Programme of Requirements:

a powerful tool to develop new, secure banknotes

Hans A.M. de Heij
De Nederlandsche Bank NV
Amsterdam
The Netherlands

Presented at:

The Conference on Optical Security and Counterfeit Deterrence
23 – 25 January 2008
San Francisco, California USA
Programme of Requirements:  
a powerful tool to develop new, secure banknotes

Hans A.M. de Heij  
De Nederlandsche Bank NV, Amsterdam, The Netherlands

Abstract

A Programme of Requirements is a very common tool for professionals working in e.g. architecture, information technology and product development, but, as yet, less so in the banknote industry. A robust Programme of Requirements (POR) is a strong and powerful tool for developing better banknotes, especially because of the balanced set of security features it produces. Providing insight to all parties involved by means of one document is another advantage of this design methodology. In practice, often a Design Brief is used instead of a POR. However, a Design Brief usually does not list all the requirements, let alone recognise wishes. Furthermore, such a document provides no follow-up to the next development phase of origination and proof printing.

Over the years, De Nederlandsche Bank (DNB) has gained experience with preparing PORs for new banknote designs. The first one goes back to as far as 1860! In 2000, DNB presented a paper entitled “The design methodology of Dutch banknotes”, giving credits to the central role of the POR and explaining that a separate POR is required for each of the following banknote development stages: 1) Design, 2) Proof Print, 3) Zero Production Run and Issue [1]. Repeat orders are based on a set of Technical Specifications.

DNB drafted the present paper in the first place in response to questions it received for more detailed information on, and examples of, this methodology (Bank of Korea and European Central Bank). A complete POR may also play a key role in Quality Management, like e.g. the ISO 9001 procedure.

Keywords
Banknote design, design methodology, design management, Programme of Requirements

1. Introduction

New banknote designs often tend to disappoint because:
- they are unattractive and contain no communicative elements,
- they contain errors, either in the text or in one of the images, or are incomplete because an element has been ‘forgotten’,
- the new note is not finished in time due to unstructured design cycles and time-consuming decision-making,
- the costs of its development exceed the budget, owing to unforeseen additional research.

Ruud van Renesse also recognised the probability of dissatisfaction in this context as will be clear from the following quotation from his book: ‘Wandering through endless design loops that only slowly, if at all, converge towards the desired product’ [2].

This paper aims to make an empirical contribution to the existing sound theories and methodologies developed for a Programme of Requirements as part of the product development cycle.

Can anybody tell me what we have to design?
This question may be heard frequently from people taking part in a banknote design project, but not only there. The design for a new passport or driver license is also often the outcome of unclear design instructions. How can this happen?
For most central banks, designing a new banknote is no routine job. It is a project that usually comes along no more than once in a decade; too infrequently for most central banks to develop a routine. Lack of experience is also the reason why many central banks prefer to outsource the complete project to a contractor, usually a security printer. Or a central bank is simply too small to do a design project by themselves.
While solving some management problems, outsourcing also has its drawbacks, though: the printer’s principal is the central bank, which all too often has little eye for the final users, like the general public, retailers or the visually impaired.

When the design process involves many parties and people a Programme of Requirements will be appreciated to keep all informed, like e.g. in the Eurosystem where 16 parties are involved: the ECB and 15 National Central Banks (situation 2008). In daily practice the ECB and 7 NCBs are taking the lead.

**Project manager from a central bank**

Central banks may prevent such a situation first of all by facilitating proper project management. To start with, a project manager must be selected, someone enthusiastic with experience in product development and project management. Preferably this manager needs not to come from a security printing works. An outsider would be unbiased by printing technologies and more focussed on customer requirements.

The project manager would most probably create a ‘New Banknote Project Team’, as is in accordance with project management practice. One of the first tasks would be to make clear what the design assignment exactly is about. One of the methodological tools to do so is to proceed from a ‘Programme of Requirements’ (‘POR’). A POR is the ‘one way’ instruction to the graphic designer. Obscurity about the requirements should be banned and working with a POR be made a prerequisite.

**Living document**

The POR document is a ‘living’ document and may be actualised at any time, even during the design phase, e.g. when it is concluded that a requirement cannot be met. A key sheet gives the updates, and an approval sheet provides the status of the updated document.

