EUROPEAN CENTRAL BANK

EUROSYSTEM

Examples of R&D activities carried out in the past

PROFIT: Enhancing the sorting process for used banknotes

Saving banknotes and saving money: not quite the same thing in our everyday job, but we achieved both.

Within the PROFIT programme we aimed to understand all the parameters that influence the accuracy of banknote fitness sorting. This allowed us to assess the functioning of different types of banknote sorting machine and to optimise their settings by adopting a new calibration system.

Once they enter into circulation, euro banknotes are exposed to all kinds of harsh treatment (friction, soiling, rough handling, etc.) which they are expected to survive for a certain amount of time. Euro banknotes are made to last, but we aim to ensure that all those in circulation are in good condition and reasonably clean. Therefore, we check banknotes as soon as they return to one of our cash sorting centres. This happens regularly as part of the normal banknote circulation cycle. It is of the utmost importance that the cash sorting centres have access to reliable banknote sorting machines so that they keep only the good banknotes and destroy only those that are unfit for circulation. Small differences in the performance of such machines can have

a huge impact on the quality of banknotes in circulation and especially on the cost to the Eurosystem, as shredded euro banknotes need to be replaced with freshly printed ones.

Eurosystem national central banks operate around 400 high-speed banknote sorting machines, processing around 30 billion euro banknotes each year. Some of these machines are able to check up to 40 banknotes per second for fitness and authenticity and either stack them or shred them!

Before PROFIT, conventional testing and calibration of banknote sorting machines involved a sample set (soil test deck) of real banknotes with different levels of soiling, in which each example was visually graded by a team of experts. This was a complex endeavour for the assessors, with the additional drawback that the sample set degraded over time. With PROFIT, we demonstrated that such expert assessment of banknote soiling is not a perfectly repeatable process, and we replaced it with the Image Classification and Evaluation (ICE) tool. This tool is software running on a computer with a colour-calibrated screen. The expert inspects images of banknotes with different grades of soiling on the screen instead of actual banknotes. The expert then classifies each image as fit or unfit so that the software can “learn”. This method yields higher quality data which ensure that the way banknotes are seen by banknote sorting machines is better aligned with the way they are seen by people on the street. As a result, we have been able to significantly reduce the number of incorrectly shredded banknotes, saving not only banknotes but also money.

CAST: Developing a consistent artificial soil test deck

Have you ever thought of using an ink-jet printer to soil your banknotes? Please don’t! Anyway, we did it for you. We soiled our banknotes to make sure your banknotes stay clean. And, yes, we did it with an ink-jet printer.

In our efforts to improve the performance of banknote sorting machines, it was difficult to assess whether deviations in banknote sorting performance were due to the sensors or the reference samples used for their calibration. The consistent artificial soil test deck (CAST) project undertaken in cooperation with the Banque de France developed a successful method for soiling banknotes in a realistic and consistent way by applying an ink-jet-printed soil template to pristine euro banknote sheets fresh from the printing works. These are now used to calibrate our sorting machines.

Before CAST, the banknotes used to calibrate sorting machines were selected manually and their quality varied depending on the perception of the operator collecting them. Things were even more complicated when evaluations were done in different places using different equipment and different test decks. As demonstrated in PROFIT, soil test decks are an essential tool to gauge the performance of sorting machines that assess banknote fitness. However, test decks comprising real banknotes collected from circulation are rather expensive and time consuming to assemble. They also age quickly and are impossible to replicate consistently for future use. The CAST test decks we have developed are twice as accurate as the benchmark set, can be produced at a fraction of the cost and can be used for over 100 sorting machines runs (about five times as many).

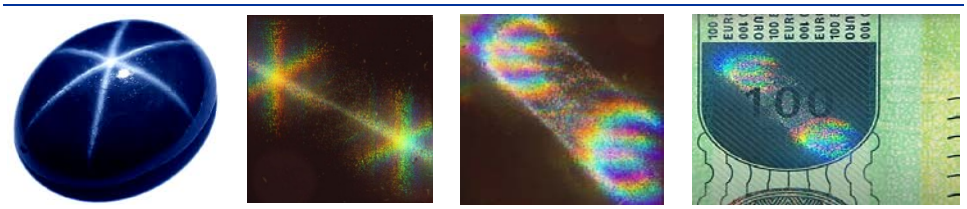
SAPPHIRE: Satellite hologram feature for euro banknotes

Inspiration from nature to improve the security of the euro.

