientist
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# HUECK FOLIEN


## ReDefining Responsibility: The Ocean Dollar Housenote of the year 2025


# FACT BOX

- The Ocean Dollar – High precision security features based on recycling materials: Hueck Folien presents a banknote concept which includes recycled components. The Ocean Dollar, awarded as "Best New Housenote 2025" at the High Security Printing Awards by Reconnaissance International.

- Vibrant and passionate - new TRILUMIC® thread Rio design: Inspired by the famous walkway on the Copacabana, created by the famous Brazilian artist Roberto Burle Marx, the design uses exciting contrasts and the latest Trilumic® technology. The design will have you dreaming of the lively, colourful and passionate beach in Rio.

- 55 years of Hueck Folien: Honouring heritage, embracing progress. Hueck Folien is success partner of the world's most secure currencies with more than 35 years of experience. Over 70 countries worldwide put their trust in high-security products made in Austria.

## THE OCEAN DOLLAR – HIGH PRECISION SECURITY FEATURES BASED ON RECYCLING MATERIALS

Hueck Folien presents a banknote concept which includes recycled components: The Ocean Dollar, awarded as "Best New Housenote 2025" at the High Security Printing Awards by Reconnaissance International. We are celebrating our 55th anniversary this year and are committed to the further development of sustainable banknote technology through the integration of high-security features and environmentally friendly processes.

The recycling concept, inspired by the hidden depths of the ocean, utilizes recycled aluminum, paper and PET, enabling central banks to meet the highest security standards while embracing environmental responsibility.

- Optomove® security thread uses unique micro-optical elements, ensuring brilliant visibility in any light and from any angle. Its vibrant colors are unmatched. Made from recycled PET and recycled aluminum, Optomove® achieves 53% CO2 savings through the raw material used


OPTOMOVE® - BRILLIANT IN ALL ITS FACETS AND PERSPECTIVES

- The Reef foil design, featuring optical nanostructures and Trilumic®, is crafted from recycled PET and recycled aluminum. New holographic features, created with cutting-edge origination technology, enhance the design, while improved UV printing for Trilumic® delivers vibrant, intensified colors. Reef foil achieves 26% CO2 savings through the raw material used.

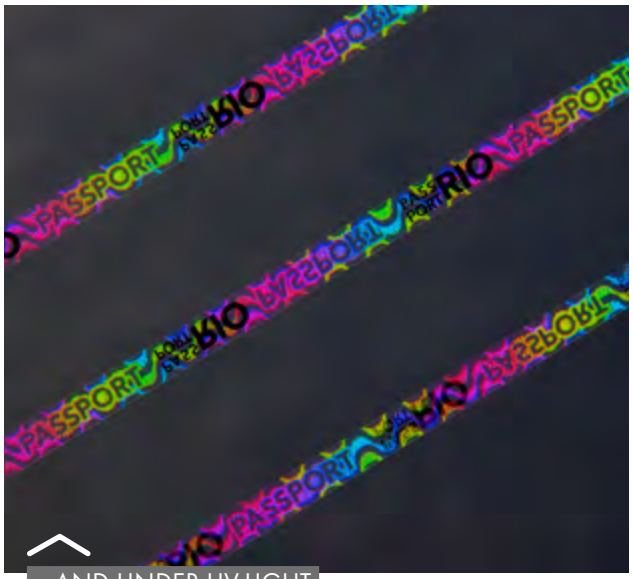

THE REEF DESIGN WITH TRILUMIC®, IMPROVED UV PRINTING

- EcoBreath® paper is an innovative solution developed by BP Security in partnership with Casa da Moeda do Brasil, which allows the recovery and reuse of fibers from banknote waste to produce recycled security papers for banknotes and passports. EcoBreath® is a solution for Central Banks that wish to include sustainability criteria for their currency, which are compatible with all security standards, including multi-tone watermarks, fibers and security threads.

## VIBRANT AND PASSIONATE: NEW TRILUMIC® THREAD RIO DESIGN

The impressive success story of TRILUMIC® started five years ago, when we first presented the TRILUMIC® holographic stripe. Meanwhile the product is placed in the market and proven in circulation on various banknotes and passports. Now, we also produced a high security thread for the sample passport of Casa da Moeda do Brasil.


TRILUMIC® RIO THREAD UNDER DAYLIGHT




...AND UNDER UV-LIGHT

The unique aspect of our TRILUMIC® inks let the design shine in extremely brilliant colors under UV light. What makes the TRILUMIC® UV printing on banknotes so special? Up to now, regular UV inks for printing on banknote paper or on the plastic substrate for high security threads were used. This is well-known, proven in billions of banknotes and in production since decades.

UV printing with TRILUMIC® changes this situation largely and makes it much more difficult for the counterfeiters. We use a special software to generate the print pattern and print all TRILUMIC® colors by three unique inks in different graduation. The three inks were specially developed in sense of brightness and light fastness, to make this UV feature more durable over the lifetime of the banknote and to separate it from regular UV printed features.

TRILUMIC® is a trademark resulting from cooperation between Hueck Folien and Banque de France.

## NANOSWITCH® - SPECTACULAR NEW DESIGN: 'CHAMELEON'

Meeting a chameleon is an extraordinary experience! In a fraction of a second, they shine in the brightest colors. Inspired by the vibrant atmosphere, colors and patterns of the jungle, the 2nd design of the new state-of-the-art security feature Nanoswitch® represents the symbiosis of creative realisations, inspired by nature.

Nanoswitch® addresses the two most distinctive human senses – sight and touch – and combines color with a 3D object. The visual attraction of the transforming 3D-color object together with the unexpected haptic experience gives Nanoswitch® unique authentication properties.


NANOSWITCH® CHAMELEON DESIGN

The integration of nanofabricated optical security elements with partial ColorSwitch™ provides Nanoswitch® with extraordinary resistance to counterfeiting and imitation, creating the highest level of banknote protection.

**Color Switching Nanostructures**

ColorSwitch™ by Hueck Folien offers six vibrant color shift variations that provide an intuitive security feature in movement as design elements are highlighted. The shades change color when the banknote is tilted. Nanoengineered optical structures, developed by IQ Structures, provide a distinctive visual appearance and maximum security.

**Design cooperation Nanovista™**

When the partner of the most secure currencies collaborates with the most innovative technology partner, and 30 years of experience meet advanced nanofabrication, the result is Nanovista™ - unique features and support right from the design stage to the finished banknote. The aim is to create the most advanced and safest banknote solution in the world.

## 55 YEARS OF HUECK FOLIEN: HONOURING HERITAGE, EMBRACING PROGRESS

For 55 years, Hueck Folien has been a beacon of stability and trust in the security industry. Our journey began in 1987 with the introduction of high-security threads for banknotes, marking the beginning of currency protection worldwide. One of our most important milestones was the production of our first thread for the Deutsche Mark, which set the standard for our future innovations.

Over the decades, we have continued to push the boundaries of security technology. In 1990, we pioneered the first industrial production of the Clear Text Security Thread, and in 2000 we became an accredited supplier for the EURO system. Our innovative spirit led to the

introduction of the first printed ColorSwitch® in 2003, PictureThread™ in 2012, Trilumic® in 2017, Optomove® in 2023 and, together with IQ Structures, Nanoswitch® in 2024.

Our motto 'Future Forward' expresses our vision to lead the industry with innovative solutions that have a strong focus on sustainability. We are proud to use recycled aluminium in all our processes, which underlines our commitment to the environment. We will continue to champion the advancement of safety technologies that not only protect, but also contribute to a sustainable future.

## ABOUT HUECK FOLIEN

One third of the world's currencies already bear the high-security product solutions by Hueck Folien, including the EURO and the SWISS FRANC. The company is trusted partner to central banks, who protect their currencies against counterfeiting with Hueck Folien's high-security solutions.

The features of the films can be efficiently processed by all security paper mills around the world. Hueck Folien has been directly collaborating with most of them for more than 35 years.

Since 1970, Hueck Folien has stood for stability, quality and innovative strength. With their passion for excellence, 300 employees are contributing to an ongoing success story. The company develops and manufactures its high-quality product solutions exclusively in the heart of Europe, and is continuously investing in new technologies to achieve ecologically neutral production by 2035.

HUECK FOLIEN GMBH

Mr. Jan Hofmann
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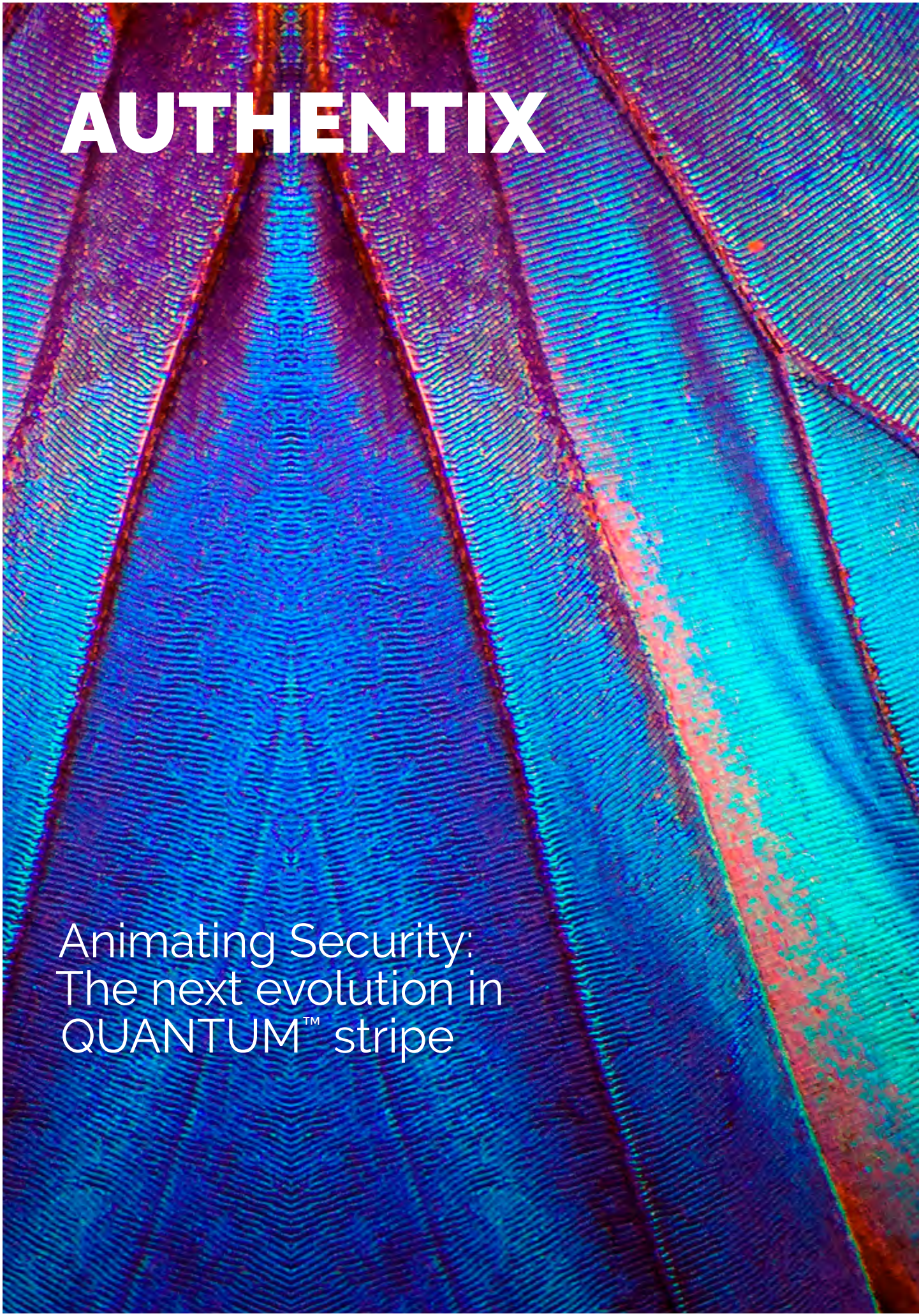
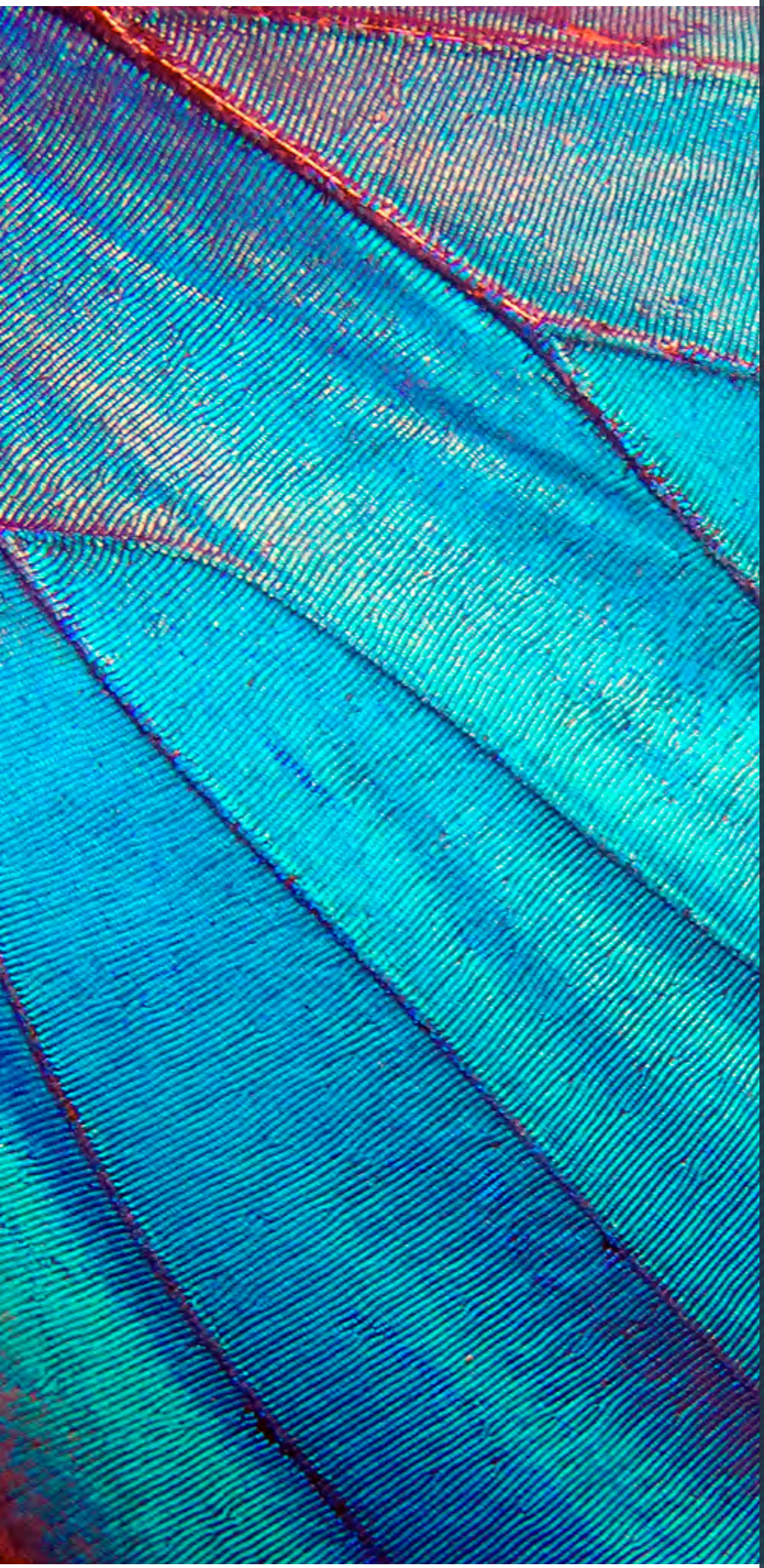

AUTHENTIX
Animating Security:
The next evolution in
QUANTUM™ stripe



# FACT BOX

- Introducing real animation in a security feature:
  QUANTUM™ Stripe now enables full frame by frame animation, bringing smooth, dynamic movement to overt security features.

- Blending Art and Authentication:
  This breakthrough allows designers to integrate visual storytelling and temporal effects like pulsing, switching, and rotation - into secure features, enhancing both user interaction and authentication.

- Raising the Bar for Counterfeit Deterrence:
  The technical complexity required to replicate animated features, especially with smooth, direction-sensitive transitions makes duplication significantly more difficult for counterfeiters.

- "Time in Motion" Design:
  A new time-themed concept, Time in Motion, showcases elements like watch cogs, moving hourglasses, and flowing sand demonstrating the potential for movement based authentication cues.

- A Platform for Future Innovation:
  This advancement opens the door to future capabilities, enhanced interactivity, increased design flexibility and higher security.

## ANIMATING SECURITY: THE NEXT EVOLUTION OF QUANTUM™ STRIPE

The world of security features has long walked the line between science and art. As banknote designers and security technologists, we aim not just to protect, but to captivate. Creating features that communicate trust, deter counterfeiting, and elevate the user experience. With the latest evolution of QUANTUM™ stripe from our Nano Optics platform, we are proud to unveil a powerful new capability that deepens that blend with full animation.

This is not metaphor or marketing flourish. We are now able to deliver real 2D animation within a secure, nano-scale overt feature with numerous frames per sequence, unlocking a new visual vocabulary for authentication. This innovation expands the creative possibilities for banknote design and security, introducing effects never before seen in this context; pulsing, image transitions, disappearance and reappearance, and rotational imagery. Think of cogs turning in a watch. Flames flickering. An hourglass slowly filling. Time made visible, and movement made secure.

We call this concept Time in Motion - a new demonstration design that captures the potential of dynamic overt features through the universal and evocative theme of time.

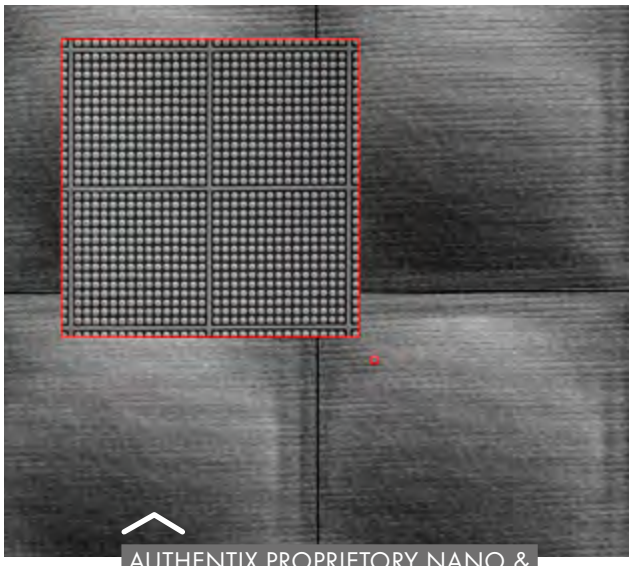
## THE ARTISTRY OF ANIMATION IN BANKNOTE DESIGN

Animation, at its heart, is storytelling through movement. It's a form of magic, the illusion of life brought to static images. In traditional media, it's a creative craft honed over decades by artists who understand timing, pacing, and emotional resonance. In the world of security features however, animation has largely remained elusive - confined to low-frame optical tricks or coarse lenticular effects with limited flexibility.

What we have developed with QUANTUM™ stripe is something altogether different. Our ability to create numerous frame animations opens the door to detailed motion effects at an entirely new scale. The result is smooth, fluid movement that mirrors the richness of traditional animation, but rendered with nanoscale precision in an overt security feature.

With this breakthrough, we can now integrate smooth frame by frame animations into our designs. A sun can rise and set. A lock can open. A symbol of national pride can come alive. These animations aren't just decorative; they serve a core authentication purpose. By giving end users something intuitive and unmistakable to look for, we make authentication easier and faster, while increasing the barrier to counterfeit replication.

EXAMPLE OF MULTI FRAME ANIMATION



AUTHENTIX PROPRIETORY NANO & MICRO STRUCTURES

## DESIGNING WITH FLOW

What makes QUANTUM™ stripe uniquely suited to this evolution is its structure. Built upon a plasmonic nano-optic platform, it uses structural color; inspired by the phenomenon seen in nature like the Blue Morpho Butterfly to generate vivid hues without pigments or dyes. This gives us remarkable control over form, color, and now sequenced movement.

The addition of animated effects transforms QUANTUM™ stripe into a platform rich with dimension and rhythm. Our design team is now not only creating features with multiple color hide and reveal, depth, and high resolution imagery but also sequencing them in time. Like animators, we work with storyboards, timing sheets, and frame-by-frame refinements - only our canvas is a microscopic landscape, and our tools are informed by optics, physics, and fabrication engineering.

To demonstrate the potential of this evolution, we're introducing a concept piece titled Time in Motion. It brings together iconic imagery of watches, cogs and hourglasses: each animated to create an intuitive, memorable interaction. A user can tilt the note and watch symbols of time shift in fluid harmony, reinforcing the ideas of movement, trust, and precision.

This design is not only visually arresting, it also reflects the layered purpose of modern banknote security: to blend beauty with deterrence, to inspire confidence while foiling counterfeiters.

## RAISING THE BAR FOR REPLICATION

Security features are only as strong as the difficulty of replicating them. Animation adds a new dimension to that challenge. Where traditional overt elements can be mimicked with static approximations or even digital print tricks, dynamic sequences demand exactitude not just in shape and color, but in frame order, consistency of movement, and directional responsiveness.

Attempting to counterfeit a feature with multiple frame animation introduces a new class of difficulty. Every frame must align. Every transition must be seamless. Every optical pathway must support the intended viewing experience. This is no trivial feat. And critically, the visual payoff - when executed correctly - is unmistakable. Movement is something the eye instantly detects and the brain remembers. That makes animation not just engaging, but secure.

Furthermore, dynamic features open up additional layers of functionality. We can create effects that appear only when tilted in a specific direction, or that reveal different content depending on viewing angle - enabling more complex authentication cues for the end user.

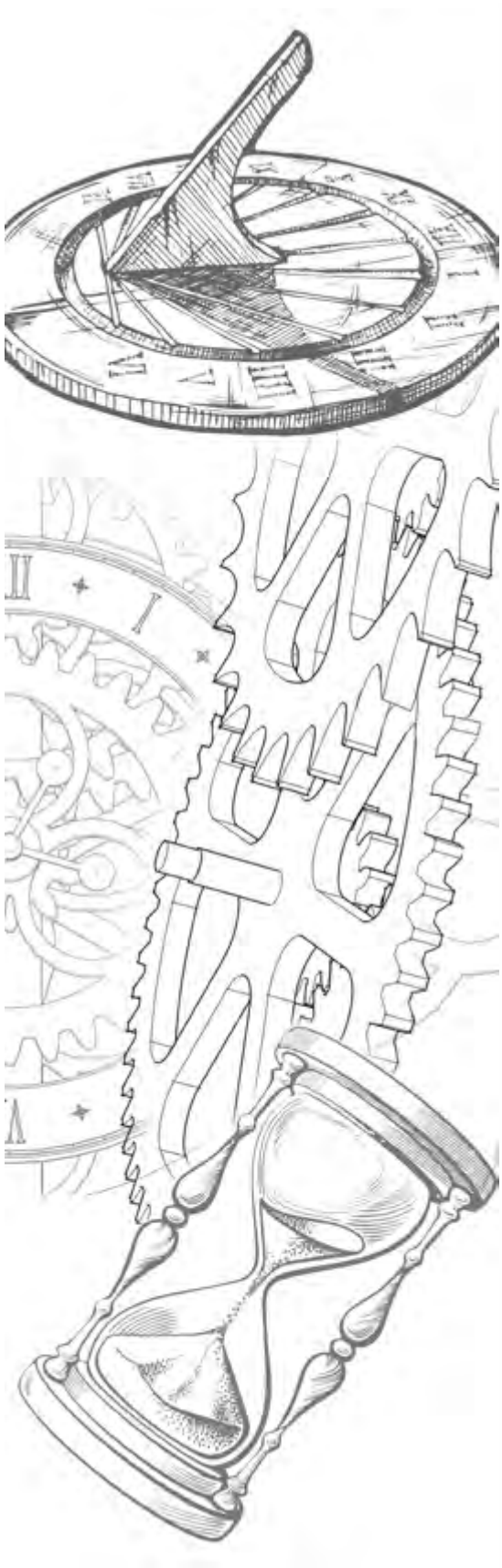
## THE BEAUTY OF FLOW, THE POWER OF PRECISION

The introduction of animation marks a pivotal moment for the QUANTUM™ Stripe platform. As the technology evolves, even greater levels of sophistication, interactivity, and design freedom are on the horizon. This next chapter cements QUANTUM™ Stripe's position at the pinnacle of innovation in the security feature industry.

Looking ahead, we see a future of greater customization, where animations are tailored to individual issuers, drawing on cultural and national themes to create deeper resonance. Combined with our proven scalability and manufacturing readiness, QUANTUM™ Stripe is not just a breakthrough, but a practical, deployable solution for central banks worldwide.

This leap into animation represents more than a technological milestone. It marks a shift in how we think about design: recognizing that movement carries meaning, that artistry can amplify security, and that the best features don't just protect...they inspire.

With Time in Motion, we offer a glimpse of a future where dynamic design becomes a new language for authentication. Where every shift in light and angle tells a story, and where the timeless principles of trust, creativity, and innovation continue to lead us forward.



AUTHENTIX

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LEONHARD KURZ
STIFTUNG & CO. KG
KINEGRAM®:
Where Movement meets Security
in the future of Banknote Design

# FACT BOX

- Despite the rise of digital payments, physical currency remains an essential and resilient form of value exchange
- Today's banknotes are sophisticated, interactive artworks and Diffractive Optically Variable Image Devices (DOVIDs) are transforming them into high-tech authentication tools
- DOVIDs can deliver dynamic, kinematic effects with depth and contrast, creating a visually intuitive layer of protection that's easy to authenticate but impossible to scan or simulate
- With advanced micro-optics, these elements are built using nano-scale structures with highly secretive production methods
- Kinematic foils offer unprecedented design opportunities, making the banknotes aesthetically pleasing as well as highly secure
- Leading currencies around the world have harnessed foils, teaming them with a multitude of security features to create the greatest challenge counterfeiters have ever faced

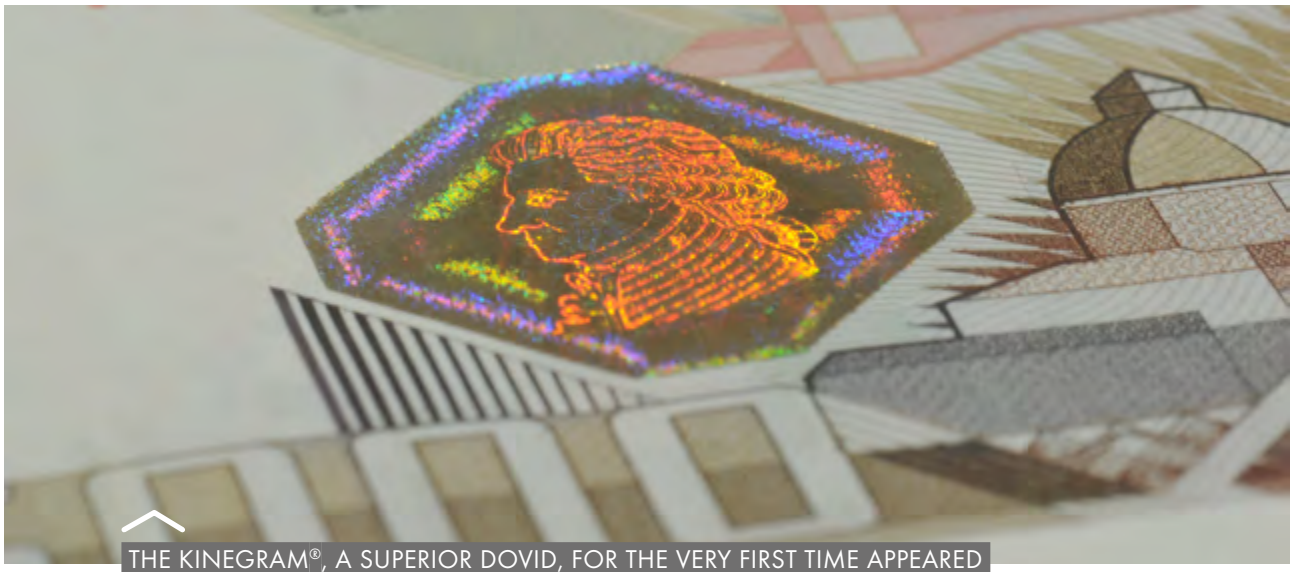
## THE ART OF MODERN CURRENCY

In a world shaped by digital innovations, physical currency is a pillar of economic resilience, a true example of always-on technology. At first glance, the fundamentals of banknotes remain as they always have been – and their physicality has advantages over digital payments that depend on networks and electricity to exchange value – but on closer inspection, complex, shape-shifting features that push the boundaries of design and security are revealed. In these elements lies the future of physical money.

For most people, banknotes are pieces of art, representations of wealth, expressions of freedom. When a new series is issued, announcements focus on the symbols of national pride depicted, the aesthetic flourishes, and the ways in which the notes can be authenticated. Over their lifespan, the last of these is most critical, and today DOVIDs – Diffractive Optically Variable Image Devices – supply first-rate protection combined with exceptional artistic freedom.
The acronym – coined by Ian Lancaster of Reconnaissance International – refers to security features based on diffractive visual effects. Lancaster observed that the security printing industry was leery of the term 'holograms', given their traditional use for decorations and toys, and proposed 'DOVID' to differentiate the technology for specific secure applications.

DOVIDs create a solid security architecture for banknotes, characterised by the potential for advanced design integration and the capacity to gather disparate techniques into one visual element for easy authentication. Developed in the 1980s and debuting on the 1988 Austrian Schilling banknote in the form of a KINEGRAM® patch, DOVIDs, and in particular KINEGRAM®'s, are today one of the most widely used security devices in the world. While standard DOVIDs were based on holographic technology, KURZ pioneered the development of DOVID with a special non-holographic technolog called KINEGRAM®.

Today, almost 40 years since their introduction, both the technology and the ways in which it can be applied have evolved drastically. The use of de-metallisation, especially with zero tolerance to the optical effects, has broadened possibilities for integrating DOVIDs into banknote design. These are expanded even



THE KINEGRAM®, A SUPERIOR DOVID, FOR THE VERY FIRST TIME APPEARED ON THE AUSTRIAN SCHILLING

KINEGRAM® VIVID, A DEEPLY DYNAMIC ADDITION TO THE KINEGRAM® PORTFOLIO

further by the option to apply a DOVID in register, fixing where each of the elements will be placed on the banknote. The introduction of colours – both stable and shifting – has also opened up new avenues for designers to become ever-more creative.

## A MOVING TARGET: WHY KINEMATIC-BASED FEATURES MATTER

KINEGRAM® technology offers an unparalled range of distinct and impressive visual effects, with an extensive variety of microstructures unreachable by conventional holograms. The know-how and machinery has been proprietary and secret since its initial development and gives the KINEGRAM® an additioal security advantage.

While many visual features through the years have relied on overt optical tricks, KINEGRAM® introduced visible dimensions that are extremely hard to simulate. That is because of a special non-holographic technology that offers an unparalled range of disctinct and impressive visual effects with an extensive variety of microstructures: virtual 3D effects, fine line movement, pumping and transformation, diffractive .watermark and many more. The most recent addition KINEGRAM® VIVID for example, has kinematic movement that spans all cardinal directions and diagonals, creating a striking illusion of fluid motion that engages the viewer's eyes and brain.

*"Our goal has always been to create security features that are instantly understood by the public, yet impossibly difficult to copy. Our KINEGRAM® technologies speak directly to the subconscious. Think of it as an optical fingerprint, with each flicker or depth contrast unique to our process. Your brain registers the motion as authentic and will instantly recognise its absence. This is a powerful tool against counterfeiting."*

Gerben van Wijk, Head of Business Area Security, LEONHARD KURZ

Where flat foils or basic holograms offer a limited impression of motion, KINEGRAM® elements are based on nano-scale microstructures engineered with extreme precision. The equipment required to produce them – from design to the production tools – is non-commercial and highly restricted, making unauthorised reproduction virtually impossible.

*"A key reason counterfeiters struggle with KINEGRAM® is because they're built on knowledge that's not even shared across our internal teams. There's a layered secrecy, not just in the materials and design, but in the manufacturing itself. This, alongside their innate complexity, offers the highest level of security."*

Dr. Harald Walter, Head of Micro and Nano Engineering, OVD Kinegram AG

For banknotes, which travel the length and breadth of every country, 24 hours a day, 365 days a year, it is critical for security features to meet people where they are. Kinematic foil elements with DOVIDs remain effective under difficult lighting conditions, meaning they are identifiable whether in the shadows of a night market or under the glare of an inspection lamp.

Another crucial factor is durability, where foil features also prove their worth. Well-integrated foils retain their brilliance throughout years of circulation, passing through tens of thousands of hands, glistening beneath the gaze of countless eyes.

## COUNTERING COUNTERFEITING IN THE AGE OF DEEPFAKES

The threat landscape for currency security is evolving more rapidly than ever before. High-resolution scanners, AI-generated textures and 3D printing technologies are becoming more sophisticated and more widely available, making traditional defences easier to mimic. Banknote authorities around the world recognise this developing risk and are investing accordingly, actively prioritising high-tech, foil-based features.

Anti-counterfeiting is where DOVIDs shine, with effects that cannot be flattened into a scan or convincingly simulated by a printer.

*"Most counterfeit attempts still fail at the foil. That's the bottleneck for fraud. When you introduce a dynamic, multi-layered feature like KINEGRAM® VIVID – something that appears to move and reacts to light in a way that feels alive – you create a near-insurmountable barrier."*

Gerben van Wijk, Head of Business Area Security, LEONHARD KURZ

A 2025 examination of counterfeiting statistics across Australia, Europe and the UK prepared by Kerrency Ltd. highlights successful measures Central Banks have taken to reduce counterfeit banknotes in circulation.

- Upgrading security features
- Improving holographic elements and integrating them with other security features, such as transparent windows
- Proactively removing older designs from circulation

The report finds that, despite the differences between the countries studied and 'varying security threats to their banknotes, all were able to decrease their counterfeiting rates by incorporating complex security features.'

## PROOF IN CIRCULATION: EXPLORING THE WORLD'S MOST SECURE CURRENCIES

A recent assessment by the currency team at BestBrokers identifies the world's most secure banknotes, focusing on the 39 most traded currencies by value. These were then ranked based on the number of security features and best estimates of how many counterfeit notes are circulating per million real ones across each country.

The Swiss Franc was ranked highest, with the Euro, Australian Dollar, Polish Złoty and Pound Sterling making the top five behind it. Which high-performance security feature do most of these have in common? DOVIDs in the form of KINEGRAM®.

Switzerland's 200 Franc banknotes showcase the nation's scientific expertise, appropriately enough, and carry a bi-colour KINEGRAM

VOLUME® developed by KURZ in close cooperation with the Swiss National Bank and Orell Füssli Security Printing. Created with laser technology, it uses distinct single colours, setting it apart from other security foils that display a typical chromatic rainbow. Alongside this vibrant colour, it has an 'on-off' optical effect, meaning the design element alternates between clearly visible and disappearing as the note is tilted.

The Australian Dollar was the first polymer banknote to feature the revolutionary KINEGRAM ZERO.ZERO® effect, enabling the use of very fine diffractive elements which beautifully enrich the banknote design. This technology is well suited to projects requiring seamless integration of security features with the art of the banknote, offering highly brilliant, metallised images at extremely high resolution, giving emphatic impressions of movement and allowing for large transparent areas.

The middle and high denominations of Euro banknotes carry a KINEGRAM REVIEW® window security feature, which displays different designs on the front and back of a banknote in addition to a see-through effect by which an image becomes visible when a banknote is help up to the light. This front-to-back verification technology introduces many design opportunities alongside enhancing authentication. On the 50 Euro banknote, the foil displays a diffractive portrait on the front of a note and a wallpaper design showing the denomination on the reverse, for example. A registered image can appear both front and back thanks to intensive R&D work. This feature was taken even further on the Cost Rica 10,000 und 20,000 Colones banknotes where the imagery in the KINEGRAM® is in line with the printed motif on either side of the banknote.


THE WORLD'S MOST SECURE CURRENCIES PROTECTED BY DOVIDS AND ESPECIALLY THE KINEGRAM®

The UK's Pound Sterling banknotes are enhanced with KINEGRAM COLORS®, a registered stripe applied over a transparent window. Extremely brilliant and eye-catching, it features the royal crown expressed in a 3D relief effect that gives the impression of protrusions from the surface, despite it being smooth and flat to the touch. As well as vibrant colours in the main motif of the security element

In all these examples, security foils are teamed with other hard-to-copy elements, and this rich combination of features lies at the heart of what makes them so difficult to counterfeit

## COMPATIBILITY MEETS CREATIVITY

As potent and flexible as one KINEGRAM® element is alone, their real strength lies in how they integrate seamlessly with the broader KINEGRAM® ecosystem as well as complementing other security elements. This enables a modular approach to security design, with form enhancing function.

By combining contrast control, brightness modulation and colour-shifting layers, banknote designers can realise very bold or very subtle effects, and achieve visual harmony without compromising on authentication power. The over 300 denominations that feature(d) KINEGRAM® technology are testament to the true meaning of design flexibility of the KINEGRAM® technologies. Observing the various currencies show that no KINEGRAM® looks the same but each and every one is unique to the country from the combination of the visual effects to the technologies used. The KINEGRAM® is truly tailored to the country´s needs.

*"We no longer think of features in isolation. Our design strategy revolves around cooperative effects and technologies that enhance each other and create deeper layers of complexity. This mix and match approach also broadens design possibilities, supporting a core role of banknotes as ambassadors to their countries and unifying cultural representations."*

Reto Karrer, Security Designer,
OVD Kinegram AG


COMPLEMENTING ANY CONCEPT - THERE ARE NO LIMITS TO CREATIVITY

SUSTAINABILITY IS AN IMPORTANT TOPIC FOR OUR PROCESSES AND ALSO THE DESIGN OF SAMPLE BANKNOTES

## SUSTAINABILITY WITHOUT SACRIFICE

It would be easy to assume these advanced technologies come at an environmental cost, as is the case with many developments unfolding in the AI space, but KURZ is determined to rewrite that narrative, with foil features designed to keep material efficiency and recyclability front of mind.

*"Our R&D teams are constantly balancing performance with sustainability. KINEGRAM® foils are made using ultra-thin layers of material, which not only reduces environmental impact but also supports central bank goals for greener currency systems."*

Dr. Violetta Olszowka, Head of Research and Development, LEONHARD KURZ

## THE ENDURING ROLE OF DOVIDS IN A DIGITAL WORLD

When banknote security features are not simply seen but experienced – visible, tangible, in motion – they become an intrinsic part of the note's identity that contributes to a clear, subconscious understanding of what makes it authentic. Without the effort of thought, a member of the public can instantly perceive the legitimacy of a real banknote. When presented with a fake, which lacks the tactility and visible motion features of the real thing, they intuitively know something is wrong. This triggers a more careful inspection, and they can easily confirm the suspicion that they are holding a forgery.

These elements of tactility and perception remain irreplaceable in an age of AI-assisted fraud and sophisticated image manipulation. This is what makes dynamic foil features a long-term investment in security, continuously evolving to stand above other trends in currency protection.

LEONHARD KURZ
STIFTUNG & CO. KG

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Website: www.kurz-banknotes.com

# NANOSWITCH®

## Color switching Nanostructures

### UNMATCHED BANKNOTE SECURITY

Optical security features must be visually engaging, easily verifiable by the public, and convincing to experts in the field. Nanoswitch® aligns perfectly with these requirements. It provides an unprecedented visual and tactile experience, establishing new benchmarks in banknote security. Developed under the Nanovista® brand, the IQ Structures and Hueck Folien consortium aims to create the world's most advanced and secure banknote security features.

### UNSEEN AUTHENTICATION EXPERIENCE

Human senses have always been essential to our perception of reality. The more senses we engage, the more intense our experience becomes. Nanoswitch® addresses the two most distinctive ones – sight and touch – by combining a dynamic color-switch with a 3D object. The visual attraction of the color-switching 3D object, together with the unexpected haptic experience, gives Nanoswitch® its unique authentication properties.

By integrating nanoengineered optical security elements with partial ColorSwitch™ technology, Nanoswitch® offers exceptional resistance to counterfeiting and imitation, ensuring the highest level of banknote protection.

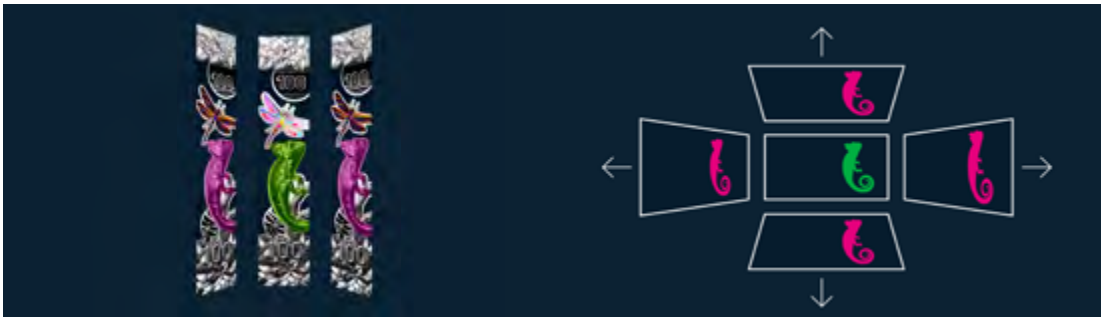
### SIX VIBRANT COLOR SWITCHING VARIATIONS

To support creative freedom and design flexibility, Nanoswitch® is available in six color-switch variations. This allows seamless integration into various banknote styles and themes, from classic motifs to modern aesthetics.

Each color variation has been carefully selected for high visibility, intuitive authentication, and strong contrast. These variations bring robust security while having great storytelling potential, whether you're highlighting key banknote design elements, reflecting cultural symbolism, or boosting public recognition.

### CHAMELEON

After the overwhelmingly positive feedback on the first Nanoswitch® design – Moonlanding, Nanoswitch® returns with "Chameleon," featuring a striking green-to-magenta color-switch. Inspired by the vibrant hues of the jungle, it further demonstrates a core Nanovista® principle: the seamless integration of the banknote stripe into the overall banknote design.




## HARMONIOUS INTEGRATION

Nanoswitch® adds vibrant colors to precisely detailed white bas-reliefs. Moreover, you can integrate a wide range of unique nanoengineered optical effects into the banknote stripe. These effects work harmoniously together and complement the overall design of the banknote. This combination further elevates the visual appeal of banknotes, while ensuring top-level security and full compliance with the latest banknote industry standards.

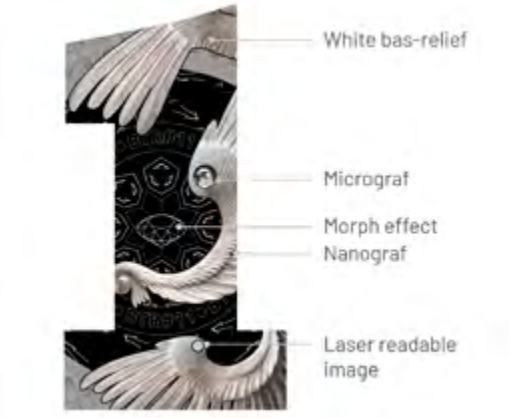
## ABOUT NANOVISTA®

Nanovista® is combining the cutting-edge nano-origination technologies of IQ Structures with the wide range of foil-based high-quality security features for banknotes of Hueck Folien.

IQ Structures is a leading supplier of anti-counterfeiting protection based on nanostructures, securing hundreds of millions of documents annually. It has received several prestigious international awards for excellence and scientific innovation.

Hueck Folien is a trusted partner to central banks, providing high-security threads and foils for one-third of the world's currencies. With over 30 years of experience, it continuously invests in new technologies to achieve environmentally neutral production by 2035.

## THE COVER?! IT'S NANOENGINEERED




**Explore the cover and opening spread of this Banknote Technology Report to experience nanoengineered optical security features that feel, move, and reveal like nothing you've seen before.**

**White Bas-relief** and its immersive haptic experience. While it looks 3D, it feels 2D.

**Morph effect** with morphing and animating 3D object outline when the feature is tilted.

**Micrograf, Nanograf and Laser readable image** – extremely small, yet perfectly detailed; visible under a magnifier (e.g., a smartphone), forensic microscope, or with a laser.

NANOVISTA®

Mr. Robert Dvorák
Mr. Michael Ritschewald
Email: contact@nanovista.world
Website: www.nanovista.world

IN GROUPE


# Powered by light. Protected by science.

Whether on polymer or paper, IN Groupe Currency brings innovation to your banknotes. Trusted by central banks, we deliver expert-engineered, custom-built solutions powered by advanced optical technologies.


# Plasmogram™ Reverso

Plasmogram™ Reverso transforms polymer windows with a unique combination of colours, visible from both sides of the banknote and through the light.

SCAN
FOR VIDEO

# GIVING WINGS TO SUBSTRATES

# LANDQART


## African Dreams Become Reality: Durasafe's® Rise to Global Standard


# FACT BOX

- First launched in 2012 with Morocco's pioneering 25-dirham commemorative note, Durasafe has transformed banknote design worldwide.
- This composite substrate combines a polymer core with cotton layers on top, delivering the tactile feel of paper with the resilience of polymer.
- Its structure enables advanced security features — such as transparent windows, large windows for embedded threads — while remaining compatible with high-speed processing machines.
- Adopted by 10 countries and over 20 denominations by mid-2025, Durasafe circulates across four continents, from Switzerland's low-counterfeit franc series to notes built for Africa's demanding climates in Algeria, Mauritania, Zambia, and Namibia.
- Proven to withstand extreme conditions, it reduces replacement cycles and lowers issuance costs. Durasafe's global success demonstrates that innovation can enhance tradition, offering banknotes that are beautiful, secure, and built to last.

Durasafe® is a name that has become synonymous with banknote innovation and resilience. While most in the industry readily associate the substrate with the award-winning current series of Swiss franc banknotes, fewer recall that its first moment in the spotlight came not from Europe, but from Africa. In 2012, Morocco became the pioneer of a composite revolution when Bank Al-Maghrib issued a 25-dirham commemorative banknote celebrating the 25th anniversary of the founding of Dar As Sikkah. This was the first circulating note printed on Durasafe – and it was a game-changer.


The Moroccan MAD25 note was revolutionary in its design and engineering. It introduced, for the first time ever in a circulating banknote, a security thread encapsulated within a polymer layer, paired with an intaglio-embossed see-through window. What it proved, more than anything else, was that a banknote could combine the familiar tactile qualities of cotton-based paper with the durability and design potential of polymer. It could look, feel, and function like paper — but perform like something far stronger.

The most compelling lesson from Morocco's experience was that these new composite notes could withstand the rigours of circulation in challenging climates and under intensive handling. The embedded thread remained perfectly intact and visible even after extended use. Crucially, the banknotes maintained their compatibility with high-speed processing machines — an operational necessity for central banks and cash centres. This early success laid a technical and psychological foundation of confidence in Durasafe's capabilities.

The momentum continued in 2014 when the National Bank of Kazakhstan became the next central bank to issue a note on Durasafe. Two years later, in 2016, the Swiss National Bank began issuing its 9th series of franc banknotes — all printed on Durasafe. This series has become emblematic of the substrate's potential, combining advanced public security features with an unmatched lifespan. Switzerland's experience has been exemplary: the SNB has reported some of the lowest counterfeiting rates in its modern history, and declared that the notes' performance and durability "meet its expectations" — a typically understated Swiss endorsement.