**Design policy and communication**

The POR for banknotes does not only contain requirements, but starts with an elaboration of the policy objectives. Also Steven Tuinstra distinguishes between a security concept and a communication concept [3], i.e. one that covers the communication policy on the security features for the public and retailers. This communication concept should not be confused with the one referring to the promotion campaign, the leaflets, posters, internet, CDs etceteras. The POR should include a chapter on design policy and communication strategy, as they are decisive for the requirements. These items are described by the author in previous publications [1, 4, 5].

Figure 1 is an illustration is of the central role of the POR in the design process of a new banknote.

**Figure 1.**

The Programme of Requirements contains the central bank’s instructions to the graphic designer. It provides the key to any successful product development, including new banknote design [1, 4, 5].
**Prepare the POR together with cashier, designer and - if possible - supplier(s)!**

The list of requirements should be one document providing for:

a) unambiguous design instructions to the graphic designer,
b) a clear overview of the requested design for the principal, showing clearly in both drawings and text what the principal has asked for,
c) complete overview for all customers/stakeholders involved. Have we forgotten anyone, anything?

In case of a complex organisation, a Programme of Requirements also offers up-to-date insight to all parties involved into the product to be developed. Once a robust POR is available, it may be used for the development of any next new banknote and serve as a ‘company’s memory’.

A crucial success factor is acceptance of this working method by all parties involved:
- principal or client (central bank),
- designer (external designer, preferably contracted by central bank),
- contractor or supplier (usually a security printer).

The first party that needs to be convinced is the graphic designer. Dutch banknote designer Ootje Oxenaar referred to DNB’s ‘telephone-directory sized Programme of Requirements’. His successor, Jaap Drupsteen was also impressed by the size of the POR: ‘On receiving a commission for a new banknote design, I also received a 3 centimetre-thick paper with requirements, telling all the security tricks. All these obstacles lead to solutions that you would otherwise never come up with.’ [6]. In reality, the POR of DNB included 63 pages and was 8-mm thick [7]. Both designers’ scepticism disappeared after they read through the POR and realised this was the only ‘bureaucratic’ document they would have to deal with, for, first of all, designers want to design (see also paragraph 6, Role and position of the designer).

2.  ISO 9001 – Design process

Nowadays, the drive to operate with a POR for new banknote designs comes from an unexpected expertise: quality management. Central banks wishing to operate in accordance with ISO 9001, sooner or later need a Quality Management System (QMS), also for their new banknote design processes.

*The 3 M’s*

Operating a design process by QMS principles means monitoring and measuring customer satisfaction. In plain words: ask the customers what they want. Make it. Go back to them and ask them if they are satisfied. Monitor, manage and measure, also referred to as the 3M’s. A fourth M is often added for Motivate.

Besides the many books and courses available on QMS, all aspects of QMS are found in all sorts of products, e.g. cars, aircraft, and pharmaceuticals. Although the standards were first implemented in manufacturing - today over 50 years ago - they are now also employed across a wide range of other types of organisations, including colleges and universities. Central banks with an in-house printing works are often ISO 9001 certified. Also the ECB reported that their banknote procedures had been granted ISO 9001: 2000 [8, 9].

ISO 9001 stipulates that design processes are based on a Programme of Requirements. The set-up of the POR should reflect a customer or stakeholders’ approach, while each requirement should formulate the need of a banknote user.

To guarantee the design process, the central bank would focus first on the following two sets of ISO certificates:

1) ISO 9001:2000 Quality Management Systems – Requirements,

ISO 9001:2000

ISO 9001:2000 combines the three formal standards 9001, 9002, and 9003 into one, now called 9001. It is intended for use in any organisation which designs, develops, manufactures, installs and/or services a product or provides a form of service. It contains a number of requirements which an organization needs to fulfil if it is to achieve customer satisfaction through consistent products and services.

The organisation should ensure customer satisfaction by matching all customer requirements, including the legal aspects. Company processes should be laid down in a quality manual and the company should operate according to these processes. The quality policy, too, should be documented and communicated to all employees.
To qualify for ISO 9001, the organisation must:
- ensure that a set of documented procedures covering all key business processes is in place,
- monitor these processes for effectiveness,
- keep adequate records,
- identify deficiencies, taking appropriate corrective action where necessary,
- review, on a regular basis, individual processes as well as the quality system itself for effectiveness,
- facilitate continuous improvement.

Once the ISO 9001 is implemented, the central bank can focus on the next step:

ISO 9004:2000 standard
ISO 9004 goes beyond ISO 9001 in that it provides guidance on how continuous improvement may be realised by using the quality management system so that it benefits not only the customers but also the employees, owners, suppliers and society in general. By measuring these groups' satisfaction, it will become clear whether improvements are realised on a continuous basis.