We conceived, designed and developed a public authentication feature based on asterism.

Asterism is an optical phenomenon that occurs naturally in sapphires, rubies and some other gemstones, producing the image of a bright two, four or six-pronged star over their polished surface which follows your gaze as the stone is tilted. To be put to good use on euro banknotes, this security feature has been designed to be hot-

stamped onto the banknote (like a hologram is today) or to be located in the transparent portrait window.



The SAPPHIRE project yielded a variety of visually interesting laboratory samples which were well-suited for potential application in banknotes. This led to the satellite hologram feature seen on euro banknotes today. While the satellite hologram requires specific origination techniques and know-how, it is produced on standard foil manufacturing equipment. This shows that novel and substantially improved features do not necessarily require new production technologies.

GREEN: Development of a vacuum deposition process for intaglio plates

Greener and better.

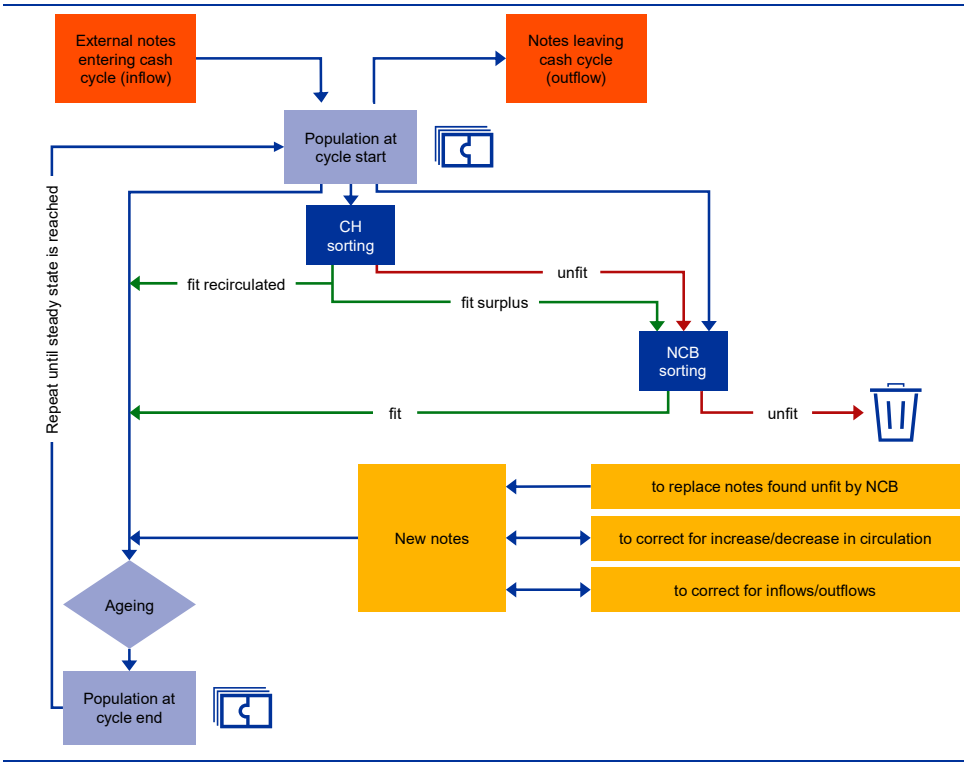
We assessed and industrially validated an environmentally friendly coating process for nickel intaglio printing plates developed in cooperation with the Banca d'Italia as an alternative to galvanic chromium plating.

Intaglio is one of the key steps in the printing of euro banknotes and gives the banknotes their characteristic tactility and feel. This process requires special metal plates, typically made of nickel. Nickel intaglio plates are usually coated with a hard layer of electroplated chromium in order to increase the corrosion and wear resistance of the printing surface. In the past this coating was applied through an electroplating process, which requires a solution of hexavalent chromium, a toxic compound with major environmental and health and safety implications if not handled properly, and recognised as a potential inhaled carcinogen. The new GREEN coating technology is based on physical vapour deposition (PVD), a very clean technique that does not require intermediate toxic substances. It was already used to chrome plate small objects like glasses, taps and car parts, but our challenge was to plate for the first time a very large, finely engraved surface where we needed to preserve every tiny little detail for the printing process. With GREEN, we have addressed and solved the risk of exposing workers to hexavalent chromium, while also outperforming the old process.