While Africa, Europe and Central Asia were early adopters, the appeal of Durasafe is truly global. Today, Durasafe banknotes are circulating across four continents, making it the most widely circulated composite substrate in the world. Its success lies in its unique construction: two cotton-paper layers fused together by a polymer core without the use of adhesive. This creates a note that feels familiar, processes like paper, but wears like polymer, and offers design flexibility impossible with either material alone.

Take for instance the Bahamas, where three denominations currently circulate on Durasafe. These notes feature large, transparent windows and modern security threads, adapted to the humid island climate — a demanding environment where paper notes degrade quickly. In the Bahamas, balance of security feature selection (Crane's RAPID thread and MOTION SURFACE foil), durability and user familiarity was key to the central bank's decision to adopt Durasafe.

Africa, the birthplace of Durasafe's story, has now become a focal point for its continued growth. In 2022, the Banque d'Algérie issued a newly designed 2,000 dinar note to commemorate the 31st Ordinary Session of the Arab League Council, held in Algiers. This note was groundbreaking for Algeria, featuring the Kinegram COLORS® thread by KURZ and an blind embossed window shaped in the silhouette of the country itself — a symbolic and technical innovation. The banknote's colour palette echoed the national flag, making it instantly recognizable and well-received by the public. It also marked the first use of Durasafe by Algeria, reinforcing the substrate's growing footprint on the continent.


Following this, in 2023, the Banque Centrale de Mauritanie completed a circulation trial with a 50 ouguiya note printed on Durasafe. The note featured SPARK and G&D's thread, again protected by the polymer in the substrate's structure. Mauritania's trial confirmed the substrate's durability even in extreme desert conditions, with the note retaining its machinereadability and embedded features intact throughout the trial period.

In March 2025, the Bank of Zambia launched a new family of Kwacha banknotes. Of these, the ZMW10 and ZMW20 were printed on Durasafe, each showcasing Crane's RAPID® HD micro-optic thread in a single, striking 27mm-tall window. This use of an oversized, continuous thread window is only possible with a composite substrate like Durasafe, and significantly enhances public authentication by making the security feature highly visible and engaging.

Namibia chose Durasafe — a decision driven by the need for durability in both urban and rural cash cycles. The notes integrate De La Rue's PureImage™ holographic thread, safely embedded behind the polymer layer, along with large blind embossed seethrough windows — a hallmark of the substrate's visual and tactile possibilities.

These African examples underscore a global shift: central banks are increasingly seeking


The most recent endorsement of Durasafe came in July 2025, when the Bank of Namibia launched its upgraded series of Namibian Dollar notes. For the NAD10 and NAD20, solutions that balance public familiarity, security, and durability, especially in challenging environments where banknotes must survive heat, humidity, dirt, and constant

use. Durasafe's proven track record provides the confidence needed for such transitions.
As of mid-2025, Durasafe has been adopted by 10 countries, with over 20 denominations in active circulation and more than 1.5 billion notes issued globally. From the high-speed cash centres of Switzerland to the rural markets of Zambia, Durasafe notes have demonstrated that innovation doesn't have to compromise tradition — it can enhance it.

The advantages of Durasafe go beyond durability and design. By preserving the feel of paper while offering the resilience of polymer, it reduces replacement cycles and thus lowers the overall cost of currency issuance. The large transparent windows and thread integration capabilities expandthe security toolbox available to designers, allowing for multi-layered features that are intuitive for the public and effective against counterfeiters.

At Landqart, we are honoured to be part of this evolution in currency design. With each new adoption, we reaffirm our belief that banknotes can be both beautiful and functional, trusted and secure. The story of Durasafe began in Africa — and it is more than fitting that its most recent milestones have brought it full circle back to the continent where it first proved itself.

From Morocco to Namibia, from Almaty to Zurich, Durasafe is no longer just a promise of what could be. It is the reality of what's possible — and what's working — in the hands of millions around the world every day.

LANDQART AG

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# BP SECURITY

## Blending Tradition and Sustainability in Security Paper

With over 135 years of history, BP Security is a leading producer of specialty and security papers in Latin America. Since 1978, we have supplied Brazil's banknote paper, and through its BP Security brand, exports to over 30 countries.

Operating three paper machines with a capacity exceeding 30,000 tons per year, the company combines tradition, cutting-edge technology, and the application of features such as holographic stripes, iridescent bands, and security threads.

Since 2020, under new leadership, BP Security has strengthened its commitment to sustainable innovation, promoting circular economy by transforming waste into raw materials — uniting technical excellence with environmental responsibility.

### TRAN$FORMA: A CIRCULAR REVOLUTION IN SECURITY PAPER

**Award-winning housenote at HSP Latin America 2025 reinforces BP Security's leadership in sustainable innovation**

The climate crisis demands an urgent transformation in how we produce and consume. In response to this challenge, BP Security — a brand of Blendpaper — joined the **Tran$forma** initiative in partnership with **Casa da Moeda do Brasil**, launching a pioneering circular economy initiative: the reuse of cotton fibers discarded during banknote production to create new paper materials, including high-security substrates.

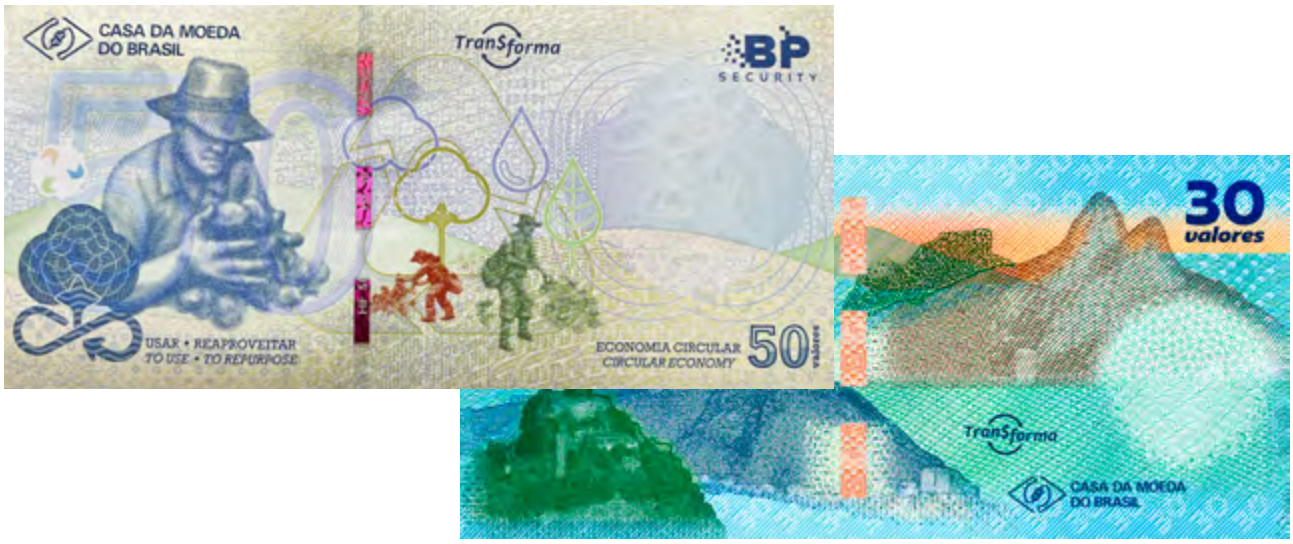
As a showcase of this initiative, the **"Cotton Cycles"** housenote was developed and recognized as **Best Housenote** at the **High Security Printing Latin America 2025** conference in Rio de Janeiro. This recognition marks a significant step toward integrating sustainable practices into the high-security printing industry and reinforces the leadership of BP Security and the Casa da Moeda do Brasil as global references in innovative, environmentally responsible solutions.

The housenote's design celebrates nature's cycles and the vital role of cotton — from cultivation to its transformation into banknotes. The obverse features the farmer, rainfall, and cotton fields, while the reverse highlights waste reuse and the industrial circularity that underpins the Tran$forma concept.

**Technology and innovation driving Sustainability**

One of the project's major technological highlights is the use of a substrate made from recycled cotton fibers recovered from Brazilian banknote production waste. Another innovation is the **Optomove®** security thread, developed by Hueck Folien, made with recycled PET and aluminum — a solution that combines excellent optical performance and enhanced security with a 53% reduction in $CO_2$ emissions compared to conventional materials.

The housenote also incorporates **Ultra-Life™**, an advanced surface treatment technology that extends the paper's durability and resistance — contributing to longer-lasting banknotes.




**Connecting through sustainability: the "Rio de Janeiro" housenote**

Following the success of the "Cotton Cycles" housenote and the hosting of HSP Latin America in Brazil, BP Security — in partnership with the **Casa da Moeda do Brasil, Oberthur, and SICPA** — developed a special edition dedicated to the city of Rio de Janeiro.

Fully aligned with sustainable principles, this new housenote was produced using recycled fibers from the **Tran$forma** initiative and Brazilian sisal fibers, combined with **Highlink™** technology — a natural latex developed by Oberthur that enhances the paper's internal cohesion. The composition also includes mineral oil-free inks supplied by SICPA.

The result is an innovative and environmentally friendly solution that significantly increases the lifespan of banknotes, while reaffirming BP Security and its partners' commitment to circular economy practices and reducing environmental impact.

**Transformation with responsibility**

The recycling process of banknote waste allows for the integration of all existing security technologies — including threads and fibers — without compromising performance on high-speed printing lines. Moreover, it provides a more cost-effective alternative compared to traditional substrate manufacturing processes.

As part of its sustainability commitment, Blendpaper also uses **green steam generated from biomass**, a renewable energy source that substantially reduces the carbon footprint of the production process.

The **Tran$forma** initiative is a concrete example of how sustainable practices can be successfully integrated into the security paper industry — promoting value, innovation, and circularity in every new banknote.

**"Nothing is lost, everything is transformed"** — including the future of banknotes.

BLENDPAPER

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# Smart Materials and the Future of Banknote Security: A New Era in Anti-Counterfeiting


# FACT BOX

- A breakthrough in anti-counterfeiting comes from optically variable fibers that respond to UV light.
- These smart fibers change color within seconds (e.g., blue  green, green  yellow, yellow  red), creating a dynamic, visible shift.
- Unlike conventional fluorescent inks, the effect is stimulus-responsive and fully reversible, making imitation impossible.
- The fibers combine fluorescence and phosphorescence in a single molecule, enabling multi-layered, timed visual effects.
- This allows a banknote to glow in one color when exposed to UV light, then shift to another after a few seconds – a feature that counterfeiters cannot reproduce.
- Manufactured from PLA bioplastic, the fibers are renewable, biodegradable, and fully compliant with EU microplastics regulations.
- They can be embedded in cotton paper or applied to polymer substrates as thin films, offering flexible integration.
- Smart materials deliver covert and overt security, protecting public trust and ensuring the future resilience of cash.

In an age where digital transactions dominate the financial landscape, banknotes remain a cornerstone of trust, tangibility, and identity in economies worldwide. Despite predictions of a cashless society, public trust in physical currency is at an all-time high. Surprisingly, this confidence comes not from frequent scrutiny of notes in circulation, but from the absence of noticeable counterfeit threats. However, this very trust presents both an opportunity and a risk: when the public stops checking notes for authenticity, even rare counterfeits can have serious reputational consequences for issuing authorities.

The most significant weapon against counterfeiters is innovation, particularly in materials science. The industry is currently witnessing a revolution driven by smart materials—technologies that could redefine how we secure and authenticate banknotes.

## CONFIDENCE AND COMPLACENCY: A DOUBLE-EDGED SWORD

The contemporary security environment for banknotes is paradoxical. On the one hand, counterfeit rates are at historic lows. On the other, this success breeds complacency. With users seldom verifying banknotes, any breach in authenticity can go unnoticed and unchallenged.

This risk is amplified by the fact that consumers are not reimbursed for counterfeit cash, unlike digital fraud victims who are typically covered by banks or credit card providers. Therefore, a single lapse in security can have disproportionately large consequences. Maintaining and reinforcing public confidence demands that every banknote issued be unquestionably genuine.

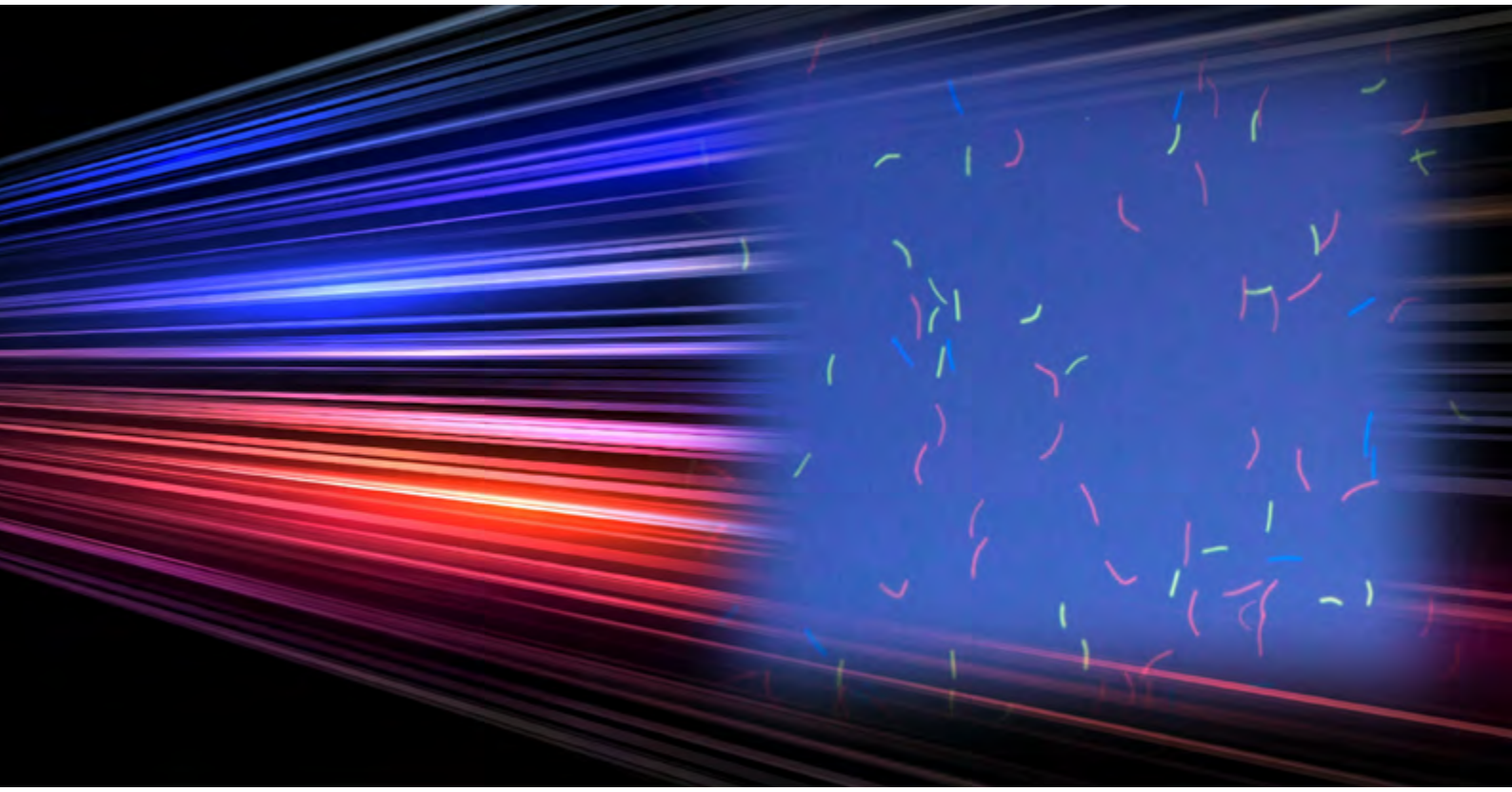
## THE POLYMER PARADOX: PERCEIVED VS. ACTUAL SECURITY

Much of the recent confidence in banknote security stems from the adoption of polymer substrates, which are often promoted as being inherently more secure than traditional cotton or paper-based notes. Polymer manufacturers point to low counterfeit rates as proof of superiority. However, this perception is not entirely grounded in fact.

Data from 2022 reveals that the European Central Bank reported just 12 counterfeit notes per million, outperforming the Bank of England's figure of 22 per million—even though the latter primarily uses polymer substrates. This undercuts the argument that polymer notes are intrinsically more secure.

Moreover, the polymer itself offers little inherent security. Its robustness and water resistance do make notes more durable, but true security is only achieved when combined with printing, windows, holograms, and other applied features. Ironically, polymer note producers now seek to emulate paper notes by introducing simulated watermarks and threads—features long native to paper banknotes.

Even more concerning is the reliance on printed features. As counterfeiters become adept at replicating optically variable inks and holograms, this reliance becomes a weakness. Compounding the issue is the wear and tear of surface-printed features on polymer notes, which often degrade faster than the substrate itself—negating some of the intended benefits of durability.



## EMBEDDED FEATURES: THE STRENGTH OF COTTON AND PAPER

Where polymer falls short, traditional cotton or paper-based substrates still excel. These materials can incorporate embedded security features—fully integrated into the substrate during production and impossible to replicate through surface printing.

These include color-shifting threads, windowed threads, machine-detectable fibers, and UV-reactive taggants. These features offer a level of intrinsic security that polymer cannot match without extensive and costly enhancements.

This highlights a critical point for banknote designers: true security is not just about surface complexity or material strength, but about embedding authentication at the structural level.

## A QUANTUM LEAP: SMART MATERIALS AND OPTICALLY VARIABLE FIBRES

Leading this next generation of intrinsic security are breakthroughs in smart materials. Security Fibres UK, in collaboration with Dr. Alex Romanov and Dr. Alexander Brannan from the University of Manchester, have developed a revolutionary class of optically variable fluorescent fibers that change color under UV light.

Unlike conventional fluorescent inks, which can be mimicked by mixing various dyes, these smart materials exhibit fully reversible, stimulus-responsive luminescence. The visible color shifts—from blue to green, green to yellow, or yellow to red—occur within seconds under 365 nm UV light and cannot be reproduced through conventional methods.


This innovation introduces a level of multimodal authentication previously unseen in the banknote industry. The result is a secure, dynamic material that delivers both overt and covert protection, easily validated with simple tools and impossible to imitate using current counterfeiting techniques.

## MATERIALS INNOVATION MEETS SUSTAINABILITY

The story doesn't end with innovation. Security Fibres UK has also ensured that their new materials meet growing sustainability requirements. The smart fibers are made from polylactic acid (PLA)—a biodegradable, compostable bioplastic derived from renewable resources like corn starch and sugarcane.

This positions the technology as not just a leap in security, but a responsible step forward in environmental stewardship. It also ensures compliance with recent EU regulations restricting intentionally added microplastics, such as Regulation (EU) 2023/2055.

The smart materials can be applied not only as fibers embedded in paper but also as thin extruded films. These can be hot-stamped or laminated onto polymer or cotton substrates and overprinted with conventional inks or foils to create latent images and color-changing patterns. This flexibility allows for application across all major banknote types and substrates.

## FLUORESCENCE AND PHOSPHORESCENCE: A UNIQUE DUAL FUNCTIONALITY

The true magic of these smart materials lies in their unique optical behavior. Unlike blended inks that rely on mixtures of fluorescent dyes, these new compounds exhibit both fluorescence and phosphorescence in the same molecule. This dual-functionality allows for complex, layered visual effects—unmatched in existing security inks.

This means one fiber or film can have multiple, distinct responses to UV light, offering additional layers of authentication. For example, a banknote could exhibit a certain glow when first exposed to UV light and then shift to a different color after a few seconds. This timed response is virtually impossible to replicate without the proprietary materials and techniques developed by Security Fibres UK and the Romanov group.

## LOOKING FORWARD: THE PATH TO ADOPTION

The path from lab to banknote is never short, but this collaboration is already well on its way. The materials have been presented at industrial conferences and are progressing through the EPSRC's iCURE programme, which supports commercial translation of academic research. With this momentum and growing interest from banknote producers, these smart materials are poised to become a foundational element in the next generation of currency.

By embedding dynamic, visually compelling, and structurally integrated features into banknotes, issuing authorities can stay ahead of counterfeiters, protect public trust, and reinforce the relevance of cash in a digitizing world.

## CONCLUSION

As the battle against counterfeiting becomes ever more sophisticated, so too must the tools we deploy. The advent of smart materials—combining the best of chemistry, optics, and sustainability—offers a transformational leap forward. With innovations like reversible UV-reactive fibers and sustainable bioplastic substrates, the future of secure, trusted, and environmentally conscious banknotes is not just imaginable—it is already here.

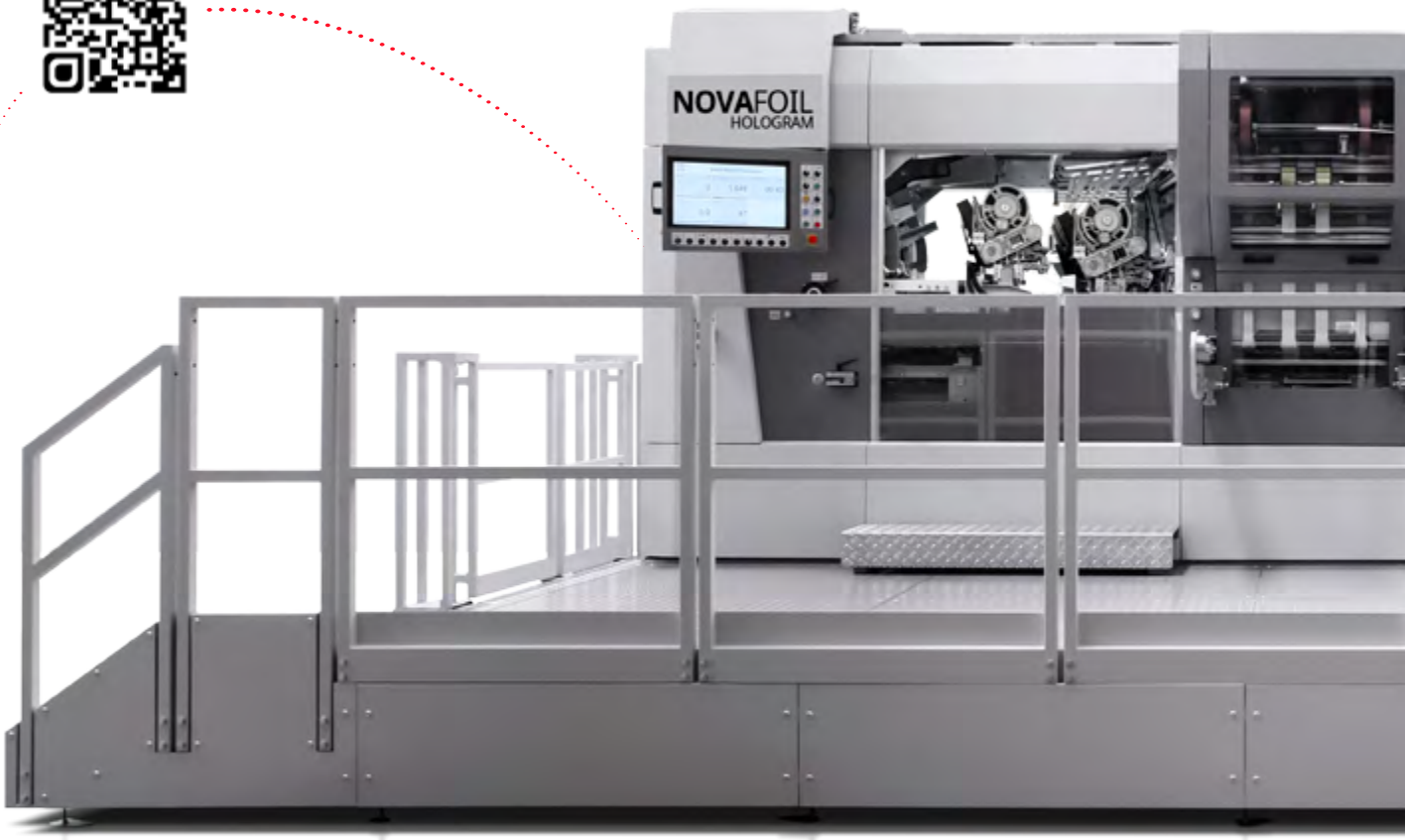
SECURITY FIBRES LTD.

Mr. Gary Spinks
Email: gary@securityfibres.co.uk
Website: www.securityfibres.com

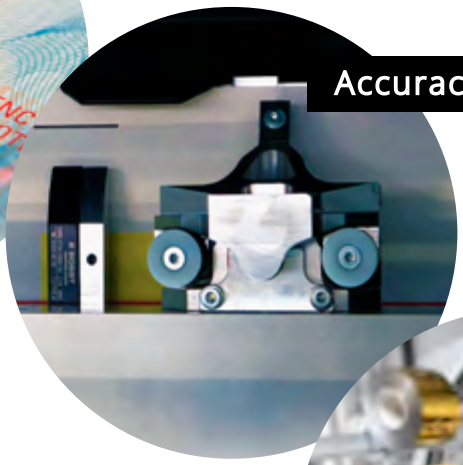
# **Unique hologram** application

The **NOVAFOIL 106 H** features a specially engineered hot stamping transfer section designed to deliver longer dwell time, even temperature and higher stamping pressure, for exceptional embellishment quality. Across the 106 width, up to 10 dedicated hologram modules - equipped with individual reel registers, motors and brakes - work together with the non-sheet-contact ACCUREGISTER system to guarantee outstanding application precision.

Discover highly efficient and adaptable hologram application, tailored to your needs:




Quality



Accuracy

Productivity


BOBST


# Q&T HI-TECH POLYMER COMPANY LIMITED

Shaping the future of greener, smarter, and more secure banknotes

# FACT BOX

- Vietnam-based Q&T is a rising global supplier of a durable, secure, and sustainable polymer banknote substrate
- POLYSECURE® substrate offers low spoilage, ink savings, and extended circulation life—proven under Vietnam's harsh climate.
- POLYSECURE® SHIELD is the world's first polymer substrate with fully embedded OVDs, protecting security features from wear.
- Supports central banks with design, R&D, onboarding, and lifecycle monitoring.
- Combines innovation and sustainability to lower lifecycle costs and increase note security and durability.

## COMPANY OVERVIEW: INNOVATION FROM THE HEART OF SOUTHEAST ASIA

In the ever-evolving world of high-security printing, Q&T Hi-Tech Polymer, headquartered in Hanoi, Vietnam, has rapidly emerged as a pioneer in polymer banknote substrate technology. In just a few years, Q&T has earned global attention by delivering cutting-edge, field-proven solutions that meet the most demanding requirements of central banks.

Backed by a strong portfolio of ISO certifications (9001, 14001, 27001, 45001), Q&T combines process discipline with breakthrough R&D to deliver next-generation polymer substrates that are more durable, secure, sustainable, and cost-effective.

Proven Track Record: A Trusted Partner in a Demanding Market Vietnam's harsh, high-humidity environment—combined with a cash-reliant economy of over 100 million people—poses one of the toughest durability tests for any banknote substrate. Since entering this space, Q&T has consistently demonstrated performance and reliability, having won seven consecutive international polymer substrate tenders from the State Bank of Vietnam over competition with other respected suppliers in technical and financial aspects.

This success affirms POLYSECURE® as a trusted benchmark for quality, durability, and cost-efficiency—and now serves as a launchpad for global expansion.

## POLYSECURE®: ENHANCED DURABILITY, REDUCED WASTE, CUSTOMIZABLE PERFORMANCE

Built on Q&T's in-house R&D platform, POLYSECURE® is a multi-layered, high-performance polymer substrate engineered for real-world resilience.

Its superior material properties translate into measurable benefits for printworks and issuing authorities:

**Lower Spoilage Rate:**
Consistent surface quality and higher ink adhesion significantly reduce print defects.

**Lower Ink Consumption:**
Optimized ink receptivity minimizes ink usage without compromising print quality.

**Extended Circulation Life:**
Proven resistance to UV exposure, crumpling, folding, thermal shocking, chemical attacks, and surface wear, as verified by UnderCurrency durability assessment.

**Customizable Physical Properties:**
Central banks can specify parameters such as:

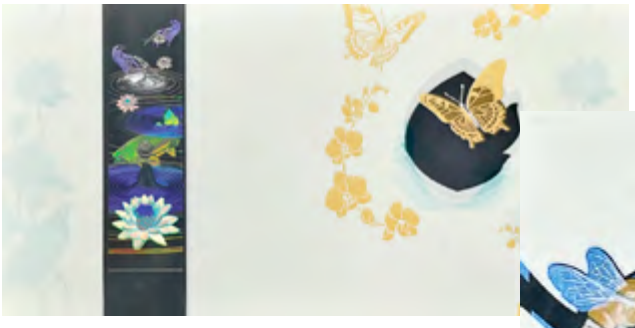
- Whiteness and opacity for vivid print and reduced show-through
- Smoothness for high-speed print accuracy, reduce and unify ink consumption while maintaining consistent color and quality.
- Stiffness and thickness to match cotton-based notes, ensuring familiar tactile feel.

These characteristics enable tailored performance and cost efficiency, empowering issuers to optimize for their own printing systems, ATM compatibility, and user preferences.

## THE EVOLUTION TO POLYSECURE® SHIELD

While POLYSECURE® offers excellent surface durability, surface-applied security features remain exposed to abrasion, friction, and environmental degradation—eventually wearing down even if the substrate remains intact.

To address this critical vulnerability, Q&T developed its latest flagship innovation:



## POLYSECURE® SHIELD – EMBEDDED PROTECTION. ELEVATED SECURITY.

Unveiled at the 2025 Currency Conference in Bangkok, POLYSECURE® SHIELD is the world's first polymer banknote substrate that fully embeds an Optical Variable Device (OVD) into the core of the substrate.

This breakthrough dramatically reduces feature degradation, extends note life, and minimizes the need for early withdrawal—lowering cost per note for central banks.

## ADVANCED FUNCTIONALITIES BUILT IN

In addition to embedded OVDs, POLYSECURE® SHIELD supports a suite of high-end security features:

- **White Opacifying Ink:** Q&T's proprietary formulation enhances visual contrast and reduces see-through
- **Magnetic Stripes:** For machine-read authentication

### WHAT IS POLYSECURE® SHIELD?

| CATEGORY | DETAILS / DESCRIPTION |
|---|---|
| **Substrate Type** | Advanced multi-layer polymer substrate |
| **Core Features** | • Embedded OVDs (Optically Variable Devices) applied via hot stamping or UV cast-and-cure, fully laminated into the polymer core<br>• Full design flexibility with overprint capability<br>• Protection against abrasion, chemicals, and crumpling |
| **Advantages over Surface-Applied Features** | Surface Foil: prone to wear, scratches, and potential early future failure Embedded Foil: shielded from damage, maintaining brilliance and security throughout the note's life |
| **Key Benefits for Central Banks** | • Reduces degradation of security features<br>• Extends note lifetime<br>• Minimizes early withdrawal<br>• Lowers overall cost per note<br>• Enhance counterfeiting resilience |

## SUSTAINABILITY AS A STRATEGIC IMPERATIVE – Q&T'S INTEGRATED APPROACH

| SUSTAINABILITY PILLAR | ACTIONS & FEATURES | IMPACT / BENEFIT |
|---|---|---|
| **1. Lower Ink, Lower Energy, Lower Carbon** | • Enhanced ink adhesion > less pigment needed for full coverage<br>• Uses 100% electric heating (no oil/steam)<br>• Factory in Hanoi partially powered by solar and hydro energy | Lower carbon footprint from less energy, longer note life, and fewer reprints |
| **2. Industry-Leading Solvent Recovery** | • Closed-loop process recovers and reuses 90%+ of solvents<br>• Avoids traditional thermal oxidization | • Avoids thousands of tons of $CO_2$ annually |
| **3. End-of-Life Recycling** | • Waste and unfit notes are fully recyclable<br>• Materials are repurposed for non-currency applications | Minimizes environmental impact and landfill usage |
| **Integrated Commitment** | Q&T is currently the only known substrate manufacturer combining:<br>• Solvent recovery<br>• Renewable energy<br>• Full material recyclability | • A truly circular and responsible substrate lifecycle |

- **Iridescent Ink:** Produces color shifts upon tilting
- **Secureshade™:** A watermark-like feature visible in transmission
- **Securegravure™:** A high-fidelity printed polymer window, visible from both sides
- **LOF (Laser Optical Feature):** A covert diffractive feature visible only under pinpoint light sources like smartphone flashlights

Together, these enable central banks to design multi-layered, overt and covert authentication systems—backed by durability that ensures these features survive in real-world conditions.

## SUSTAINABILITY AS A STRATEGIC IMPERATIVE

Q&T doesn't treat sustainability as an add-on. It's built into the entire substrate lifecycle—from formulation to disposal:

Q&T combines solvent recovery, renewable energy, and material recyclability at this scale.

## BUILT FOR GLOBAL CURRENCY MODERNIZATION

From field performance to feature customizability, Q&T has earned recognition as a fast-moving, highly capable substrate partner. Beyond supplying material, Q&T supports central banks and printworks with:

- Technical onboarding and customization
- Banknote design collaboration
- Ongoing performance monitoring
- Joint R&D and prototype testing

As banknote security and ESG requirements grow more complex, Q&T offers not only the product, but also the partnership to meet them.

## CONCLUSION: THE FUTURE IS EMBEDDED. SECURE. SUSTAINABLE.

Q&T Hi-Tech Polymer is at the forefront of currency innovation. From POLYSECURE® to the game-changing POLYSECURE® SHIELD, Q&T is redefining how polymer substrates perform, protect, and preserve value—both economically and environmentally.

For central banks seeking to elevate durability, strengthen security, reduce environmental impact, and lower total lifecycle costs, Q&T delivers a proven, future-ready solution.

Q&T HI-TECH
POLYMER COMPANY LIMITED

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Website: www.qt-hitech.com

luminochem
Bright marking solutions

# The Global Manufacturer of UV Fluorescent Pigments for Security Printing

**Luminochem is the leading dedicated manufacturer of UV fluorescent pigments and dyes — purpose-built for high-security printing applications. We support ink manufacturers and security printers worldwide with consistently high-quality pigments, strategically maintained inventory for rapid order fulfillment, and a flexible, customer-first approach that adapts to each client's specific packaging and delivery needs.**

## Invisible in daylight. Brilliant under UV.

Our pigments deliver unmatched fluorescence intensity, with exceptional chemical resistance and lightfastness. Available in a diverse palette — from brilliant whites to deep reds, rare purples, and signature oranges.

## Driven by Science

Our in-house R&D team develops custom-engineered UV fluorescent pigments for security applications where durability and precision are non-negotiable. From pigment design to performance optimization, we tailor every product to meet our clients' exacting protection standards.

## Security Applications

Luminochem pigments are used to protect the world's most secure documents — from banknotes and passports to tax stamps, ID cards, and secure certificates — in applications where anti-counterfeiting performance and compliance are mission-critical.

## Trusted. Proven. Secure.

Formulated to protect. Engineered to perform.

***Not working with us yet?***

- Request your free pigment sample — and experience the quality.
- Or tell us your most specific pigment requirement — and we'll find a solution.


COVESTRO
Redefining currency with Autentium®, a new class of polymeric printing substrates for the future of banknote printing

# FACT BOX

- With its vision of becoming fully circular, Covestro is transforming towards an alignment with circular economy principles and utilizes alternative raw materials, innovative recycling and collaboration with various stakeholders.
- Covestro is one of the leading suppliers of polymeric substrates for secure identification documents (IDs) and has more than 40 years of experience in developing innovative materials for high-secure IDs.
- Now, the company is using its many years of experience with IDs in conjunction with its innovative thermoplastic polyurethane materials and applying them to the banknote printing technology to develop a unique polymer substrate in its own class: Autentium®.
- Autentium® is designed exclusively for currency printing solutions. It offers excellent printability, durability and enables enhanced security features while recyclable.
- Autentium®'s advanced properties make it an ideal material choice for banknotes, demonstrating high-quality tactility, color brilliance and extended longevity in circulation which ensures the integrity of printed currency.

## THE NEED FOR NEW MATERIALS IN BANKNOTE PRINTING

Counterfeiting, wear and tear, and negative environmental impact are among the key challenges of modern currency printing. New innovative materials can contribute to an evolution in the development of printed banknotes and preserve the integrity of a national currency.

Integrity in the context of currency refers to the overall trustworthiness, authenticity, and reliability of a nation's money, particularly its physical banknotes and coins. It is a critical concept that underpins the functioning of a stable and secure financial system. Currency integrity ensures that money is not only genuine but also resistant to counterfeiting, durable in everyday use, and consistently recognized and accepted by the public.

One of the primary aspects of currency integrity is authenticity. Banknotes must be easily distinguishable from counterfeits, which is achieved with advanced security features such as watermarks, holograms, color-shifting inks and tactile- and microprinting. These features make it difficult for counterfeiters to replicate notes and help the public and financial institutions verify their legitimacy.

Security is another vital component. A secure currency deters criminal activities such as forgery, money laundering, and fraud. By incorporating cutting-edge technology into banknote design, central banks can stay ahead of counterfeiters and protect the economy from the destabilizing effects of fake currency.

Durability also plays a role in maintaining integrity. Banknotes must withstand frequent handling, folding, and exposure to various environmental conditions. Durable notes reduce the frequency of replacement, thereby lowering production costs and ensuring that the currency remains in good condition for longer periods.


PASSPORT BOOKLET CONCEPTS ENABLED BY TPU FILMS. © COVESTRO

MEDICAL-GRADE TPU FILMS FOR ADVANCED WOUND CARE. © COVESTRO

Moreover, public confidence in the currency is essential. When people trust that the money they use is legitimate and holds its stated value, they are more likely to engage in economic transactions. This trust is foundational to a functioning economy and is closely tied to the perceived integrity of the currency.

Finally, maintaining the integrity of banknotes contributes to a country's international reputation. A secure and reliable currency reflects economic stability and governance, which can influence foreign investment and trade relations.

In summary, currency integrity is crucial for preventing counterfeiting, ensuring economic stability, supporting law enforcement, fostering public trust, and upholding a nation's financial credibility. It is a cornerstone of modern monetary systems and a key responsibility of central banks worldwide.

Innovative polymers and new synthetic materials are solutions that address the key challenges of modern currency printing and ensures its integrity.

However, the concept of polymer banknotes is not new and debuted in the late 1980s. Back then, their modern design allowed for the incorporation of new security features, which had previously been impossible with paper. Over time, countries like Australia, Canada, and the United Kingdom have fully transitioned to polymer banknotes as their primary currency medium. Despite this progress, today most banknotes worldwide continue to be made from paper and cotton composites, but they have inherent limitations such as a comparably short lifecycle and limited recyclability.

By utilizing Covestro's successful track record as a leading supplier of materials for secure identification documents, the company is combining its experience in secure ID applications and modern engineered polymer knowledge to address the challenges of today's currency printing.

This took Covestro a step further in the direction of new types of polymeric materials for value printing – different from what the

SKIN-FRIENDLY FILM SOLUTIONS FOR SPORTSWEAR AND DEMANDING OUTDOOR APPAREL. © COVESTRO

industry has been using for a millennium. The polymer solution belongs to the family of thermoplastic polyurethanes (TPUs) and provides many benefits, making it an ideal material for currency printing.

## TRANSFORMING BANKNOTE MATERIALS WITH THERMOPLASTIC POLYURETHANES

TPUs are versatile polymers featuring desirable properties such as tailored hardness and stiffness, tear resistance, abrasion resistance and low electrostatic charge. TPUs consist of linear segmented block copolymers composed of hard and soft segments, contributing to their unique physical properties. The chemistry of TPU can be tailored to enable customized features like surface finishes, colors and mechanical properties to create a unique solution serving customer and user needs.

Because of their versatility, TPUs are used in numerous applications, affecting all our daily lives. For example:

- Medical TPU-grades are non-toxic and hypoallergenic, which makes them perfect for breathable, comfortable wound dressing. Their molecular structure provides good resistance to acids, alkalis, and other harsh chemicals, making them suitable for medical devices that require sterilization.

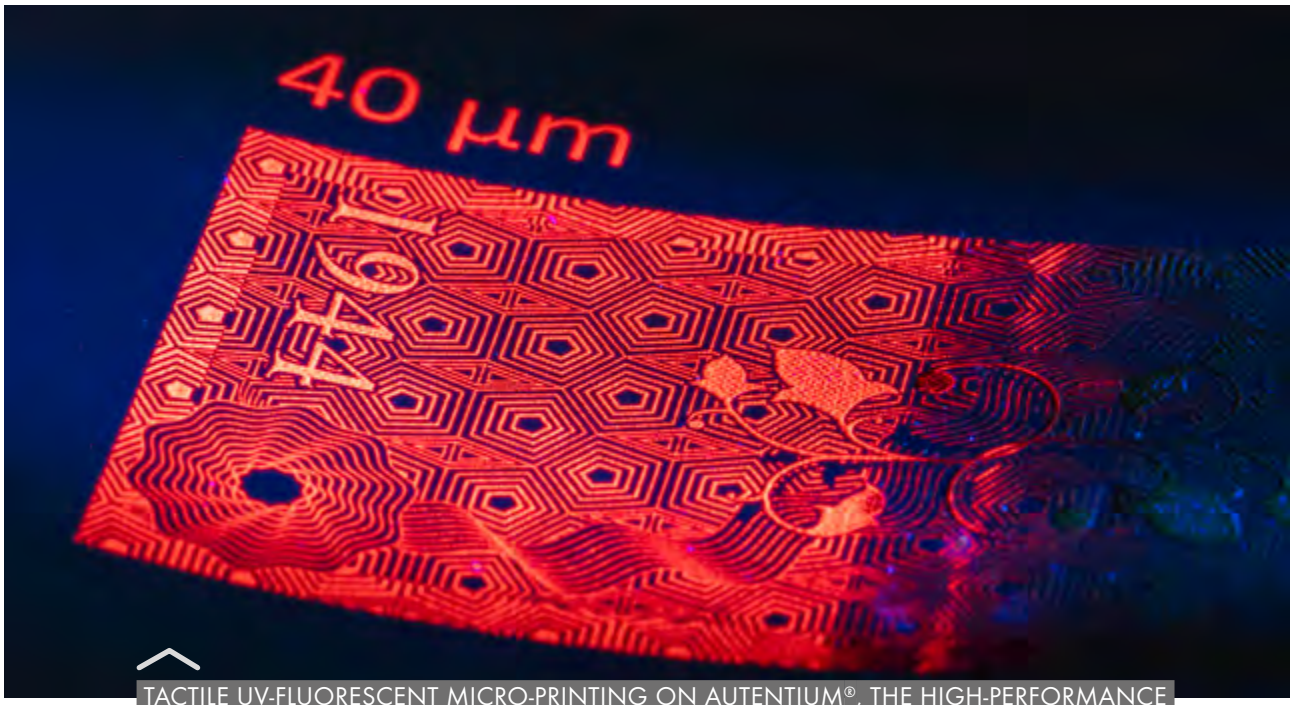
- TPU is also used in industrial applications in more rugged conditions, for example as timing belts which are subject to high loads.

- In the automotive industry, the material again shows its versatility in a variety of uses. It can be applied as an abrasion and UV-resistant film for coating protection as well as for beautiful interior parts with soft and textured surfaces and even as a synthetic leather, providing pleasant haptics and aesthetics.

- Looking at even more everyday things, TPU is broadly used in apparel, sports and leisure goods. Shoes, yoga pants, balls and smart phone cases represent only a small selection of all the applications that benefit from the design freedom, functionality and longevity of the material.



INNOVATIVE TIMING AND CONVEYOR BELT SOLUTIONS WITH COVESTRO'S TPU FILMS. © COVESTRO




TACTILE UV-FLUORESCENT MICRO-PRINTING ON AUTENTIUM®, THE HIGH-PERFORMANCE POLYMER SUBSTRATE FROM COVESTRO. © COVESTRO

The properties that make TPU films suitable for so many diverse industries and applications also make them highly attractive for banknotes, helping to ensure they are durable, secure and resistant to the rigors of daily use.

## AUTENTIUM®: SETTING NEW STANDARDS IN BANKNOTE SECURITY WITH POLYMERIC TECHNOLOGY

To address the challenges of today's currency printing and in response to the growing demand for more sustainable solutions, Covestro is introducing Autentium®, a recyclable polymer substrate designed specifically for banknotes.

Autentium® has several unique features that set it apart in currency printing.

The TPU composition offers exceptional printability, making it compatible with standard security printing inks and with all relevant technologies, including offset, intaglio, silk screen and flexographic printing. Its polyurethane-typical high surface energy contributes to excellent ink receptivity and ink adhesion, eliminating the need for additional primers or varnishes. This streamlines the printing process and improves durability.

However, varnishes or other surface treatments can still be applied to provide additional functionality.

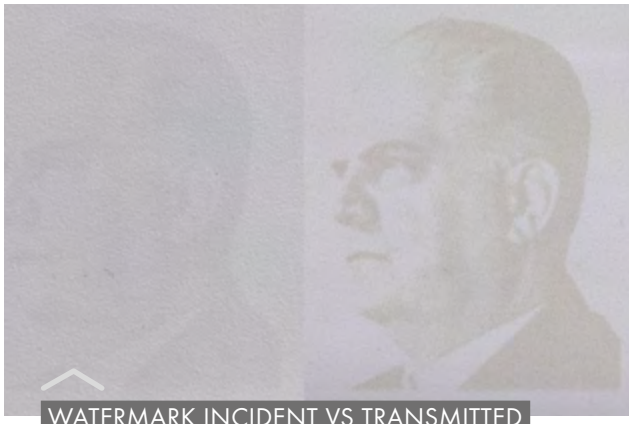
Autentium® is inherently white-opaque, with the option for other colors on demand. The colors and opacities are integrated during substrate production, inside of the polymer matrix, rather than applied on top. This composition eliminates the need for opacifying coatings or pretreatments before security printing, improving the abrasion resistance of the printing.

One of its standout qualities is the customized embedding of images inside the material by selectively manipulating optical density, inspired by traditional paper watermarks. These watermark features offer high resolution and fine details, producing grayscale images with excellent contrast. They remain low visibility under incident light but reveal a clear and strong image in backlight.

Another key feature is its blind embossing ability, which allows for high embossing depths in intaglio printing. This results in sharp corners and high resolutions that remain durable even after offset overprinting. The achievable embossing depth exceeds the possibilities of current solutions significantly. Autentium® stands out for its exceptional combination of flexibility and durability. These properties deliver high tear resistance and prevent tear propagation while maintaining isotropic material behavior—meaning mechanical properties remain consistent in all directions. This unique characteristic allows for the integration of complex-shaped windows with sharp corners through punching or cutting processes.

The TPU molecules in Autentium® feature natural polarity that enables moderate moisture absorption. This quality prevents

THE INTEGRATION OF COMPLEX-SHAPED WINDOWS WITH SHARP CORNERS THROUGH PUNCHING OR CUTTING PROCESSES, ENABLED BY AUTENTIUM®. © COVESTRO



WATERMARK INCIDENT VS TRANSMITTED LIGHT. © COVESTRO

BLIND EMBOSSING ENABLES DEEP, SHARP, AND DURABLE IMPRESSIONS, OUTPERFORMING CONVENTIONAL INTAGLIO TECHNIQUES. © COVESTRO

electrostatic charge buildup, ensuring clean and consistent processing. Furthermore, Autentium® readily accepts laser marking, making it possible to incorporate serial numbers or micrographics that enhance document security features.