The following quality management principles should be used to improve customer satisfaction:

1) Have a customer focus; understand customer needs. All levels of staff should be aware of the importance of providing what the customer requires and their responsibilities within the business.
2) Identify essential banknote activities and consider each activity as part of a process; follow the banknote from ‘its cradle to its grave’.
3) Manage processes as what they are, namely part of the same system; this should lead to greater efficiency and sharper focus.
4) Continuous improvement is a permanent business objective.
5) Senior staff base decisions on thorough analyses of data and information.
6) Managers recognise that banknotes and their suppliers depend on each other (mutual beneficial supplier relationship).

3. Methodology of a Programme of Requirements for banknotes

History
Since 1814, the year of DNB’s, Joh. Enschedé in Haarlem has been the Dutch central bank’s supplier of banknotes. The relationship has always been a commercial one, also within the framework of DNB’s design commissions to Joh. Enschedé. Over the years the body of design instructions evolved from a few lines in 1860 [10] to a 63-page paper in 1995 [7]. A historical overview of the Programme of Requirements used by DNB is provided in Appendix I.

Requirements for new banknote designs are often set in terms of the available production processes. This also used to be the case at DNB until 1965, the year when the first customer oriented requirements appeared, like the texts to be used on the new note. However, these requirements still also extended to the production machines, which in fact are not part of the product requirements but are regarded as production constraints (see paragraph 3.3).

Central bank publications on banknote design PORs are scarce. One of the first authors to publish internationally on the crucial role of a Programme of Requirements for security products like banknotes is Van Renesse (the first time in 1996 [11]). In ‘A path to the next generation of U.S. banknotes’ the National Research Council also points out the relevance of requirements for the banknote design process [12], e.g. when it is said: ‘To the degree that several new features may be more effective than a single feature, they should be incorporated in a set of features so as to provide a layered defence against an array of counterfeiting threats.’ This is certainly true: the different techniques involved by the production of a banknote could be much further exploited by combining techniques and using the tolerances between the techniques [5].
Stock-taking of customer requirements by ECB

The European Central Bank, too, is in favour of identifying the requirements to be fulfilled by new banknotes: ‘The focus is on the different kinds of customers and users: the general public (including the visually impaired), cashiers, vending machines, banknote processing machines, cash handlers, law enforcement authorities and the note-issuing authority itself. Each has different needs in terms of convenience, authentication, efficiency, resilience and cost, and these needs also differ for low, medium and high denomination banknotes’ [8].

The ECB published several times on their stock-taking of customer requirements: ‘In the course of 2005, the ECB established the functional and technical requirements of different groups of banknote users through consultation and market research [13]. ‘Basic functional requirements for the new banknotes, including a shortlist of security features, are being established on the basis of market research and consultations with European consumer associations and the European Blind Union. The consultation process has also involved the European banking, security transport, retail and vending machine sectors, as well as the association of banknote equipment manufacturers’ [14].

The results of this work will be systematically listed in the POR for the new euro designs.

POR is a tool to come to better designs

First of all the POR should only list the product requirements and should refrain from project management items like planning, procedures or decision making processes. A POR provides a basis for discussions on design elements of the new note such as the watermark, paper tint and numbering. Discussions based on a POR will direct the focus to the banknote design and help clarify the design commission. Used in this way, the POR is a means - efficient, important and powerful - to come to better designs, but not an end in itself. A thorough discussion of the POR specifications will enable:
- a higher design quality,
- shorter development time,
- project cost savings,
- a clear working programme, agreed on by all involved members.

Problem setting

Requirements should be formulated in terms of ‘problem setting’ and not as solutions. Solution-based statements are usually unnecessarily restrictive to innovative design concepts. Often, printing experts will argue that a given requirement is not feasible, and the (customer) requirement will be skipped! While a problem-setting requirement will be a challenge to creativity!

Detail the requirements as much as possible

The POR must be as complete as possible. If essential criteria are overlooked, the final product will not be successful. The more detailed - and sharply - a requirement is formulated, the better it is. Therefore, think and re-think before committing a requirement to paper! Circulate the POR document, asking the recipients for general and detailed comments. The design process already starts with the initial paperwork behind the desk! This may seem bureaucratic, but will save a lot of unnecessary design loops!