CIRCULATION MODEL: Two computer-based models for the simulation of euro banknote cash cycles

Keep the cash rolling!

We know that the quality of banknotes in circulation in euro area countries varies, even though they all use identical euro banknotes. We also know that this is influenced by national characteristics, such as the way people use banknotes and the involvement of the central bank in cash processing operations, but the importance of all relevant parameters has not yet been established. Below we describe two computer-based models for the simulation of banknote cash cycles that we use to predict what happens to banknotes when they are in the wild.



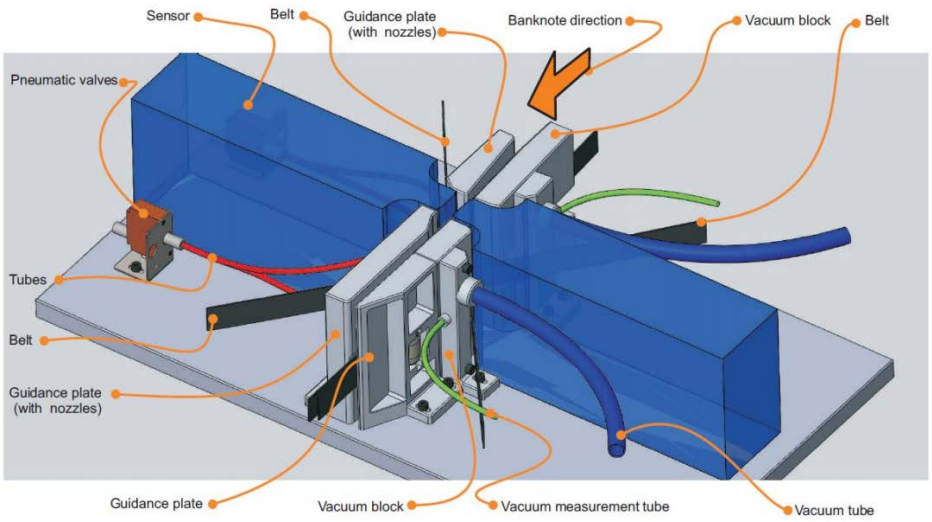
The first model simulates a cash cycle using a theoretical approach based on key figures and models banknote fitness as a one-dimensional profile of fitness levels. The model identifies (i) the frequency with which banknotes are returned to the central bank, (ii) the fitness threshold used in automated banknote processing at the central bank, and (iii) the banknote lifetime as the three main drivers of the quality of banknotes in circulation and banknote cash cycle costs. Production variations in new banknotes, the fitness threshold applied by commercial cash handlers and the accuracy of the fitness sensors used in the sorting process have been found to have a lower but non-trivial impact. The second model simulates banknotes in circulation as individual items and is oriented towards modelling country-specific cash cycles using available data on individual banknotes. The model is constructed using data collected by monitoring banknotes in circulation over the duration of a “circulation

collected by monitoring banknotes in circulation over the duration of a “circulation trial” carried out in three euro area countries. We compare the predicted quality results of the second data-based model against actual cash cycle data collected outside the circulation trial, discuss the reasons for deviations found and conclude with considerations for an optimal theoretical national banknote cash cycle.

CDI2: Open standard for high-speed banknote sorting machines

Sharing is caring.

The Common Detector Interface 2 (CDI2) is a novel open standard for high-speed banknote sorting machines (see PROFIT above) developed by the European Central Bank and the Federal Reserve System in cooperation with De Nederlandsche Bank and Oesterreichische Banknoten- und Sicherheitsdruck GmbH. CDI2 marks a paradigm change, as it allows central banks and other commercial users in cash sorting centres to be fully in control of their banknote sorting machines.



In the past, banknote sorting machines were typically closed systems with very limited access to data about their core functioning. The adaptation of the sorting logic or the integration of new detectors always required in-depth knowledge and support from the sorting machine vendor – at a cost. CDI2 provides access to the underlying sorting logic, as well as the banknote image as captured by the sorting machine and the related sorting data. It allows central banks to install new compliant detectors themselves and offers new data processing possibilities. A CDI2 simulator with all the underlying source code is now available along with the technical support needed to implement the interface.

CDI2 simulators are already being used by two major banknote sorting machine manufacturers as well as a number of detector manufacturers to develop

CDI2-compliant units. The set of simulators developed also includes a mechanical banknote conveyor, allowing in-depth testing of new detectors prior to installation on a banknote sorting machine.

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