## SUSTAINABLE AND DURABLE FOR MODERN BANKNOTE PRODUCTION

As a thermoplastic mono-polymer compound, Autentium® is recyclable, addressing the demand for sustainable materials in banknote production. Currency, made of Autentium® can be thermo-mechanically recycled, ensuring a high purity of polymer recyclate and a low amount of foreign materials, as the substrate holds only inks and patches. In other words, as there is no need for additional opacifiers, primers and varnishes, the quality and purity of Autentium®'s polymeric material remain high.

Its high tear propagation resistance and excellent ink adhesion contribute to an extended printed currency lifespan, which, in turn, can help reduce the environmental impact and conserve resources.

Furthermore, its durable composition can translate into long-term cost savings by minimizing replacements, making it an ideal choice for governments and the public sector that prioritize security and environmental responsibility.

## CONCLUSION

Counterfeiting, durability and environmental impact are very real issues facing modern currency. Fortunately, as the demands facing today's banknote industry continue to evolve, so does materials technology and innovation. Autentium® is a new material that stands out as a mono-polymer substrate exclusively designed for currency printing solutions. It offers excellent printability and durability, improved security against counterfeiting and simplified recycling. More than a material breakthrough, it's a significant step forward in the effort to advance innovations in banknote printing that instill public confidence while addressing other important industry priorities.

COVESTRO

Mr. Daniel Hentschel
Email: daniel.hentschel@covestro.com
Website: https://solutions.covestro.com/en/brands/autentium

RECYCLABLE. DURABLE. SUSTAINABLE. AUTENTIUM® SETS A NEW STANDARD FOR BANKNOTES. © COVESTRO


# GIVING WINGS TO INK

# LUMINESCENCE SUN CHEMICAL SECURITY

## Enhancing Banknote Design: The Role of Colour in Banknote Design.

# FACT BOX

- A member of the DIC Group: we are the World's Leading Provider of Inks, Pigments and Advanced Materials.
- Proven Excellence: Our inks are qualified and trusted for currency printing by many central banks and currency printers globally, reinforcing our reputation as a top-tier supplier in the industry.
- Responsive and Supportive: At LSCS, we pride ourselves on global supply with local support. With our global reach, we offer personalised, in-person support to all our customers, ensuring they receive timely and effective Security Solutions from our experience team of technicians.
- Compliance and Ethics: We are fully compliant with BNEI and ISO 37001 standards, underscoring our commitment to ethical business practices and the highest standards of anti-bribery management.
- Versatility in Product Offering: Beyond banknote inks, LSCS also provides high-security inks and security solutions for other critical documents such as passports, ID cards, and tax stamps, making us a versatile partner in document security.
- Inspiring Confidence: Our mission is to inspire confidence in every interaction and product delivery, ensuring our customers can trust in the security and quality of their most critical documents.

## INTRODUCTION

Colour plays a crucial role in banknote design, serving both functional and aesthetic purposes. Beyond its visual appeal, colour is a key aspect of banknote security, helping to prevent counterfeiting while ensuring easy recognition and usability. Different colours carry cultural and psychological significance across regions, influencing the way banknotes are perceived and trusted by the public. Luminescence SCS, a global leader in security printing solutions, is at the forefront of innovation in this space, providing advanced colour technologies for banknotes worldwide.

## UNDERSTANDING COLOUR

Colour is more than just an artistic choice; it is an essential element of security and functionality in banknotes. The selection of hues, tones, and shades influences recognition, accessibility, and security. A well-designed banknote incorporates a carefully chosen colour palette that aligns with the issuing country's identity and deters counterfeiting through advanced printing techniques.

LSCS VIBRANT COLOUR RANGE

## THE IMPORTANCE OF COLOUR IN BANKNOTES

## SECURITY AND ANTI-COUNTERFEITING MEASURES

Colour is a fundamental aspect of security in modern banknotes. Advanced printing methods, and the use of specialised features such as colour-shifting inks and UV-reactive pigments, make counterfeiting more difficult. These elements add layers of security that are easily recognizable by the public while being extremely difficult to replicate.

## PUBLIC RECOGNITION AND USABILITY

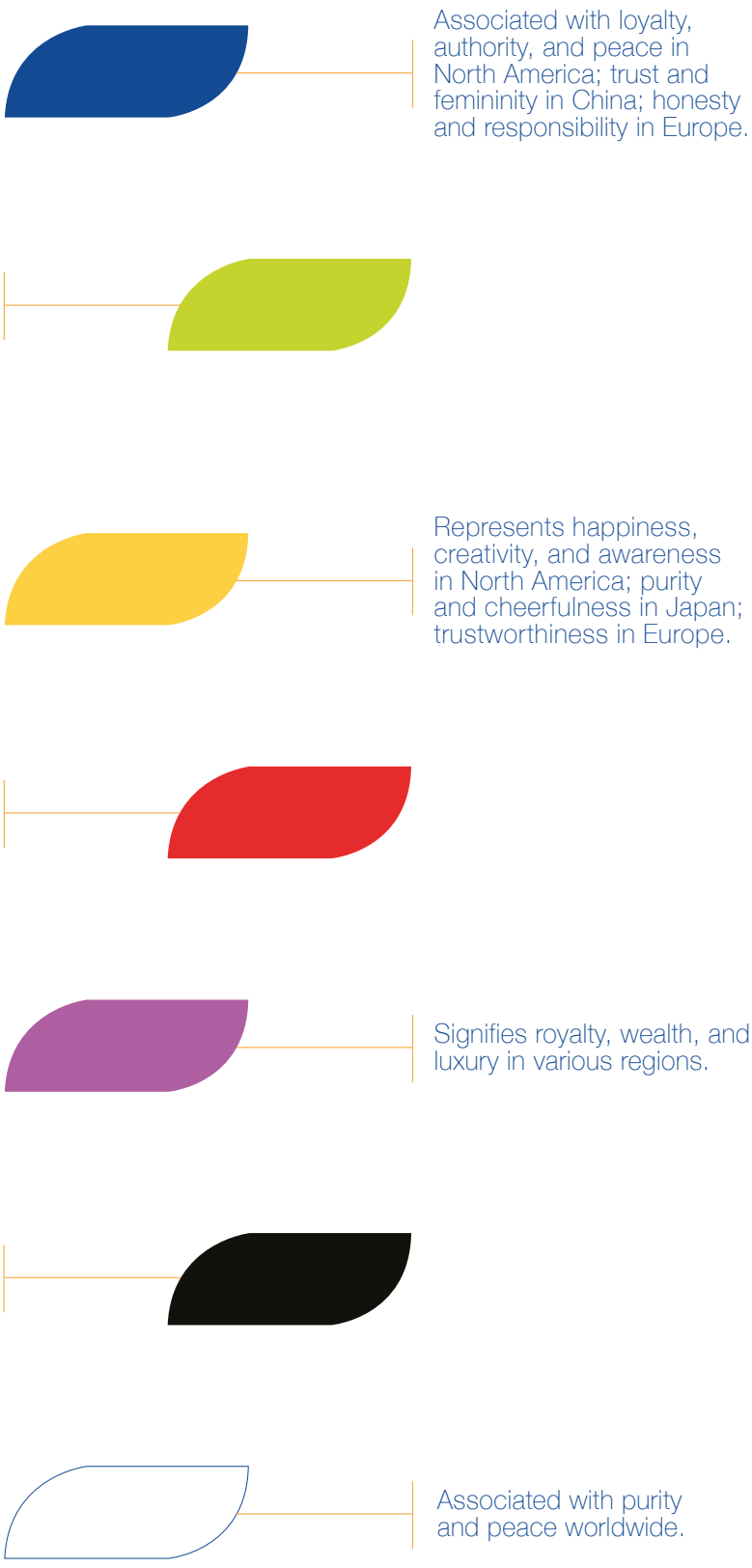
Distinct colour schemes help individuals quickly differentiate between denominations. Many countries use consistent colour coding across different currency series to enhance familiarity and prevent confusion.

## CULTURAL AND REGIONAL SIGNIFICANCE

Colours have deep cultural meanings that vary by region. Banknote designs often reflect national identity, historical events, and local traditions through their colour schemes. Understanding these associations is crucial for central banks and designers.

## THE IMPORTANCE OF COLOUR IN BANKNOTES

Each colour carries specific meanings that influence how a banknote is perceived. The psychology of colour varies by region, impacting trust, value, and recognition. Here are some key colour associations across different parts of the world:




COLOUR MAP - PSYCHOLOGY OF COLOUR

## TRENDS IN BANKNOTE COLOURATION

### Representing national identity and heritage

Central banks often use colours that reflect national symbols, historical events, or prominent figures. This approach strengthens the public's connection to their currency.

### The role of Luminescent and specialized inks

Modern banknotes use intricate multi-colour patterns, microprinting, and advanced security elements such as holograms and threads to enhance security while maintaining aesthetic appeal. These innovations make it increasingly difficult for counterfeiters to replicate genuine banknotes.
Security printing has evolved to include specialised Inks, such as:

- UV-visible inks that reveal hidden security elements under ultraviolet light.
- Colour-shifting inks that appearance based on viewing angles.
- Infrared-absorbing inks that enhance machine readability for authentication.

Bi-fluorescent Inks bring another dimension to banknote security as they fluoresce in two distinct colors when exposed to different wavelengths of ultraviolet (UV) light. Originally longwave 365nm UVA and shortwave 254nm UVC excitation wavelengths were used but UVC can be harmful to health.

At Luminescence SCS, we have recently expanded our range of Helio Switch inks. These Inks fluoresce in two distinct and contrasting colours when exposed to different wavelengths of long-wave UV light. The UV light wave lenghts used are only about 25 nm apart on the UV spectrum, which makes this feature unique and extremely difficult to replicate. Originally supplied as inks which are invisible in daylight, coloured Inks are now also available to complement banknote colour schemes. This enables increased layering and combining within a banknote design to add extra security and more vivid UV fluorescent effects.

### Innovations in multi-colour security features

Modern banknotes use intricate multi-colour patterns, microprinting, and holographic elements to enhance security while maintaining aesthetic appeal. These innovations make it increasingly difficult for counterfeiters to replicate genuine banknotes.

## LUMINESCENCE SCS: A LEADER IN SECURITY INKS

### Global presence and expertise

With facilities in the UK, France, US and Brazil, Luminescence SCS is a trusted partner for banknote printers worldwide. As part of Sun Chemical's security division, Luminescence SCS maintains the highest level of security and control, ensuring reliable and advanced ink solutions for banknote production. Our dedicated global technical and sales teams provide expert support at every stage, delivering seamless collaboration and tailored solutions for our customers across the globe.

### Cutting-edge security solutions

Luminescence SCS offers a broad range of security inks and printing solutions designed to enhance the durability and security of

banknotes. By integrating luminescent pigments, infrared detection, and colour-shifting technologies, the company ensures that banknotes remain both functional and secure across all major printing technologies.

## LUMINATING THE WAY

The strategic use of colour in banknotes is essential for security, usability, and national representation. As counterfeiting threats evolve, innovations in colour-based security features will continue to play a critical role in safeguarding currency. Luminescence SCS remains at the forefront of this industry, developing cutting-edge solutions that blend science, security, and design to create the next generation of banknotes.

LUMINESCENCE
SUN CHEMICAL SECURITY

Mr. Jamie Ashley
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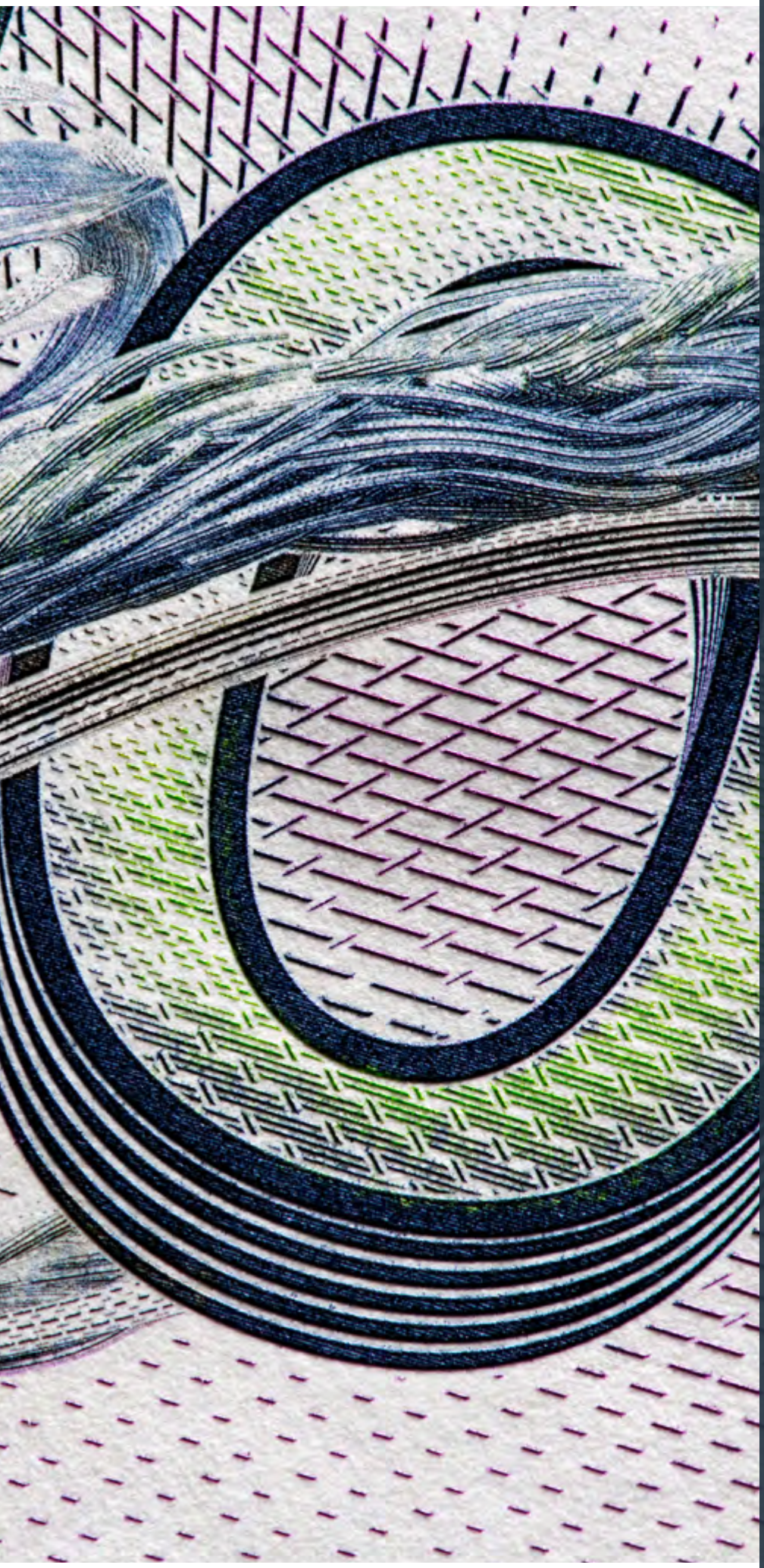
Website: www.luminescence-scs.com

HIGH DEFINITION OFFSET AND INTAGLIO INK


SICPA
High Security Printing
with Intaglio



# FACT BOX

- SICPA is a trusted global security partner to central banks and high-security printers. For over seven decades, SICPA has established itself as a leading developer and supplier of security ink technologies, protecting the majority of the world's banknotes from the threats of fraud and counterfeiting.

- Intaglio printing is one of the oldest printing processes, and reserved exclusively for the use of high security documents.

- We have played a part in the creation of intaglio inks and the development of their security features for several decades.

- Intaglio inks bring colour and nuances to the full expression and depth of banknote design, becoming the backbone of banknotes.

## INTAGLIO PAST, PRESENT & FUTURE

To better understand the role that intaglio has played, and continues to play, in high security printing, we have interviewed an expert, our very own Intaglio Lab Manager, here at SICPA, Olivier Lefebvre.

## WHAT IS INTAGLIO?

Intaglio printing is the process of carving a design into a plate, creating texture and depth through repeated engraving, then applying ink to the plate which will be transferred onto a substrate. It was fully utilised in an artistic format in the early 1500s, with Albrecht Dürer becoming the leading figure, raising its status from craftmanship to art.

## HOW DID INTAGLIO BECOME A PRINTING PROCESS FOR BANKNOTES?

Due to its sophistication and technicality, it became the exclusive printing process for central banks in the 19th century and was eventually recommended by Interpol in 1969. Whilst it was originally fully made and operated by people, mechanical printing and automation was developed in the 1940s, simplifying, and speeding up the production.

## WHEN DID SICPA GET INVOLVED?

SICPA was involved early on, in the production of intaglio printing inks, with the first being used in 1948 on the Spanish Peseta banknotes. Since then, SICPA has continued to develop intaglio inks, providing more versatility, security, and durability to banknotes globally.

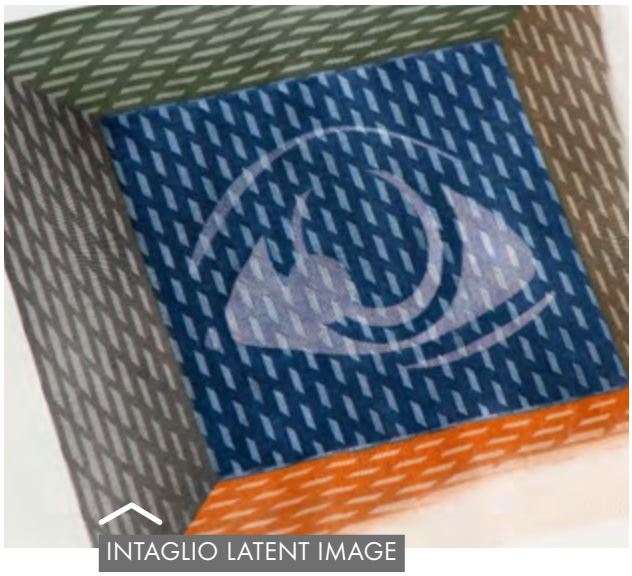
## HOW DO INTAGLIO INKS ALLOW YOU TO AUTHENTICATE BANKNOTES?

At SICPA we have created and identified four dimensions of security in intaglio, each with their own authentication methods and processes.

**Human Verification**

This is the first basic and intuitive method that any member of the public can perform. There are two key elements to look out for.

Texture: Intaglio demonstrates unique tactile properties; it creates the unmistakable banknote feel that everyone instantly recognises. The distinctive sensation provides a fast, automatic signal to the brain that is used to establish authenticity. It is also thanks to the layers of ink and depth of engravings that intaglio fosters inclusivity:



INTAGLIO LATENT IMAGE

the tactile marks are easy to identify by the visually impaired, simply by touch.

Colour: Intaglio inks display vibrant and deep saturated colours, providing opportunities for security and complex designs that are instantly verifiable by the public. They are printed in thick layers and can therefore produce shades of light and dark, creating high-definition details and depth in the artwork found on banknotes.

**Machine Readability**

Used as a vehicle to incorporate pigments with advanced security properties, intaglio inks provide multi-level protection. They are used to integrate SICPATALK® and NEOMAG® machine-readable features.

Infrared (IR): Intaglio-printed portraits or designs are often printed as an IR ink pair for security reasons; one part being IR-transparent and the other part IR-absorbing, which machines can then detect. Standard IR-absorbing intaglio inks are usually dark in colour due to the use of carbon black IR-absorbers. A specific family of enhanced machine-readable inks, SICPATALK®, uses IR-absorbing pigments which are clean and bright in colour and have unusual IR profiles, forming high security IR absorbing features.

Magnetic: Intaglio inks are also efficient hosts for magnetic pigments, which are frequently used in the cash cycle for machine authentication. The NEOMAG® intaglio magnetic inks constitute a very robust protection against counterfeiting. Commercially available magnetic inks could be used in attempts to reproduce the magnetic signal, but they fail to reproduce the clean visible colour and the unusual IR-transparency of NEOMAG®.

SICPATALK® and NEOMAG® can also be combined into an IR pair, as the "ultimate" machine-readable solution. They are the ideal couple, the first one being IR-absorbing and the other being IR-transparent. Additionally, SICPA can formulate them into the exact same colour in order to raise the bar of counterfeit-resilience even more.

**Forensic Investigation**

In addition to the IR and magnetic machine-readable features, we can provide a further dimension, the forensic security feature. This allows for an additional layer of safety and authenticity on highly sensitive documents and banknotes.

**Digital Checks**

The intaglio symbology is designed to take advantage of the highly secure intaglio printing process present on banknotes and some high security documents. SICPA proprietary symbology provides robust authentication and allows for data to be integrated into these prints. The data information is embedded into a high-definition proprietary code (CUPSIA®) that can be detected by digital devices such as the smartphone or other point of sales devices and relies on multifactorial authentications.

## HOW DO YOU VIEW THE PRESENT AND FUTURE DEVELOPMENT OF INTAGLIO PRINTING?

Intaglio inks have developed enormously over the years since their initial production and use, and SICPA is an innovative company with dedicated teams, therefore I believe that there is always potential for growth.

## WHAT DO SICPA INTAGLIO INKS PROVIDE?

**Security:**
We always aim to meet customer demands and requirements whilst retaining the highest standard of protection against counterfeiting and safety. Over the decades that SICPA has been producing security inks, we have greatly developed their quality and reliability. A big focus for us in recent years has been to push the boundaries on the components of our inks to create a more sustainable solution.

**Versatility:**
Intaglio inks are compatible and evenly integrate with any substrate, from cotton paper long-lasting or reinforced papers to polymer. Thanks to the versatility of SICPA's intaglio inks, it is possible to verify their authenticity across the four dimensions previously mentioned.

**Durability:**
Banknotes are handled and used daily, which, without proper protection, can result in deformation that may make them unusable. To prevent that, SICPA uses inks and varnishes that will protect the banknote and its security features, making them more durable to various treatments.

A high coverage of intaglio print, coupled with the calendaring effect of double-sided intaglio, improves the overall durability and anti-soiling properties of banknotes, allowing them to stay in circulation for longer.

## WHAT DRIVES INNOVATION?

Innovation is driven by the desire to improve. As previously stated, SICPA provides secure, durable, and versatile inks, but in this modern day, sustainability is a large focus for every industry. SICPA intaglio inks have proven to provide a longer lifespan for banknotes, therefore contributing to a more sustainable cash cycle. This is thanks to our strong sustainability framework driving innovation even further with four key pillars.

**Banknote production efficiency:**
The 9SE intaglio ink series is optimal for low consumption and instant drying. The inks have low set-off levels, as well as a stable production process, all whilst producing high print quality. 9SE intaglio inks also offer maximum design flexibility when creating and deciding on the visual features for the banknotes.

**Product safety:**
With any product being released and handled manually, it is vital to make sure that it is safe. SICPA intaglio inks have been through close monitoring of chemical classifications and have very strict selection rules for raw materials. We comprehensively monitor

and manage our products throughout their lifecycle, in order to keep them safe and of high quality. Thanks to this rigorous process all our intaglio inks are cobalt & octoate-free.

**Bio-renewable content:**
In collaboration with multiple industry partners, our R&I teams have developed innovative formulations to reduce fossil fuel dependency. In addition, we almost doubled the bio-renewable content of our intaglio inks.

Through innovation and development, we have reduced the volatile organic compounds in intaglio inks, creating a safer solution for the environment.

**Banknote lifecycle optimisation:**
Intaglio is the ideal vehicle for IR-absorbing & magnetic features, supporting the optimisation of the cash cycle by enabling banknote automation, decentralised cash cycle, and reduced transportation.

## DO YOU THINK THERE IS AN OPPORTUNITY FOR THE GROWTH OF INTAGLIO PRINTING ON BANKNOTES?

The demand for banknotes around the world remains high, and therefore so is the need for intaglio inks. Our dedicated team of R&I experts continue to work daily on the development of intaglio inks to improve their efficiency, security and versatility, to meet the high demands of central banks.

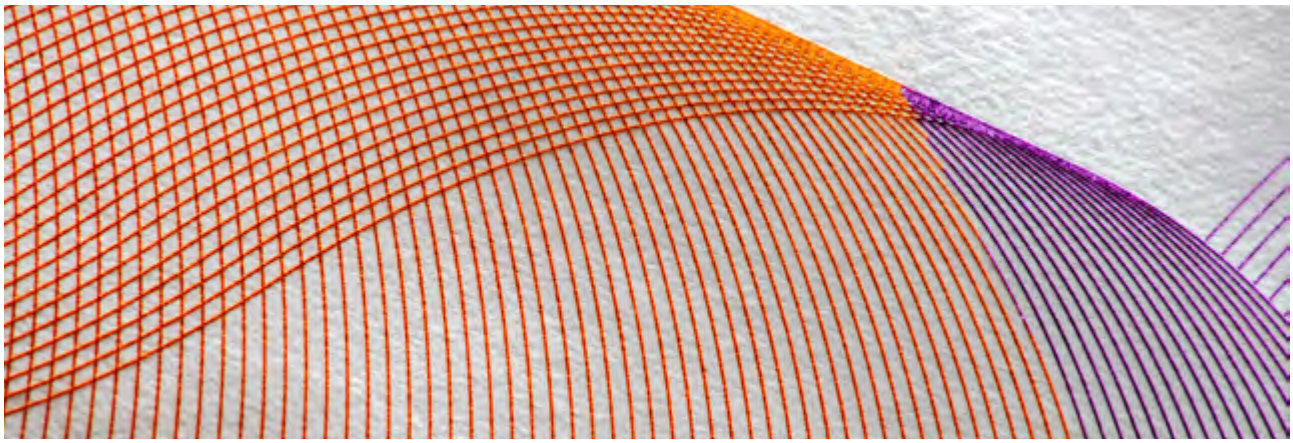
## SHOULD WE CONTINUE USING INTAGLIO?

Intaglio stands as the backbone of banknotes, seamlessly integrating artistry, security, versatility and durability. Thanks to its unique qualities, intaglio is reserved exclusively for high security printing. With 95% of banknotes worldwide carrying intaglio, it is proven and trusted by every country for their banknotes, providing reassurance to the central banks and the public. Although additional inks and security levels can be added to banknotes, they can't replace intaglio, as it is the most versatile interface for people and machines.

SICPA

Email: security.inks@sicpa.com
Website: www.sicpa.com

Supporting SICPA artworks by Swiss based intaglio artist and banknote designer, Lukas Schuler.



since 1892

# Gietz stands for reliability in the security industry

Gietz has a long-standing history in Banknote production and is recognized as a pioneer in the application of Heat Transfer Security Features.

**FSA 870 NOTA 1** → **FSA 870 NOTA 2** →

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With over 40 years of experience in the banknote industry, Gietz takes pride in both its past and its latest innovation:
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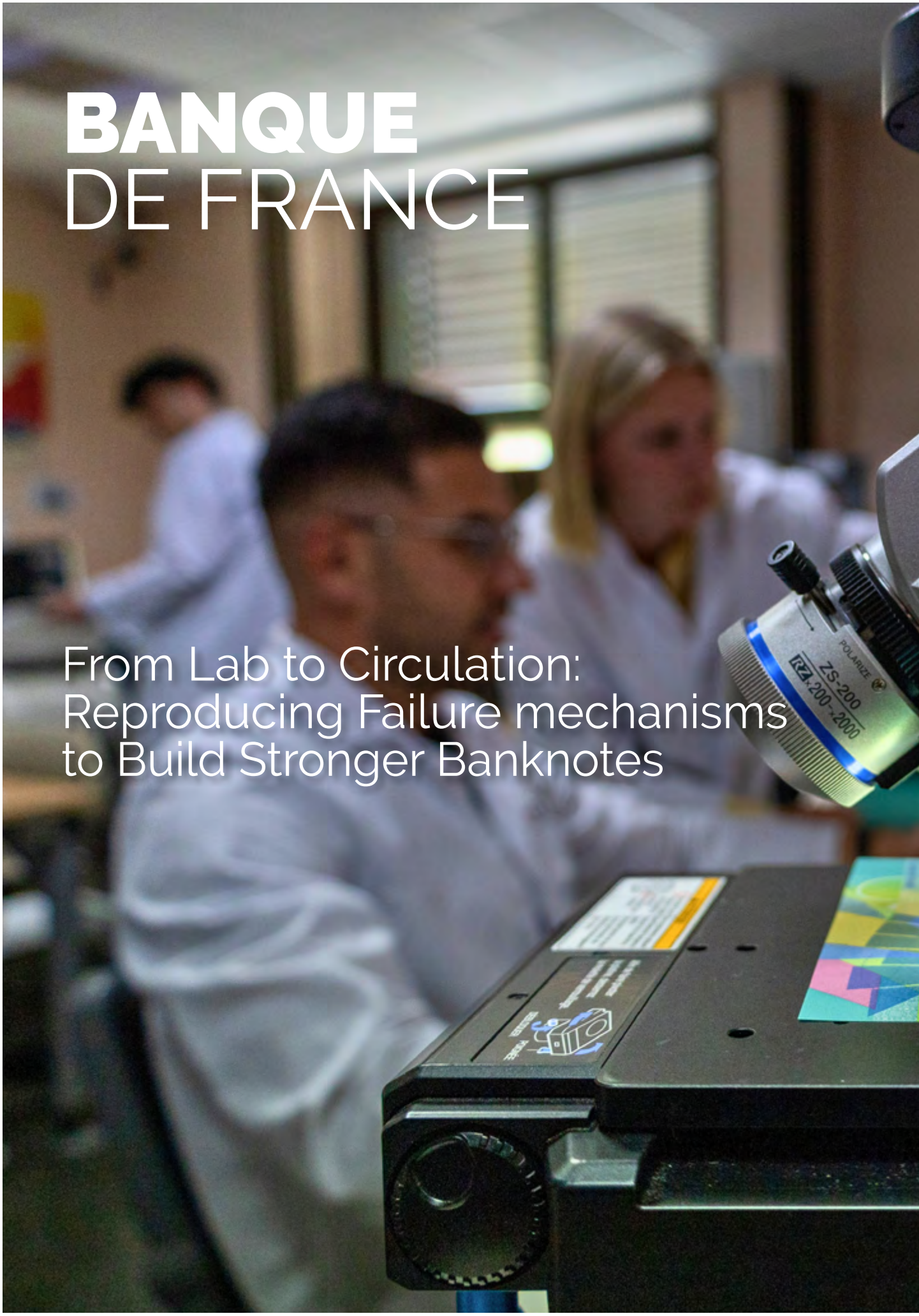
# GIVING WINGS TO PRODUCTION


BANQUE
DE FRANCE
From Lab to Circulation:
Reproducing Failure mechanisms
to Build Stronger Banknotes


# FACT BOX

**Trusted Export Supplier**
Banque de France delivers banknotes and substrates to over 40 countries, producing 5,000+ tons of security paper and up to 3 billion notes per year, in line with the industry's highest technical standards.

**Integrated Production Hub**
With papermaking and printing on a single site, Banque de France ensures full value chain control — from cotton fibre to finished banknote — enabling faster innovation and optimal print compatibility.

**Shared Laboratory Platform**
A joint laboratory for printing and papermaking supports over 30 test methods, combining ISO/TAPPI protocols with SEM, FTIR and DSC analysis to evaluate durability at every scale.

**Field-Based Testing Protocols**
Each ageing test starts with a circulation failure, reproduced in lab via calibrated sequences. Protocols simulate real-life banknote ageing within a condensed laboratory timeframe.

**Calibrated Durability Solutions**
Validated under accelerated stress, EverFit® multiplies banknotes lifespan by ×4 in harshest circulation environments. EverFit® and LongerFit® are adjusted to match each client's climatic and circulation profile.

In the world of banknotes, durability is no longer a secondary attribute — it has become a strategic imperative. The banknote durability now directly impacts economic efficiency, environmental footprint, public confidence, and the operational cost of cash management systems. At Banque de France, we understand that ensuring durability requires more than resistance to superficial wear. It demands an uncompromising scientific method: observing failure in the field, decoding the mechanisms that cause degradation, and replicating those mechanisms in a laboratory environment to develop real, sustainable solutions. This article unveils how Banque de France has built one of the world's most advanced scientific platforms for understanding banknote ageing by mastering the underlying physics and chemistry of banknote degradation. From microscopic contaminations to macrostructural failure, from real circulation to controlled ageing tests, Banque de France transforms field experience into laboratory precision, and laboratory precision into next-generation durable banknotes.

## BANQUE DE FRANCE LABORATORY: AN INTEGRATED PLATFORM FOR SCIENTIFIC EXCELLENCE

Durability is not a matter of intuition; it is the outcome of structured, reproducible, and multi-parameter scientific investigation. At Banque de France, this investigation is conducted within a world-class laboratory embedded in the Chamalières printing works and shared

COMPONENT ANALYSIS USING SCANNING ELECTRON MICROSCOPE (SEM).

with the EuropaFi paper mill. This dual location fosters close collaboration between printing and papermaking experts, enabling seamless integration of materials research and process optimization. This integrated laboratory system combines traditional papermaking expertise with advanced analytical science, enabling a comprehensive and multi-dimensional evaluation of banknote durability.

At its foundation is a suite of physical assessments based on internationally recognized ISO and TAPPI standards. These include measurements of tensile strength, tear resistance, folding endurance, stiffness, and bursting resistance — essential metrics for characterizing how substrates respond to mechanical stress over time. Complementary tests such as air permeability (Bendtsen), bursting strength (Mullen), and flexural rigidity (Taber) further refine our ability to compare materials and protective treatments with a high level of precision. Yet, mechanical metrics alone cannot fully capture the complexity of banknote degradation. To bridge this gap, our evaluations are systematically supplemented by physico-chemical analyses. Scanning Electron Microscopy (SEM) allows for high-resolution imaging of microstructural damage, revealing fatigue in fibres, abrasion paths, or incipient interface delamination. Fourier Transform Infrared Spectroscopy (FTIR) identifies chemical residues and transformations — including contamination or interface degradation — providing insight into the chemical stability of substrates, inks, foil/thread adhesives and

REVIEW OF AGEING TEST RESULTS ON A LIGHT TABLE IN THE ANALYSIS UNIT.

VISUAL ASSESSMENT OF PAPER SAMPLES AFTER MECHANICAL AND CHEMICAL STRESS TESTS

coatings. Differential Scanning Calorimetry (DSC) adds a thermal dimension to this analysis, characterizing the behaviour of polymeric banknote components (adhesives, films, inks, …) over a wide temperature range.

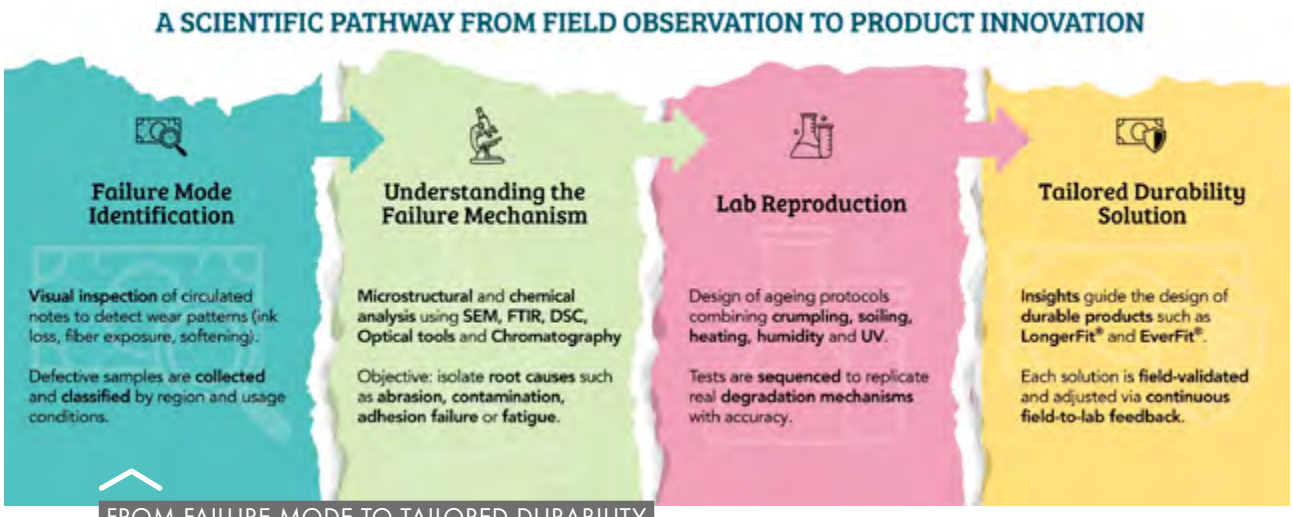
This dual-layered methodology —empirical and analytical — allows Banque de France to not only observe how materials perform, but to understand why they degrade. By correlating mechanical performance with molecular evidence, and by applying stress scenarios that mirror real-world environments, the laboratory closes the loop between diagnostics, material development, and final product validation.

To reinforce these findings, a range of accelerated ageing equipment is also deployed: dynamic crumpling devices, paper degradation machines, abrasion simulators, chemical contamination tools, climatic chambers and high-intensity xenon arc units are used to stress test banknotes under extreme or prolonged conditions. Together, these tools contribute to a robust experimental framework that captures the full spectrum of physical, chemical, and environmental aggression that a banknote may encounter in circulation.

## BEYOND SURFACE: UNDERSTANDING AND REPRODUCING BANKNOTE FAILURE MECHANISMS

Durability cannot be reliably assessed by appearance alone. A banknote that looks aged may reveal little about the underlying physical or chemical processes that compromise its structural and functional integrity.

At Banque de France, we focus not on superficial resemblance to circulated notes, but on understanding and replicating the actual failure mechanisms that occur in the field — with scientific rigour and methodological precision. Our analytical approach begins with a detailed failure mode identification process. Banknotes returned from circulation are examined to detect recurring signs of wear, such as fibre disintegration, loss of surface coatings, delamination, fading of printed features, or localised soiling. These symptoms are not treated as isted defects, but as the visible outcome of deeper, often multi-factorial degradation processes. Once identified, representative samples are collected and characterised through both macroscopic inspection and microscopic analysis.




FROM FAILURE MODE TO TAILORED DURABILITY

Using tools such as Scanning Electron Microscopy (SEM), Fourier Transform Infrared Spectroscopy (FTIR), and Differential Scanning Calorimetry (DSC), we investigate the physical and chemical transformations associated with each case of degradation. SEM reveals microcracks, inter-fibre fractures, interface failures; FTIR detects residual contaminants and chemical by-products that compromise adhesion or substrate integrity; DSC informs us about the thermal resilience of coatings or adhesives. These analyses allow us to formulate hypotheses about the failure mechanisms at work — whether they stem from mechanical stress, thermal exposure, humidity, light/UV radiation, chemical interactions.

**"A durability test is only relevant towards an established failure mechanism. The durability test that reproduces the exact circulation conditions, all at once, does not exist and will never be."**

JAR TEST COMBINING MECHANICAL, ABRASION AND SOILING STRESS SIMULATION

Once a mechanism has been identified, our laboratory designs a dedicated test protocol to reproduce it in controlled conditions. This multiphysics process involves not only selecting the relevant stressors —folding, crumpling, abrasion, heat, contaminants — but also applying them in the correct sequence and intensity, based on what has been observed in real circulation. For example, applying a chemical contaminant such as acids/bases, artificial sweat, greasy substances, solvents after subjecting a note to mechanical stress may better simulate human handling than the reverse. This sequencing is not arbitrary: it reflects the kinetics and interactions of real-world degradation.

One of the most illustrative demonstrations of this methodology concerned the unexpected degradation of early protective coatings in demanding real-world conditions. Although these notes had performed reliably under conventional solvent exposure and mechanical stress tests, they exhibited premature deterioration when subjected to environments marked by heat, humidity, and intense human handling.

The turning point came when Banque de France hypothesised that specific contaminants introduced through routine manipulation — when combined with mechanical fatigue and environmental stress— were compromising the adhesion strength of ink layers or foils and/or the physical properties of security features. This hypothesis was validated through the design of a bespoke ageing protocol, deliberately combining dynamic folding sequences with controlled chemical exposure. The test successfully reproduced the

degradation observed in circulation, enabling a direct correlation between observed field failures and laboratory outcomes. This scientific insight laid the groundwork for the reformulation of inks, substrate sizings, protective coatings and led to the successful industrial deployment of a more resilient solution: EverFit®.

This paradigm — identify, analyse, reproduce, improve — is central to all our ageing protocols. As examples, it applies whether the failure involves the fading of an ink under UV, the mechanical disintegration of a fibrous substrate after moisture exposure, or the adhesion failure of a laminated foil under thermal cycling. We do not pursue generalized stress tests; we construct simulations rooted in empirical evidence. Our ageing platforms are therefore modular and adaptable, able to reproduce region-specific conditions, environmental aggressors, and usage patterns.

In essence, the credibility of an ageing test lies in its ability to replicate a known mechanism of degradation. Only then can laboratory results inform predictive performance and guide material innovation. At Banque de France, every durability claim is grounded in this principle — that understanding failure is the only path to engineering resilience.

## FROM FAILURE TO INNOVATION: TAILORED DURABLE SOLUTIONS

Field failure analysis does not merely inform our scientific understanding; it fuels our innovation pipeline. At Banque de France, every insight gained from ageing studies is transformed into concrete enhancements for high-durability products — designed not generically, but tailor-made for specific circulation environments.

LongerFit® was developed to address intermediate needs: reinforcing mechanical and soiling resistance without altering the tactile experience of cotton-based notes. By optimizing fibre bonding and surface sizing, LongerFit® extends life expectancy where notes suffer from moderate abrasion and contamination, without requiring complex infrastructure changes from banknote printers and central banks.

EverFit® goes even further. Designed for the most demanding circulation conditions — including tropical humidity, intensive manual handling, and decentralized cash cycles — EverFit® applies a double-sided protective lamination onto fibers-based substrates. This configuration strengthens the substrate's mechanical properties while ensuring long-term resistance to soiling and to ink abrasion.

CROSS-FUNCTIONAL MEETING ON TESTING RESULTS AND PRODUCT DEVELOPMENT STRATEGY


OPTICAL ANALYSIS OF A SECURITY FEATURE.

Its development through an iterative process for continuous improvement) has been guided not by assumptions or marketing considerations, but by laboratory protocols explicitly reproducing the failure mechanisms observed in the field: folding under contamination, stress-induced adhesion strength analysis, ultraviolet ageing, and environmental soiling simulation.

Resistance to soiling, abrasion of printed elements, and stable mechanical performance over time — these three pillars define Banque de France's scientific approach to durability.
Thanks to this scientifically-driven R&D process, EverFit® now offers field-proven durability superior to traditional cotton notes, extending lifespan by factors of four in the harshest conditions of circulation.

Far from an universal solution imposed on all clients; our portfolio products can be tuned to local realities, reflecting Banque de France's core belief: durability is fit-for-purpose, not one-size-fits-all.

## DURABILITY ENGINEERED BY SCIENCE

At Banque de France, durability is the result of scientific discipline, technical precision, and a comprehensive understanding of the real conditions banknotes face in circulation.
By systematically identifying failure mechanisms, replicating them in controlled environments, and designing materials and protocols accordingly, we ensure that durability is measurable, reproducible, and relevant to real-world conditions.

Applied to a banknote substrate, a security feature or the overall banknote, this approach does not aim to simulate how a worn note might look — it seeks to understand why it fails, and how to prevent it. From material fatigue and contamination to environmental and chemical stress, each stressor is analyzed not in isolation, but as part of a cumulative, multi-factorial degradation process.

In an era where central banks are expected to optimize both cost and sustainability, scientific credibility must underpin every claim of durability.

BANQUE DE FRANCE

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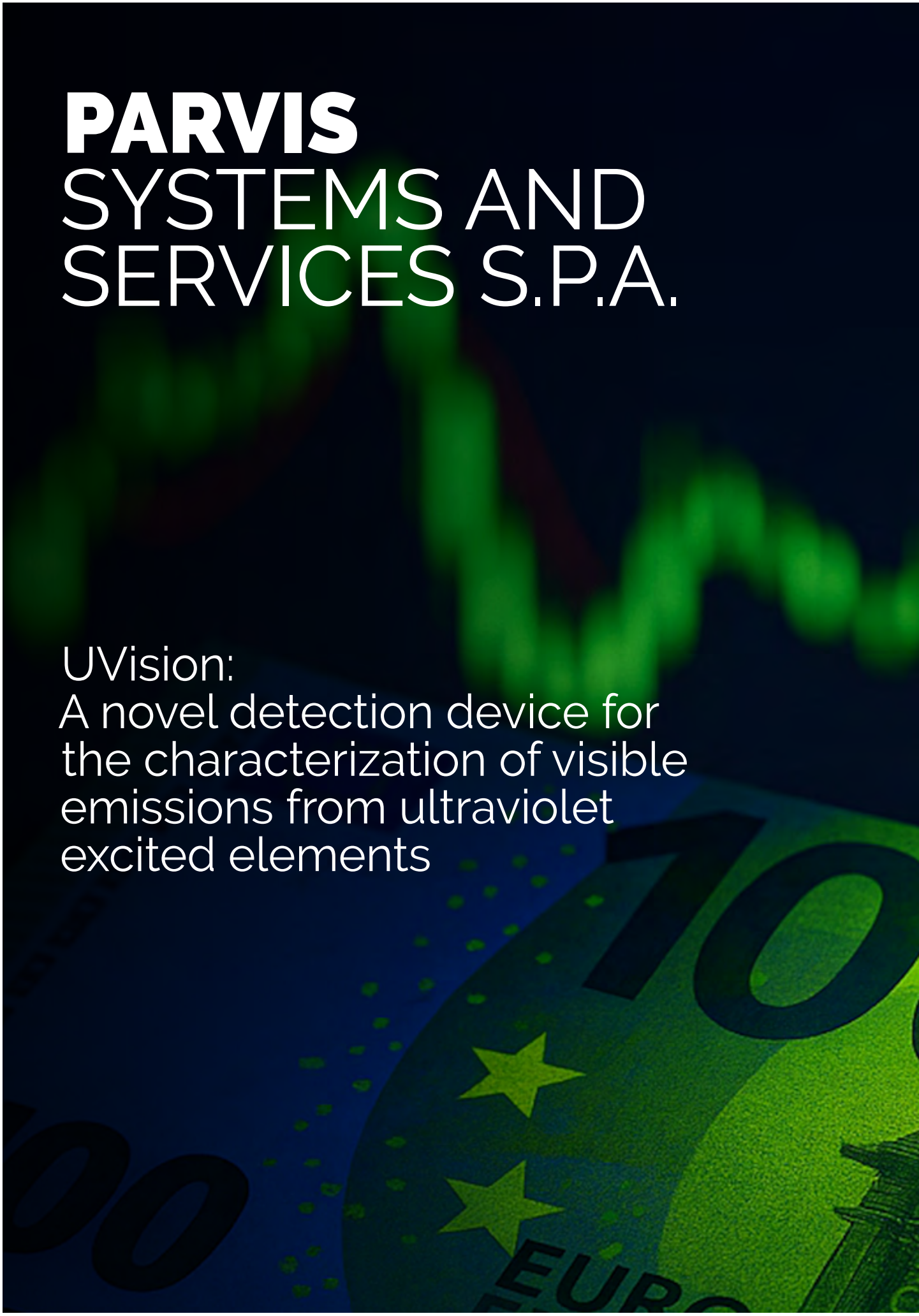

# PARVIS SYSTEMS AND SERVICES S.P.A.

## UVision: A novel detection device for the characterization of visible emissions from ultraviolet excited elements

# FACT BOX

- Context: Security documents, increasingly rely on ultraviolet excited photoluminescent features for authentication and anti-counterfeiting.
- Technology: Photoluminescence is a general optical phenomenon that includes both fluorescence and phosphorescence, where materials emit visible light upon UV excitation.
- Classification: Photoluminescent features are a subset of Machine-Readable Security Features (MRSFs), designed for reliable, automated detection by verification systems.
- Importance of printing quality control: Defective MRSFs can lead to high rejection rates in sorting machines, false rejections by ATMs and vending machines and, therefore a reduction of public confidence in cash as a payment method.
- Measurement needs: Manual inspection is inconsistent and labor-intensive. A semi-automated measurement device offers higher repeatability and accuracy, faster quality assessment and reduced operator dependency.
- Goal: UVision ensures that photo-luminescent MRSFs perform reliably across production batches with the aim of main-taining document security and system interoperability.