‘Think before you print’ also holds true for banknote design. Do not provide a large budget at the beginning of a design process. Smaller, phased budget portions are much more effective, since the design team will focus on the priorities and will avoid sidelines. Printing trials that are not well thought through will cause budgets to be exceeded.

Identify all requirements

‘Synthesize the totality of needs and requirements that a new banknote must satisfy’ [12]. Identify every single requirement with a number, e.g. requirement 11.3 (11. Value recognition, Requirement 3).

Group related requirements together, e.g. all requirements related to the texts on the note in one group. Value recognition, security features and durability are other paragraphs in the document (see Appendix II for an example).

Customer requirements versus tradition and culture

New dilemmas appear if the identified customer requirements differ from the central bank’s common sense. Should we really print such large numerals for the visually impaired? Should we really make the notes more suitable for banknote acceptors? This shows that a customer approach still has to deal with counter-forces as presented by parties advocating ‘committee design’ or with the tendency to opt for a design based on the lowest common denominator of what members find acceptable [1, 4].
Avoid fragmented decision-making
Although there is not yet a complete image of the new note, some decisions are taken beforehand, while such early decisions are usually not necessary for time planning. Examples are: the main theme, main image, the notes’ dimensions and colours, and the signature. The reason for doing so is to collect opinions and perceptions of the people involved. To ground such opinions a POR is helpful; senior management could make decisions on a higher policy level like those regarding the design policy and corresponding communication strategy.

The actual designing may not commence until all requirements are known and set. Therefore, approval should be sought for the complete package of requirements, i.e. the complete POR, including the design policy and communication strategy!

In line with a complete POR, only present complete designs to senior management. If officers at this level are shown various alternatives, they will think there is no clear proposal and that the design team wants them to decide. This is just what they will do, as they will not want to delay the project. This carries the risk that senior management will ask for the face of one design to be combined with the reverse of another. Therefore, invite the designer to such decision making meetings; if the design is not accepted, ask the designer to come up with a new design.

Freeze the POR
Pages of the approved POR are dated and can only be changed with the principal’s approval. The POR has now been assigned the status of ‘working document’, meaning that only ‘agreed requirements’ are listed. Approved documents can be distributed. Review and re-approve documents whenever they are updated. Prevent the accidental use of obsolete documents.

Knowledge-driven design
To build a POR is a three-phased procedure [2, 15]:
1. Collect all criteria,
2. Analyse all criteria,
3. Revise all criteria.

Or in terms of ISO 9001: Identify customers’ product requirements, identify the requirements dictated by the product’s use and identify the requirements imposed by external agencies. Finally identify the requirements that your organisation wishes to meet.

Customer requirements could be fulfilled on the basis of the MAYA-principle (Most Advanced Yet Acceptable). The new banknote may be innovative and have a contemporary design, but it must not be too progressive as it will be used by all members of the community.

Requirements
There are three types of ‘requirements’:

a) criteria (must be met),
b) wishes (nice to have),
c) constraints (e.g. inherent in the production processes, e.g. banknotes printed on a Simultan offset press).

Requirements as used in this paper, refer to a), b) and c). The POR should only list the requirements as such, without making reference to non-technical explanations, arguments or decision-making processes. The underlying argumentation should be laid down in separate documents, which must be listed in the ‘References’ paragraph (see Appendix II). However, it is helpful to include the possibility of comments on the POR:

d) comments.

Figure 2 is an illustration of the desired POR document.
Finally, a requirement may become a specification. A specification is a nominal value or norm and the corresponding tolerances. The term ‘specification’ is reserved for the production volumes in accordance with the Technical Specifications (see also Figure 5).

### 3.1 Requirements

A requirement is a demand; the proposed design should fulfil this requirement. A requirement is in fact a knock-out criterion. If the requirement is not met, the proposed design is not accepted. Therefore, it is important to distinguish between requirements and wishes, a step that is often omitted. Too often all criteria are labelled as a requirement.

A requirement is a description of something not yet realised. Requirements should be:
1) problem-setting (from a customer or user’s point-of-view),
2) measurable.

**Measurable**

If a requirement cannot be measured, it does not exist. In other words: requirements should be ‘operationally’ formulated. The requirement should also specify how the result based thereon can be verified and checked. Figure 3 explains this process. For example, if a requirement stipulates as target value that the banknote should measure 133 mm x 72 mm, the reviewer will check if the note meets this specification by measuring it with a ruler.