## PHOTOLUMINESCENT FEATURES IN SECURITY DOCUMENTS

In the field of security printing, photoluminescent features are increasingly integrated into printed elements for document authentication. This trend, particularly evident in banknotes, passports and ID cards, requires robust methods for the evaluation of the printing quality to enhance anti-counterfeiting measures and enable automated verification processes.

Photoluminescent elements are defined as those materials that emit visible light when excited by ultraviolet (UV) radiation. Ensuring the quality and consistency of these elements is critical and must begin even before the printing process, from the selection of inks that comply with well-defined spectral specifications and the selection of the substrate, which must exhibit low photoluminescence characteristics to avoid interfering with the measurement and evaluation of the printed features. Subsequently, it is essential to verify that the spectral characteristics of the wet inks are preserved, under a certain tolerance, when applied through standard printing processes, typically offset and intaglio.

Nowadays, photoluminescent elements applied to security documents, particularly inks, can be characterized by the color of the visible emission, detectable by naked eye, and the shape and intensity of the emission spectrum, which is typically characterized by one or more peaks, each defined primarily by its wavelength and intensity.

Moreover, a characterization method based on the decay rate of the emission signal after the UV excitation is turned off is increasingly gaining traction. In particular, the “decay time” refers to the characteristic time required for the signal to fall to 50% of its initial value. In the context of photoluminescent materials, decay time provides critical information about the nature of the emission process, distinguishing between fluorescence (short decay times typically nanoseconds) and phosphorescence (longer decay times, ranging from microseconds to seconds or more).

Commercially available photoluminescent inks may exhibit different emission behaviors depending on the wavelength range of the UV excitation, which can span from UVC (100–280 nm) and UVB (280–315 nm) to UVA (315–400 nm)."

Additionally, certain substrates are engineered to contain a number of randomly distributed security fibers (or fibrils), which exhibit photoluminescent properties when excited by UV radiation. This feature enhances the security of a document by introducing a non-uniform, unpredictable emission pattern. In quality control processes, particular attention is given to the spatial distribution map of these fibrils across the sheet, as their presence and density can be indicative of substrate authenticity and consistency.

Furthermore, when performing spectral measurements of photoluminescent inks, the presence of a fibril within the measurement area must be carefully detected since a fibril’s emission can interfere with the spectral signature of the ink, leading to inaccurate or non-representative results.

As such, automated or semi-automated systems should include mechanisms capable of identifying and excluding or compensating these local anomalies to ensure reliable and reproducible measurements.

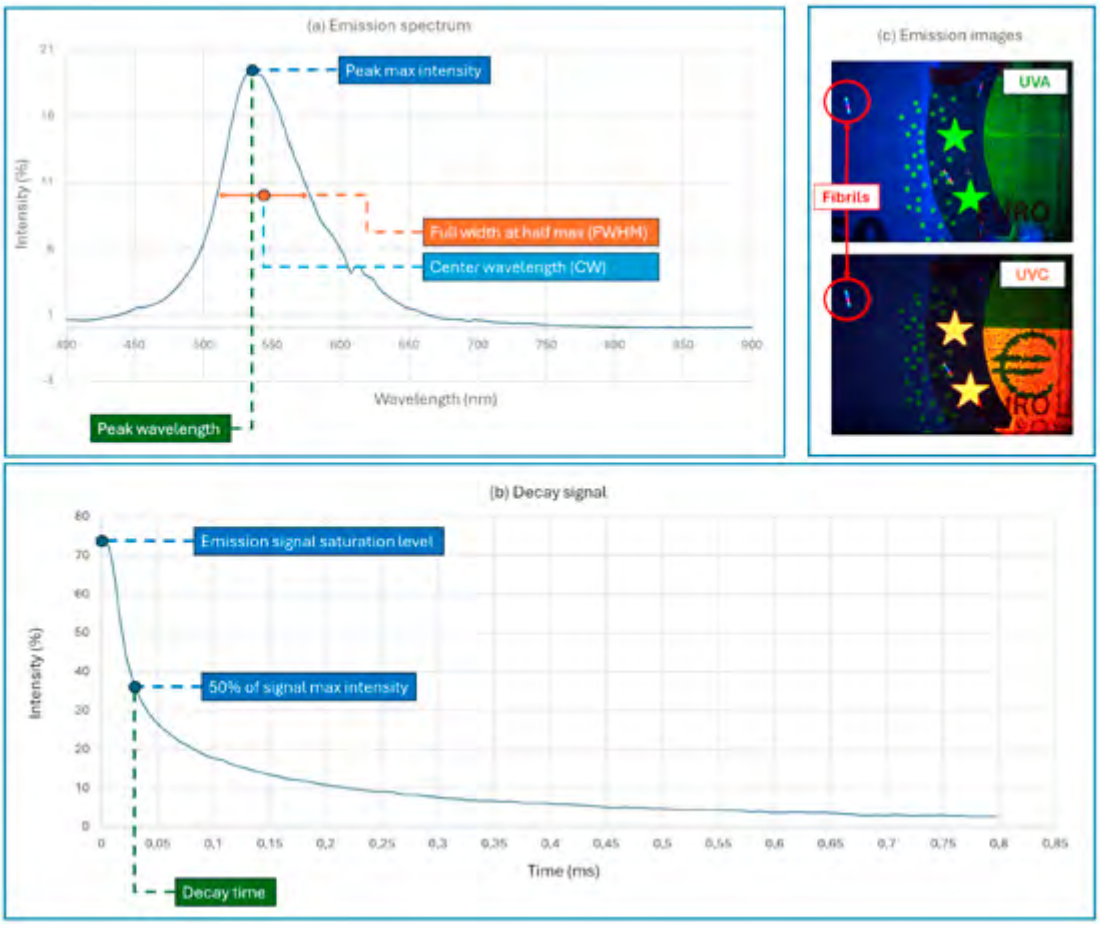


FIGURE 1: (A) DESCRIPTION OF THE MAIN CHARACTERISTICS OF THE EMISSION SPECTRUM PEAK; (B) EXPLANATION OF THE DECAY TIME; (C) EXAMPLE OF EMISSION IMAGES, SHOWING ALSO THE PRESENCE OF FIBRILS, ACQUIRED WHILE EXCITING A 50€ BANKNOTE BY UVA AND UVC LIGHTS.

## THE UVISION SYSTEM

PARVIS has recently developed "UVision", a hand-held device for the measurement of the characteristics of photoluminescent elements. UVision is composed of several key components designed to ensure accurate and repeatable characterization of photoluminescent features under UV excitation:

- An LED board, which includes visible-light LEDs used for initial positioning of the device over the measurement area, and UVA, UVB, and UVC LEDs used sequentially to excite the photoluminescent element under different UV wavelengths during acquisition phases.
- A camera, which serves a dual purpose: aiding in precise positioning of the device on the target area and capturing images of the photoluminescent emission during UV excitation.
- A spectrophotometer, dedicated to acquiring the emission spectrum of the

photoluminescent element with high spectral resolution under controlled UV excitation conditions.

- A decay sensor, used to record the temporal decay of the emission signal after UV excitation is interrupted.
- An integrated cooling solution and dedicated electronic circuitry to maintain measurement repeatability by compensating for environmental condition variations such as temperature.
- A calibration base for the periodic calibration of the spectrophotometer.
- A specific setup to allow measuring wet inks.

The device is supplied with a dedicated control software, pre-installed on a companion PC, which manages all measurements and system operations. The software includes the following key functionalities:

- Calibration management: The software alerts the operator when recalibration is required, either at regular intervals or when an internal temperature variation of ±2 °C is detected. Recalibration is performed by placing the device on its dedicated calibration base, with the process fully guided through the interface.
- Diagnostics and configuration: The system provides access to diagnostic functionalities and allows the configuration of device parameters to adapt to different measurement needs.
- Reference model generation: Customers can create reference models, which serve as a baseline for evaluating new measurements, enabling the software to assess the compliance and consistency of photoluminescent features.
- Measurement sessions and data export: The software enables full control of measurement sessions and allows the export of detailed measurement reports and raw data. These outputs can be used for post-processing and statistical analysis of the printing process, supporting process control and quality assurance.

The device can be employed either for the measurement of inks on finished banknotes, as part of production batch validation, or directly during the printing process to support and optimize printing quality.

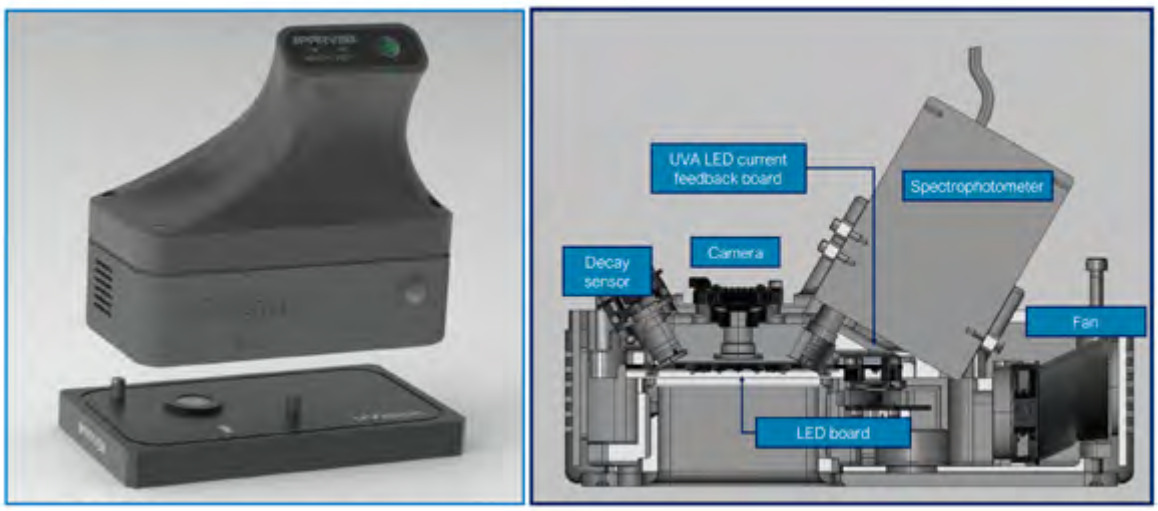


FIGURE 2: UVISION MAIN COMPONENTS

## MEASUREMENTS AND CONTROLS

UVision enables comprehensive analysis through a single acquisition process, streamlining measurements across multiple ultraviolet spectral bands. This capability is particularly valuable for evaluating photoluminescent materials, authenticity features, and substrate characteristics under controlled UV excitation.

Within a single acquisition of the photoluminescent element, the device allows several measurements and controls which are conditional and performed only if enabled by the operator within the selected reference model. This ensures flexibility and adaptability of the system for diverse analytical or inspection tasks.

**1. Spectral emission analysis under UVA excitation**

While exciting the sample with UVA light, the device is capable of acquiring high-resolution spectral emission data from active photoluminescent elements (e.g., wet or printed inks). Specifically, it can detect and analyze up to three distinct emission peaks for which the characteristic wavelength and intensity are measured. In more detailed spectral analysis, each peak can also be described by its center wavelength (CW), i.e. the wavelength at which the emission intensity reaches its maximum, and by the full width at half maximum (FWHM), which quantifies the spectral bandwidth of the emission at 50% of its peak intensity.

This functionality is essential in characterizing materials based on their luminescence signature and can be used in authentication, quality control, or the definition of ink specifications .

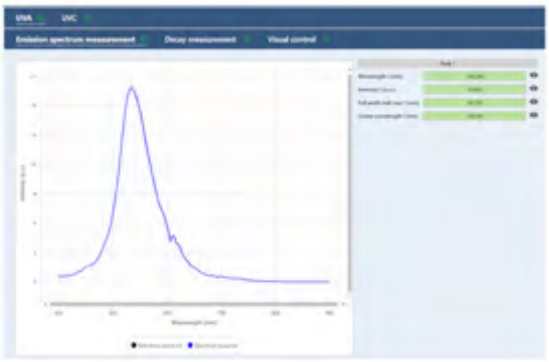

FIGURE 3: UVISION MEASURE OF EMISSION SPECTRUM PARAMETERS

**2. Emission spectrum comparison against a reference under UVA excitation**

Alternatively, the device can be used to acquire the emission spectrum of a substrate and compare it against a stored reference threshold. This is particularly useful for evaluating the optical dullness of paper, polymer or composite substrates under UV excitation.

This functionality is important for paper mills to certify substrate batches provided to printing facilities, and for the latter, to validate the substrate at the incoming paper phase.

FIGURE 4: UVISION MEASURE OF PAPER DULLNESS

FIGURE 5: UVISION MEASURE OF DECAY TIME

### 3.Decay signal analysis

Once the UVA excitation is interrupted, the system records the photoluminescence decay signal and measures the decay time. This enables detailed kinetic analysis of materials with short to medium photoluminescent lifetimes.

The ability of extracting decay time, provides insights into the physical and chemical properties of photoluminescent elements, supporting novel applications in inks identification and counterfeiting detection

### 4.Visualization of color emissions under UVA, UVB, and UVC

The device supports the acquisition and visualization of images under ultraviolet illumination across the three main bands UVA, UVB, and UVC.

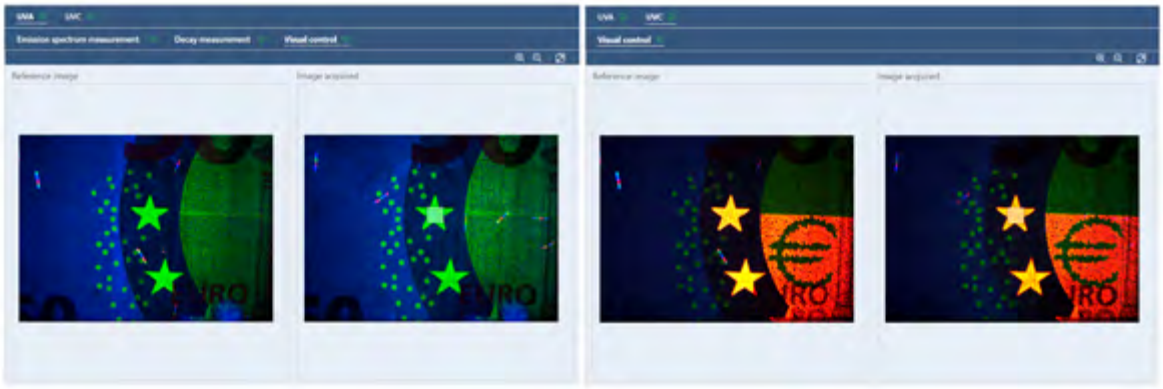

FIGURE 6: UVISION ACQUISITION OF EMISSION IMAGES BY MULTIPLE UV LIGHTS

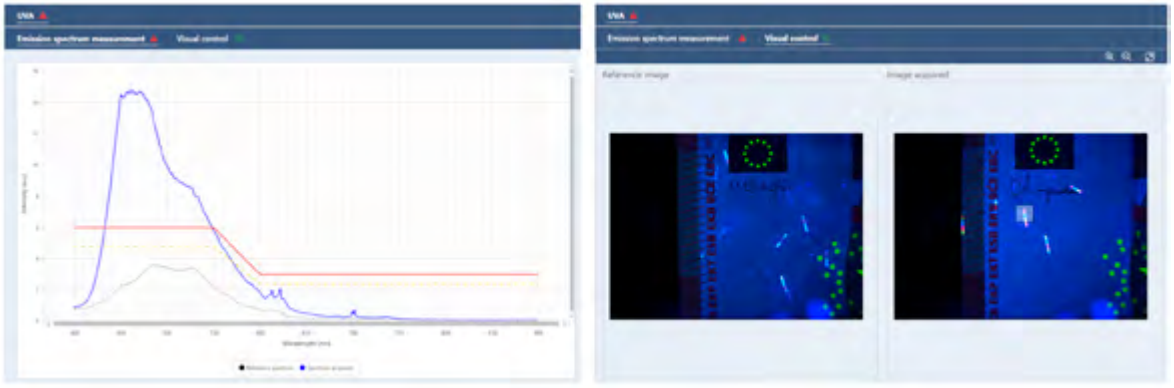

FIGURE 7: EXAMPLE OF NON-COMPLIANT PAPER DULLNESS MEASURE DUE TO THE PRESENCE OF A FIBRIL, EASILY RECOGNIZED BY THE UVISION VISUAL CONTROL

These images allow for qualitative and comparative analysis of the emitting elements, ink contamination invisible in the visible spectrum, and allow detecting possible fibrils under the measuring area which may affect the measurement of the spectral characteristics.

Moreover, for each measured parameter, the system automatically compares the measured value against the tolerance range, specified in the reference model. Based on this comparison, each measurement is classified according to the following criteria:

- Compliant: if the measured value falls within the acceptable tolerance range.
- Warning: if the measured value is compliant but close to the measure tolerance.
- Non-compliant: if the measured value is outside the defined lower or upper tolerance limits.

This compliance evaluation mechanism enhances the objectivity and repeatability of the inspection process and supports decision-making in quality control and certification workflows.

## ADDITIONAL APPLICATIONS AND FUTURE DEVELOPMENTS

In addition to the UVision device, PARVIS has developed over the years several other automated systems for offline quality control of unprinted substrate and of the offset and intaglio printing stages, respectively named Proxima-p, Proxima-o, and Proxima-i. These systems are designed to support the printer by enabling sample-based inspection of sheets during production of a batch, allowing for timely interventions during the printing process.

This approach helps reducing production waste and minimizing the number of process-related issues detected at the final single note

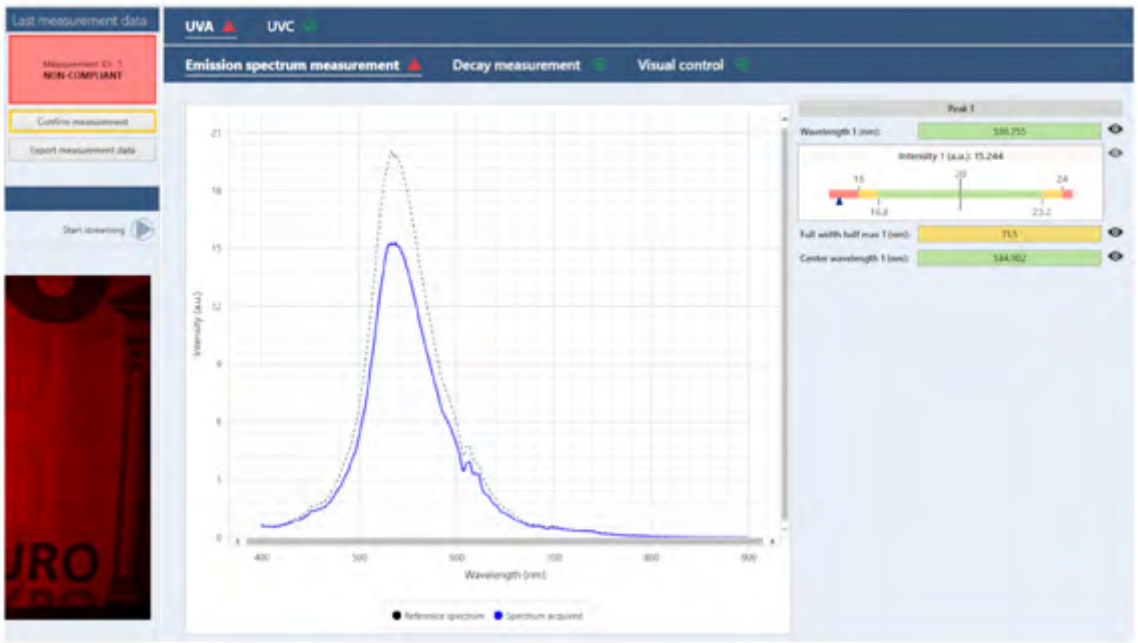


FIGURE 8: AN EXAMPLE OF NON-COMPLIANT MEASURE BECAUSE OF THE SPECTRUM INTENSITY. ON THE LEFT SIDE, THE MEASURE AGGREGATED STATUS IS SHOWN. ON THE RIGHT SIDE, THE NON-COMPLIANT PARAMETER CAN BE FURTHER ANALYZED BY EXTENDING THE DISPLAYED DATA

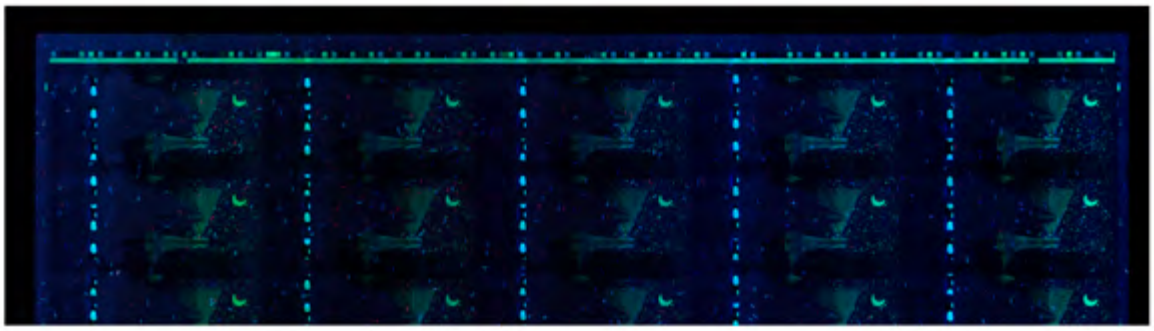

FIGURE 7: EXAMPLE OF NON-COMPLIANT PAPER DULLNESS MEASURE DUE TO THE PRESENCE OF A FIBRIL, EASILY RECOGNIZED BY THE UVISION VISUAL CONTROL

inspection stage, when corrective actions are no longer possible.

Specifically, PARVIS has integrated a UVA light source into the Proxima-o system to enable the detection of emission deviations in areas printed with photoluminescent inks, as well as to verify the registration accuracy and integrity of transparent UV inks.

Future developments will be focused on the extension of the Proxima-o capabilities to apply UV measurements and controls also to the production of passports, and on the integration of new functionalities into the Proxima-p system, specifically targeting full-sheet evaluation of substrate paper dullness and the characterization of the spatial distribution of embedded security fibers.

PARVIS SYSTEMS AND SERVICES S.P.A.

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cbn

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## Core Offerings

- From reprinting banknotes to complete introduction of new series of banknotes
- Provision from tax stamp to complete government tax revenue solutions

## Capabilities, Quality, Efficiency

- Flexibility to produce on all substrates (Cotton, Hybrid, Polymer)
- State of the art equipment with real-time inspection, efficient UV drying, and flexible numbering systems allowing maximum quality, efficiency and flexibility
- Staff with excellent international banknote and tax stamp production experience.


## Certifications & Standards

- ISO 9001, 14298, Health & safety certification, Banknote Ethics Initiative (BnEI) accredited

# FACT BOX

OUMOLAT SECURITY PRINTING

## About Us

- Independent, modern high-security printing facility located in Abu Dhabi, UAE, operating since 2016 for export and local banknote demand
- Since 2016 printing all banknotes for UAE with the recent introduction of the new banknotes series on Polymer.
- Production of tax stamps and revenue tracking solutions

## Made in UAE

- well positioned in global business hub of UAE with excellent logistics to reach clients globally.
- Your partner in the UAE for Banknotes, Tax Stamp, ready to serve you
- Opportunity to collaborate in G2G frameworks and long-term contracts

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# BUNDESDRUCKEREI


## A Journey to Infinity

## Introducing STELLA: The Foundational Note of the Black EX NIHILO Series


# FACT BOX

Together with leading industry partners, Bundesdruckerei is realising the paradigm-shifting black EX NIHILO house note series. STELLA, Latin for "star", is the series' new note. It seeks to showcase pioneering materials and progressive security features, including:

**SUSTAINABLE POLYMER SUBSTRATE**
GUARDIAN™ ENVIRO by CCL Secure is a polymer substrate with a greener approach. It contains renewable, plant-based raw materials, is fully recyclable, and retains its significantly longer lifespan compared to paper-based banknotes.

**NEXT-LEVEL SECURE WINDOWS**
SUSI Optics® JAZZ™ uses Simultan Offset printing to take the possibilities of windows to the next level. While the windows remain transparent, tilting the banknote reveals intuitively understandable optical security effects..

**DEEPLY DYNAMIC SECURITY**
Based on the established, unique KINEGRAM® technology, a KINEGRAM ZERO.ZERO® patch with KINEGRAM® VIVID effect from KURZ displays vibrant movement and an extraordinary perception of depth, combined with a colorful movement.

**TRANSFORMATIVE TACTILE MARKS**
STELLA employs a high-precision laser method by Lang Laser to simultaneously cut and notch the banknote's edges. The highly precise tactile marks ensure optimal perceptibility for visually impaired users, and serve as an additional Level 1 security feature.

## EX NIHILO – THE BLACK SERIES CONTINUES

Infinity. No edges, no limits, no boundaries. Like the endless expanse of the universe, infinity is boundless, embracing everything we know and everything beyond our reach. We cannot grasp infinity – wherever we try, it is always elusive, always reaches further. In the infinite expanse of the universe lies the origin of life. Stars transform basic elements into heavier elements. Carbon, forged in stellar cores and expelled into the universe, is a fundamental building block for life itself. Every carbon atom in our body was once forged in a star – hence, it is physically true to say that we are all children of the stars. The formation of carbon, which correlates with the birth of life itself, marks the thematic origin of the EX NIHILO series.

Continuing the journey through the universe of this house note series, Bundesdruckerei builds on the dialogue sparked by its radical concept. In an increasingly digitalised world with changing needs and behaviours, EX NIHILO explores the idea that money does not have to retain its conventional form and appearance.

IGNIS, the previously introduced EX NIHILO note and the first-ever banknote with a fully functional, high-performance chip, invited the user to bridge the two worlds: analogue and digital. Very soon, STELLA, the next note of the series, will be fully committed to sustainability, returning to the conceptual starting point of the EX NIHILO series – and to the beginning of life itself: Being children of the stars inspires us with a sense of responsibility to safeguard this precious heritage.

Sustainability is not only a question of using the most sustainable materials, but also, of using less overall. With this in mind, STELLA will send you on a journey, to the smallest format a banknote could possibly take while still providing enough space for security features and enough room for an appealing design. This balancing act could only be met by unprecedented design strategies. As a first, security features will be placed at the edges of the banknote, with their effects continuing seamlessly from one edge to the other. As a second, STELLA will link the smallest with the largest – the small size of the banknote with the design theme of infinity.

## STELLA – A SYMBOL OF OUR ORIGINS

When we allow ourselves to think of money as evolving from physical to increasingly digital forms, its materiality seems to diminish and approach a form of "nothingness". Both the IGNIS and the new STELLA notes express this through their absolute darkness – a common symbol for nothingness. A black background means a maximum of light absorption, making conventional colours, which are light-absorbing, ineffective. Instead, we have to print light, by using special pigments that reflect it. If all colours are mixed the maximum amount of light is obtained: pure white.

The design of STELLA will further elaborate on the story of carbon unfolding in our universe. The note depicts the origins of carbon, which itself becomes the origin of life. We are made of carbon, or in other words, we are children of the stars, and we live in a complex and fragile environment. We must take care of this valuable heritage by protecting and conserving our planet – this guiding principle inspired STELLA's dedication to the essential value of sustainability.


The artwork of the note portrays the birthplace of carbon: the stars creating carbon inside a growing galaxy. The denomination "3K" represents a trace of the Big Bang that can still be found and measured throughout the universe: the first light ever emitted after the Big Bang, now detectable as background radiation with a temperature of 3 Kelvin.

The galaxy in the centre of the front is perfectly aligned with a commanding eye motif on the note's reverse that engages the viewer's gaze. It exhibits fine lines immersed in a play of gold hues that shift to green when the note is tilted. We open our eyes and turn our gaze towards the place of our origin: the stars.

Complementing the edge-to-edge layout and reinforcing the concept of infinity, fractals delineate the windows at the note's top and bottom edges. Fractals are patterns that repeat endlessly, no matter how closely we zoom in. In STELLA's design, their endlessly detailed patterns are reminiscent of coastlines. With each closer look, we discover new curves and bends, expanding the fractals' circumference and turning them into yet another symbol of infinity.

To refine the edges and provide fractal patterns of even higher resolution, black intaglio was printed alongside the edges of the windows, resulting in a unique play of a glossy black surface and matt black intaglio print. The colours are fluorescent, which generates a striking security effect: sharp, lightning-like bursts of light can be observed when the note is exposed to UV light.

When the note is tilted, the SUSI Optics® JAZZ™ feature will bring the fractals to life inside the windows, revealing the motion of

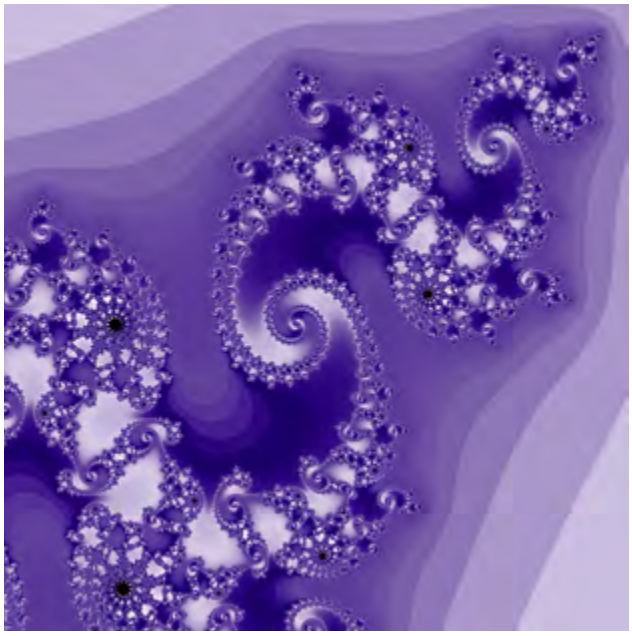
these mathematical patterns. Aligning with our edge-to-edge strategy, this motion is seamless and extends across both windows. In addition, the feature's colours are also fluorescent, making the movement of the fractals also visible under UV light..

## FINITE MEETS INFINITE – SUSTAINABILITY IN FOCUS

Central banks are seeking more effective ways to improve the sustainability of banknotes without compromising security or public trust. Sustainability is also the central theme and core value inherent in the concept of STELLA.

Two deliberate choices increase the note's sustainability, the first being the use of a new and particularly sustainable polymer substrate. Unlike industry-standard polymer, it is based on natural and renewable resources, and when notes reach the end of their lifespan, they can be fully recycled. In addition, polymer is more durable than paper-based substrates, enabling longer note lifespans and thus reducing the need for reprinting, making banknote management more efficient and saving economic and environmental costs.

The second and even more substantial choice for STELLA is the deployment of a much smaller banknote size. This enables the addition of more banknotes per sheet and in consequence, the saving of raw materials, energy, and time in banknote printing. Combined with the use of more ecological materials, reducing the size of banknotes is a major step towards more sustainable banknotes. It conveys the respect for the finite resources of our planet, and utilises the possibilities for affordable, innovative and responsible currency design.



The necessity of more sustainable practices in banknote printing is undisputed. STELLA's minimised physical substance will promote a viable approach of implementing such practices into currency production – and in more abstract terms, will illustrate a feasible way of respecting our natural heritage. The small format will demonstrate a logical and practicable method to reduce the environmental impact of banknote printing, minimise resource consumption, and optimise cost efficiency.

## SECURITY – (NOT) A QUESTION OF SIZE

Crafting a significantly smaller banknote requires a delicate balancing act between minimising the note and maintaining sufficient space for advanced security features. STELLA, printed on fully recyclable GUARDIAN™ ENVIRO substrate by CCL Secure, will propose a revolutionary design that intends to engage the edges of the banknote, maximising the available space. In an industry first, the substrate uses a deep black base colour.

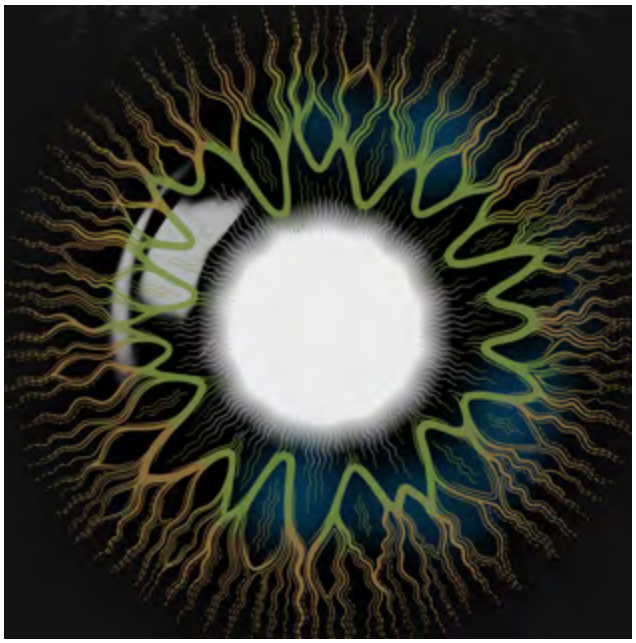
The edge-to-edge strategy includes the use of novel tactile marks, in the form of small notches along the edges, allowing for optimal identification of a banknote's denomination. Rather than going through separate notching and sheet cutting, a simultaneous, laser-based new method completes both steps in one process, resulting in perfect semicircles on both sides of the banknote. This eliminates registration issues and, as an inherent consequence, creates an additional Level 1 security feature.

The large window areas at the top and bottom of the note enable the use of pioneering features such as Koenig & Bauer's SUSI Optics® JAZZ™. This technology is based on highly precise Simultan Offset printing and was developed in collaboration with light field experts, including Fathom Optics. Transparent areas will reveal printed elements in multiple colours that display motion, depth, and image flip effects when the banknote is tilted. In addition to this, STELLA is equipped with a surface-applied, highly secure Diffractive Optically Variable Image Device (DOVID), namely a KINEGRAM ZERO.ZERO® patch with KINEGRAM® VIVID effect from KURZ, which is cut in half and positioned at the edges of the banknote, aligned with the edge-to-edge strategy. Based on the unique, highly precise KINEGRAM® technology, it is enhanced by a colorful movement.

In summary, STELLA aims to illustrate that counterfeiting resilience, rather than depending on size, relies on the ingenuity of a banknote's design and its security features, as well as on the technical capabilities of its printer. Minimising banknotes opens up new opportunities for central banks: they may opt for smaller notes in order to pursue affordability and sustainability goals, while at the same time enhancing security, design flexibility and note production. Where more notes are positioned on one sheet, the printing process saves resources, time and energy. This could pave the way for more efficient and significantly more sustainable currency printing.

## NOVEL DIMENSIONS – PROVEN TECHNICAL EXCELLENCE

Exploring the creation of smaller, more compact banknotes also presents new opportunities for innovation. With longstanding expertise in design and printing, supported by state-of-the-art equipment, Bundesdruckerei is well positioned to provide customers with tailored and forward-thinking solutions. Our technical capabilities help make novel concepts and features achievable. STELLA will exemplify one such concept with its radical minimising approach and use of the latest printing technologies.



While the EX NIHILO series expresses Bundesdruckerei's overall commitment to technological advancement and environmental protection, STELLA will demonstrate the benefits of using the most sustainable substrate available and the smallest feasible size. It will highlight how our experience and collaborative approach allow us to guide central banks through ambitious design innovations and sustainability considerations alike.

## THE INFINITE VASTNESS OF THE UNIVERSE – THE JOURNEY CONTINUES

Ambitious innovation projects demand substantial commitment, expertise, and resources. We extend our sincere thanks to all industry partners involved for their ongoing collaboration and their continued willingness to join us in this exploration.

This shared effort permits STELLA to push the boundaries of the banknote printing universe even further, challenging our industry's views about size, security, and sustainability. The project will illustrate that future banknotes could take on new forms if their dimensions are reconsidered, enhancing security and offering significant sustainability benefits.

The radical design approach and conceptual innovation of STELLA aim to evoke new considerations for the future of cash, and to demonstrate practical advantages for central banks in addressing sustainability, efficiency, and public perception.

The full reveal of STELLA's design and security features will take place in May 2026 at the Banknote Conference in Washington, D.C. Be sure not to miss this journey to infinity. Expect a house note that will redesign the boundaries of physical currency!

BUNDESDRUCKEREI

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Website: www.bundesdruckerei-gmbh.de


QUALITY RELIABILITY
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de Moneda y Timbre

# NOTE PRINTING AUSTRALIA

## Note Printing Australia drives productivity gains as a strategic priority

SPEED MERCHANTS: THE OPTINOTA H PRINT CREW INCLUDING SECURITY PRINTERS (L-R) LINCOLN SOMERVILLE AND JACK MCAULLAY HAVE ENJOYED STRATEGIC BREAKTHROUGH PROJECTS UNDERTAKEN ON THE PRESS THAT HAVE SEEN DRAMATIC INCREASES IN THROUGHPUT.

# FACT BOX

- Note Printing Australia was founded in 1913, the year it issued Australia's first banknote, and for the last 44 years has been located in Craigieburn, 30km north of Melbourne's CBD.
- NPA is a wholly-owned subsidiary of the Reserve Bank of Australia, with its five person board chaired by Christopher Kent, Assistant Governor (Financial Markets).
- Led by CEO Malcolm McDowell, NPA currently employs 300 staff responsible for printing banknotes, passports, and birth, death and marriage certificates.
- In addition to NPA, the 54 acre Craigieburn site and neighbouring property is also home to Innovia Films, CCL Secure, and the RBA's National Banknote Site (NBS) that stores and issues Australia's banknotes, as well as fitness checking and granulating unfit notes.
- 100% of NPA's polymer production waste is recycled.
- NPA is taking action to reduce its Scope 1 and 2 carbon emissions to Net Zero by 2030.

In a rapidly evolving high security manufacturing landscape, Note Printing Australia (NPA) continues to demonstrate how innovation, operational discipline, and a commitment to continuous improvement can lead to exceptional productivity gains.

NPA has adopted a multifaceted strategy to enhance productivity, reduce costs, and maintain its competitive edge. Through a combination of incremental operational enhancements, investments in new machinery, spoilage reduction programs, strategic breakthrough initiatives, and an unparalleled commitment to safety, NPA is aiming to maintain its reputation for high quality banknotes and passports while achieving new levels of efficiency and employee engagement..

## INCREMENTAL OPERATIONAL PERFORMANCE: EVERYDAY EXCELLENCE

NPA's most consistent source of productivity improvement stems from incremental performance enhancements on existing equipment. In FY24/25, the organisation reported a 12-15%increase in throughput compared to the previous financial year. These gains were achieved through a rigorous focus on traditional manufacturing key performance areas (KPAs), such as press speed, downtime reduction, and waste minimisation.

Central to this success is NPA's Daily Management System (DMS), a framework that allows teams to identify and resolve deviations from planned performance on a daily basis. This system ensures that even the smallest inefficiencies are addressed promptly, resulting in a cumulative impact that significantly boosts overall output. By embedding this discipline across its operations, NPA has created a culture where small, consistent improvements are valued and celebrated.

## NEW MACHINERY: LEVERAGING TECHNOLOGY FOR PRODUCTIVITY GAINS

Another crucial element in NPA's productivity strategy is its willingness to invest in advanced manufacturing equipment. A standout example is the recent replacement of a 45-year-old German lathe with a state-of-the-art Okuma lathe from Japan.

ROLLS ROYCE TO FERRARI: (L-R) NPA PRODUCT TOOLING APPRENTICE CLAUDIO PARDELHA IS SOAKING UP KNOWLEDGE ON A DAILY BASIS FROM GORDON ANDERSON, A PRODUCT TOOLING TECHNICIAN WITH ALMOST 45 YEARS-EXPERIENCE.

The new lathe represents a significant technological leap, offering micron-level precision and automated polishing capabilities that dramatically improve both the quality and durability of wiping cylinders—essential components in Super Orlof Intaglio (SOI) presses.

Where the old lathe required manual finishing and had limited control over cutting precision, the new machine allows for adjustments in

1-micron increments and completes finishing using diamond-tipped tools. This innovation has extended the usable life of wiping cylinders from 160 to 300 reams, an 85% productivity gain. Additional benefits include reduced energy consumption, automated sleep modes, and a far quieter, more comfortable working environment.

The impact of this upgrade goes beyond simple output metrics—it also boosts staff morale and safety, as evidenced by employee testimonials highlighting the reduced noise levels and ease of use. As long-serving technician Gordon Anderson put it, the upgrade is like trading in a "Rolls-Royce for a Ferrari."

## DIGITAL TRANSFORMATION: IGNITION MES SYSTEM IMPLEMENTATION

In parallel with hardware upgrades, NPA has embraced digital transformation to further streamline its production workflows. In 2024, the organisation began replacing its legacy eView system with a new Manufacturing Execution System (MES) built on the Ignition SCADA platform. The rollout began in the Passports department and will eventually extend across Finishing and the Print Hall.

This new system offers real-time visibility into production data, enabling faster response to issues, better decision-making, and increased transparency across departments. According to Anoop Ronald, Passports Shift Manager, the immediate access to data has already improved responsiveness and informed decision-making in meaningful ways. Engineered by a cross-functional team from engineering, IT, and maintenance, the Ignition MES system bridges the gap between enterprise software and factory floor control. It lays the foundation for a fully connected, data-driven production environment—an essential step for any modern manufacturing enterprise pursuing operational excellence.


FLYING: IMPROVEMENTS IN TEAMWORK AND COLLABORATION BY THE INTAGLIO PRINT TEAMS THAT INCLUDE (L-R) SECURITY PRINTERS DANIE STEYTLER AND KYLE TAYLOR HAVE SEEN EFFICIENCY AND THROUGHPUT RATES MAKE IMPRESSIVE GAINS.

SAVINGS BANK: A SMALL BUT INSIGHTFUL PROTOCOL IMPROVEMENT LED BY (L-R) PROCESS ENGINEER SOBHAN FAHR AND SUPPORTED BY PERFORMANCE IMPROVEMENT COORDINATOR STEPHEN NICHOLS HAS LED TO COST SAVINGS AND DOWNSTREAM PROCESSING BENEFITS.

## SPOILAGE REDUCTION: BENCHMARKS DRIVE IMPROVEMENT

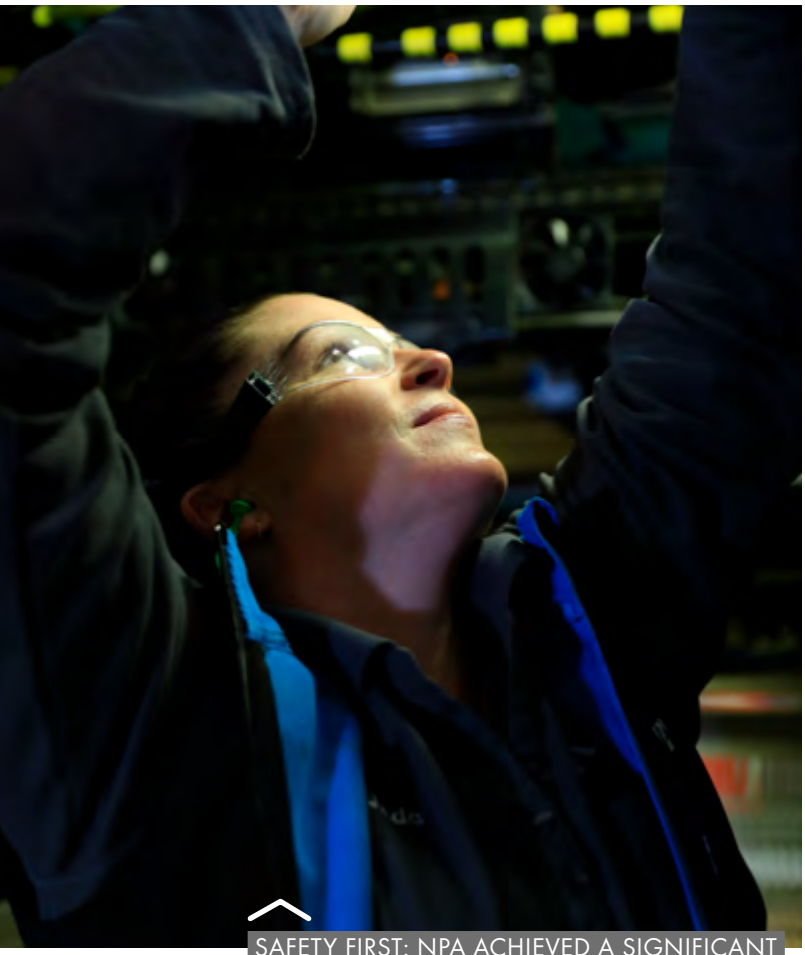
Another key focus for NPA has been reducing spoilage — a critical cost driver in high-precision printing operations. In response to a predicted decline in domestic banknote demand, NPA specified a challenging spoilage target for all jobs exceeding 10 million pieces.

While ambitious—especially given the stringent technical specifications of Australia's Second Polymer Banknote Series — the initiative has already delivered substantial results. Average spoilage across all NGB runs has dropped to record lows. Subsequent production runs in which the banknote's specification was designed to work well within the printing constraints of the presses, such as the Philippines 1000 Piso note, have achieved spoilage rates well below the target benchmark.

These results have been achieved through a collective effort across multiple departments, including Print Hall, Finishing, Quality, Logistics, Pre-Production, Planning, and Maintenance. The initiative underscores the value of interdepartmental cooperation and shows how a shared goal can galvanize an entire organisation to improve performance.

## STRATEGIC BREAKTHROUGH INITIATIVES: INNOVATION FROM WITHIN

Beyond incremental improvements and process optimisation, NPA has also implemented



SAFETY FIRST: NPA ACHIEVED A SIGNIFICANT SAFETY MILESTONE EARLIER THIS YEAR WHEN IT RETURNED ITS LTI RATE TO ZERO, A RECORD THAT EVERYONE AT NPA IS DETERMINED TO MAINTAIN INCLUDING SECURITY PRINTER JADE MCDONALD.

strategic breakthrough initiatives aimed at unlocking larger productivity gains. Through its Strategic Policy Deployment (SPD) framework, NPA encourages staff across all levels to propose and lead initiatives that can significantly impact operational performance.

One example is the development of a new squeegee maintenance protocol on the screen-printing machine. While conceptually simple, the refined protocol has yielded a raw material cost savings during a single high volume print run, and more significantly has reduced downstream processing issues such as blocking and feeder stops. With verification complete, the new procedure will now be standardised across all applicable jobs—proof that even modest process innovations can generate substantial returns when executed effectively. SPD has also fostered a greater sense of ownership and engagement among employees. By inviting contributions from across the business, it has cultivated a workplace culture where continuous improvement is everyone's responsibility.

## SAFETY PERFORMANCE: ZERO LOST TIME INJURIES

Crucially, NPA has managed to improve productivity without compromising employee safety. In fact, the company reached a significant milestone in March 2025 by achieving a (rolling 12 month) Lost Time Injury Frequency Rate (LTI) of zero—its best result since June 2023.

This milestone reflects a comprehensive and proactive approach to workplace safety. From encouraging employees to speak up about unsafe practices to implementing ongoing safety improvements and prioritising psychological wellbeing, NPA's commitment to creating a safe, supportive workplace is unwavering.

As HSE Manager Chris Lait noted, "The progress we've made in safety is the result of every team member looking out for and looking after one another and embracing safer ways of working."

With new initiatives like the introduction of 20 Wellbeing Support Officers being recruited and trained within the existing workforce, NPA is not only maintaining but expanding its commitment to employee safety and wellbeing.


SINGULARITY: NPA'S ON-GOING PRODUCTIVITY GAINS IN THE PRINTING OF BANKNOTES AND PASSPORTS IS DRIVEN BY THE OPERATIONS MANAGEMENT TEAM OF (L-R) DANIEL ROBERTS, ANDREW ATWELL, MICHEL BEEKMAN, MARK KISIELEWSKI, RAJ PRASAD, LARRY SAFAYA, MOHAMED TAOUMI AND VIET VU.

## CONCLUSION: A MODEL FOR SUSTAINABLE MANUFACTURING EXCELLENCE

Note Printing Australia's success in boosting productivity is the result of a well-rounded, strategic approach. By combining incremental gains with strategic investments in technology, reducing spoilage, enabling innovation from within, and fostering a culture of safety and collaboration, NPA has established a blueprint for sustainable manufacturing excellence.

This holistic strategy has delivered impressive results—from reducing spoilage rates to extending the lifespan of critical components and achieving zero lost time injuries—all while fostering a more engaged and empowered workforce. In doing so, NPA not only strengthens its competitive position but also reinforces its reputation for producing high quality polymer banknotes and passports driven by a collaborative culture in which its people are 'Better Together'.

As Chief Production Officer Raj Prasad put it, "We are one team—Team NPA. If we continue to look out for each other and improve across every aspect of our strategic pillars—Safety, People, Quality, Delivery, Cost—we will achieve world class print performance. This is not just a goal – it's an outcome we will deliver."

NOTE PRINTING AUSTRALIA

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Website: www.noteprinting.com

CCL SECURE

THE POLYMER BANKNOTE PEOPLE

# Harnessing a history of innovation to make **greener** banknotes

| | |
|---|---|
| Guardian | Guardian ENVIRO |
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**TRUSTED FOR MORE THAN 35 YEARS**

**STRONGER**
Durability delivers significantly longer circulation life

**SAFER**
Security features proven to reduce counterfeit rates

**CLEANER**
Hygiene benefits derived from strong moisture barrier

**GREENER**
Environmental benefits of reduced emissions and recycling

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# Future Forward

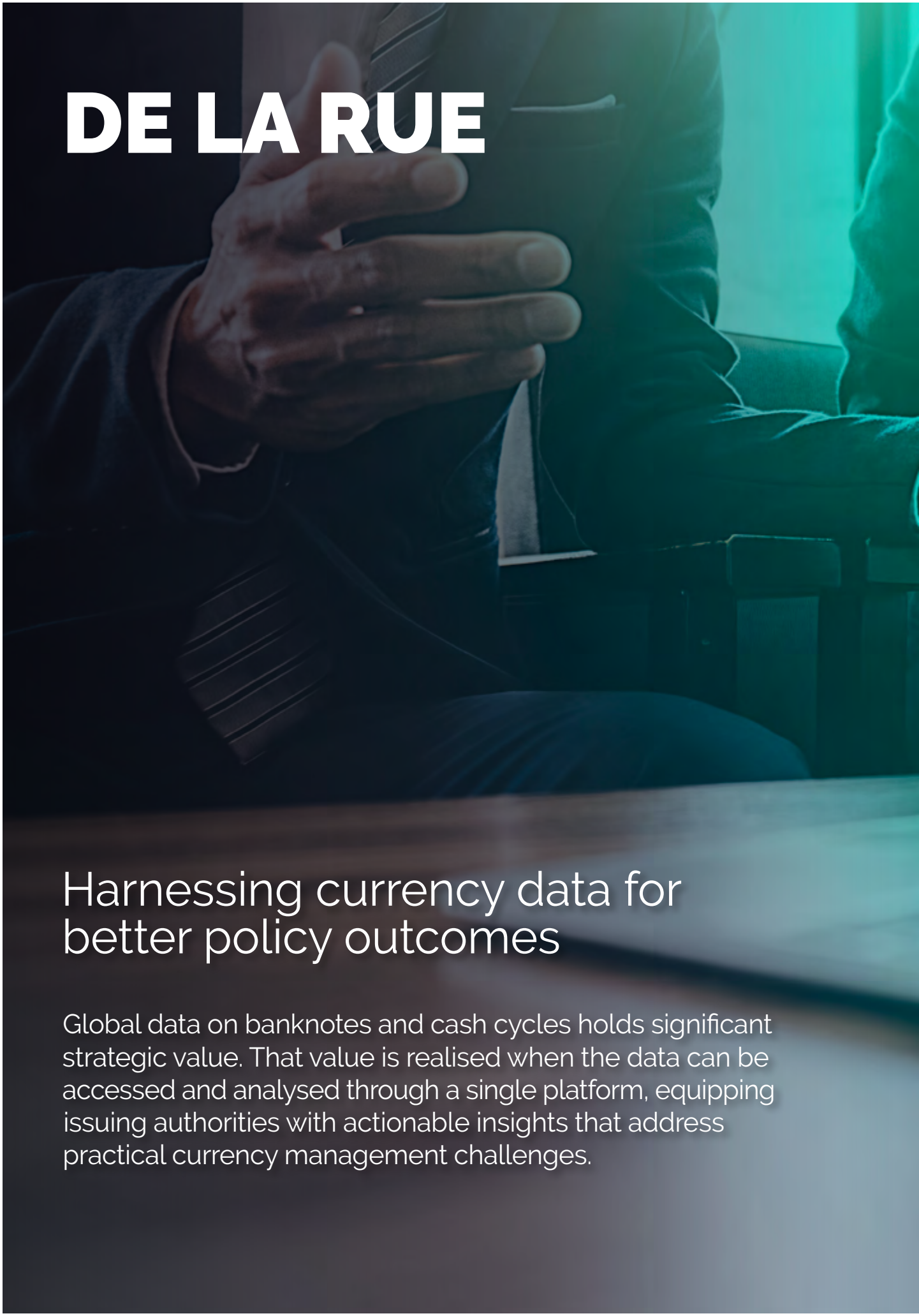
# There is nothing more precious to a country than its national currency. We are honored that over 70 countries worldwide put their trust in our high-security products to protect their national pride from counterfeiters.


**55 years of stability and trust**
Chosen by national banks worldwide, we are shaping a new era of banknote security – combining sustainable features with highest protection.

# We look forward to shaping the future of secure currency together.

More about Highest Security **hueck-folien.com/security**

# GIVING WINGS TO SERVICES




# Harnessing currency data for better policy outcomes

Global data on banknotes and cash cycles holds significant strategic value. That value is realised when the data can be accessed and analysed through a single platform, equipping issuing authorities with actionable insights that address practical currency management challenges.

# FACT BOX

- Central banks and issuing authorities worldwide use DLR Analytics™ to make evidence-based decisions that improve efficiency, optimise cash cycle management and support strategic denominational planning
- Freely available to issuing authorities, the platform offers access to a rich dataset that powers advanced tools for trend analysis, forecasting banknote demand and understanding banknote lifespan
- The D-METRIC® tool, part of the DLR Analytics™ suite, helps determine optimal denominational structures, such as the coin/banknote boundary and the highest practical denomination
- Evidence-based decision making de-risks changes to denominational structures and helps to quantify the potential impact including improved efficiency across the cash cycle and the resulting economic, environmental and societal benefits

To demonstrate the practical application of the DLR Analytics™ platform, which aggregates open source data published by central banks, the IMF and World Bank, De La Rue has based the following scenario on a real-world situation using authentic, anonymised data.

We explore how the introduction of a New High-Value (NHV) banknote can be successfully delivered as part of a proactive, data-led policy decision. It demonstrates how central banks can apply analytical tools to assess evolving cash usage patterns, evaluate denominational efficiency, and support strategic adjustments to currency structures.

When guided by evidence and implemented with clear objectives, the introduction of a NHV note can provide substantial long-term benefits, including improved efficiency across the cash cycle and a broad range of economic, societal, and environmental sustainability gains.

## HOW ONE CENTRAL BANK EVOLVED ITS DENOMINATIONAL STRUCTURE

**2014**

Denominational structure:

| 1 | 5 | 10 | 50 | 100 |
|---|---|---|---|---|

Volume of banknotes in circulation: **1.8 bn**

Value of banknotes in circulation: **70 bn**

In 2014, the central bank maintained a five-banknote denominational structure.

By 2018, the volume of 100-unit banknotes in circulation had increased significantly, highlighting a growing reliance on higher denominations to meet currency demand. Mid-range denominations remained relatively stable, while circulation of lower-value notes, especially the lowest denomination, declined steadily. (Figure 1 – Volumes in circulation, split by denomination).

IMF forecasts projected a continued upward trend in the value of banknotes in circulation from 2017 through to 2020.

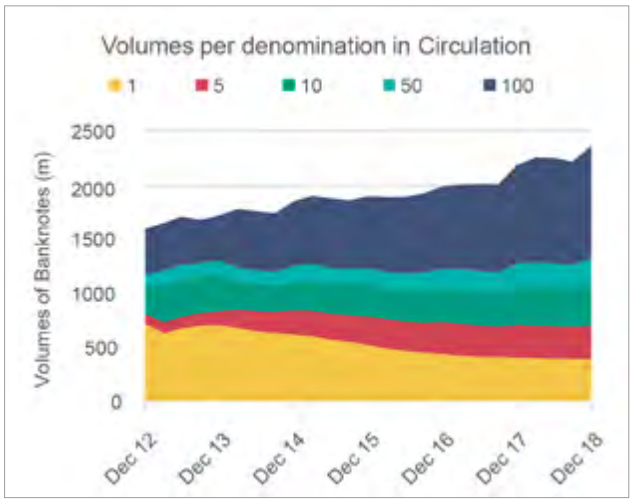



FIGURE 1 – VOLUMES IN CIRCULATION, SPLIT BY DENOMINATION

In response to both observed trends and forecasted data, the bank initiated a review of its denominational structure. As a result, it introduced a new 200-unit banknote to the series, which was launched in 2020.

Since the introduction of the high-value banknote, the total volume and value of notes in circulation has continued on an upward trend. However, the rate of increase of overall volume of notes has remained steady, and the value of notes in circulation has remained in line with the 2017 IMF forecast.

Retrospective analysis indicates that without the introduction of the new high-value banknote, the number of banknotes in circulation, and the associated cash cycle costs, would have increased substantially.

## A RETROSPECTIVE ASSESSMENT OF DENOMINATION POLICIES

Using detailed historical data, De La Rue's D-Metric® modelling tool, which provides data-driven recommendations including the optimal value for the highest useful denomination, concluded that the bank's denominational structure would benefit from being expanded to include a 200-unit banknote. (Figure 2 – Volumes in circulation, with NHV).

This retrospective analysis validated the bank's decision to introduce a new high-value (NHV) banknote.

Further modelling was conducted to simulate an alternative scenario in which no NHV banknote was introduced. This analysis revealed that, by March 2024, an additional 800 million banknotes would have been required to achieve the same total value in circulation. (Figure 3 – Volumes in circulation with no NHV)

## THE BENEFITS OF AN OPTIMISED DENOMINATIONAL STRUCTURE

For the example central bank referenced in this paper, the introduction of a 200-unit banknote led to a reduction in the overall number of banknotes required in circulation. This adjustment delivered measurable benefits across economic, societal, and environmental dimensions.

**Economic Sustainability**

- Reduced cost to establish the required value of cash in circulation
- Reduced cash cycle costs with fewer banknotes to be transported, handled, and processed
- Volume remains within manageable capacity levels for cash centres

**A comparison of banknote volumes in circulation with and without the introduction of a New High Value note**

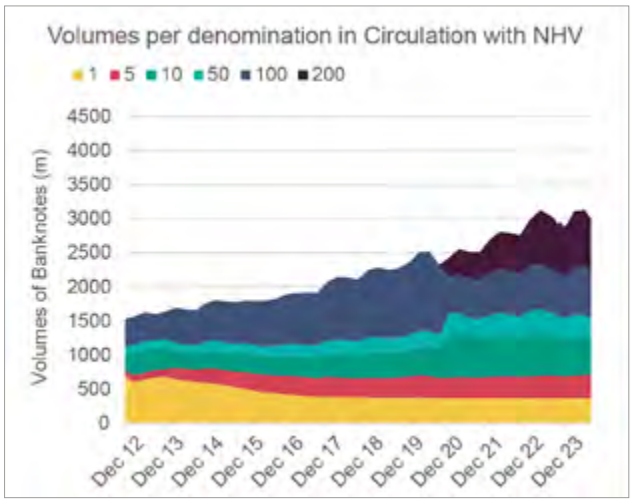



FIGURE 2 – VOLUMES IN CIRCULATION, WITH NHV

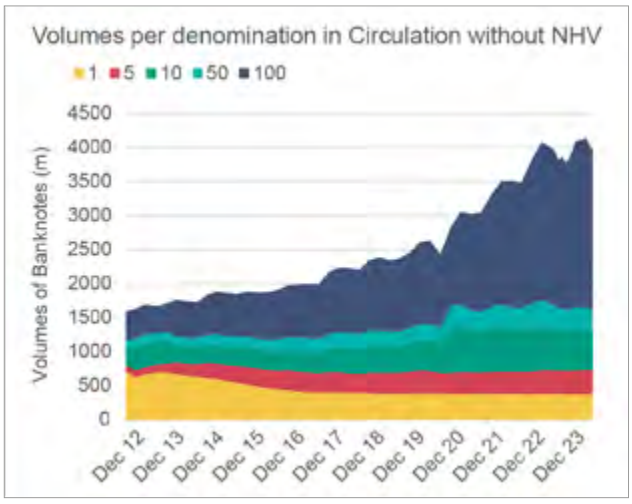



FIGURE 3 – VOLUMES IN CIRCULATION, WITH NO NHV

**Societal Sustainability**

- Cash circulating faster and being inspected more frequently, ensuring that the condition of the banknotes remains higher
- Fewer banknotes required to complete cash transactions, making transactions simpler and faster

**Environmental Sustainability**

- Reduced consumption of energy and resources during manufacturing
- Less manufacturing waste
- Lower emissions levels
- Lower shipping carbon footprint

These environmental gains can be further enhanced by adopting a more durable banknote technology, such as De La Rue's SAFEGUARD® polymer substrate which significantly extends the lifespan of banknotes, reducing the volume needed over time.

At a time when sustainability is a global priority, a demonstrable commitment to all three pillars, economic, societal, and environmental, reinforces public trust and supports policy alignment.

## THE BENEFITS OF DLR ANALYTICS™

DLR Analytics™ offers an unrivalled global perspective on currency, viewed through the specific context of an individual country or region. By aggregating publicly available data from central banks, the IMF, and the World Bank, it equips issuing authorities with the tools to identify trends, conduct comparative analysis, and make informed decisions about currency management. This data-led approach supports more strategic, evidence-based policymaking. Tools within DLR Analytics™ support a range of currency management functions:

- **Banknote lifetime analysis** enables central banks to assess the impact of changes in banknote specifications, sorting technologies, or policy decisions

- **Banknote demand forecasting** translates macroeconomic indicators into practical insights on future note demand and stock requirements, helping to fine-tune replacement rates

- **Global and regional trend analysis** allows issuing authorities to benchmark their cash cycle performance against regional and global standards.

- **Analysis of banknotes in circulation and currency value in circulation** helps visualise historical data and identify when and where policy interventions may be necessary

- **Optimal denominational structure assessments** with D-Metric®, De La Rue's proprietary modelling solution, provides tailored recommendations including guidance on coin-note boundaries and high-value note requirements.

## VOLUME AND VALUE IN CIRCULATION ANALYSIS

Currency issuance data is collected on a per issuing authority basis over multiple years and presented in DLR Analytics™ through impactful charts and graphs, providing a clear and accessible view of key trends. DLR Analytics™ currently maintains data coverage for a substantial share of the world's issuing authorities, enabling a robust basis for analysis and comparison.

D-Metric®, part of the DLR Analytics™ suite, was developed by De La Rue in response to research

identifying a strong empirical relationship between currency usage and wage levels. Further study of denominational structures in relation to daily Gross Domestic Product (GDP) across a diverse range of countries revealed consistent patterns between daily GDP (the D value) and optimal denominational structures.

The tool applies these patterns to model and recommend optimal denominational frameworks, including the appropriate placement of the coin/banknote boundary and the value of the highest useful banknote denomination. It is designed to support central banks in establishing effective, evidence-based currency structures.

Recognising the evolving nature of currency use, D-Metric® has been rigorously reassessed in recent years. Retrospective modelling of 48 currencies confirmed its ongoing relevance and validity in today's economic environment. The tool now encompasses data from over 190 countries spanning multiple decades.

## WHY EFFECTIVE DENOMINATIONAL STRUCTURES MATTER

An appropriately structured denominational range is essential for ensuring both operational efficiency and user convenience. Without the right balance of coins and banknotes, excessive volumes may be required to support transactions, creating inefficiencies for central banks and inconvenience for the public.

Equally important is the central bank's ability to meet demand for the total face value of currency in circulation. An optimised structure ensures this can be achieved effectively and efficiently.

Used by a large number of central banks worldwide, DLR Analytics™ helps assess whether a denominational structure aligns with the currency needs of a population, and generates actionable recommendations.

## LEARN MORE

To understand how DLR Analytics™ can support your currency analysis work, please contact De La Rue to request a live demonstration.

## ABOUT DE LA RUE

De La Rue partners with governments, central banks, and state printworks to deliver secure currency solutions that preserve the integrity of national cash systems. By strengthening trust in physical currency, De La Rue enables countries to facilitate everyday transactions, promote financial inclusion, and support sustainable economic development.

De La Rue supplies fully finished banknotes, polymer substrates, security features, and a suite of related services, meeting the needs of more than half of the world's central banks and issuing authorities.

## SOURCES

DLR Analytics™
IMF
World Bank
Central bank data

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De La Rue

Mr. Phil Moffat
Email: Phil.Moffat@delarue.com
Website: www.delarue.com


KOENIG & BAUER
BANKNOTE
SOLUTIONS
Making Banknotes
do More in Society

# FACT BOX

- In developed nations, the single largest cost and ecological impact from cash in circulation (>70%, ECB PEC 2023) comes from making cash available via ATM networks and the associated logistics and recycling process.
- An estimated 120 billion banknotes per year are moved to centralised cash recycling centers for one core task – taking a picture of them to assess fitness and authenticity.
- In highly cash-dependent countries where more than 80% of all cash circulates, the majority of banknotes never return to a cash center for reprocessing. They remain circulating in local or regional loops outside of cash recycling infrastructures for extended periods.
- Approximately 50% of the world's population are adversely affected by the financial literacy deficit.
- The OECD reports that since 1985, financial literacy levels have only increased by 0.5% on average and in many countries are actually in decline.

## MAKING BANKNOTES DO MORE IN SOCIETY

As a payment tool, every banknote our industry produces must pass through a dedicated distribution and service system before it can be used and create value for society. The banknote product and the service system upon which it depends are therefore inextricably interconnected and have a direct impact on each other.

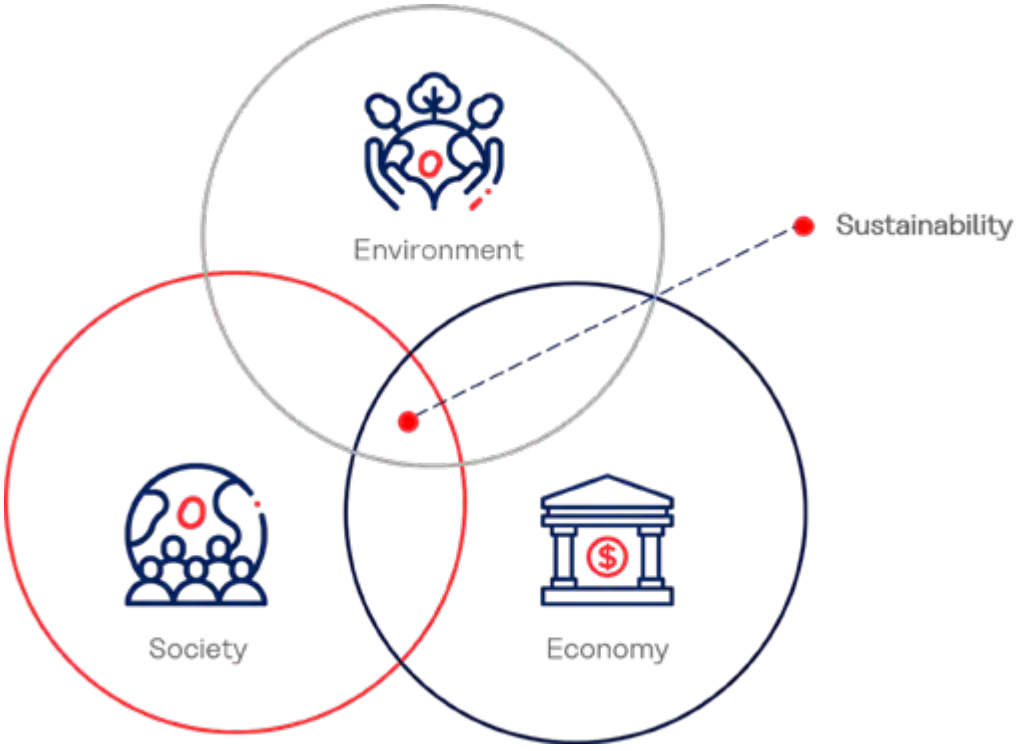
Today, evidence tells us that banknotes are much more than a payment tool and are performing essential life supporting roles such as:

- Store of value & saving,
- Crisis management,
- Responsible budgeting,
- Empowering informal economies,
- Educational & cultural.

Since banknotes are evolving into new use cases and performing new roles in society, our community must evolve too and view this evolution as an opportunity to make banknotes do more in society.

Koenig and Bauer Banknote Solutions is taking a more holistic and inclusive look at the role of banknotes in society and how we can leverage their intrinsic assets and characteristics to make banknotes do more for the >80% of the world's population who use them every day.

We are basing our work on what we call "Sustainable Innovation". In practice, "Sustainable Innovation" translates into any development work that creates positive impact on costs, ecology and society – and our goal is to center our efforts on work where all three goals coalesce.



Following this philosophy, we direct our resources and investments into creating a process that makes banknotes better, lower cost and sustainable.

Let's look at some concrete examples of "Sustainable Innovation" in the banknote product, the banknote service system and society.

## BANKNOTE PRODUCT: SELECTIVE INKING

While banknote printing contributes only marginally to the total cost and ecological impact of cash, our "Sustainable Innovation" work has recently enables us to make this number lower by making Intaglio printing;

- Simpler and more efficient,
- Greener and more sustainable,
- More Consistent and precise than ever before.

In the past, the Intaglio printing process has largely depended upon printer knowledge and experience to achieve the highest standards in printing. Print quality and consistency frequently became more of an art than a science as operators continually adjusted machine parameters to achieve success.

Today, we leave the constraints of the past behind us and take a giant step forward by offering a simple, precise and perfectly controlled way to transfer ink into the Intaglio engraving, using a selective cylinder and a metering blade.

THE SELECTIVE INKING SOLUTION ON THE MACHINE

So what are the real benefits of Selective Inking?

- Since all ink transfer parameters are now precisely configured during the pre-press digital workflow onto the ceramic cylinder, there is no longer any need to use ColorTronic or spend time on ink duct settings.

- Since inking parameters are locked in place via the ceramic sleeve, print quality and consistency is assured even between end of shift operator changes and ink-drying time is significantly reduced.

- Production variability is also dramatically reduced, enabling more constant and controllable printing, ultimately reinforcing Intaglio Security Feature value by ensuring consistency and repeatability.

- Both directly and indirectly, the Selective Inking process contributes to a more efficient and cost-effective printing process.

And these substantial cost-savings are all achieved while reducing the ecological footprint of intaglio.

Perhaps most exciting of all is the new generation of Intaglio designs and features that are made possible by this ultra-precise inking process.

Selective Inking is a clear example of how the banknote printer can create even more value for society while significantly reducing costs and its ecological footprint.

## BANKNOTE SERVICE SYSTEM: CASH MANAGEMENT

The cost and ecological impact of cash in circulation is having a direct negative impact on cash access and acceptance globally. Most importantly, the issue of who actually pays for cash has resulted in a shifting perception by many key cash access/acceptance stakeholders (commercial banks & retailers) who now view cash as a cost whereas digital payment tools are perceived as a lucrative and growing revenue stream.

Today, capturing data on banknote authenticity, fitness, quality and many other criteria is

possible using existing mobile devices at logical high volume cash touch-points (e.g. retail POS, Mobile Money Agents, CashBack services, Cash-on-Delivery services). The data is then transmitted to the Central Bank in a highly granular or aggregated fashion, in real-time; to provide valuable data insights at a level that far exceeds current cash-center based recycling models.

Koenig & Bauer Banknote Solutions has developed an innovative technology that functions on mobile devices to capture key banknote-metric data and make it available via dashboards for Central Banks and if required, other Cash Cycle stakeholders. ValiCash+ is a proprietary banknote analytics algorithm that captures processes and transmits banknote data from an App running on mobile devices.

The type of datasets generated include:

- Banknote authenticity,
- Real-time counterfeit alert,
- Counterfeit type/clusters/identifiers and print source,
- Banknote fitness/integrity/soiling level,
- Compliance with clean-note policies,
- Denomination flows/demand patterns.

ValiCash+ is intended to act as a compliment to Cash-Center Recycling and act as an empowering agent to significantly change existing Cash Management models. While centralised Cash Recycling may make sense in high population density urban areas, the model fails when it involves transporting banknotes outside of a certain catchment area. ValiCash+ provides the opportunity to capture banknote data in regions where no data insights exist and a sustainable model for decentralised recycling by existing Cash Stakeholders involved in high growth cash access sectors such as:

VALICASH+ MOBILE APP AVAILABLE ON APPLE AND PLAY STORE FOR DOWNLOAD

- Mobile Money Agents,
- Cash-in-Shop agents,
- CashBack services,
- Cash-at-Home services,
- Cash-on-Delivery services.

ValiCash+ does not require any modification to an existing banknote design and denomination-specific algorithm development for a series of banknotes can be achieved in 10 days.

## SOCIETY: FINANCIAL LITERACY

Financial Literacy refers to a person's ability to understand basic financial principles (including numeracy) and apply these principals in their day-to-day lives to foster responsible and sustainable financial attitudes and behaviour. It is an essential prerequisite to using financial products and tools and has a direct impact on the individuals quality of life and a nations potential for socioeconomic development.

Financial Literacy or more appropriately, the deficit in Financial Literacy is most symptomatic in societies with high cash dependency levels and is visible via high levels of over-indebtedness, unemployment, health problems , crime and social exclusion.


BEESMART MOBILE APP AVAILABLE ON APPLE AND PLAY STORE FOR DOWNLOAD

So how can banknotes help? While most people associate banknotes with two primary functions (payment and store of value), they actually play an invaluable third role in our lives. Banknotes act as a unit of account, enabling us to assign value to goods and services and cash values are used across the globe in education as we teach young people basic numeracy and mathematical skills.

We have built upon the publics affinity for, familiarity with and trust in banknotes as a unit of account to develop a digital and physical educational platform to empower youth financial competency development using banknotes. We call this BeeSmart.

Depending on the digital readiness of a user group or a nation, Central Banks and Departments of Education can opt to adopt the physical or digital version of our platform and make it available to the public via integration into national educational curricula for teacher-directed learning or to the public for self-directed financial competency development.

BeeSmart empowers each and every learner to embark on a highly contextualised and life-relevant learning journey. The App combines Artificial Intelligence, tasks, games and exercises to coach as well as challenge the user to make financial and budget decisions while constantly monitoring and mentoring each individual and providing data-metrics on learning, financial attitude and behavior development.

At the heart of the BeeSmart educational platform are banknotes, educational banknotes, reinforced by a robust educational curriculum developed by our NGO partner, AFLATOUN International, the global leader in financial and life skill development.


## SUPPORTING CENTRAL BANKS TO MAKE BANKNOTES DO MORE IN SOCIETY

Koenig & Bauer Banknote Solutions has a dedicated multi-disciplinary team of experts available to the international Central Banking Community to support you as we redefine the role of cash in society and ensure that it meets evolving needs such as Store of Value, Cash-in-a-Crisis, responsible budgeting and saving and of course, education.

We envision a future where the attributes of cash will make the wider payment ecosystem more resilient and robust. Our mission is to make cash do more for society and foster the development of equitable and sustainable payment ecosystems defined by choice and inclusivity.

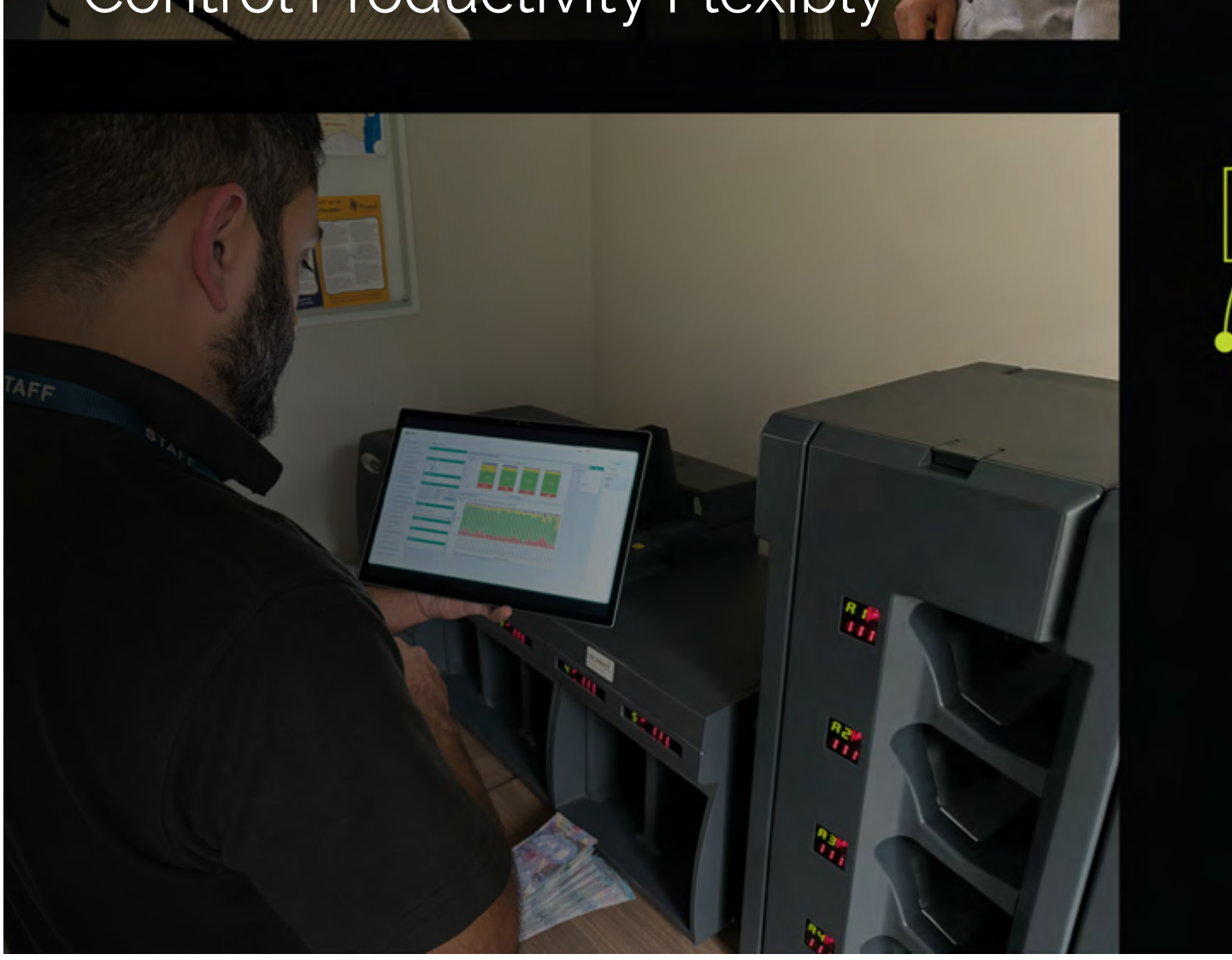
Join us on our journey into the future and discover how you can make banknotes do more for society in your nation. It is an exciting time for all of us as we explore and reinvent the role of cash in society and we look forward to sharing our insights and sustainable innovation work within our community.

KOENIG & BAUER BANKNOTE SOLUTIONS

Mr. Mark Stevenson
Email: mark.stevenson@koenig-bauer.com
www.banknote-solutions.koenig-bauer.com

# ENTERPRISE CASH MANAGEMENT (ECM)

Control Productivity Flexibly



# FACT BOX

ECM is a specifically designed software solution for banks that:

- Manages the banknote lifecycle processes from new note production, monetisation, circulation and recycling to eventual end-of-life destruction, providing end-to-end security and control
- Monitors fitness standards of recycled banknotes to track adherence to policies
- Provides visibility of new note, recycled and custodian inventories, controls issuing of new notes to the banking sector and monitors the circulation of
- Provides unparalleled security capability, enabling dual authorisation control, restrictions in cash transfer and an authorisation hierarchy ensuring internal processes and procedures are upheld
- Integrates into core banking systems for seamless, end-to-end operational management
- Operates with a wide variety of banknote sorter and automation equipment from different hardware vendors giving you complete flexibility of solution options
- Securely manages and audits the handling of cash across single or multi-centre cash operations

ECM™ is an integrated suite of software solutions developed by ECM Ltd to manage the end-to-end cash cycle. The ECM™ suite has been designed, and is continuously improved, to provide central banks with:

- Total operational visibility to improve control
- Best practice processes to increase productivity
- Configurable rules to provide the flexibility needed for the future
- Advanced analytics to optimise the entire end to end cash supply chain to reduce environmental impact, enhance security & deliver operational savings

## BALANCING CONTROL & VISIBILITY WITH PRODUCTIVITY AND FLEXIBILITY

### CONTROL & VISIBILITY:

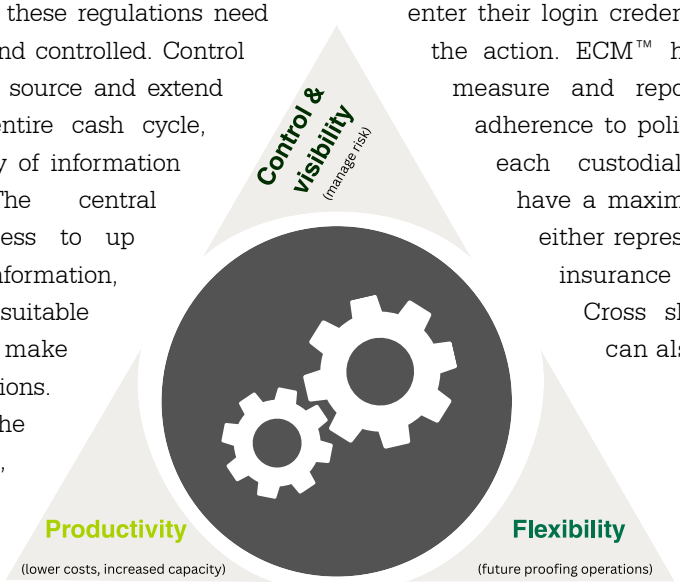
Implementing tight regulations is essential for a central bank to perform its role, however, to be meaningful, these regulations need to be monitored and controlled. Control needs to begin at source and extend throughout the entire cash cycle, for which visibility of information is crucial. The central bank needs access to up to date information, presented in a suitable format to make informed decisions. This includes the quantity, fitness, age and location of banknotes in circulation, performance of individual banknote features, stocks and performance of the commercial sector against regulatory benchmarks and the efficiency of the banknote printing supply chain.

## INCREASED OPERATIONAL CONTROL

ECM™ provides a centralised inventory of all banknotes and unverified deposit containers that are tracked by location and updated in real time. This gives you an instantly available view of the entire cash stock across all your locations. The movement of inventory is controlled and recorded in ECM™, making a thorough audit report quick and easy.

## INCREASED OPERATIONAL SECURITY

All actions within ECM™ are controlled through role-based access rights with the ability to restrict key actions with dual authorisation. The logged-in user performing the action is recorded, alongside a second user with the necessary access rights who's required to enter their login credentials to authorise the action. ECM™ has the ability to measure and report on risk, and adherence to policies. For example, each custodial inventory will have a maximum cash holding, either representing a physical, insurance or policy limit. Cross shipping activities can also be monitored.



## VISIBILITY AND CONTROL OF THE COMMERCIAL SECTOR

Through integration with sorting machines, ECM™ enables you to enforce fitness policy by identifying banknotes that have been incorrectly classified by a commercial processor. Tolerances and reporting levels for fitness discrepancies can be configured to define the process required for policy violations.

## INTEGRATED SUPPLY CHAIN

Further visibility of the commercial sector can be achieved through open architecture and ECM™ COP (Common Operating Platform). COP accepts data feeds from organisations external to the central bank that are running ECM™, or third-party vault management systems, and displays their information alongside the central bank's own data. This provides you with full traceability and visibility across the cash cycle. In addition, you can present this information to the commercial banks.

## OPTIMISING PRODUCTIVITY

Managing tight budgets, reducing costs and increasing efficiency, without compromising levels of control and visibility can be very difficult, and must involve adopting the latest practices and technologies. ECM™ enables you to achieve this balance.

With ECM™, information is captured at source, reducing manual data entry and the associated human error. Any manual data entry mistakes that are made are flagged immediately through a central warning console. ECM™ also reduces the manual handling of cash and automates back-office accounting and reporting activities, increasing operational efficiency.

Capturing data efficiently and accurately is important, but as infrequently as possible or eliminating it altogether is the key. ECM™ ICSP provides the commercial banks with greater self-service capability to enhance the data capture process and eliminate it from your deposit preparation time.

Alongside operational efficiency, with the right information, an appropriate level of risk analysis and mitigation strategies, tactical and strategic decision making such as 'just in time' ordering can reduce costs.

## MAXIMISING FLEXIBILITY

Like any other organisation, a central bank must ensure that they are prepared for the future. In many cases, commercial banks and business look to the central bank for such guidance and direction. It is critical that you have the tools to adapt and flex to changes in the cash cycle e.g. an increase or decrease in volume requiring changes to resources, a change in statutory obligations or policy that requires process change. All must be possible with the minimum of disruption or cost.

The ECM™ configuration engine enables you to make future adaptations and changes to the solution yourself, on-site.

## ECM CENTRALISED CONTROL:

ECM™ Centralised Control offers customers of all mainstream hardware, efficiency analytics as a service. Our ECM™ Centralised Control platform positively influences performance in a cash centre and provides management with detailed data of the entire operation in-real-time. The dashboarding provides real-time information for a machine operator about the performance of the machine, against pre-defined acceptable standards.

These standards could include acceptable levels of throughput, reject rate and downtime. This enables the operator to continually meet or exceed the standards required, optimising performance of the operation.

While the analytics engine consolidates data from multiple machines within a cash centre or even across multiple sites, which can be viewed in real-time and analysed by management, to measure performance against Key Performance Indicators (KPIs) as well as to influence and inform business strategy.

The Centralised Control system allows central banks to analyse banknotes with serial number reading and tracking, to determine the characteristics of the banknotes in circulation, age of banknotes, and whether certain specific features are operating optimally or not.

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ECM

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Website: www.ecm.software

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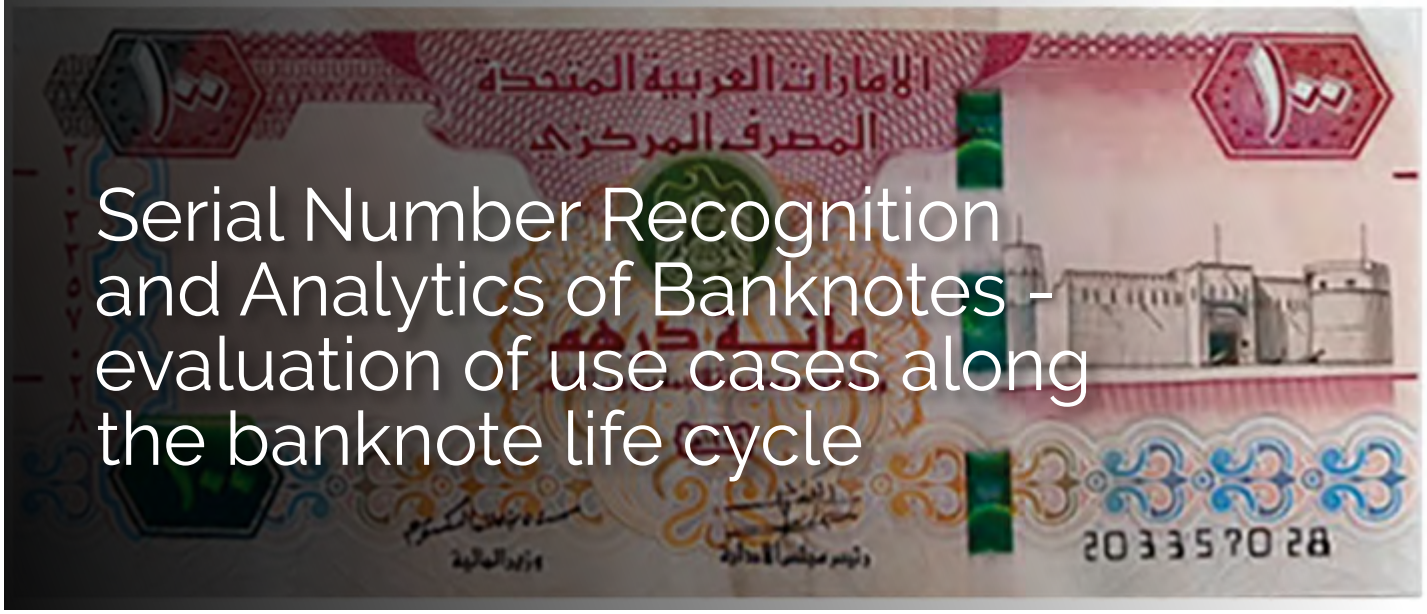
# CASH INFRA PRO


## Serial Number Recognition and Analytics of Banknotes - evaluation of use cases along the banknote life cycle




# FACT BOX

- The serial number is the unique fingerprint of a banknote and the identifier to distinguish the individual banknote from other banknotes.
- The serial numbers differ depending on the currency in terms of size, font, alphanumeric characters, and for example check digits.
- Use cases for public sector fall often in the scope of law enforcement and crime prevention authorities. The central banks provide valuable services to the investigating authorities as they have direct access to the physical banknotes in the cash centers.
- Automated serial number reading beyond the printing process depends on the sensor in the banknote processing machine and capability for data management. Installed technology in the field limits the deployment of advanced use cases.

Central banks around the world are asking for technical concepts of banknote serial number recognition and analytics in the cash cycle. This raises the question of which goals are to be achieved for the respective use cases, including the transportation of the serial number applications defined for the purposes of printers to a serial number for the banknote life cycle.

The National Central Banks´answer to the question of their project purpose for serial number recognition and analytics remain rather vague. This article provides an initial overview of the subject.

## SERIAL NUMBER ON BANKNOTES IN PRINTING PROCESS

The serial number of a banknote serves as a unique identifier for distinguishing each individual banknote in a series from others, even if they have the same denomination and come from the same printing plant, and more advanced come from the same production batch. The serial number is therefore the unique fingerprint of a banknote.

The serial numbers on banknotes are currently designed for the purpose to ensure process control during the production and enable later a back tracing for quality assurance in printing plants. The mainly alphanumeric format of serial numbers may include encoded information about the denomination and series, the issuing central bank, the factory, and the year of production, etc. Modern designs of serial numbers contain in addition algorithms that are integrated as check digits to enable a control function during subsequent reading.

Serial numbers are printed conventionally using the letterpress method; the new inkjet technology has not yet become established in serial number printing for banknotes.
Inks with integrated security features in the form of UV, infrared and magnetic hard metal particles are mainly used to print serial numbers on banknotes. The numbers are embossed into the paper surface in such a way that they cannot be removed and are wear resistant.

The result is that the serial number on a banknote enables a basic check for authenticity and tracing during production and in circulation. The additional rule settings and security features in the serial number make it even more difficult for counterfeiters to produce large quantities of counterfeit banknotes without being detected. The serial number plays therefore an essential role in the integrity of the currency as legal tender.

Automated serial number reading beyond the printing process depends on the sensor in the processing machines.

The question arises whether serial number reading can be used as a reliable method to provide banknote specific data for further analytics. This depends primarily on the sensor technology in use and its reliability to provide stable data for further data evaluation.

Manufacturers offer various sensors and modules for the automated banknote authentication and processing in systems installed in cash centers, or sensor modules for deposit and recycling devices in ATMs or integrated in payment systems installed in retail PoS or back office. The installed sensor module differs in terms of processing speed, resolution and reliability for data capturing and recording. The image of the banknote and its serial number must be analyzed in step two by a signal processing unit with

optical character recognition (OCR). Such OCR technology interprets the alphanumeric characters of each serial number using high-resolution images and algorithms based on patterns by converting the letters and numbers into machine-coded texts of the scanned banknotes.

## FUNCTIONALITIES OF BANKNOTE SENSORS:

The quality of sensor type and signal processing unit are decisive for the individual use case in mind, because a 99.99% accuracy in serial number reading can be low. In cash centers with a processing throughput of 1'000'000 banknotes per shift, 100 notes cannot be identified correctly; at a cash recycling ATM with a sensor of 99.8% accuracy, 40 notes per month are not read correctly for a cash-in volume of 240'000 notes p.a.