![Figure 3](image)

**Figure 3.**
A requirement also describes the requirement compliance checking procedure [16].

Table 1 provides some insight into objective criteria (do the note’s dimensions match the requirements?) or subjective (is the design contemporary?). Both may be evaluated, again, objectively or subjectively. Requirements that remain immeasurable may be submitted to a panel’s judgment. In case of aesthetic advice, the opinion of some professionals on contemporary design matters may be invited. For other requirements, the opinion of laymen may be polled using techniques like in-depth interviewing or focus group meetings. The decision could also be left to the design review.
<table>
<thead>
<tr>
<th>Criteria</th>
<th>Evaluator</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Objective</td>
</tr>
<tr>
<td>Objective</td>
<td></td>
</tr>
<tr>
<td>Subjective</td>
<td></td>
</tr>
</tbody>
</table>

Table 1.
Matrix of objective/subjective criteria versus objective/subjective evaluator [16].

group. The eventual outcome of a requirement compliance check will be either a positive or a negative decision: yes the requirement has been met, or no the design doesn’t meet this requirement.

Unclear requirements - wrong hierarchic level

‘The banknote should be secure’ is not an operationally formulated requirement. When the banknote is reproduced by a colour copy machine - standard settings - and accepted by a maximum of 2 people of a group of 50 laymen, the note is secure against this type of counterfeiting, is an operationally formulated requirement indeed. It is useless to a designer since it does not tell what should be designed. The problem touched on here is that the requirement itself is too generally formulated. This problem is solved if the ‘target - means hierarchy’ is worked out in more detail, inviting lower level entries to be added. An example is provided in Annex III.

The above requirement could be rephrased to: 25% of the note’s surface should be reserved for public security features. This requirement is based on deeper analyses of the previous banknote and the means-target hierarchy. Such a space analysis has been made for the 50 euro banknote (see Appendix IV).

Subdivision of a requirement

A requirement is often subdivided in several items, as the examples show in Appendix V. For each item the methodology could be kept as described in Figure 3. Finally the scores on all items are aggregated and a decision can be taken. In daily practice often not all items match the target. In such cases the review team should make a decision.

Conflicting requirements

Often, the first stage of formulating a POR - collecting all the criteria - yields several incompatible or conflicting requirements. In such cases a choice has to be made for one of the two using the design philosophy. As a result, the status of one of the two conflicting requirements is reduced to a wish.

An example is shown in Figure 4: Marks for easy identification of banknotes in the wallet are preferably placed along a banknote’s longitudinal edges, which would be in line with a horizontal or landscape banknote orientation. However,

Figure 4.
An example of conflicting requirements: landscape style is preferred for modern wallets, while portrait style is used for feeding a banknote into a vending machine.
feeding a banknote into a banknote acceptor would plea for a vertical or portrait orientation. A solution to this
dilemma would be to create the design in landscape orientation for both the front and the reverse and provide the
design with a clear, natural feeding direction (see ‘Banknote dimensions and orientation: user requirements’ [17]).

**Requirements not taken on board**
The POR document may also include a chapter on items deliberately not taken on board as a requirement, e.g. ‘there
are no requirements to the banknote’s reaction to theft deterrence systems’ or ‘there is no need for a denominational
code in machine-readable features’.

### 3.2 Wishes

In the context of this paper, a wish is a property that might benefit a banknote design, but is not really necessary. If
two out of three design proposals match the requirements, the fulfilment of the wishes will make the difference [16].
Fulfilment of a wish may be ascertained using the same measurement process as employed for checking requirement
compliance (Figure 3), but other evaluation processes - mathematical or otherwise – are suitable as well. A check for
fulfilment of a wish need not necessarily be performed to arrive at a positive or negative decision, but may also serve
to determine a score on a nominal, ordinal, interval or ratio scale. The total ‘value’ of all the fulfilled wishes together
may be determined by using an additive value function. This method is tricky, since it is like adding apples and
oranges.

### 3.3 Constraints

Constraints are limitations to the feasibility of a banknote design. Often, these constraints are inherent in the
production equipment used, e.g. the presses available at the security printers’ house. Constraints specify e.g. the
number of dry and wet offset plates to be used and the tolerances between them. Or in case of low banknote volumes,
the case of a small central bank, dimensions, paper tint and watermarks are kept the same for all denominations.
But constraints may also be determined by legal, environmental, social, health-related and safety-related aspects.

### 3.4 Comments

Comments may be a useful aid in understanding the requirement.