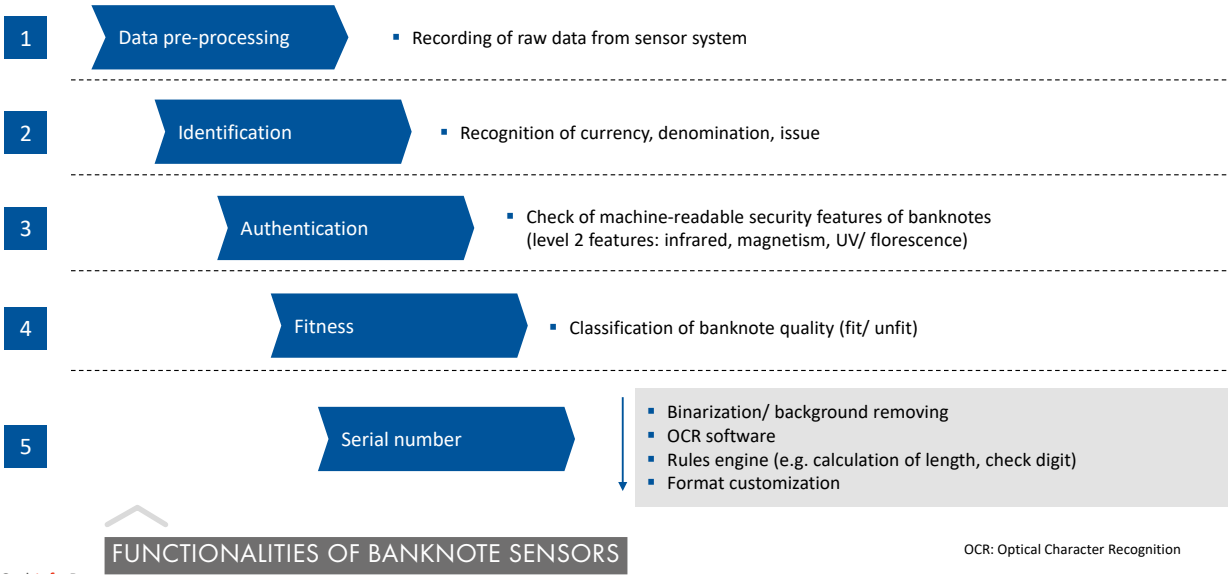
A poor banknote quality worsens these figures if soiled and damaged banknotes must be processed in day-to-day operations outside of the printing plants. All these factors increase the reject rate of banknote processing systems with manual reconciliation, but also the overall rate of serial number misreading. Such factors severely limit the use cases that rely on a hundred percent error-free reading.

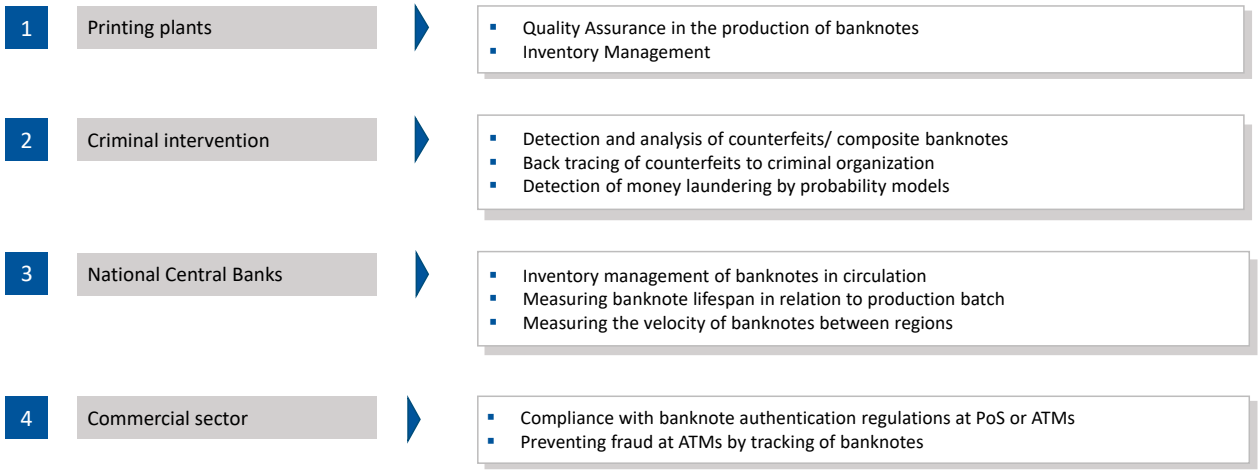
## USE CASES MUST BE EQUIPPED WITH SUITABLE TECHNOLOGIES

The sense and purpose of a use case determines which technology must be installed to achieve its objectives. On the other hand, the installed technology in the field limits the deployment of the use cases.

Use cases for serial number recognition are mandatory in printing plants, further approaches can be found in cash centers of National Central Banks (NCB), police and prosecution authorities, and in commercial banks and other professional cash handlers who are involved in the cash cycle. In most cases, the aim is to track and trace the unique banknote and its features along the cash cycle.

The purpose can be different, e.g. at NCBs for inventory management with tracking of banknotes over their entire life cycle, and at law enforcement agencies for fraud






CLASSIFICATION OF USECASES

protection by the detection of counterfeiting, financial crime or money laundering. Hence, such serial number recognition, recording and analytics can support the public and the commercial sector.

## USE CASE FOR CRIMINAL INVESTIGATION

The integrity of the currency in circulation can be supported by reading and analysis of serial numbers on banknotes as they serve as unique identifier that can be traced back to its origin.

Counterfeit banknotes should therefore be stopped from entering the cash cycle. When a counterfeit banknote is detected in a bank branch, or in ATMs, the suspect banknote including the serial number must be recorded and connected to the depositor. A similar process can be installed for cash-out processes at ATMs, if the banknote serial numbers are recorded during ATM cassettes filling to prevent fraud if the "client" later claims to have received a counterfeit from the ATM and demands compensation from the bank. The banknotes in the ATM cassettes can also be traced back to the criminal organizations by the law enforcement authorities via the serial numbers in the event of ATM attacks.

Depending on the structure and content of the serial number, in future data intelligence and algorithms can be used to generate further analyses that lead to a more efficient strategy for fighting crime. Probability models enable calculations, where deviations in the standard distribution of banknote serial numbers in a region can indicate criminal events, such as commercial money laundering in the retail sector. Of course, this also means that the regular retail deposits must be processed in the cash center with machines equipped with serial number reading, same is applicable to ATMs if the depositor uses this banking channel. Pilot applications show that such measures have the potential to support law enforcement authorities, also if such processes do not request a 100% recording of the banknote numbers. However, a nationwide introduction of serial number recognition refers to an overall cash strategy, since this possibility is linked also to banknote design including the serial numbers and is not only

based on the opportunity of serial number capturing and analytics at a later stage.

There are many more sub-categories of these use cases, all based on the same principle of criminal investigation, i.e. the phenomenon of composite banknotes can be identified by reading the serial number on both sides of the banknote.

## USE CASE FOR NATIONAL CENTRAL BANKS

The Central Banks monitor the banknotes in circulation and record the issue and lodgment volumes per denomination. They could link the fresh banknotes with the serial number when they receive the shipments on basis of carton and of bundle from the printing plants before issuing (positive list). In theory, this can also happen in reverse at NCB level, when the banknotes are withdrawn from circulation and destroyed because they are unfit (negative list). The use case is limited if not all banknotes run through a banknote processing system with online shredding and 100% serial number recognition, because the banknote quality is poor at the end of the life cycle. Therefore, a large number of NCBs around the world do not even record the serial numbers on banknotes when issuing into circulation. And many others safe costs by only randomly checking and processing the small denominations before destroying the complete bundles directly in offline shredders.

The technique in conjunction with the operational processes limit the idea of a complete list which banknote is exactly in circulation. The economic arguments outweigh, especially when the manual processing of reject notes on the processing machines must also be taken into account.

Analyses of the destruction rate as a function of the production batch can support test trails, allowing conclusions about the substrate, security features, and ink based on and in relation to serial numbers. Measuring the velocity of banknotes between regions can also only be supported in pilot projects, but not in day-to-day operation.

## USE CASE FOR COMMERCIAL SECTOR

Commercial cash center operators, such as cash-in-transit companies (CiT), are not permitted to carry out so-called cash pooling of different customer funds when processing banknotes if they do not have a license as a financial service provider. CiT companies usually do not have such a license. They must process the deposits for each bank separately, which leads to inefficiencies in cash processing, lower capacity utilization and therefore higher costs.

If the allocation of a banknote to a deposit can be clearly assigned to the customer's origin by recording the banknote serial number, CiTs could also be allowed to pool deposits across banks during banknote processing without applying for a financial service provider license. However, this procedure requires the highest level of accuracy in serial number recording and analytics, otherwise the results of the deposit reconciliation will be called into question. The procedure is not confirmed by the current field tests and therefore not be approved by the banks.

## CONCLUSIONS

Each party which is watching out to use cases based on serial number recognition is confronted with the limits of the existing processes and currently installed technique

in order to achieve a positive and efficient result. For Central Banks, serial number reading requires high-speed banknote processing systems with a high-quality image sensor enabling a high-resolution, and fast and reliable image capturing. OCR is then fully integrated in the system with a real-time, high-accuracy OCR and with an AI-based correction. Such a high-speed banknote image processing by 30 banknotes per second goes in line with massive data handling. The capability of data storage and management depends heavily on processor capacity and requires a robust data management system. There is usually a trade-off between speed and accuracy, and the integration of the system with other modules can be challenging.

The commercial sector has additionally the need to upgrade the current processing systems in order to achieve the required process accuracy and financial benefits for them through serial number recognition. Error rates in day-to-day operations can increase due to poor banknote quality, varying fronts, and complex backgrounds, leading to reduced benefits of use cases which requires high accuracy at each cash point along the cash cycle.

The initiators should define the sense and purpose of the program and evaluate the technical and procedural implications. This means that the Central Banks must evaluate if the defined target can be solved by introduction of serial number recognition and analytics only, or by other methods in a more efficient and reliable way. In this context, the technique must be economically viable for the public and the commercial players – otherwise the cost of cash is negatively impacted.

In the discourse, we need to distinguish between the sovereign tasks within the public sector. Several use cases fall within the scope of law enforcement and crime prevention authorities and are therefore primarily the responsibility of the Ministry of the Interior and the police authorities. It is the souverain task of the Central Banks to protect the integrity of the national currency. As part of its remit and with the direct access to the physical banknote in NCBs' cash centers, the Central Bank provides a valuable preliminary service to support the investigating authorities in connection with banknote crime and money laundering.

## SOURCES:

Authentix Inc, Bundesdruckerei Gruppe GmbH, CI Tech Sensors AG, European Central Bank, Europol, Elephant & Castle IP GmbH, Giesecke + Devrient Currency Technology GmbH, Glory Global Solutions Ltd.

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CASH INFRASTRUCTURE PROJECTS AND SERVICES GMBH

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# Consultancy

## Advice on security printing

S O L U T I O N S

**JURA IS A GLOBAL FIRM** focused on planning and designing banknotes security documents. The company constantly consults with national banks and with issuing authorities to unlock possibilities that give measurable advantages and benefits to our clients.

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Jura is an independent company that does not have the capability of printing banknotes but is in contact with the industry and understands the process of the smallest details and could deliver a neutral value-added solution with a competitive edge.

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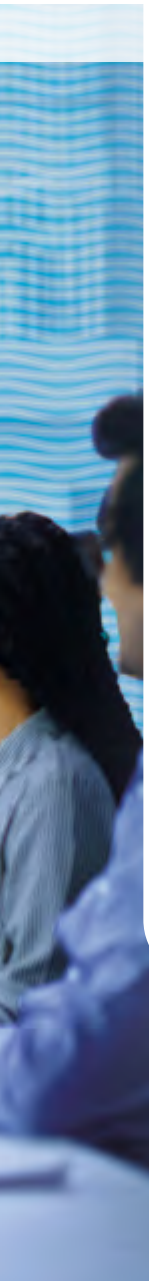
## OUR SERVICES AND PRAGMATIC SOLUTIONS:

- **Documents specification** – Good specification is unbiased, consistent, competitive and therefore reliable. It offers for all interested contractors and suppliers a play field in which to compete and thereby directly expands the purchaser's options and opportunities. Our goal is to give our customers the best value for money.
- **Concept design** – A good concept design reflects value, history, past, everything the country stands for. The concept design creates a sense of exaltation, must be pleasing for the eye. Our job is not to argue the aesthetics, but to understand the message and integrate into a structural design, bring it in line with the technological possibilities, integrating the latest security design elements in the right places.
- **Materials** – Product development is always a key issue in security printing. The range of materials available is endless. Our task is to put together a list that presents the options in a transparent way, objectively presents the pros and cons based on the available information and helps to make a decision on a very complex product selection.
- **Printing technologies, security features, machine readability** – The available and used printing technologies are known for industry, usually the challenge would be how to optimize the existing options and use a cost-effective solution with the highest protection. Our goal is to support our partners to have a high-quality product that withstand the vicissitudes of practical life.
- **Partners** – The high security products are complex ones, understanding the whole process and the helicopter view is an integral part of the planning and execution, it is possible only with good partners and excellent teamwork. Our network and many decades of experience in industry make the whole process more transparent and smoother, at the end together we can enjoy the fruits of our joint work.
- **Education and support** – Our education will not concentrate on any public education but rather an internal information sharing and continuous support to strengthen the confidence by explaining the reasons behind a process, talking about the features or elements included in the product.



# GIVING WINGS TO SUSTAINABILITY

# CCL SECURE

Introducing
# GUARDIAN™ ENVIRO

The Next Step
in Sustainable
Substrate

# FACT BOX

- GUARDIAN™ ENVIRO is an even more sustainable version of GUARDIAN™ substrate. It reduces reliance on fossil feedstocks by incorporating bio-renewable alternatives.
- Traditional fossil feedstocks are replaced with used cooking oil, from the hospitality sector, or tall oil, a byproduct of forestry. This drives greener outcomes.
- GUARDIAN ENVIRO provides the same cash cycle performance as a standard GUARDIAN banknote, in terms of durability and security features. They share the same chemical and physical characteristics. Only the source feedstocks are different.
- The feedstocks are broken down into chemical 'building blocks' via a process called cracking. These building blocks are chemically identical regardless of whether they come from fossil raw materials or sustainable alternatives.
- The use of sustainable feedstocks is tracked in accordance with rigorous International Sustainability & Carbon Certification requirements.
- Central banks can designate the level of substitution, ensuring control over the cost and speed of transition, while providing a pathway to gradually phase out fossil feedstocks.

GUARDIAN ENVIRO is a more sustainable version of GUARDIAN substrate. It enables central banks to substitute fossil feedstocks for bio-renewable alternatives. The finished GUARDIAN ENVIRO banknote is chemically identical to a GUARDIAN note. Only the feedstocks change.

The process involves substituting a proportion of traditional fossil raw materials with used cooking oil, from the hospitality sector, or tall oil, which is a byproduct of sustainable forestry.

While reducing the use of fossil feedstocks has obvious environmental benefits, it requires no compromise in terms of durability, security features, design, or existing sustainability attributes.

The feedstock substitution occurs right at the start of the polymer manufacturing process. The alternative feedstocks are fed into a cracking plant where the long chain hydrocarbons in the feedstock are broken down into chemical building blocks. These building blocks are then used to produce the polymer monomers that are subsequently polymerised into long chain polymers. This means the GUARDIAN manufacturing process remains unchanged, and CCL Secure can guarantee GUARDIAN ENVIRO will perform to the same level as traditional GUARDIAN notes.

The additional sustainability benefits of GUARDIAN ENVIRO are also supported by independent verification and accounting, compliant with International Sustainability & Carbon Certification.

GUARDIAN ENVIRO provides a step-by-step pathway to reduce the use of fossil raw materials, while enabling central banks to retain complete control over the speed and cost of transition. It's the next step in sustainable substrate. For a greener cash cycle.

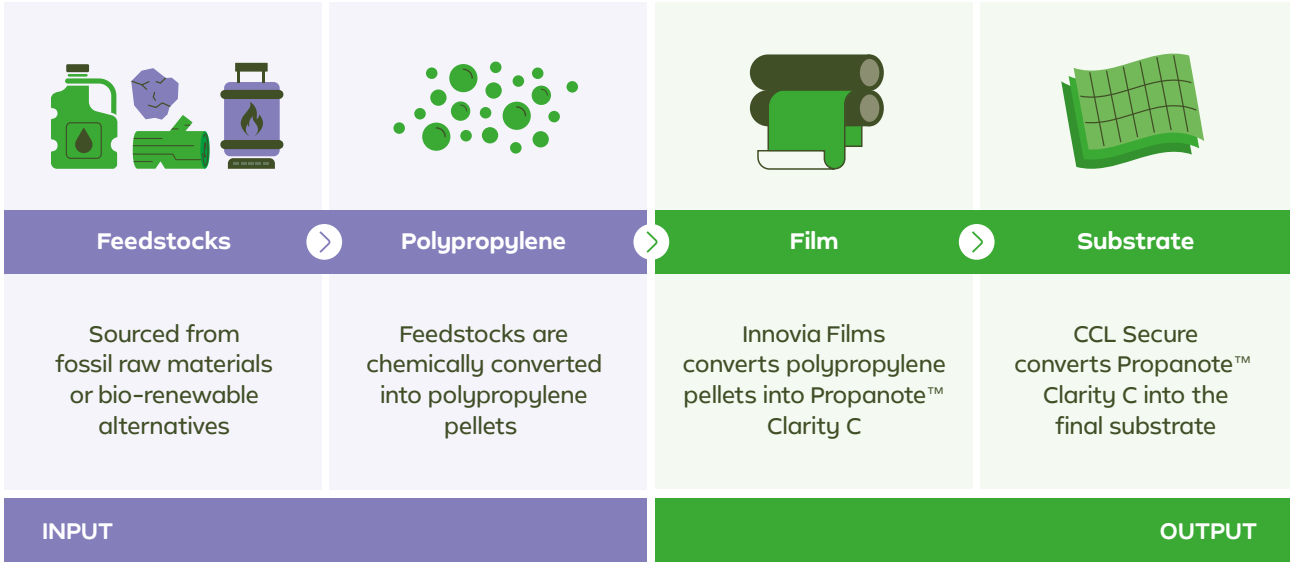
## PERFORMANCE GUARANTEE

GUARDIAN ENVIRO is chemically identical to traditional GUARDIAN banknotes. It's based on the same polymer film, Propanote™ Clarity C, which is produced by our sister company, Innovia Films. While the feedstocks used to manufacture the film are sourced more sustainably, they're chemically identical due to pre-production processes undertaken at a polymer cracking plant.

Here's how it works. The raw materials are fed into a polymer cracking plant that breaks long chain hydrocarbons into smaller chemical 'building blocks' which can be converted into monomers. These are small molecules that are able to react together and form the lager molecules we know as polymers. The monomers are chemically identical regardless of whether bio-renewable or fossil feedstocks were used. That's why product performance is guaranteed.

For Propanote Clarity C, the propylene monomers derived from fossil feedstocks or bio-renewable alternatives – react together to form polypropylene which is supplied to Innovia Films as small pellets. Innovia Films takes these polypropylene pellets and extrudes them into a four-storey 'bubble' that creates the biaxially oriented polypropylene film which underpins all GUARDIAN banknotes, Propanote Clarity C.

After this, CCL Secure applies the series of printed layers that collectively constitute the final substrate, including specialised security features, opacification and spot colour inks, and so on.




THE SUBSTRATE PRODUCTION PROCESS

The fact both GUARDIAN and GUARDIAN ENVIRO are based on the same film and production process means they provide identical performance in terms of durability and security features.

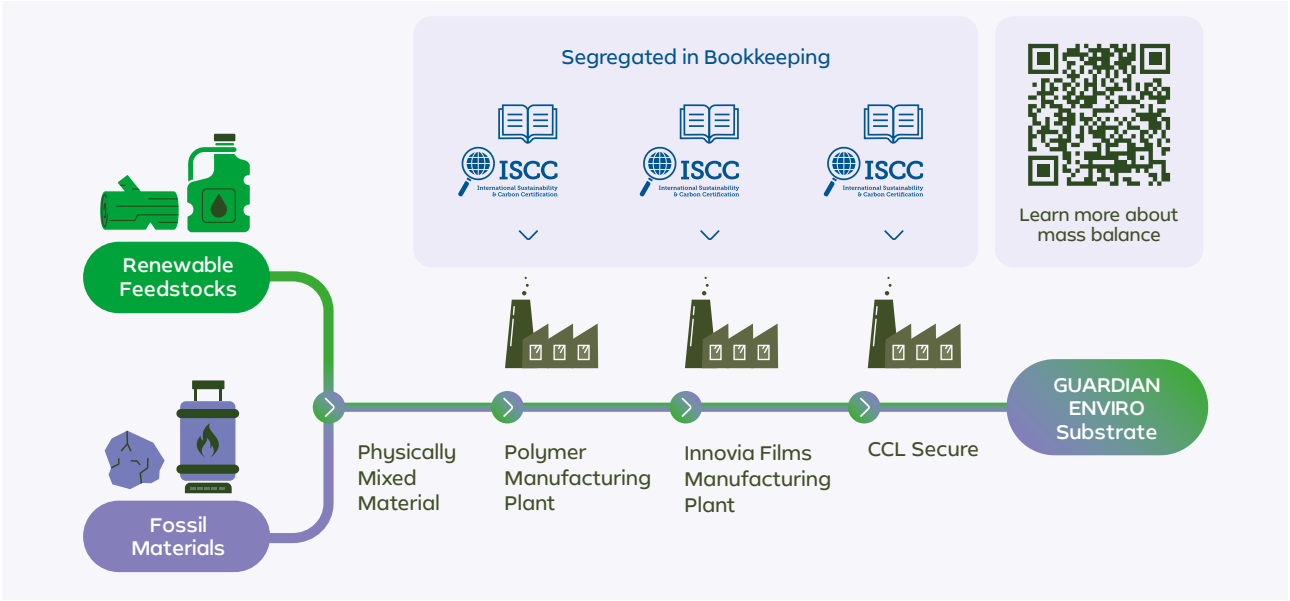
Central banks can select from the same range of proprietary security features developed by CCL Secure, as well as third party features. This tried and tested security platform is proven to reduce counterfeits, with decades of data from central banks clearly demonstrating real-world results.

The longevity of both banknotes is identical too. All GUARDIAN polymer banknotes last three to five times longer in circulation than their cotton-paper counterparts. This provides important environmental benefits, including the capacity to recycle banknotes easily using an established industry process. Currently, 85 per cent of all GUARDIAN notes are being recycled.

Studies commissioned by central banks in Canada, Mexico, the Philippines and the United Kingdom also demonstrate that increased longevity reduces the use of raw material and lowers transport emissions, largely because banknotes that last longer require replacement less often.

Over time, this lowers procurement volumes, which increases seigniorage in turn. The data demonstrates central banks will save money through their transition to polymer banknotes. The Reserve Bank of Australia provides one example. In 2019, their cost-benefit analysis showed transitioning to polymer banknotes delivered savings of nearly AUD1 billion over 25 years.

This combination of environmental and economic benefits is the reason standard GUARDIAN banknotes remain the first step towards a greener cash cycle. Initial polymerisation will enable recycling, reduce raw materials use, and lower emissions, while simultaneously enhancing seigniorage at the same time. Savings can later be re-invested to phase out fossil feedstocks with GUARDIAN ENVIRO.




ACCOUNTING FOR FEEDSTOCKS UNDER MASS BALANCE

## FEEDSTOCKS ARE ACCREDITED AND ACCOUNTED FOR UNDER ISCC

GUARDIAN ENVIRO is accredited under International Sustainability and Carbon Certification, a globally recognised framework for verifying the characteristics of sustainable feedstocks. ISCC also provides the methodology, rules and guidelines to track accredited sustainable feedstocks throughout the supply chain. This certified bookkeeping precedes the polymer cracking process and continues up to the point at which GUARDIAN ENVIRO is dispatched for final printing.

CCL Secure has committed to compliance with an independent, established and standardised system of environmental reporting to ensure central banks can credibly communicate the sustainability benefits delivered by GUARDIAN ENVIRO with their stakeholders. We have also selected the most efficient methodology possible to support a clear and cost-effective process for scaling up over time.

## THE ISCC 'MASS BALANCE' METHOD

There are several accounting frameworks within the broader umbrella of ISCC. Each reflects the industrial processes of various sectors. CCL Secure will implement a chain-of-custody model known as the 'mass balance' method for GUARDIAN ENVIRO, because it suits our industry best.

Mass balance doesn't guarantee sustainable feedstocks are 'physically' there. Instead, it relies on detailed bookkeeping to track these as a proportion of all feedstocks used. This ensures central banks receive accurate information about the percentage of final product produced using sustainable feedstocks, as opposed to fossil raw materials.

The key advantage of the mass balance method is that it enables fossil feedstocks to be mixed with sustainable alternatives without changing the existing GUARDIAN production

process. This intermingling occurs at the polymer plant, and the monomers derived from fossil feedstocks and/or sustainable alternatives are accounted for and tracked using the mass balance method from this point onwards. It's a system that offers central banks flexible options as well as the guarantee which comes with decades of data from billions of circulating GUARDIAN notes.

## CENTRAL BANKS CONTROL THE COST AND SPEED OF TRANSITION

Mixed manufacturing through the mass balance model means CCL Secure can readily adjust the quantity of both bio renewable and fossil feedstocks that are used during film production. This means central banks are able to designate the quantity of alternative feedstocks we use.

The mass balance system ensures central banks retain control over the cost and speed of transition by providing flexible options for scaling. This ability to gradually ratchet up the use of bio-renewable feedstocks provides a step-by-step pathway to phase our fossil raw materials.

Central banks could choose to use 25, 50, or 75 per cent bio renewable feedstocks, for example, while reducing their use of fossil raw materials to the same degree. CCL Secure has actively worked to ensure GUARDIAN ENVIRO offers this choice and flexibility because we understand individual central banks will be at different stages of their sustainability journey.

## TAKE THE NEXT STEP TOWARDS A GREENER CASH CYCLE

CCL Secure has been supporting central banks to increase the sustainability of banknotes for decades. We have promoted recycling since GUARDIAN banknotes were first issued, in 1988, reducing waste to landfill, as well as emissions from production and transportation. GUARDIAN ENVIRO now allows central banks to take the next major step towards a sustainable cash cycle.

We understand the green transition can't be achieved overnight. That's why GUARDIAN ENVIRO has been developed to provide for a gradual transition towards greener outcomes, backed by transparent, robust, and globally recognised reporting through the ISCC mass balance method.

If you're ready to start phasing out fossil feedstocks, please get in touch for more information.

CCL SECURE

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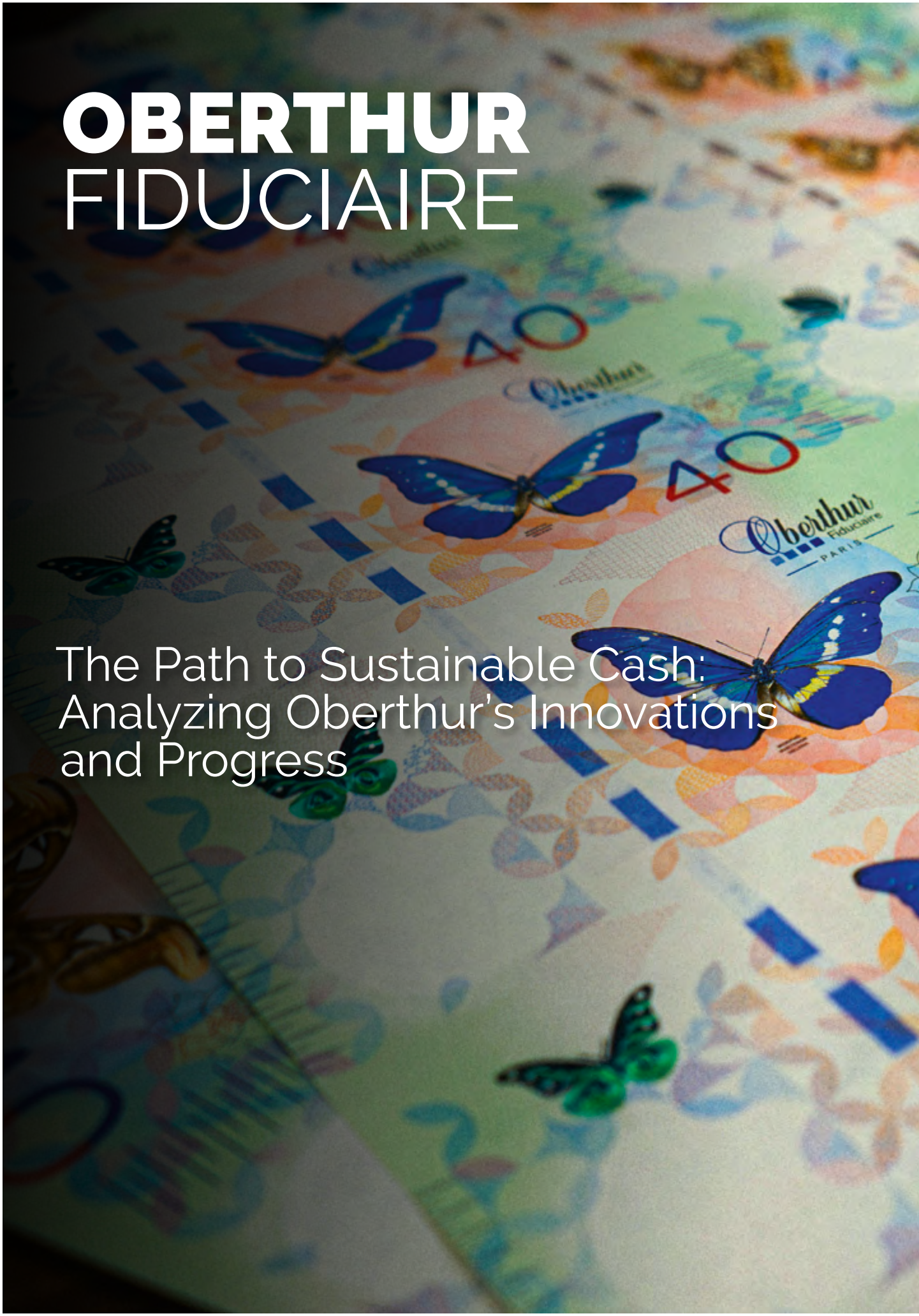
OBERTHUR
FIDUCIAIRE
The Path to Sustainable Cash: Analyzing Oberthur's Innovations and Progress


# FACT BOX

- **Sustainability Focus:** Reduce fossil fuels, minimize waste, and use renewable materials while maintaining durability and security.
- **Main Sustainability Pillars:** Renewable Materials, Energy Efficiency, Recycling & Circular Economy, Waste Reduction
- **Banknote Composition Enhancements:**
  - Substrate (99%)
  - Inks Offset & Intaglio
  - Security Threads
  - Additives
- **Innovations:**
  - Local Organic Fibers
  - Highlink™
- **Security + Sustainability:** Metal-free optical effects and eco-friendly threads maintain high security
- **Progress & Goals:**
  - 91% renewable content achieved.
  - Remaining 9% (mostly inks/ security features) under active R&D

As global awareness of environmental challenges grows, industries are adapting to sustainable practices. Currency production, long seen as an industry reliant on resource-heavy processes, is undergoing its transformation toward sustainability. This report details Oberthur's advancements in making banknotes more environmentally sustainable by evaluating their approach to raw materials, production processes, recycling, and innovation. The goal is to move closer to 100% sustainable banknotes without compromising on security, durability, or usability. Oberthur's progress from 86.6% to 91% renewable materials marks a significant milestone, yet challenges remain. This report explores their journey, the obstacles, and the way forward.

## DEFINING SUSTAINABILITY IN BANKNOTE PRODUCTION

Sustainability, at its core, is the principle that resources used to create goods and services should be renewable and environmentally responsible. The concept is especially challenging for industries like currency production, where durability, security, and functionality are paramount. Banknotes must withstand years of circulation while incorporating security features that prevent counterfeiting. Oberthur's vision of sustainable banknotes . focuses on reducing reliance on fossil fuels and non-renewable resources, minimizing waste through circular economy practices, and finding alternative materials that maintain or enhance the quality of the banknotes.

Key Elements of Sustainability in Banknotes:

- Renewable Materials: The shift towards bio-based materials that can be replenished.
- Energy Efficiency: Reducing the carbon footprint of production through more efficient energy use.
- Recycling and Reuse: Developing closed-loop systems where materials from old banknotes are repurposed for new ones.
- Minimizing Waste: Reducing overall waste through recycling and using waste-derived materials in production.

## COMPOSITION OF BANKNOTES: BREAKING DOWN THE SUSTAINABILITY COMPONENTS

A typical banknote is made up of several key components, each contributing to its security, durability, and usability. The challenge for sustainability is that each component must be carefully evaluated for its environmental impact while maintaining high standards of performance.

OUR EARTH 365 MANAGEMENT PROGRAM IS THE CENTRAL PILLAR OF OUR CSR APPROACH.

SISAL IS A LOCAL ORGANIC FIBRE USED IN BANKNOTE PAPER PRODUCTION.

Here is a breakdown of the key elements of a banknote and how Oberthur is working to make each more sustainable:

- **Substrate (99%):**
  The substrate forms the bulk of a banknote's composition and is traditionally made from cotton fibers or polymer. Oberthur has introduced bio-sourced durable substrates, sourced from waste recovery processes in industries like textiles. For example, cotton fibers used in banknotes now come from clothing industry waste, providing both environmental and economic benefits by repurposing materials that would otherwise go to landfills.

- **Security Thread (0.05%):**
  Security threads are essential for preventing counterfeiting and ensuring the authenticity of banknotes. While a small percentage of the overall composition, innovations are being made to develop metal-free optical effects and security threads that rely on less resource-intensive materials.

- **Inks:**
  Offset Inks (0.10%): Oberthur has made significant strides in using alternative offset inks that do not contain mineral oils. These inks are made from natural raw materials, some of which are derived from waste recovery. The goal is to replace traditional inks with ones that have a reduced environmental impact without compromising print quality. Intaglio Inks (0.85%): Intaglio inks are responsible for the raised print on banknotes and are a key element in both durability and security. Though progress has been made in reducing mineral oil content, the search for fully bio-sourced intaglio inks containing natural renewable raw materials, some of which are derived from waste recovery, is ongoing. These inks remain an area where more innovation is needed to increase the percentage of renewable content.

BIOCHAR IS A BANKNOTE RECYCLING OPTION

- **Numbering and Other Additives:**
  Numbering and minor additives make up the remaining negligible percentage of a banknote's composition. Although small in volume, these elements still require careful attention to ensure they contribute to the overall sustainability goal.

## SUSTAINABLE MANUFACTURING PROCESSES: ENERGY AND WASTE REDUCTION

Sustainable manufacturing involves more than just using renewable materials—it also requires minimizing the energy used in production and managing waste effectively. Oberthur has focused on creating energy-efficient manufacturing processes and adopting circular economy principles to ensure that waste is minimized and reused wherever possible.

- **Energy Efficiency:**
  Reducing the energy required for production is crucial for minimizing the carbon footprint of banknotes. Oberthur has implemented

RECYCLING SHREDDED BANKNOTES INTO CONSTRUCTION MATERIAL.

energy-saving technologies at their manufacturing plants, which includes the use of renewable energy sources where possible. Their efforts focus on improving the energy efficiency of machinery, optimizing production workflows, and reducing waste heat.

- **Recycling and Circular Economy:**
  Oberthur is actively involved in the recycling of shredded banknotes, which traditionally would be considered waste. The qualification and testing of these shredded notes for reuse in various applications is part of their broader strategy to integrate circular economy principles into their manufacturing process. Additionally, they are exploring partnerships with industries that can repurpose banknote materials, further closing the loop on waste.

## INNOVATIONS IN SUSTAINABLE COMPONENTS

One of the most exciting areas of innovation is the development of banknotes made from local organic fibers. These fibers are not only environmentally friendly but also support local economies and promote sustainable farming practices.

- **Local Organic Fibers:**
  By sourcing fibers from local organic farms, Oberthur helps promote ethical and sustainable farming practices. This approach strengthens the local economy by creating jobs in the agricultural sector and reduces the environmental impact of transporting materials over long distances. Additionally, the transparency of the supply chain is improved, ensuring that central banks and consumers can trust that their banknotes are made responsibly.

- **Highlink™ Technology:**
  Oberthur has also developed a proprietary process called Highlink™, which strengthens the cohesion of fibers in the substrate, enhancing the durability of banknotes. This technology uses bio-based latex made from renewable vegetable natural waste raw materials, to bind fibers, further reducing the reliance on non-renewable materials.

## ADDRESSING SECURITY WHILE MAINTAINING SUSTAINABILITY

Maintaining the high-security standards of banknotes while shifting to sustainable materials is a significant challenge. Oberthur has managed to innovate in the realm of security features, developing metal-free optical effects and alternative inks that maintain the integrity of the banknote's security.

- **Metal-Free Optical Effects:**
  These security features have traditionally relied on materials that are resource-intensive to produce. Oberthur's solution has been to develop metal-free alternatives that are both secure and environmentally friendly.

- **Security Threads and Watermarks:**
  Similarly, Oberthur is experimenting with security threads that use fewer non-renewable resources and watermarks that can be embedded in substrates without increasing the environmental impact.

## THE FUTURE OF SUSTAINABLE BANKNOTES

Oberthur has already achieved significant progress, with their banknotes now composed of 91% renewable materials. However, the remaining 9% presents unique challenges, particularly in the areas of inks and specialized security features. Reaching 100% sustainability will require continued innovation, particularly in bio-sourcing materials that meet the rigorous standards required for banknote production.

- **Offset Inks:**
  As of now, offset inks can be made entirely from bio-sourced materials, but intaglio inks still need further development to increase their biosourced content.

- **R&D for Future Materials:**
  The path forward will focus on continuous research and development, seeking to replace fossil-based materials with renewable alternatives in every component of the banknote.

## OBERTHUR'S COMMITMENT TO A SUSTAINABLE FUTURE

Oberthur's journey toward fully sustainable banknotes demonstrates the feasibility of creating high-quality currency with minimal environmental impact. Their commitment to innovation, from bio-sourced fibers to renewable inks and energy-efficient processes, positions them as a leader in sustainable currency production. However, the journey is ongoing, and achieving 100% sustainability will require the collective effort of stakeholders across the value chain.

The call to action is clear: as consumers, banks, and regulators become more environmentally conscious, the push for sustainable banknotes will only grow stronger. Oberthur is poised to meet this demand, but their success will depend on continued collaboration, innovation, and a shared commitment to sustainability.


THE ART OF BUTTERFLIES: OBERTHUR'S LATEST HOUSENOTE.

# 100% RENEWABLE FIBRES

## INTRODUCING THE FUTURE OF SUSTAINABLE BANKNOTES

### OBERTHUR FIDUCIAIRE'S COMMITMENT TO A GREENER WORLD!

Oberthur Fiduciaire proudly unveils its bold new logo—a signature ring symbolizing our unwavering dedication to sustainability and innovation. This powerful emblem reflects our enduring promise to integrate 100% renewable fibres into every banknote, pioneering a more responsible and greener future.

At the prestigious 2024 GCF Conference in Muscat, Oman, we launched our groundbreaking Sustainable Banknote Program. This initiative sets a new benchmark in the industry, underscoring our mission to create the most sustainable, secure, and durable banknotes. Because your money should safeguard more than value—it should help protect our planet.

### SUSTAINABILITY: SUSTAINABLE BANKNOTES

Sustainability isn't just a concept at Oberthur Fiduciaire—it's a promise. Our signature ring embodies this commitment, representing our integrated approach to using renewable resources and innovative practices. Through this framework, we deliver premium-quality, long-lasting banknotes that maintain the highest standards of security and durability. Durability is twofold: not only do our banknotes endure rigorous use throughout their lifecycle, but they are also made from naturally renewable resources. This approach ensures the balance between longevity and environmental responsibility.

### A GREENER CHOICE: COTTON BANKNOTE PAPER

Our banknote paper, crafted from renewable cotton and alternative vegetal fibres, constituting 99% of each note's mass, is a smart choice for today and tomorrow. By prioritizing renewable materials, we promote sustainability and the careful stewardship of natural resources. For over 15 years, our Earth365 Strategy has driven our efforts to minimize environmental impact. It's not just a program; it's a core part of our identity. Every day, our teams work diligently to reduce our footprint and responsibly manage the planet's resources. Because protecting the Earth is a shared responsibility—and we take ours seriously.

### THE SIGNATURE RING: A SYMBOL OF COMMITMENT

Our new logo is more than a design; it is a signature ring, a symbol of our pledge to sustainability. This emblem, prominently displayed across all our materials, represents our role as the trusted sustainable partner in banknote production. Through innovative solutions powered by renewable resources, we enable our clients to make greener choices every day.

### JOIN US ON THIS JOURNEY

Together, let's shape a future that is secure, robust, and above all, sustainable. With Oberthur Fiduciaire, your banknotes don't just represent value—they embody a commitment to the planet.

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OBERTHUR FIDUCIAIRE

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# From Waste to Forests: Biobankmulch® Turns Withdrawn Banknotes from decirculation into Sustainable Tree-Growing Rings



# FACT BOX

- Biobankmulch® is a biodegradable ring created by the Colombian company Biobanknote from withdrawn circulation cotton paper banknotes. The product acts as a solid humic amendment that supports tree planting and reforestation.

- The rings help young trees retain up to 250% moisture, promote microbial life, and create favorable root conditions. They fully biodegrade in about nine months, enriching the soil during the biodegradation process.

- Each ring sequesters carbon at the soil surface, significantly reducing CO2 emissions compared to landfilling or incineration. The product complies with Colombian regulation NTC 5167 and contains no toxic substances or heavy metals.

- Biobanknote has produced more than 12,000 rings and tested them in various climates and altitudes across Colombia. In a pilot study involving 5,000 trees, the rings showed visible improvements in soil quality and biodiversity.

- The company offers scalable micro-factory solutions that can be established within or near central banks. These centers require minimal space and do not need complex permitting, making Biobankmulch® a practical innovation for sustainable cash lifecycle management.

## FROM WASTE TO FORESTS: BIOBANKMULCH® TURNS WITHDRAWN BANKNOTES FROM DECIRCULATION INTO SUSTAINABLE TREE-GROWING RINGS

In a move that redefines the end-of-life journey for withdrawn banknotes, Biobanknote, a Colombian company with extensive expertise in the banknote and document security sector, has developed a pioneering solution that merges banknote sustainability with ecological restoration. The innovation, named Biobankmulch®, is a patent-pending ring-shaped product made entirely from briquettes (shredded paper) composed of cotton-based banknote waste. It is designed to support tree planting and reforestation efforts, offering an efficient, biodegradable alternative to traditional waste disposal methods.

## TURNING CURRENCY WASTE INTO CLIMATE ACTION

Traditionally, withdrawn banknotes are incinerated or disposed of in landfills—options that contribute to carbon emissions and environmental degradation. Biobankmulch® offers a circular alternative by transforming this waste into solid humic amendments. These biodegradable rings are produced in a facility just 30 km from Bogotá, using low-tech methods and 100% organic components. The production process itself is entirely waste-free; all the organic material from the shredded banknotes is repurposed into the final product.

This model eliminates residual waste and provides a second life for material that is typically discarded, contributing directly to soil restoration and climate change mitigation. This makes Biobankmulch® one of the few post-currency products with a measurable ecological return.

Indeed, this solution fits perfectly within the circular economy of the cash cycle and the environmental policies that central banks are increasingly adopting.

## PROVEN RESULTS FROM FOREST TO SOIL

Biobanknote has produced approximately 12,500 Biobankmulch® rings, which have undergone field testing in tree plantations across various Colombian departments. These sites span a range of altitudes and climates, confirming the rings' adaptability and consistent performance.

NEWLY PLANTED TREES WITH A BIOBANKMULCH® RING

AERIAL TAKE FROM FACATATIVÁ, NEAR BOGOTÁ, WITH 4,500 TREES AND RINGS PLANTED

Rings fully degrade within 6 to 11 months, depending on environmental conditions, with an average of about 9 months. Their ability to retain up to 250% of their own weight in moisture aids in establishing newly planted trees by conserving water near the roots. This makes them a valuable tool for providing moisture to trees in arid areas.

They also promote the growth of a thriving micro-ecosystem within days of soil contact. The soil beneath the rings shows increased activity from fungi, bacteria, insects, and macroorganisms such as mites, springtails, spiders, and worms. This biological presence accelerates decomposition, enhances nutrient availability, and supports long-term tree health.

A pilot involving 5,000 trees highlighted visual improvements in soil texture and color, enhanced ground cover quality, and a notable difference in vegetation vigor compared to trees planted without rings.

Each Biobankmulch® ring features a QR code that allows you to digitally register and monitor planted trees on the MyBiobanknote platform. This functionality enables transparent tracking of growth cycles, ecological impact, and reforestation efforts. It also supports long-term data collection for forest management programs, reinforcing Biobanknote's commitment to accountability and continuous improvement.

According to environmental analyses, the rings have a carbon-to-nitrogen (C/N) ratio of 60.52, indicating a high concentration of biodegradable organic carbon—ideal for enhancing soil fertility. Nitrogen, phosphorus, and potassium levels remain below 1%, minimizing the risk of chemical overload in sensitive ecosystems.

## SAFE, COMPLIANT, AND READY FOR SCALE

Biobankmulch® complies with Colombian regulation NTC 5167, which governs ecological and biodegradable products. Independent lab testing has verified the product as follows:

BIOBANKMULCH® BEING CARRIED TO BE PLANTED

- pH neutral (non-corrosive and safe for plants)
- Non-reactive in water, which prevents chemical runoff or leachates.
- Free from toxic gases and heavy metals, this ensures environmental safety and safety for human handling.

Importantly, this product is not classified as hazardous waste, which significantly simplifies logistics, permits, and handling procedures compared to traditional composting or waste incineration processes. According to Colombian regulations, the Biobankmulch® ring is considered a "solid humic amendment".

## WASTE-FREE PRODUCTION WITH GLOBAL POTENTIAL

The Biobankmulch® manufacturing process is remarkably efficient. It utilizes 100% of the organic waste generated from shredded banknotes, producing zero additional residues. This positions the solution as cost-effective and environmentally superior to conventional waste treatment methods. Given the conditions of banknote residual material, it does not require large amounts of water and other organic materials.

Unlike composting plants, Biobankmulch® production centers do not require specialized environmental licenses or drainage systems, as they do not produce leachates or toxic by-products. These micro-factories can be set up in minimal space, making them ideal for installation in central banks, note-processing centers, or secure document facilities.

The result is a dramatically lower carbon footprint, as banknote waste no longer needs to be transported to distant treatment sites. Additionally, production can be tailored to meet the needs of reforestation campaigns, with rings distributed directly to environmental organizations or ministries.

## BRIDGING BANKNOTE WASTE AND PUBLIC POLICY

Biobanknote actively collaborates with national and regional governments to integrate Biobankmulch® into state-sponsored tree-planting programs. The rings have already been installed in areas managed by the Colombian State under the oversight of local and national environmental authorities. These collaborations help governments meet climate targets, enhance degraded soils, and demonstrate tangible results in biodiversity regeneration.

The company also proposes that ministries of environment and agriculture in other countries explore public-private partnerships with central banks. Countries can align waste management with global sustainability

commitments by repurposing withdrawn banknotes into reforestation tools.

Beyond the environmental dimension, Biobanknote implements community engagement programs in reforestation zones. These include educational sessions for local populations on biodiversity, ecological restoration, and the responsible use of waste, adding a strong social impact component to the initiative.

## REDEFINING THE LIFECYCLE OF A BANKNOTE

Biobanknote's solution demonstrates that a banknote's lifecycle doesn't have to end in a fire or a landfill. Through Biobankmulch®, withdrawn currency transforms into an agent of ecological repair, promoting greener practices within an industry under increasing pressure to reduce its environmental footprint. By integrating Biobankmulch® into the broader banknote lifecycle, institutions can adopt a holistic sustainability model that includes secure printing and circulation and responsible end-of-life reintegration into nature.

As the financial sector shifts towards greener operations and ESG compliance, Biobankmulch® offers a ready-to-deploy, scientifically validated innovation. With proven results and scalable potential, it stands out as one of the global banknote industry's most compelling circular economy initiatives.

Biobankmulch®: Longer Life, Less Impact.

BIOBANKNOTE

Mr. Rafael Cruz
Email: recruzd@biobanknote.com
Website: www.biobanknote.com

BIOBANKMULCH® RING AND QR CODE FOR TRACKING OF THE TREES INVENTORY


POLISH SECURITY
PRINTING WORKS
PROJECT MEADOW
security, sustainability,
storytelling

# FACT BOX

Project MEADOW, a collaboration between Polish Security Printing Works (PWPW) and Leonhard KURZ, redefines banknote design by seamlessly integrating cutting-edge security features, eco-friendly materials, and artistic storytelling.

**Key Innovations:**

Eco-friendly paper blend – Made from cotton and hemp fibers, reducing water and energy use.

Vertical security thread – Registered KURZ THREAD with KINEGRAM COLORS®, enhancing security and design- PWPW is one of the few companies having experience with this technology

Advanced watermarks – Including Multihexa® honeycomb and a mole in multi-tone watermark.

MIR4Note® iridescent stripe with unique IR properties.

Zora4Note® multicolor latent image – A vibrant, angle-dependent security feature.

Intaglio & offset printing – Featuring hidden images and fluorescent inks.

Digital numbering – Algorithm-based, with a custom font and dynamic positioning.

**A New Standard in Banknotes**

Project MEADOW proves that security, sustainability, and design can coexist, setting a new benchmark for future banknote production.

In today's world, innovation must balance sustainability, cutting-edge security, and compelling storytelling. Project MEADOW, our latest house note, is the result of this challenge—pushing the boundaries of design and security while minimizing environmental impact.

Developed in close collaboration between Polish Security Printing Works and Leonhard KURZ, MEADOW integrates groundbreaking innovations at every stage of production—so ambitious that it even had some production managers scratching their heads. More than just a technical achievement, this project marks a major milestone for the industry, proving that a modern banknote can be both highly secure and artistically sophisticated. Every element of the note plays a role in a larger narrative, making it more than just currency.

## GRAPHIC DESIGN

The theme of nature was chosen not only for its beauty and the opportunity to showcase a rich palette of colors but also for its universal and neutral appeal—essential qualities for a promotional banknote intended for diverse markets around the world.

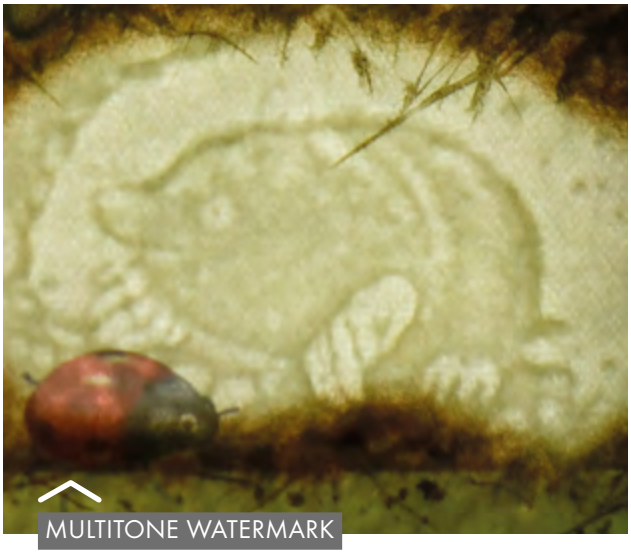
The format of the note itself is also an innovation. It was produced in a vertical orientation, but what truly sets it apart is the security thread, which is also positioned vertically. This unique combination required an unconventional production approach and posed significant technical challenges. Traditionally, even when banknotes feature a vertical design, their security threads are placed horizontally, cutting across the graphic composition.

The artwork depicts the meadow landscape referenced in the project's title, viewed from a layered perspective of flora and fauna. The upper section represents the sky, while the lower section transitions through the earth and into the underground, capturing nature's complexity across different levels.

## UNIQUE TECHNOLOGIES

The substrate for Project MEADOW was produced using a blend of cotton and hemp fibers—one of the latest trends in banknote manufacturing due to its reduced environmental impact. Hemp requires less water to cultivate and consumes less energy during processing compared to

FILIGREE WATERMARK WITH MULTIHEXA® PATTERN



MULTITONE WATERMARK


MIR4NOTE® - MACHINE READABLE IRIDESCENT STRIPE

cotton. Additionally, when with appropriate technology, it does not compromise key physical and chemical properties such as fold durability or tear resistance. Another advantage is its local, European origin, which contrasts with the cotton typically imported from Asia, significantly reducing both transportation energy and time.

The banknote features two distinct watermarks, each integrated with a unique technological approach. The first is positioned in the "sky section" of the design and consists of a single-tone filigree bee, placed alongside a Multihexa® watermark—a honeycomb-like structure made up of multiple hexagons. The second watermark appears in the "underground" section at the bottom of the note. This is a multi-tone watermark depicting a mole digging its burrow, further reinforcing the layered perspective of the design.

The security thread mentioned earlier is the Registered KURZ THREAD with KINEGRAM COLORS®, produced by KURZ. Measuring 5mm in width, it is visible through six window openings ranging from 14 to 20mm in length. This technology stands out by combining a holographic effect with a colored background. Each window showcases a different thread color and diffractive effect, harmonizing with the overall graphic design. For instance, the window positioned in the "sky section" displays flying insects, while those in the "earth section" feature insects native to that environment.

Another innovative element is the MIR4Note® iridescent stripe on the reverse side, located on the right. This security feature is printed using two iridescent inks—gold and violet—each with a unique behavior under infrared light. One ink is absorptive, while the other is transparent. Previously, similar effects were only possible with opaque inks, such as intaglio, but never with transparent or iridescent inks.

Additionally, the printing process itself contributes to the eco-friendly nature of the banknote. The MIR4Note® feature was applied using a screen-printing technique with water-based inks. These inks are free from crosslinking agents that are harmful to the environment, and their production allows for the use of water instead of solvents for cleaning—further reducing the ecological footprint of the note.

FLUORESCENT INKS

ZORA4NOTE® MULTICOLOR LATENT IMAGE

## ADVANCED PRINTING TECHNIQUES

The offset printing process for Project MEADOW utilizes high-resolution specialty screens, which define most of the background elements, including flowers, birds, and selected insects. However, an exception to this approach can be found in the sky background on the front of the note, which was created using Link technology.

Link is an advanced technique that embeds hidden images within high-resolution offset backgrounds by uniquely directing the screen lines. When viewed with a magnifying glass, these lines form a visually intricate maze. More importantly, a dedicated visual scanning application can decode hidden information within this background—in this case, revealing the denomination "100" embedded within the design.

The same printing process was also used for fluorescent images, utilizing specially developed inks by PWPW S.A. These inks exhibit unique colors and properties:

- On the front side, two transparent inks remain invisible under daylight but fluoresce under UV light—one glowing white and the other orange.
- On the reverse side, one ink is phosphorescent, glowing orange under UV light—a significant innovation, as

INTAGLIO PORTRAIT

phosphorescent inks in banknotes typically emit only green light. Another ink reacts under different UV wavelengths, glowing green under UV 365 nm and orange under UV 254 nm.

This combination of hidden security elements and advanced fluorescence effects further enhances the note's security, making it a technological milestone in modern banknote production.

## INTAGLIO PRINTING – THE ART OF DETAIL AND SECURITY

The next stage in production was intaglio printing. The central element of this process is the dragonfly portrait, located on the right side of the front of the note. This feature stands out graphically due to its integration with multiple printing techniques.

The dragonfly's wings were designed as intaglio contours, but directly underneath them, a multicolor underprint (green, red, and blue) was applied, giving the portrait a vibrant, lifelike appearance. Additionally, selected areas of the dragonfly were further enhanced using Coat4Note® Gloss—a high-gloss varnish applied separately via flexographic printing. This finishing touch mimics the delicate sheen of a real dragonfly's wings.

Directly beneath the dragonfly is a multicolor angle-dependent security feature developed by PWPW S.A.—Zora4Note®, depicting a bee sitting on a flower. This anti-counterfeiting element is unique due to its multicolor effect, achieved through the interference of offset and intaglio lines. The design consists of alternating offset lines, overlaid or embossed with a precisely engineered structure, creating a Moire effect—smooth color transitions. Where the structure is printed, the effect remains visible regardless of the viewing angle and light source. However, where it is embossed, the color shift is only visible when viewed at an angle against a light source.


INK-JET NUMBERING, SERIAL NUMBER AND FLYING CHECK DIGIT

Another distinctive feature are the micro-embossed intaglio images, located in several areas of the note. Beneath the dragonfly's tail, positive and negative floral patterns can be found, while the left side of the note, above the flowers, features butterflies and a bee.

Below the multicolored flower, a group of insects is printed with OVI® (Optically Variable Ink) featuring Umbra4Note® technology. When tilted toward a light source, these insects not only shift color from gold to green but also reveal hidden radial textures, adding another layer of dynamic security.

Further reinforcing the theme and visual cohesion, intaglio printing was also used for decorative elements such as the roots of flowers in the "underground" section and tree branches in the upper part of the note, seamlessly blending various printing techniques into a unified design.

## INNOVATIVE DIGITAL NUMBERING

The final stage of the printing process was the numbering of the banknotes. Traditionally, banknote personalization is done using letterpress printing with specialized inks. However, for Project MEADOW, we embraced one of the latest trends in printing technology—digital printing. While still relatively uncommon in the industry, this method allows for the integration of unique features that are impossible to achieve with conventional printing techniques.

On the reverse side, the numbering appears in two locations:

- The first number is placed in the upper section. It features a two-letter series ("PK") in a horizontal format, followed by the serial number printed vertically just below it.

- The second number is found in the lower section, among the flowers, and includes several distinctive features:

  1. Custom Typeface – Designed by the PWPW S.A.'s design studio, this numbering font incorporates floral decorative elements, blending seamlessly with the surrounding natural motifs.

  2. Variable Positioning – The number's placement is dynamically determined by a computer algorithm, meaning its exact location may vary

  3. Algorithmic Serial Numbering – The serial number itself is also calculated based on special algorithm, ensuring a level of personalization beyond traditional numbering methods.

## SUMMARY

Project MEADOW is the result of a successful collaboration between Polish Security Printing Works (PWPW) and Leonhard KURZ, aimed at exploring new directions in modern banknote design. The project demonstrates how sustainability, security, and visual storytelling can be effectively combined in a single concept.

In response to the industry's growing focus on reducing environmental impact, the note was developed using more sustainable materials and production methods. At the same time, it incorporates a wide range of integrated security features designed to meet current anti-counterfeiting standards without compromising design integrity.

Visually, Project MEADOW follows a nature-inspired theme, presented through a vertically oriented layout that reflects different layers of the natural world. Each element of the design supports this narrative, contributing to a unified and coherent visual experience.

Rather than treating technical and aesthetic elements separately, the project brings them together in a cohesive way—demonstrating that modern banknotes can be secure, environmentally responsible, and visually engaging at the same time. Project MEADOW stands as a strong example of how thoughtful design and technological collaboration can help shape the future of banknote production.

POLISH SECURITY PRINTING WORKS

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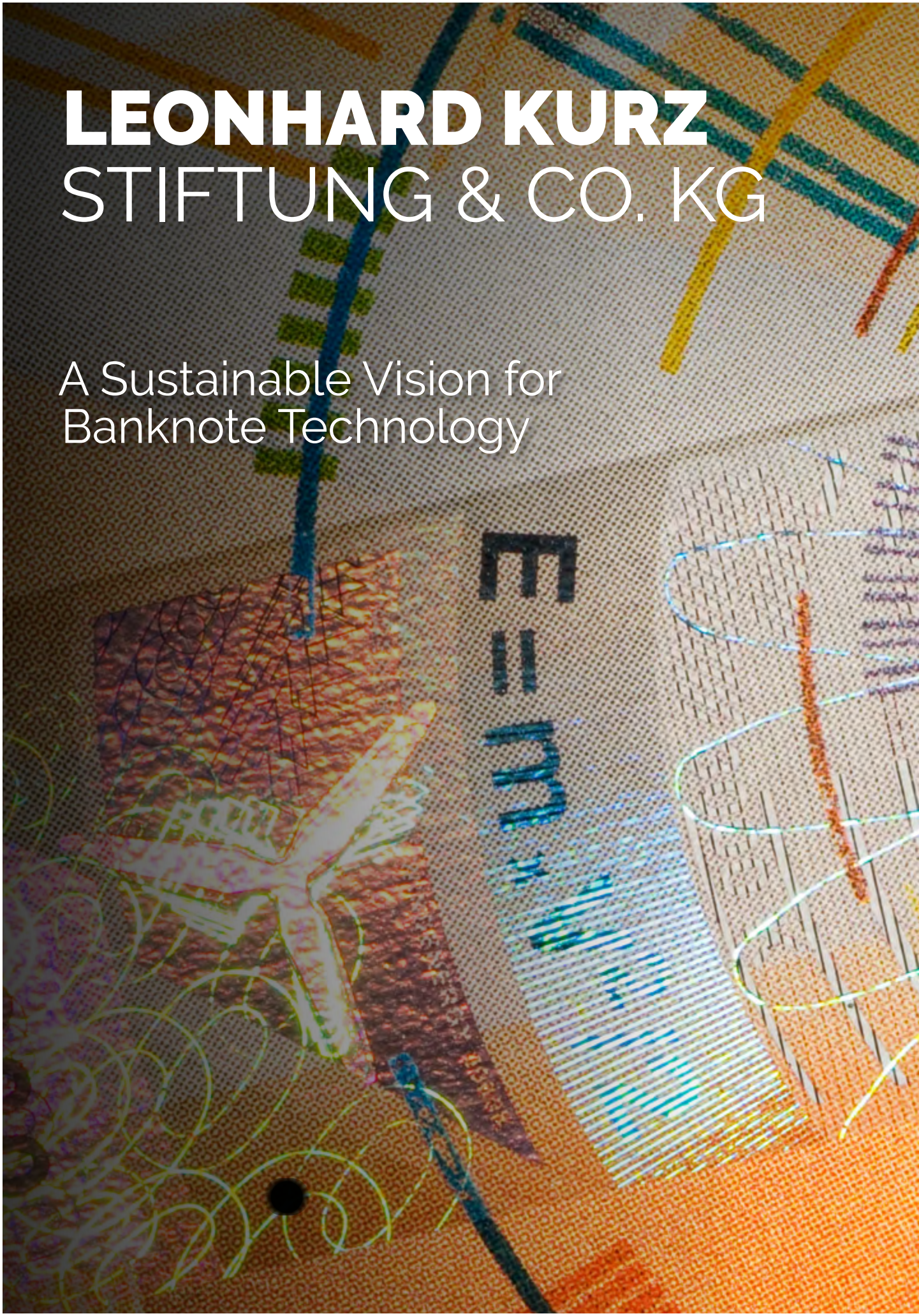
LEONHARD KURZ
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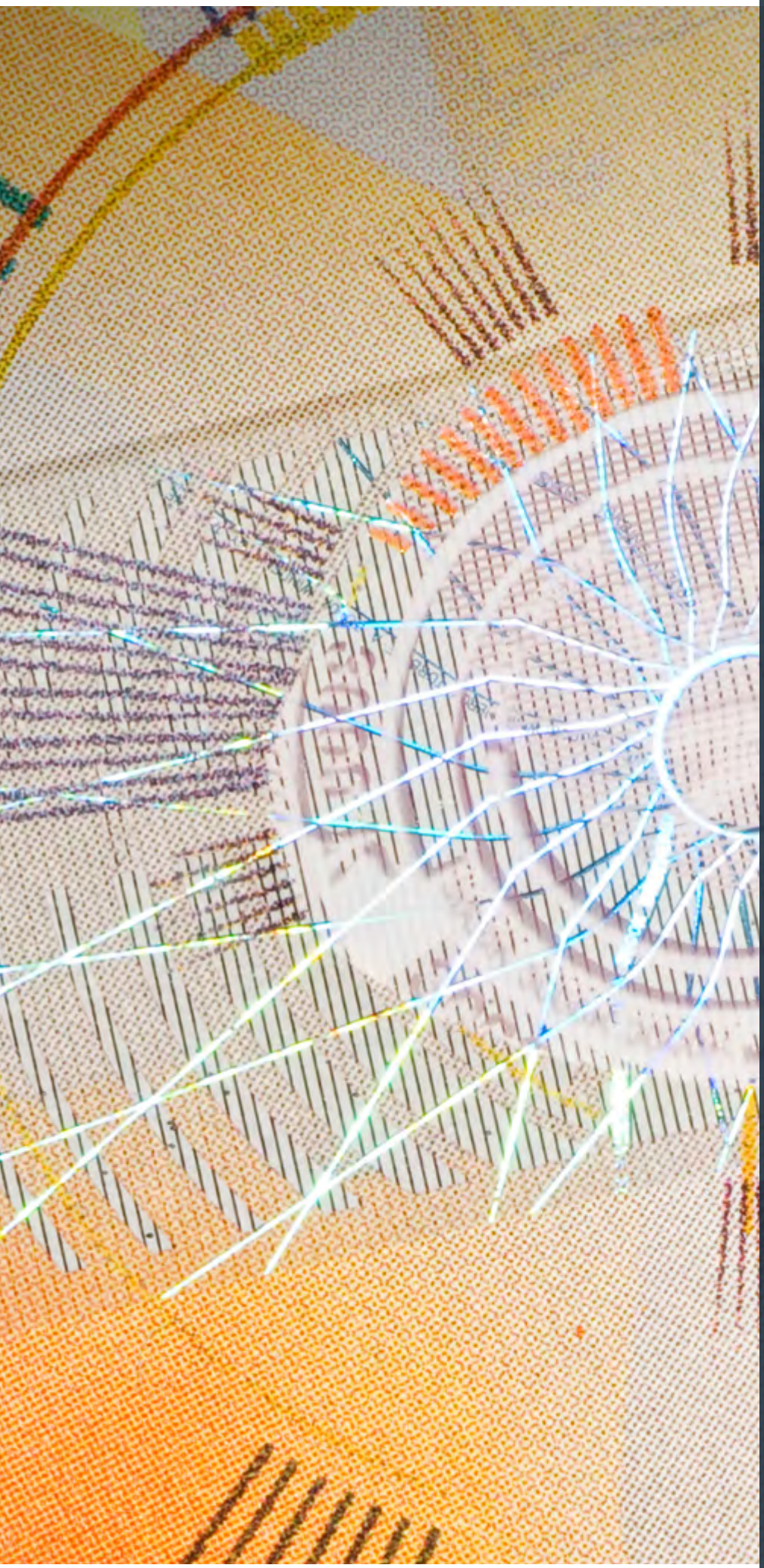
A Sustainable Vision for
Banknote Technology



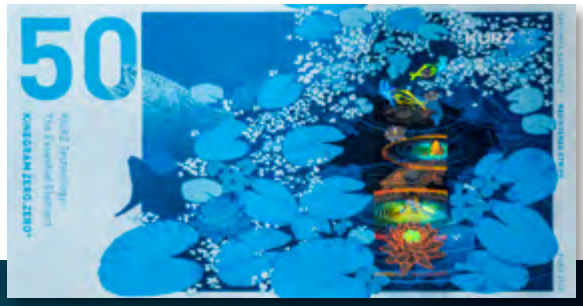
# FACT BOX

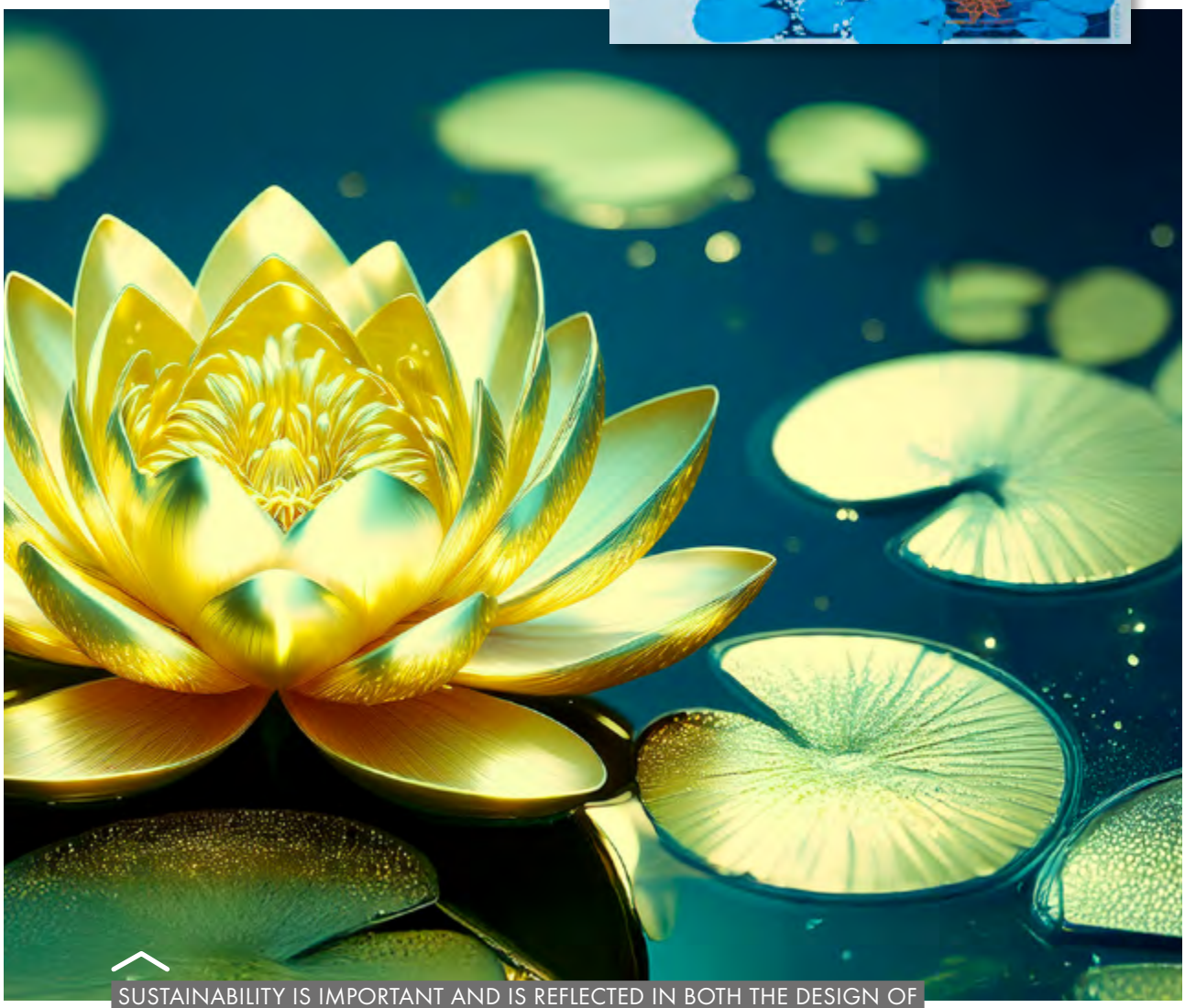
- With environmental concerns shaping global industry trends, Central Banks and currency producers are prioritising sustainability in banknote production, design and end-of-life strategies
- There is a shift towards eco-conscious substrates, recyclable materials and energy-efficient manufacturing processes, with lifecycle analyses and environmental certifications becoming standard
- Advanced security elements now consider both performance and sustainability, aiming for minimal material use and compatibility with existing recycling systems
- Sustainability strategies are tailored for both cotton-based and polymer banknotes, with much innovation focused around supporting full recyclability without compromising security
- ISO 14001 and ISO 50001 certifications are increasingly common, promoting structured environmental and energy management
- LEONHARD KURZ is going beyond compliance to support biodiversity and employee engagement with sustainability through initiatives such as beekeeping and green spaces

## SUSTAINABILITY IN THE CURRENCY SECTOR

Global priorities are shifting towards sustainability and resource-conscious innovation. Companies in every field are re-evaluating their environmental impact and those in the banknote industry are no exception. As greener economies become prevalent, stakeholders throughout the banknote lifecycle—from Central Banks to substrate manufacturers and security feature providers—are adopting a holistic approach to ecological responsibility.

Once, banknotes were designed around aesthetics, longevity and security. Looking ahead, those needs must coexist with considerations around green credentials, prompting a revolution in material innovation, manufacturing efficiency and a fresh look at end-of-life processes for physical currency.



SUSTAINABILITY IS IMPORTANT AND IS REFLECTED IN BOTH THE DESIGN OF SAMPLE BANKNOTES AND OUR SUSTAINABILITY REPORT

## EXPERIENCE MEETS INNOVATION

The evolution of banknote sustainability starts with design. Modern banknotes are expected to perform well over many years of circulation, withstanding challenging environments—perhaps even being put through a wash cycle in a jacket pocket—while having the lowest possible environmental impact across their lifecycle.

A significant development in this area is the increasing use of eco-efficient security features. Building on knowledge and experience of traditional foils and multi-layer plastics, which left significant room for improvement in terms of wastage, industry innovators are creating transfer technologies that apply just the essential design layers to a substrate, leaving no plastic or carrier material behind. This reduces resource usage and improves recyclability at end of life.

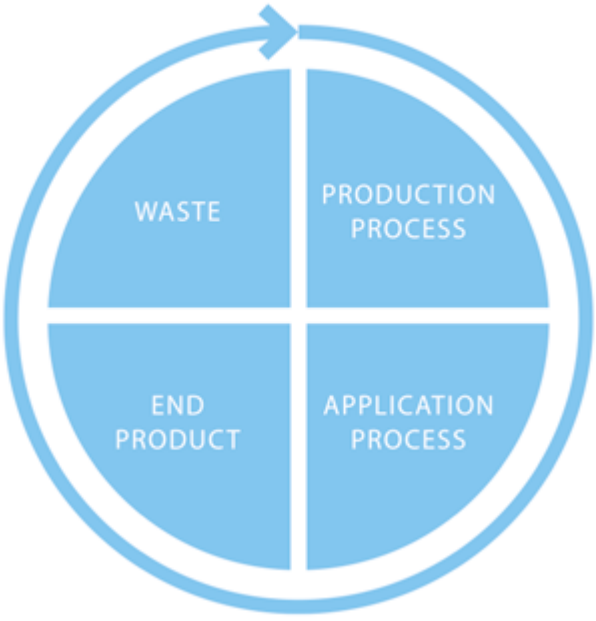
LEONHARD KURZ has successfully reduced transfer carrier thickness, applying only the functional layers of a security element to a banknote surface. No PET carrier film remains on the final product, and KURZ is currently the only manufacturer committed to recycling surplus PET. Approaches such as this illustrate how advanced security can be achieved with minimal material usage and no compromise in protection.

## CIRCULAR ECONOMY PRODUCTION PRINCIPLES

Banknote manufacturing is increasingly incorporating circular economy principles, with products being designed for reuse, recycling and minimal waste from cradle to grave. Specifically, this means incorporating renewable or recyclable materials, reducing leftover materials and creating closed-loop systems for resource recovery.

Across the industry, manufacturers are investing in systems to repurpose production waste, optimise energy and water usage and reintegrate unused materials. The advantages are clear: more eco-friendly production, long-term cost savings and higher operational efficiency.

KURZ has demonstrated this model by recovering unused carrier materials and reintroducing them to our production stream. Our facilities also undergo regular assessments to identify and action opportunities for waste reduction and improved energy efficiency. We have planned a power-to-heat system in 2026 with thermal storage, which will significantly reduce emissions and help us take another step towards our goal of a fully sustainable production lifecycle and CO2 neutrality. The system will seamlessly integrate into KURZ's existing thermal oil infrastructure, providing stable, on-demand heat while drastically reducing reliance on natural gas.




AREAS OF RESPONSIBILITY

## HOW CERTIFICATION DRIVES ACCOUNTABILITY

Greenwashing is a major problem in our industry, with companies presenting their products and policies as more environmentally friendly than they actually are. While carefully selected statistics and studies can suggest something is 'green', it is important to consider the broader context of its lifecycle. For example, the chemicals used in initial production, how associated wastewater is disposed of and—at end of life—the item's recyclability. Furthermore, even if it can be recycled, are there actually facilities that can do this at scale?

There are ways to ensure sustainable practices are more than good intentions and greenwashing PR, by applying measurable outcomes. This is where environmental and energy management certifications, such as ISO 14001 and ISO 50001, are key to making real, impactful change.

ISO 14001 – Environmental Management System aims to 'reduce environmental impact, inspire trust in an organisation and improve brand reputation.' It provides a framework through which companies can measure and improve their environmental performance while still meeting the needs of their business.

ISO 50001 – Energy Management System targets 'enhanced resilience against changing energy costs and saving money through efficient energy management.' It helps companies take steps towards reducing their reliance on fossil fuels while managing any risks around their energy supply, 'improving energy efficiency, staying current and compliant with legislation, and getting future-ready.'

COMMITMENT TO RESPONSIBLE ENVIRONMENTAL PROTECTION WITH PHOTOVOLTAIC SYSTEMS

KURZ holds the 14001 certification for several of its locations, and has implemented energy monitoring systems that allow real-time tracking and continuous optimisation. 100% of the electricity used at KURZ Germany already comes from renewable sources, with some of it produced in-house through extensive photovoltaic systems at our Sulzbach-Rosenburg and Fürth sites. Internationally, we're also making progress, with our rooftop solar panels recently doubled and now covering 20,000 square metres of our KURZ China facility.

## TAILORED TO PAPER, POLYMER OR HYBRID SUBSTRATES

Substrate selection has a pivotal role to play in banknote sustainability. Cotton-based paper and polymer substrates each have their own pros and cons, meaning the choice between them must consider local infrastructure and banknote usage patterns.

Paper notes are traditionally derived from cotton fibres, making them biodegradable and recyclable through standard systems. However, they may have shorter lifespans, necessitating more frequent replacement.

Polymer notes can circulate longer, spreading their environmental impact over more time. They are also more heat and water resistant, making them suitable for harsher climates (and the aforementioned adventures in washing machines). However, their end-of-life recycling is more complex and requires dedicated infrastructure.

Security features must be fully compatible with both types of substrates without compromising their recyclability. This means avoiding laminated layers or embedded plastics that could interfere with the recycling process.

KURZ security elements are designed to be substrate-agnostic and retain recyclability, meaning they can be applied to polymers, paper, or a composite of the two, such as DuraSafe. This allows Central Banks absolute flexibility in choosing a substrate based on regional needs while also meeting eco-friendly criteria.

## UNDERSTANDING THE LIFECYCLE OF A BANKNOTE

Modern banknote sustainability is not just about production. As we've seen in the substrate decision process, it must cover the entire lifecycle. This includes raw material extraction, manufacturing, transport, circulation and, eventually, withdrawal and disposal. Lifecycle analysis is a valuable tool for Central Banks and suppliers to identify environmental issues and reduce their impact. Key considerations include:

- Sourcing of raw materials and prioritisation of renewable or responsibly harvested resources
- Striking the right balance between longevity and energy and resource requirements
- Ensuring notes can be recycled, composted or otherwise disposed of without releasing microplastics or other hazardous materials
- Preventing elements from contaminating waste streams at any stage of the process

Lifecycle-oriented design should ensure a banknote's sustainability performance is visible from production, throughout its useful life, right up to the moment of disposal. KURZ is proud to have achieved excellent results in the 2024 EcoVadis Sustainability Rating,

which covered four areas: environment, labour and human rights, ethics, and sustainable procurement. The assessment is based on high standards and monitored by an international scientific committee, examining not only aspects such as raw materials but also responsible treatment of employees and commitment to greater diversity and inclusion. We received a Bronze Sustainability Rating, scoring well in all areas, and have taken this as encouragement to continue and expand our efforts.

## THE FUTURE OF BIOBASED MATERIALS

One realm of exciting possibility in sustainable banknote development is biobased materials. As pressure mounts to reduce reliance on petrochemicals, companies across the currency industry are experimenting with renewable feedstocks for films, coatings and colourants. Biobased alternatives aim to provide the same high-performance characteristics (including durability, counterfeit resistance and visual appeal) while reducing environmental impact. Plant-derived polymers, for example, could replace conventional plastics in carrier films or security elements.

SOME BEE COLONIES HAVE FOUND A HOME AT KURZ AND SWEETEN THE EVERYDAY LIFE OF THE EMPLOYEES WITH HOMEMADE HONEY

KURZ is actively researching biobased and energy-efficient alternatives for our future security elements. We intend to reduce carbon emissions and improve recyclability while continuing to meet the high standards Central Banks and citizens demand of their hard-working money.

## A CULTURE OF CORPORATE RESPONSIBILITY

Embedding a core of sustainability today with innovation to serve tomorrow should go beyond product development. Cultural values community engagement and the support of biodiversity are important aspects of corporate responsibility. Many companies are enhancing their green credentials not simply through compliance, but by actively investing in initiatives that promote ecological balance and employee involvement.

KURZ saw an opportunity to harness green spaces at our Fürth site and, in 2022, teamed up with a local beekeeper to provide a habitat for five bee colonies. This symbolises a commit-ment to the health of our local ecosystem and makes a direct contribution to employees who enjoy the honey produced, fostering awareness and pride in our environmental ethos.

Initiatives such as this may not directly correlate to product output, but they can help build a culture of caring about sustainability that permeates every aspect of a business.

## STRENGTH IN COLLABORATION

Creating a sustainable future for banknotes requires more than individual actions scattered across companies and countries, it demands collaboration across the industry. Central Banks, substrate producers, feature suppliers and security printers must align their goals, share data and work together to develop and implement best practices.

Momentum is building in this area. Industry forums and working groups are increasingly focused on sustainability, tackling topics such as common recycling standards, carbon footprinting methodologies and substrate comparison frameworks. Collective innovation will help avoid duplication of effort and ensure scalable solutions that benefit whole ecosystems, and offer companies and governments greater efficiencies and cost savings.

KURZ actively participates in these forums, sharing expertise in thin-film technologies, recyclability and energy-efficient production, and contributing to an industry-wide knowledge base to build ever more sustainable currency.

## CHALLENGES - AND OPPORTUNITIES - TO COME

The road ahead has many obstacles. Regulatory frameworks vary between jurisdictions. Needs are different on a country-by-country basis. Central Banks must balance cost, durability and security requirements against longer term environmental goals. Still, momentum is being built. New technologies, responsible design principles and greater industry transparency are creating opportunities to forge a greener future. Companies that invest early in these areas can not only fulfil their environmental obligations, but also build trust with clients, regulators and the public.

By aligning our high standards for the security, longevity and aesthetics of banknotes with equally lofty ambitions of environmental responsibility, the industry is


SAMPLE BANKNOTE 'BEE' WITH KINEGRAM® TECHNOLOGY

poised to redefine what a modern banknote represents. They can be not only a symbol of national pride and economic worth, but also a sign of shared values across borders around sustainability and green stewardship.

Setting an example as an industry leader, LEONHARD KURZ demonstrates how innovation, certification and cultural engagement can work synergistically to reduce the environmental footprint of truly secure currency. As others follow suit, a sustainable future for the banknote industry looks not only possible, but inevitable.

LEONHARD KURZ
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# GIVING WINGS TO PROCESSING

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## Navigating uncertainty: Industry, innovation, and the future of data

# FACT BOX

- CPS understands the world and the requirements of the industry are changing. CPS offers flexibility across a wide product range to ensure that any customer requirements are met.
- Increased focus on sustainable cash processing:
- CPS pledges to maximize production while minimizing environmental impact.
- Using data to improve efficiency and banknote suitability.
- Exclusive product range that meets all unique customer requirements including High-speed sorters, V Series High Speed Compact Sorters with shredding and strapping capability, X Range Medium sorters with strapping and bundling capability.
- The SmartVision™ range represents CPS's most advanced technology for banknote identification, delivering unmatched accuracy, image clarity, and sorting performance.
- Designed to support the highest standards required by central banks, SmartVision™ ensures optimal implementation of clean note policies, robust authentication, and efficient fitness sorting — all with market-leading imaging technology and configurable detection modules.

## NAVIGATING UNCERTAINTY: INDUSTRY, INNOVATION, AND THE FUTURE OF DATA

In a world increasingly defined by unpredictability, industries across the globe are grappling with profound challenges. From geopolitical tensions and economic instability to technological disruption and regulatory upheaval, the landscape is shifting rapidly.

Businesses from all sectors are now consolidating services to remain viable, central banks are outsourcing operations, and businesses are reevaluating their risk management strategies.

The overarching theme is clear: the old models no longer suffice.

## OPERATING IN AN UNCERTAIN WORLD:

Businesses must move beyond reactive strategies and embrace proactive, data-informed planning.

This means fostering a culture of continuous learning, collaboration, and innovation. It means leveraging technology not just to automate tasks, but to enhance decision-making and strategic foresight. Organisations must recognize that the challenges we face are not unique to one sector—they are shared across industries and borders.

The path forward lies in embracing uncertainty, learning from past mistakes, and building systems that are not only efficient but resilient. The future may be unknowable, but with the right tools and mindset, it is navigable.

## INTELLIGENT MACHINES, NOT JUST DATA

The manufacturing industry offers a roadmap. Over the past few decades, manufacturers have moved from basic data collection to predictive analytics. They began by extracting data from machines using spreadsheets and pivot tables, then evolved to real-time monitoring and forecasting. This journey enabled them to optimize operations, reduce waste, and improve agility.

The financial and banking sectors can follow a similar path. But they must avoid the mistakes of the past—where automation was implemented without a clear data strategy, leading to costly failures.

## BECOMING DATA CENTRIC:

In a world where conditions change rapidly, systems must be adaptable. This includes hardware, software, and staffing. Organizations must also consider the risks of supplier dependency. If a single vendor controls your automation infrastructure, you could be locked in for decades, limiting your ability to pivot. Flexibilty is key.

So how can an organisation become data-centric, it starts with being flexible. The solution lies in a targeted, modular approach. Instead of overhauling entire systems, organizations should identify specific areas where automation can deliver measurable value — it starts by understanding what organisational data you hold: So, start off by asking:

- What data am I getting off my machines,
- Can I do a comparison of shift by shift?
- What does the maintenance scheduling look like?

If the answer is we don't have that information – then there is your starting point, as this level of insight is essential not just for engineers, but for CFOs, operations directors, and governance teams. Everyone needs visibility into system performance to make informed, strategic decisions to build a robust automation strategy. As without data AI and automation cannot be effectively developed.

## WHY IT'S TIME TO START ASKING THE RIGHT QUESTIONS:

The time for our industry is now, it's time to start having the difficult conversations within organisations and stop being reactive and become a fully connected, proactive industry. By turning data from information on a spreadsheet into actionable insights that can help improve organisations, by making them more efficient, more sustainable and resilient to uncertainty and black swan events.

For the first time, the technology is there, so it is time for the industry to embrace it, by upgrading machines to generate better data, the industry can generate greater intelligence, support smarter decisions, stronger partnerships between multiple parties and therefore, become a more connected industry.

## AUTOMATION BUT NOT FOR AUTOMATIONS SAKE:

Central Banks and organisations must now also start looking towards automation and creating a data-centric first mindset. However, we cannot just embrace automation for automation's sake and believe that it will the silver bullet quick fix, many predict.

Automation when correct can be transformative for a business, but when implemented incorrectly can be paralysing.

Automation must be targeted, not sweeping. The key is to avoid building massive systems that are obsolete the day they're installed. One of the key lessons we can learn from other industries is how quickly full automation practices can become outdated, restrictive, expensive and not actually solve the original issue.

Projects designed to solve today's problems may not be fit for tomorrow's realities. Instead, businesses must become more agile, leveraging data and technology to make informed, adaptive decisions.

Therefore, it is imperative that they are aligned with business needs, and to start with, organizations should focus on upgrading existing systems—particularly cash processing machines—to make them more intelligent. This means enabling machines to generate real-time data that can inform decisions about performance, maintenance, and efficiency. Without this foundational intelligence, any leap to AI or full automation is premature.

## THE TIME IS NOW...

The time for saying I don't know has passed, there is no excuse for not knowing anymore whether that be in cash processing, logistics, overtime or maintenance. The technology is here so it's time that we embrace it. As data is the thread that enables partnerships.

Otherwise, just like Kodak, we will be left behind, wondering why we didn't start asking the questions earlier…

So, as an industry go and ask:

- Are we automating for the right reasons?
- Are we using data effectively?
- Are we learning from other industries, or repeating their mistakes?

Cash Processing Solutions Ltd

Mr. JJ Haigh
Email: jj.haigh@cps.world
Website: www.cps.world

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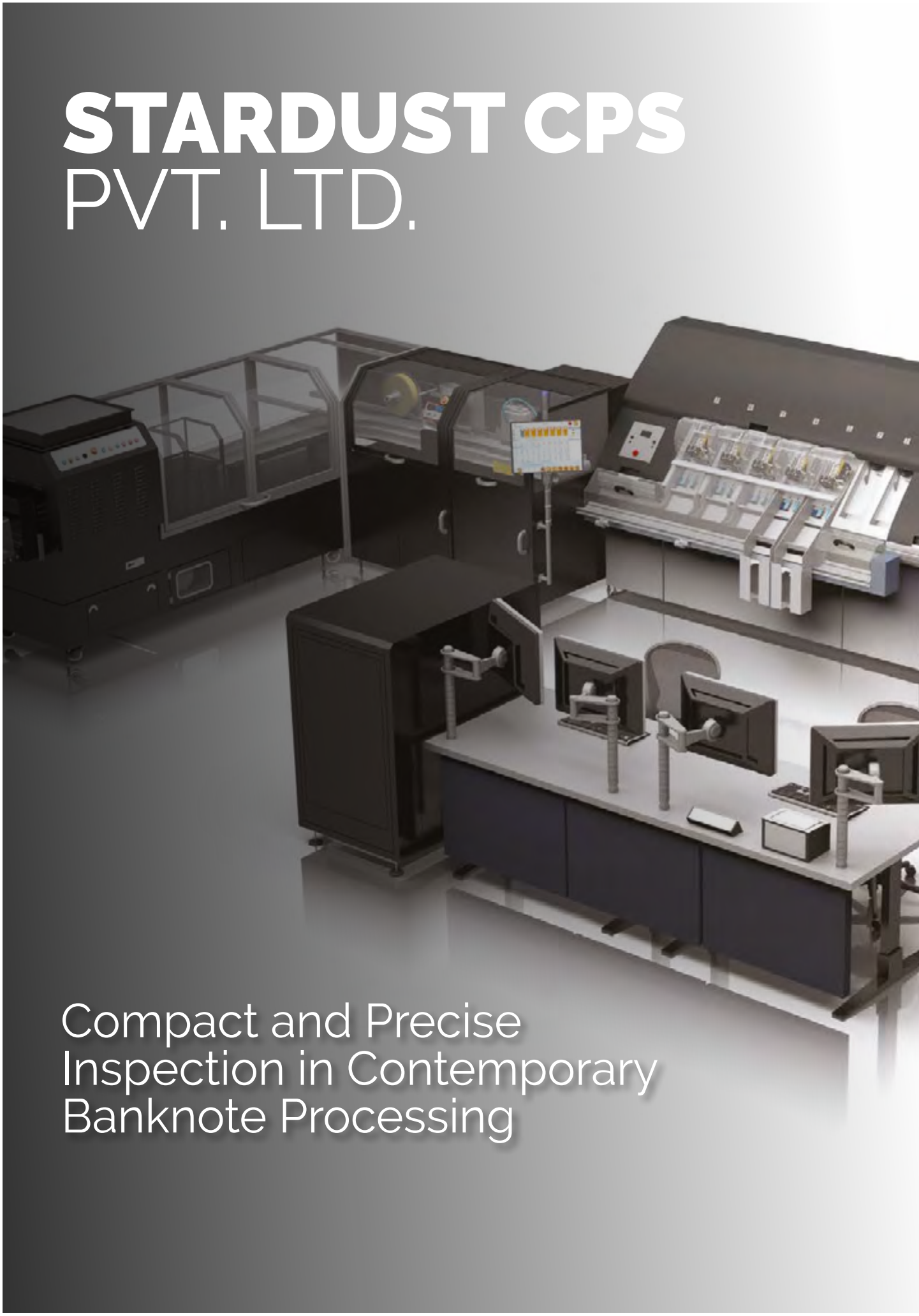


## Compact and Precise Inspection in Contemporary Banknote Processing

# FACT BOX

- The Stardust CPS 9000 system offers ultra-fast, high-precision inspection of banknotes at speeds up to 40 banknotes per second, tailored for high-volume banknote printwork environments.
- Integrated five-camera system captures RGB and IR imagery (front RGB/IR, rear RGB/IR, transmissive IR) for detection of print defects, substrate flaws, and security feature inconsistencies.
- Modular design supports seamless integration with upstream and downstream systems, including optional modules for shredding, high-capacity automated feeding, and packaging.
- An innovative belt-free banknote transport path ensures consistent image capture at high speed, maintaining accuracy without distortion across print variations.
- The software architecture includes IPA, MCA, and GUI modules running on distributed servers, ensuring traceable, real-time inspection with responsive operator control.
- Built-in analytics, remote diagnostics, and predictive maintenance tools reduce downtime and enhance lifecycle efficiency, while sustainable features minimize waste.

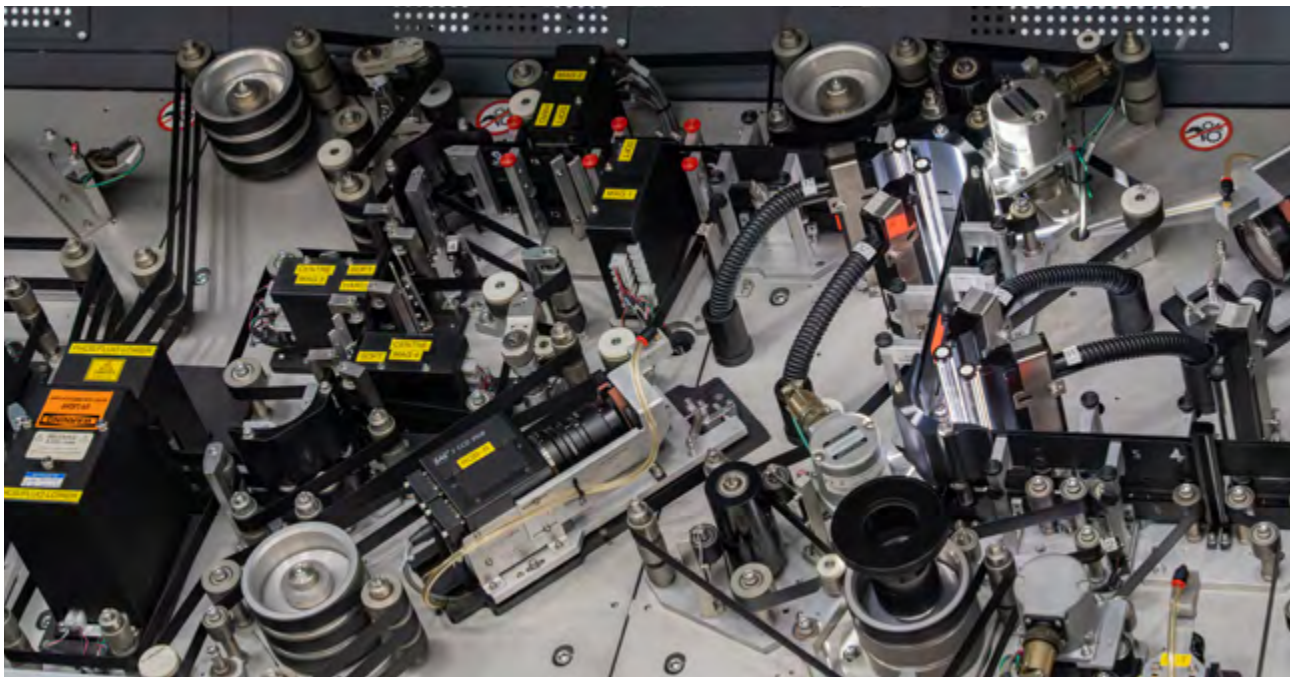
## STARDUST CPS: HIGH-SPEED AND PRECISE INSPECTION IN CONTEMPORARY BANKNOTE PROCESSING

Modern banknote production demands inspection systems that combine precision, speed, and adaptability while supporting high volumes and strict quality standards. Stardust CPS Pvt. Ltd., a joint venture Company of Pigments and Allieds, Stardust and CPS, based in India, has developed advanced solutions that meet these needs through its 9000 series banknote inspection platforms. Designed for both online and offline use, these systems incorporate multi-camera setups, intelligent software, and seamless integration with upstream and downstream processes including high-capacity automated banknote feeding and in-line automated packaging systems. The 9000 series, capable of inspecting up to 40 banknotes per second, scalable on customer demand, reflects a design philosophy that emphasizes user-centric engineering, accuracy through a customized, curved, belt free and stabilized banknote travel path, and sustainability-focused operations, making it a robust and future-ready solution for state and commercial printworks.

## INTEGRATED SECURITY AND INSPECTION APPROACH

Stardust CPS is a joint venture that combines Pigments and Allieds expertise in providing special effect Pigments, security features, and chemicals to the global and Indian banknote industries, Stardust Secured's capabilities in covert taggant and authentication technologies, and CPS's proven strengths in optical sensing, detection hardware, and industrial automation.

The result is a fully integrated platform that combines chemical feature detection with high-resolution visual inspection. In the CPS 9000, machine-readable features and taggants are detected alongside detailed image analysis, creating a dual-layer quality assurance and authentication system. The robust design, track-and-trace capability, and



inspection standards reflect the combined vision of two complementary domains working toward a unified goal: precision, compliance, and security in every banknote inspected.

## THE ROLE OF INSPECTION IN BANKNOTE PROCESSING

Cash processing is a critical part of any national currency cycle, ensuring that only secure, verified, and high-quality banknotes reach the public.

Before banknotes enter circulation, they must undergo thorough inspection to detect any printing defects, alignment errors, or substrate flaws that could affect durability or trust. A defective banknote in public hands can lead to loss of confidence indicating operational inefficiencies for central banks. At the same time, unnecessary rejection of banknotes due to inconsistent inspection standards can increase waste. This is where high-precision image analysis and data-driven decision-making play a crucial role. Final-stage inspection systems, like those developed by Stardust CPS, enable traceable, analytics-supported validation of each banknote. This not only improves quality control but also supports sustainability by reducing rejections. In the context of national currency, this is a sovereign function tied to public trust, making accurate, efficient inspection a competitive and strategic advantage.

## SYSTEM OVERVIEW

The 9000 system is intended for high-volume, inline processing environments and functions as a Single Note Inspection Machine (SNIM). It uses a five-camera layout that captures front and rear RGB and IR images along with a transmissive IR view, enabling precise detection of print quality issues, substrate defects, and security feature inconsistencies. This also has the capability to integrate third-party sensor responses to provide a comprehensive inspection solution for complete banknote inspection. The system operates at up to 40 banknotes per second and integrates seamlessly with upstream and downstream including high-capacity automated banknote feeding and in-line automated packaging systems.

## UNIQUE DESIGN AND ENGINEERING FEATURES

The design of the Stardust CPS 9000 system reflects a deliberate focus on both precision and practicality. Unlike many conventional machines that rely on long, belt-based paths which often introduce instability and image distortion, this system uses a uniquely engineered curved travel path. A guiding plate stabilizes each note during transit, minimizing vibration and mechanical noise. This enhances image clarity, particularly important for high-speed, multi-sensor inspection.

To meet installation and space constraints, the machine's overall footprint has been kept compact. Achieving this required careful adjustment of sensor positions and internal layout, allowing the system to deliver advanced functionality without increasing size. Though this approach adds to the complexity of engineering and assembly, it simplifies the end-user experience. The result is a system that is technically demanding to build, yet exceptionally easy to operate and maintain, underscoring the company's emphasis on long-term usability and customer-centric design.

## UNIQUE SELLING PROPOSITION

The Stardust CPS inspection systems are designed to address the real-world demands of high-speed banknote processing while offering flexibility, sustainability, and future-readiness. A key advantage is the modular architecture, which allows individual components and subsystems to be configured for specific production needs. This modularity supports tailored workflows and makes the systems easily adaptable to evolving currency features or processing requirements.

The ability to integrate seamlessly into upstream and downstream systems enhances operational efficiency without requiring major reconfiguration. Built-in analytics tools monitor system health and performance, enabling real-time feedback and predictive maintenance. This helps reduce unplanned downtime and supports tighter quality control with less waste.

Each banknote processed is tracked through a secure audit trail, meeting compliance needs and reinforcing operational transparency. The systems also support in-line shredding of rejected banknotes and offer automated packing functions aligned with sustainability goals.

From a usability standpoint, the systems feature a compact footprint, intuitive design, and ergonomic layout, improving operator comfort and minimizing space requirements. Region-specific feature modeling, spectral analysis, and digital twin compatibility further position these systems as robust tools for both production and development environments. The offline platform supports testing and process validation before deployment, while the overall design philosophy remains centered on scalability, precision, and long-term maintainability.

The system offers user-defined dashboards for monitoring processed volumes, sorting summaries in real-time. Reports can be customized to align with the printworks MIS and audit requirements, ensuring seamless integration into existing workflows.

A robust local service network ensures rapid on-site support and minimal downtime for the 9000 SNIM system. Preventive maintenance and remote diagnostics further enable quick issue resolution to maintain continuous operations.

The machine is engineered with durable components and minimal wear parts, ensuring a long operational life even under heavy-duty cycles. Combined with low maintenance needs and energy-efficient operation, it reduces the total lifecycle cost for the user.
The system incorporates advanced damping structures and optimized mechanical designs to reduce operational noise and vibration. This ensures a quiet working environment, improving operator comfort and focus during high-volume processing.

## SOFTWARE AND SYSTEM ARCHITECTURE

The inspection systems developed by Stardust CPS are supported by a modular software architecture built for speed, traceability, and flexibility. At the core are three coordinated components: the Image Processing Application (IPA), the Master Controller Application (MCA), and the Graphical User Interface (GUI) system. These components are deployed across distributed servers to handle real-time image capture, data processing, system control, and user interaction.

The IPA modules process high-resolution images from each of the five cameras, applying detection algorithms to identify defects, misalignments, or deviations from model references. The MCA functions as the central controller, managing the synchronization between sensors, actuators, and external systems. This structure allows the system to maintain continuous operation without bottlenecks, even under high-speed processing conditions.

The GUI system operates independently and provides users with live monitoring, model building, and adjustment capabilities. This separation of control and visualization ensures responsiveness and stability, while also allowing for customization of inspection parameters without interrupting operations.
Together, this software framework enables fast, traceable, and user-configurable inspection while remaining scalable for future enhancements or specialized deployments.

## USE CASES AND DEPLOYMENT READINESS

The Stardust CPS 9000 system has been deployed in high-throughput banknote processing environments where reliable print inspection is critical. It integrates with feeding, sorting, and packaging modules to enable uninterrupted single-note validation in production settings. By working in tandem with our serial number search database system (BMIS), it provides traceable inspection outcomes aligned with established currency management protocols.

Inspection models can be created and fine-tuned on-site through the graphical interface, allowing adaptation to different banknote series or changes in feature configurations. This flexibility reduces setup time and supports consistent inspection quality across production runs. The system's performance has been validated in operational conditions, demonstrating its readiness for real-world print-works applications.

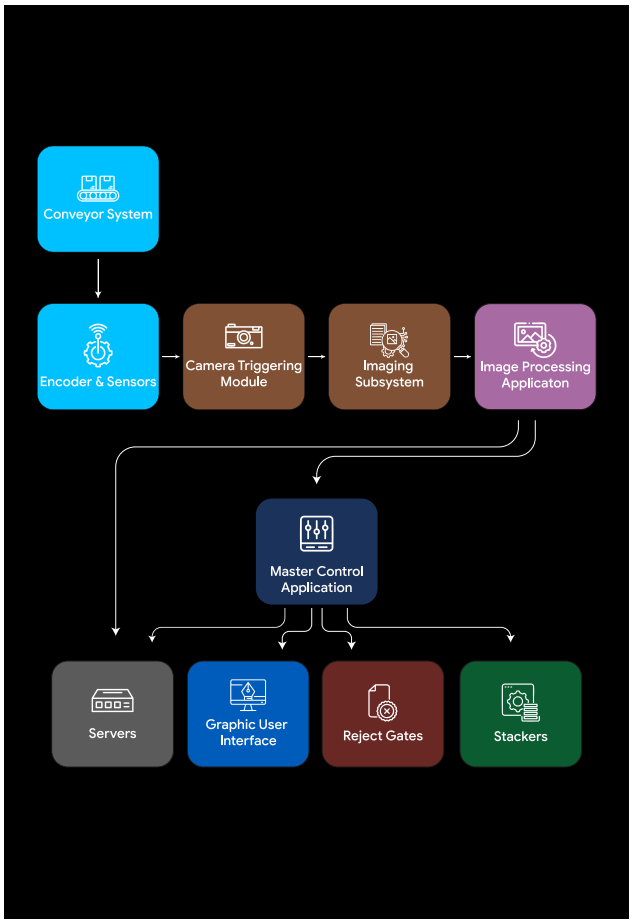


**Image Subsystem:**
- Cameras
- RGB
- IR (Reflective)
- IR (Transmissive)
- Frame Grabber
- Image Alignment
- Pre-processing
- ROI Extraction

**Image Processing Application**
- Print Inspection
- Security Feature Validation
- OCR
- Dimension and Skew detection
- Quality sorting

**Master Control Application**
- Inspection coordination
- Camera Trigger Control
- Inspection Logging

**Graphical User Interface**
- Live Image Display
- Inspection results
- Parameter settings
- Counters
- Machine Status & Alarms

**Servers**
- Banknote Quality Inspection System (BQIS)
- Banknote Management Information System (BMIS)

## SUSTAINABILITY AND SUPPORT

Sustainability is an integral part of the system's design philosophy. The Stardust CPS 9000 emphasizes efficient material handling and reduced waste through accurate inspection, which helps minimize unnecessary rejection of acceptable banknotes. The inclusion of in-line shredding and automated packing not only streamlines the process but also supports environmentally responsible disposal and packaging practices.

The compact design contributes to better space utilization and can lower the overall power, and infrastructure demands of a facility. Modular components and field-configurable settings also reduce the need for excessive hardware replacements over time, helping extend the system's service life.

Comprehensive support services are structured around system uptime and ease of maintenance. The user-focused engineering approach means that routine servicing, updates, and model adjustments can be handled with minimal disruption to operations. The overall system is built to balance reliability, efficiency, and long-term usability, reflecting the operational needs of high-volume banknote handling environments.

## FUTURE DEVELOPMENTS AND ROADMAP

As requirements for inspection systems continue to evolve, Stardust CPS is aligning its development roadmap around smarter software, broader functionality, and system stability. One major area of focus is the enhancement of internal software tools that support model creation, diagnostics, and tuning. The goal is to offer a more unified and accessible interface, improving usability across different operator levels and use cases.

## CONCLUSION

Inspection technology plays a vital role in the quality, security, and credibility of modern banknotes. With rising demands for accuracy, speed, and traceability, systems like the Stardust CPS 9000 are positioned not just as

tools for defect detection, but as essential infrastructure for secure and efficient cash management. From its compact, user-friendly design to its real-time model control and integration with broader systems, the platform reflects a careful balance between engineering complexity and operational clarity. As the industry shifts toward smarter, more connected inspection systems, the ongoing development efforts around software, analytics, and new detection methods show a commitment to long-term adaptability. The result is a system that is grounded in proven performance, yet responsive to the evolving needs of sovereign currency operations.

STARDUST CPS PVT. LTD.

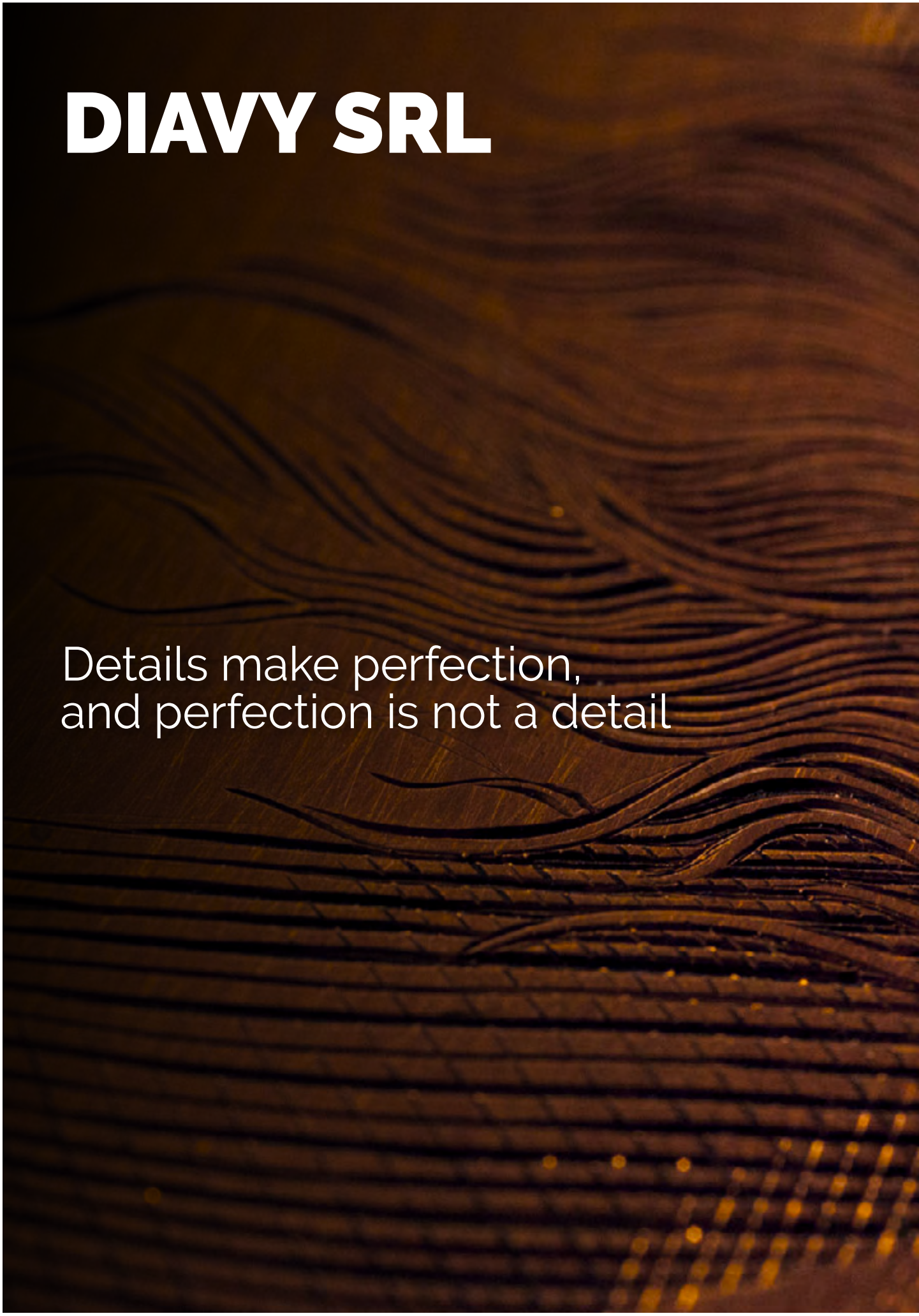
Mr. Kiran Suraktal
Email: ksuratkal@stardustcps.com
Website: www.stardustcps.com

| | |
|---|---|
| Context | 100% inspection of freshly printed banknotes |
| Processing Speed | 40 banknotes per second |
| Detection Accuracy | ≥ 99.8% (for defect detection as per central bank defined acceptance levels) |
| Inspection /Sorting Accuracy | ≥ 99.95% (correct pocket allocation based on fitness and defect detection) |
| MTBF | ≥ 1,200 operational hours |
| Throughput Efficiency | ≥ 97% (ratio of actual output to maximum theoretical output at 40 bps) |
| Energy Consumption | ~3.5 kW during operation |
| Noise Level | ≤ 75 dB |
| Input Hopper | 4,000 notes capacity (continuous feeding possible with HCF) |
| Stacker Pockets | 7 stacker pockets (configurable/expandable for denomination or fitness sorting) |
| Reject Pocket Capacity | One standard, up to 2,000 banknotes capacity Configurable reject pocket |
| Note Size range | Width: 57-100mm / Length: 100-185mm |
| Inspection Channels / Sensors | 12 Channels including third party sensors |

# GIVING WINGS TO EQUIPMENT

# DIAVY SRL

Details make perfection,
and perfection is not a detail



# FACT BOX

Founded in 1971, Diavy Srl is specialized in high-precision machinery for security printing, banknotes and battery industry

- Offers modular, fully customizable machine design for flexible, scalable production lines.
- All critical manufacturing phases are performed in-house for a vertical quality control.
- Trusted supplier to security printers and paper mills worldwide.
- Expertise includes foil application, embossing, coating, and advanced printing systems.
- DMB platform supports multiple process in line like: hot foil stamping, screen/ flexo/ gravure printing, UV curing, micro-perforation, and window generation.
- Machines are custom designed on customers need, with special consideration on design and process performance.

Since 1971, Diavy Srl has been delivering engineering excellence. Originally specializing in cold sheet metal stamping and custom machinery for the paper converting industry, Diavy has evolved into a key technology provider for the global security printing market.

Thanks to strategic investments and a strong innovation culture, the company expanded its scope during the 1980s, entering the holographic sector and start offering specialized machines. Today Diavy is a trusted partner of the world's top producers of banknotes, id documents, tax stamps and a recognized name among paper mills manufacturing the most sophisticated banknotes in circulation.

## MODULAR, TAILORED, SCALABLE

At the heart of Diavy's offer, there's a modular machine platform: flexible, customizable, and designed to meet each customer's unique process requirements. Different modules can be combined to create tailored configurations whether you're looking to expand your capacity or launch a full-scale production line.

Our in-house design team, using advanced 3D software, provides full machine and line layouts, giving customers a clear and realistic preview of every component and process before a single part is built.

## ENGINEERED IN-HOUSE FOR FULL CONTROL

From metal machining and welding to grinding, finishing, and high-precision CNC component manufacturing, every critical phase happens in-house. This vertical integration guarantees quality, consistency, and fast lead times and enables us to adapt quickly to project specific needs.

## INNOVATION MEETS INDUSTRY KNOW-HOW

Diavy's strength lies in the combination of technical expertise and industry specific insight.
What drives the company is simple: passion, precision, and a commitment to innovation.

## A COMPLETE RANGE OF ADVANCED SOLUTIONS

Machines portfolio includes:

- Recombining machines
- Galvanic electroforming tanks
- In-line coating and embossing systems
- Seamless and soft embossing machines
- Hard embossing for PET and PC foils
- UV casting machines
- In-line printing and demetallization systems
- Multi-stage printing, coating, and lamination machines
- Stripe application lines for paper or polymer banknotes
- Patch application machines for PC data pages
- Coating machines

Every solution is fully tailor-made from design to final assembly ensuring that customers receive systems perfectly aligned with their production goals.

And for those looking for complete independence, Diavy also offers turnkey plants and technology transfer packages, providing not just machines, but full know-how in different process.

## FOIL APPLICATIONS TECHNOLOGIES; DMB 900 / DMB 901: SECURITY FOILS FOR BANKNOTES

Today foil on banknotes combined with special printing effects are probably the most sophisticate, versatile, and flexible security features that a central bank can choose for their banknotes.

Today many leading producers can combined with an advanced optical technologies the creation of truly unique features that integrated into a banknotes create a result of security and visual appearance. The application of the most sophisticated foils onto banknotes is a very specific process and as such, requires extensive experience and know-how in foil manufacturing than in application technologies.

This continue development on foils design and manufacturing has required today unique production solutions that integrated in line many different process to create the most cost effective and secure banknotes substrate.

Going into more details about foils application, Diavy deep knowledge about application processes, and excellent connection with customers has allow us to create the DMB machine platform, that is a unique multi process hot stamping machine for application of foil stripes in roll to roll.

Each stamping machine of the DMB line is individually set up to customer specifications and in particular are designed for foil stripes application in register or not, on single or double side all in one pass

To have a more complete configurations each customer has personalized the machine design adding functionality like screen printing, flexo or direct rotogravure printing, UV coating, paper reconditioning, micro perforation or windows generation by mechanical or laser die cutting.

Diavy since 2010 has produced different DMB versions for different customers, and actually the most complete configuration can be identified on the model required to produce paper banknotes with window application.

Euro second series ES2 that is the most famous example of this banknote architecture is the reason for the development of this particular

technology. The production machine required a very specific configuration that includes in line : paper unwinder with watermark edge control reading, screen printing, back foil application, paper perforation, web turning, front foil application in register with the perforation , paper reconditioning, 100% inspection control.

For customers not interested on paper perforation and two foil application unit, the DMB 901 it's definitely the preferred choice.
This light configuration includes paper unwinder, a printing unit with dreyer section equipped with trolley system capable to process in register Screen printing, Flexo or Rotogravure printing, UV curing, in register foil application module, paper reconditioning, 100% inspection control and rewinder.

That machine configuration is already running with success on two paper mills in the world and is dedicated for those customers not involved on ES2 production.

A team of highly experienced technicians are at customer´s service, especially if that customer implements foil application for the first time or works for new banknotes design or application.

Working on a new banknotes design production sometimes require process optimization or software modifications on the existing machine and this is why the highly sofisticated electronical and mechanical architecture of DMB machine ensure long life and allows also to easy follows future machine expansion to add new functionality or new process in order to increase security features combination on the substrate without compromise the original quality and stability.

For papermills involved on banknotes paper manufacturing, the production process is highly hidden to preserve proprietary know how, but to protect the continuous production and efficiency, implementation of preventive measures is essential in contributing to effective risk management.

Diavy general approach on machine design is to simplify the transition when components become obsolete, ensuring that the replacement part precisely mirrors the original's functionality and offering machine expansion, retrofitting and revamping as part of its core service. This is guarantee thanks to a unique proprietary machine software design and due to high class electronic components used, that are totally scalable.

Diavy can manage the integrity of the project after many years to ensure long life and not obsolecence of functional parts like drives, controllers, and human-machine interfaces (HMIs), that manufacturers cease to produce, and so like-for-like replacements cannot be easily sourced in the event of a part failure.

DIAVY SRL

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# HUNKELER SYSTEME AG

## Towards a cleaner end-of-life: Modern banknote destruction built on sustainability, security, and efficiency

# FACT BOX

- Purpose-Built for Central Banks: Secure, modular disintegration systems tailored for cotton, polymer, and hybrid banknotes.
- Maximum Security: 100% closed system, tamper-proof process, DIN 66399-compliant particle sizes, full traceability.
- Smart Control: Hunkeler Control Manager (HCM) enables full monitoring, destruction reports, and banking system integration.
- Knife service life: Long lasting and durable knives incl. self-protecting mechanisms to reduce operating and maintenance costs.
- High throughput capacities: Offline shredding systems with up to 2'000kg/h throughput capacity at security level P5
- Automated feeding systems: reduce manual labour resources and direct access to live money by system operators.
- Sustainable Design: Clean air filtration, energy efficiency, and substrate separation support recycling and carbon reduction goals.
- Global Support: Worldwide service network, remote diagnostics, customizable service contracts.
- Trusted Worldwide: ~200 systems installed in central banks around the world.

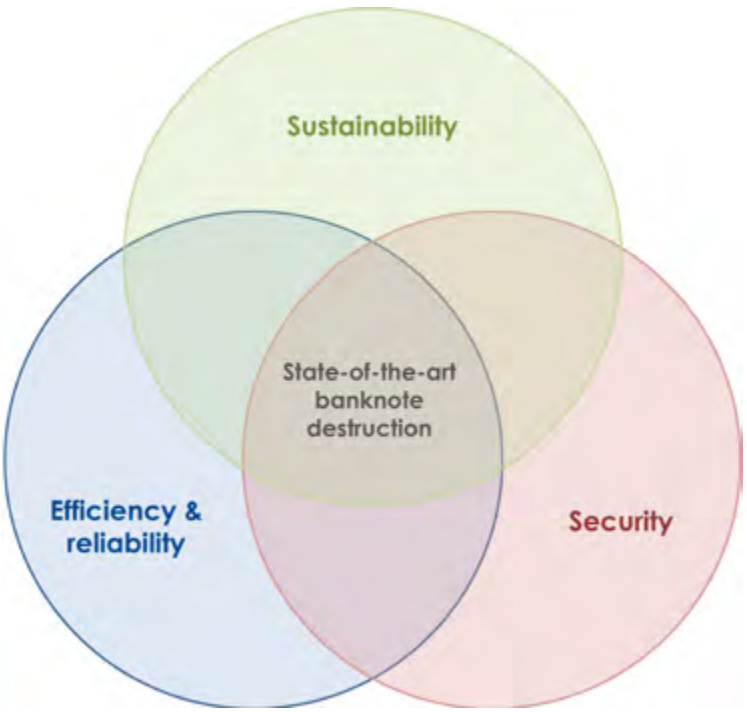
In the lifecycle of a banknote, end-of-life disposal has long been regarded as a necessary evil — essential but often overshadowed by the complexity and glamour of design, production, and issuance of banknotes. Yet today, as central banks and security printers face increasing pressures around security, sustainability, and operational efficiency, destruction and disposal technology are becoming a strategic cornerstone of a state-of-the-art cash cycle infrastructure.

At the forefront of this evolution is Hunkeler Systeme, a Swiss company with more than eight decades of experience in the disposal business. With around 200 installed shredding and disposal systems at central banks worldwide and a deep understanding of the unique requirements of banknote destruction and disposal, the company is helping central banks to reframe how unfit banknotes are managed — not simply as waste, but as a critical component of a secure, sustainable, and transparent cash system.

## THE SECURITY IMPERATIVE: 100% TRANSPARENCY AND TRACEABILITY

For central banks worldwide, the destruction of unfit currency is not merely a logistical task — it's a matter of national and economic trust. Hunkeler Systeme AG destruction systems are engineered with a 100% closed and tamper-proof process, ensuring 100% security and transparency through the destruction and disposal process including:

- Fully enclosed feeding and shredding units to prevent unauthorized access to live money
- Mechanically guaranteed particle size output meeting stringent standards like DIN 66399 (e.g., P3-P6 levels)
- Integrated monitoring and job report systems for full auditability and traceability of destruction jobs



Such features are critical in maintaining the integrity of destruction processes and cash — particularly as public and regulatory scrutiny of material disposal grows. Whether handling cotton-based banknotes or new polymer or hybrid substrates, Hunkeler Systeme solutions offer a level of security that matches the sensitivity of the material.

## EFFICIENCY AND RELIABILITY BY DESIGN

The disposal of banknotes may not be headline-making, but it is highly technical — requiring around-the-clock availability, minimal manual handling, and maximum throughput capacity. Systems by Hunkeler Systeme are designed to deliver precisely that, including key operational features according to the central banks individual requirements:

- Automated feeding systems to reduce working steps and manual labour resources
- Long lasting and durable shredding knifes to reduce operating and maintenance costs
- Self-protecting shredding systems against foreign materials to increase uptime and availability without system stoppages
- Modular system configuration to fit a system exactly according to the operational requirements and strategies of a central bank

Each system is optimized for minimal downtime, low operational costs, and maximum availability — making the system ideal for central banks which even must manage high annual destruction volumes or shred multiple substrates and denominations simultaneously.

## SUSTAINABILITY: FROM WASTE TO RESOURCE

Banknote destruction and disposal — traditionally viewed as a necessary environmental cost — is now being reconsidered as a point of ecological opportunity. Hunkeler Systeme technology integrates sustainability principles at every level of the system:

- Separation of substrates to enable central banks to achieve 100% pure substrates for proper recycling opportunities
- Filtered air for dust-free environment to increase a clean and safe working environment
- Reduction of energy consumptions during shredding, extraction, and transport
- Compacting of shredded material to reduce logistic and disposal costs

This approach supports central banks in aligning with broader national and international sustainability targets — from carbon reduction targets to circular economy models.

## SERVICE THAT MATCHES THE MISSION

Technology is only as effective as the support structure behind it. Hunkeler Systeme understands this and has built a comprehensive and global service network:

- Over 20 experienced engineers at its headquarters in Wikon, Switzerland
- A global service network close to our customers for fast reaction times and support
- Remote diagnostics and hotline assistance for immediate response
- Customizable maintenance contracts and regional spare parts warehousing

This commitment to service ensures that each installation not only meets technical expectations but operates reliably year after year, even in the most demanding environments.

## A FUTURE-PROOF INVESTMENT FOR CENTRAL BANKS

Hunkeler's destruction systems are more than machines — they are infrastructure investments designed to secure and support national currency systems for decades. In doing so, they support a broader vision: one where security, environmental responsibility, and operational excellence are not competing goals, but integrated design priorities.

In a time when digital innovation often dominates headlines, cash remains vital — and with it, the responsibility to manage physical currency responsibly from cradle to grave. Hunkeler Systeme offers a compelling vision for how that final stage — destruction — can be handled with the same care, precision, and innovation as every other phase in the banknote lifecycle.

HUNKELER SYSTEME AG

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Website: www.hunkelersysteme.com

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**www.ait.ac.at/hvs**

# ROYAL DUTCH KUSTERS ENGINEERING

Advancing currency destruction and recycling technologies


# FACT BOX

- For 114 years, Royal Dutch Kusters Engineering has been a trusted name in engineering excellence, and for the past 45 years, a global leader in secure currency destruction.
- Kusters partners with central banks worldwide to help manage the complete lifecycle of banknotes, printing waste and coins safely, sustainably and in compliance with the highest global standards.
- With systems installed in over 80 countries, Kusters has the global experience and engineering capabilities to tailor solutions to your needs, regardless of size or scope. Our long-term partnerships with central banks are based on trust, transparency and technological excellence.
- Our commitment doesn't end at installation. We offer full-service support, upgrades, training and remote monitoring to keep your operations running at peak performance.

www.royaldutchkusters.com

## INSIGHTS FROM ROYAL DUTCH KUSTERS ENGINEERING

In a world where cash continues to play a vital role, despite the rise of digital payment technologies, central banks face increasing pressure to manage banknote lifecycles efficiently, securely and sustainably. Royal Dutch Kusters Engineering (Kusters) has been the market leader in this domain for decades, developing and supplying equipment for secure and controlled banknote, printing waste and coin destruction. This article provides an insight into several core technologies developed by Kusters, with a focus on the banknote destruction systems, briquetting systems and shred collection systems, as well as a preview of our SMART module capabilities and developments related to polymer banknote recycling.

## CURRENCY DESTRUCTION SYSTEM: MODULAR EFFICIENCY

The Currency Destruction System (CDS) is a proven solution trusted by central banks and government institutions in over 85 countries for the secure and efficient destruction of unfit banknotes. Engineered for long-term reliability, safety and performance, the CDS supports high-volume banknote destruction while meeting the highest international security and environmental standards.

The CDS streamlines the destruction process by combining key steps into one integrated system: a fully enclosed and lockable feeding system, high-security shredding and safe and dust-free collection of the shredded material.

The system is designed with a modular architecture, allowing full customization based on the customer's specific requirements, whether it's processing capacity, available floor space or compliance with local regulatory standards.

A huge advantage of the CDS is its ability to handle both cotton and polymer banknotes without major mechanical adjustments. The hardened steel blades and precision-engineered cutting system guarantee a

CDS: FULLY ENCLOSED, LOCKABLE STORAGE AND FEEDING SYSTEM SUITABLE FOR ALL SUBSTRATES

consistent shred size that complies with international security guidelines. The shredded output can be directly transferred to optional briquetting units, allowing for compact and environmentally responsible waste handling.

To ensure operational continuity, especially in critical environments, the CDS is equipped with advanced safety systems. This ensures reliable operation even in locations where access to spare parts or technical support may be limited.

With more than 260 installations worldwide and a destruction capacity of up to 1,000 kg/hour, the CDS delivers modular scalability, unmatched durability and proven performance. It is the industry standard for central banks seeking a future-proof and sustainable solution for banknote destruction.

**Key performance highlights**

- Modular feeding and destruction capacities
- Designed to handle cotton, polymer and hybrid banknotes
- Shredded output meets highest security levels
- Optional integration with briquetting or loose shred handling solutions
- High quality design for low maintenance and minimal downtime, ensure lower Total Cost of Ownership (TCO)

## SECURE SHRED HANDLING

For central banks that want to separate the destruction process from later waste handling, the Online Briquetting System (OBS) offers a practical and secure solution. The OBS collects shredded banknote material and presses it, without any added substances, into solid and easy-to-handle briquettes.

This flexible system is usually placed after a Currency Destruction System (CDS), one or multiple high speeds sorters and more often a mix of both.

BRIQUETTING IS SUITABLE FOR COTTON SHREDS, CAPACITY UP TO 1,200 KG/HR

It is especially useful in places where reducing waste volume on-site is important, or where shredded banknotes need to be stored temporarily before they are taken away.

Because it handles shredded material in compact form, the OBS adds flexibility, whether for storage, internal and external transport or recycling and disposal.

For central banks with several cash centres or external destruction partners, the OBS can be an important part of a wider system. Briquettes can be weighed and tracked per batch, making the process more transparent and helping to meet audit and reporting requirements. Keeping the destruction and waste handling processes separate also improves reliability.

The OBS is designed for high efficiency. It automatically transports, compresses and handles shredded banknotes with little need for manual work. It works with cotton and most hybrid banknotes and can handle input from up to 20 high speed sorting machines. It has a capacity of 75 to 1,200 kg per hour, which makes it suitable for both small and large cash centres.

Importantly, the briquetting process makes shredded material up to 8 to 9 times denser, greatly reducing the total volume. This saves space, lowers transport costs and makes disposal or reuse, such as for energy or recycling, more efficient.

By including briquetting in the overall destruction process, central banks gain more control over the shredded output and depend less on complex logistics. Whether used at central locations or smaller local sites, the OBS improves the safety, reliability and efficiency of shred handling and offers a modern, sustainable solution for currency disposal.

## COST EFFICIENT SHRED COLLECTION

In certain applications, briquetting is either not economically viable or technically possible. This is particularly true in cases such as the disposal of polymer banknotes, which are unsuitable for briquetting, or in emergency scenarios where rapid shred collection is required. To address these needs, we offer a range of dedicated solutions—among them, the Shred Collection Unit (SCU).

The SCU has been specifically developed for use in high-security environments, often in combination with our Currency Destruction System (CDS) and Online Briquetting System (OBS). It ensures the secure and dust-free handling of shredded banknote materials, maintaining a fully enclosed destruction process.

The SCU offers several key advantages. It efficiently collects loose shreds from both online and offline destruction systems, making it adaptable to various operational setups. It supports all substrate types (cotton, hybrid and


AN INSTALLATION OF THE SHRED COLLECTION UNIT, WHICH RUNS COMPLETELY AUTOMATIC

polymer) and can handle input from multiple sorters simultaneously, increasing throughput and flexibility.

The system runs fully automatically, minimizing the need for operator intervention and reducing the risk of human error. Moreover, its design ensures a dust-free environment, contributing to both cleanliness and safety in high-security facilities.

With the SCU, central banks benefit from a reliable, cost-effective and secure alternative to briquetting—especially when flexibility and material containment are essential.

## MAKE IT SMART

The System Management and Reporting Tool (SMART Module) is an integrated system tool within the Currency Destruction System (CDS) that provides detailed insight into the destruction process and machine performance. It captures and stores key process data, enabling structured reporting and analysis.

Operators and supervisors can create batches directly from the system's HMI, including metadata such as operator ID, supervisor approval, currency denominations and destruction volumes. Once a batch is completed, the system can generate automated reports, throughput and equipment runtime, ready for export.

**The SMART Module supports:**

- Up-to-date batch reporting directly from the HMI
- Automatic data transfer in XML format, reducing manual paperwork and minimising errors
- Centralised data collection for head offices, enabling comparisons between branches
- Trend analysis of destruction volumes and shredder performance
- Predictive maintenance triggers, optimising spare part usage and minimising downtime

By delivering accurate and structured destruction data, the SMART Module helps central banks to optimise their cash cycle planning, ensure regulatory compliance, and reduce reliance on manual processes. It forms a crucial link between decentralised destruction activities and centralised cash management strategies.

## CHALLENGES OF SHREDDED BANKNOTE WASTE RECYCLING

Recycling of shredded banknote waste, be it cotton, polymer or hybrid is becoming a topic of concern for central banks and printworks globally. Although the impact on the total life-cycle of a banknote is quite limited, it is certainly a visible one. Kusters is committed to helping its customers to find appropriate solutions for this need.

Kusters is actively exploring the feasibility of recycling shredded banknotes. Initial studies have confirmed the high quality of shredded output which can be used for high level applications, yet a number of technical and logistical challenges remain.

**These include:**

- Banknote waste often contains inks, varnishes, and security features
- Waste volumes are low and spread across regions
- Local recycling markets vary in maturity
- Banknotes have diverse materials and compositions
- Centralized recycling is complex due to logistics and regulations

Although full-scale implementation is still in development, we remain committed to supporting central banks and printing works seeking to reduce their environmental footprint. Our approach is rooted in transparency, technical validation, and cross-sector collaboration, as we continue to work toward practical and responsible solutions or polymer currency recycling.

## AN INTEGRATED LIFECYCLE PERSPECTIVE

Modern cash management requires more than high-performance hardware, it demands a system view of the entire currency lifecycle. From issuance to destruction and from security to sustainability, each step must align with a broader policy and technological framework.

By offering modular and scalable systems like the CDS, OBS and SCU (complemented by SMART monitoring), Kusters seeks to enable central banks to operate with greater control, flexibility and foresight. These technologies are not static; they evolve in response to changing regulatory, environmental and operational requirements.

ROYAL DUTCH KUSTERS ENGINEERING

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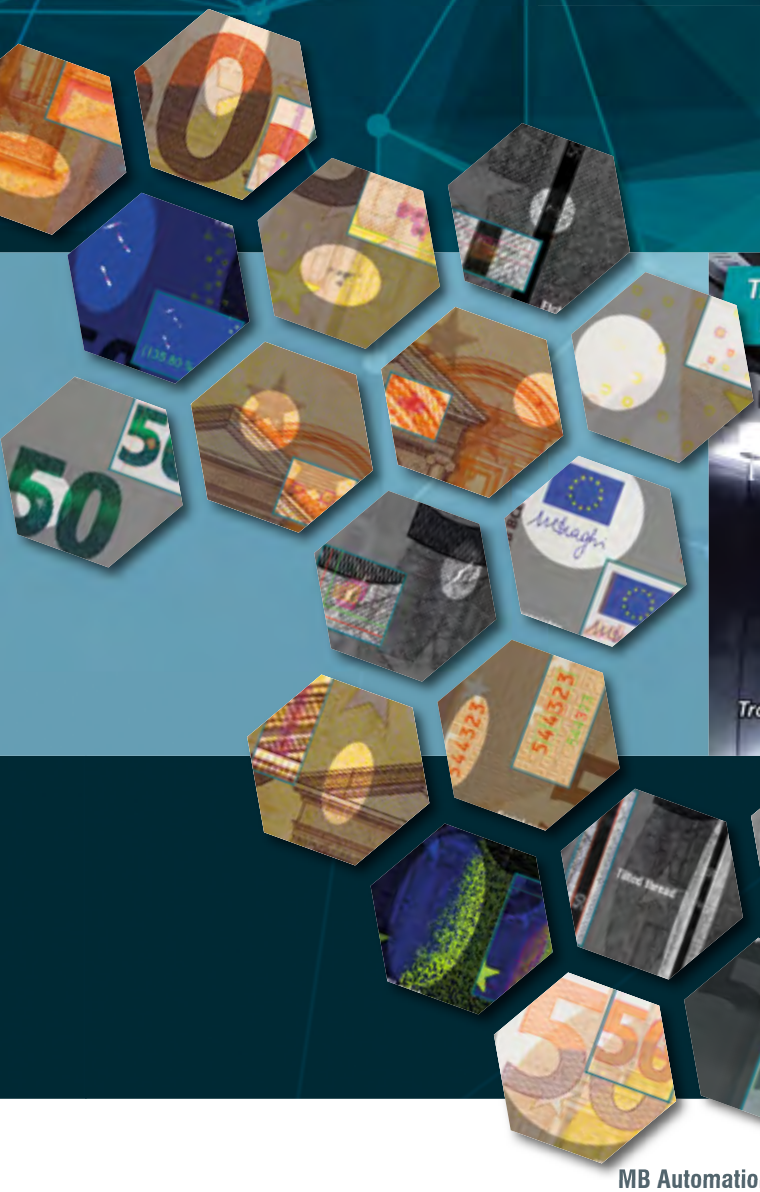

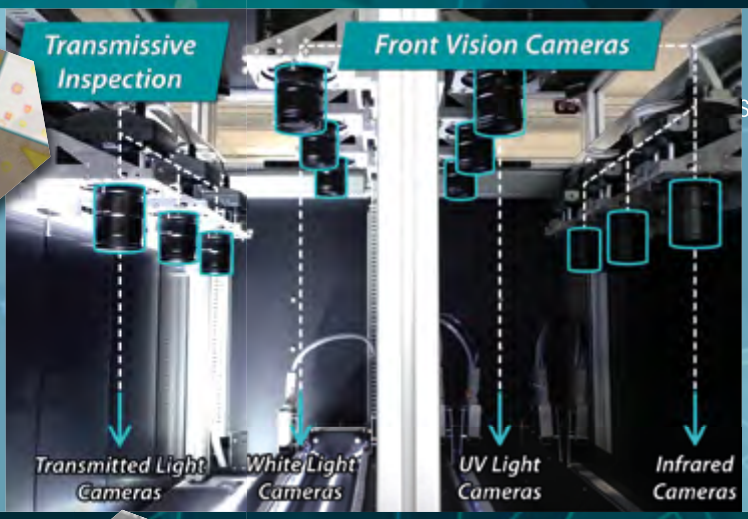


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**206** CENTRAL BANKS, GOVERNMENT & LAW ENFORCEMENT

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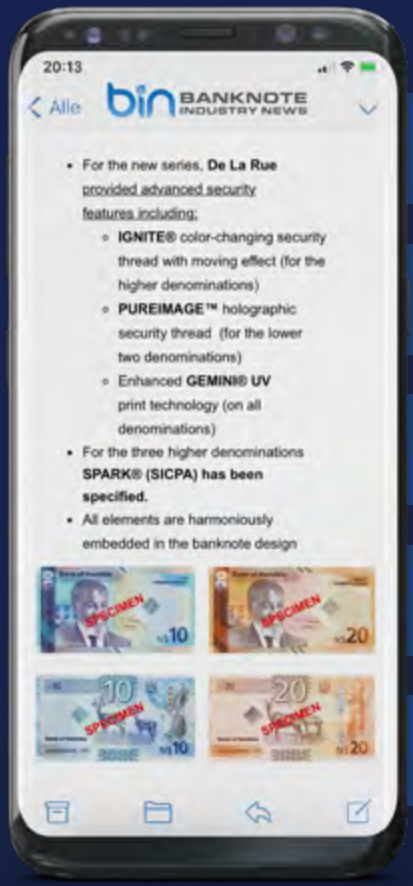


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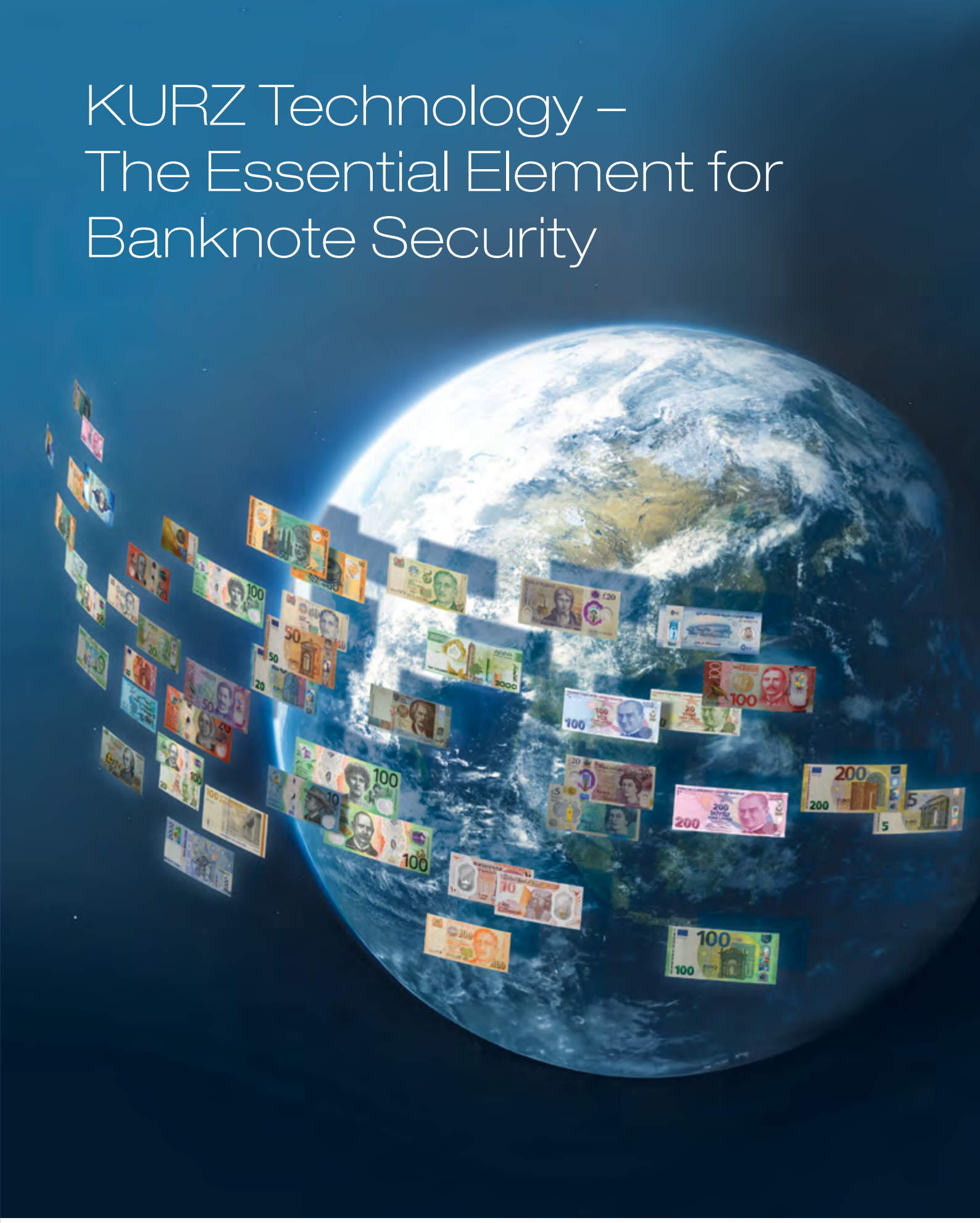



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