### 4. Checklist

As stated before, the POR is a methodological tool to gather all the requirements. This makes this document at the
same time useful as a checklist. Integrate requirements and checklist into one document. After all, the review team
should check the same items. This could be done by preparing an Annex with all the numbered requirements, wishes
and constraints, each provided with a short title and a scoring box.

**Approval**

Before a development phase of a new banknote design can be closed, the design result should be reviewed. Does the
design meet all listed requirements? Which design scores best on the wishes? Does the design satisfy all the technical
constraints?

It seldom happens that a design phase is approved without any changes being required. The agreed changes should be
listed and implemented in the next development phase. From an ISO 9001 point of view this means:
- Manage and conduct systematic reviews in order to determine that the new banknote design objectives will be
  achieved.
- Use your records to prove that requirements have been met.
- Ensure that communication occurs throughout the organisation.
- Validate the recommended changes.
**Carry out design reviews**

Testing during the different phase’s banknote development phases is also in line with ISO 9001: verify if your customers are satisfied; develop a process to control communications with customers. They could be offered one single proof print, but it is also possible to offer the customers a choice. During the design development, three variants of the same banknote design could be developed, e.g., with different sets of security features (packages A, B and C) and/or with different design options (e.g. packages A1, A2 and A3, B1, B2, C1 and C2). Public testing will make clear which option is the favourite.

If competition between design teams were introduced, as is customary in automotive design, a wider range of designs could be offered to the future customers.

Ensure that product design reviews are recorded. The POR makes recording of design reviews efficient and involves a relatively low workload.

**5. Three PORs**

Besides the POR, the so-termed Security Programme may be introduced [2]. This programme is the response to the POR, as it describes how the requirements are to be met. The Security Programme may therefore be regarded as a preliminary design on a high conceptual level.

**Three PORs instead of Security Programme**

For Dutch banknote design, no formal security programme was ever established. Such a programme was not felt to be necessary. Studies to new features were done prior to the design process. And the graphic designer was asked to come up with so-termed ‘discussion models’ at a very early, pre-design, phase.

The planning scheme for a new guilder note provided for 3 development phases, each with its own POR (see Figure 5). And finally, the search for new features and related research activities were performed prior to the start of the design project, as described in ‘The Design Methodology of Dutch Banknotes’ [1].

---

**Figure 5**

Flow diagram of three different Programmes of Requirements and the Technical Specifications.

QC = Quality Check

Input from different stakeholders like retailers, the visually impaired, CIT companies, sorting departments, printers, …

- list of all the requirements, wishes, constraints and comments

QC1: check if design matches all requirements, score the wishes. If not: change POR Design or adapt design

- list all requirements for origination and proof printing. Including files/films, dies, etceteras.
- reference notes

QC2: check if proof print matches all requirements, score the wishes. If not: change POR Proof Print/Origination or adapt proof print.

- list all requirements and wishes for pilot production and issuance
- typical production volume: one day production (0,5 – 1 million notes)

QC3: check if design matches all requirements, score the wishes. If not: change POR Pilot Production or adapt pilot production.

- repeat orders
POR Sketch Design
The POR Sketch Design could follow the structure shown in Annex II. In Annex V two practised requirements are set out by way of an example.
For the central bank it is important to describe what deliverables it expects in each stage from the 'New Banknote Product Team'. In the sketch design stage, the final result is e.g. a good laser print of the front and reverse. This stage will be followed by, probably, two or three rounds of alterations - foreseen in the planning scheme! - which will lead to the final sketch design. The requirements for this sketch design may specify the scale (e.g. 1:1), that the watermark and the intaglio area are each shown on a separate print; that the front and reverse are both printed on the same A4-sheet; and that all the required texts and security features are implemented in the design.

POR Origination and proof print
Origination covers the process of translating the (sketch) design into a detailed design, divided over the different printing plates. Also the watermark and the foil feature have to be turned into a prototype. Simply put, origination is everything that must be done before the papermaker can make a proof run of paper, the foil manufacturer several kilometres of foil and the printer a first proof print. The POR Origination might also be called POR Proof Print or combined POR Origination/Proof Print.

Requirements that are already listed in the POR Design are not repeated in succeeding PORs like Origination and Proof Print. More detailed information is added to a requirement if necessary for the proof print. Chapter and paragraph numbering are identical in all POR documents, to keep the overview. One example is the Small Circle mark in the POR Design; the designer indicates the area where SC marks are planned. The POR Origination and Proof Print specify the number of SC marks, the line width, the density and the tolerances. Neither is it necessary to specify in the design phase special additives to paper or ink, e.g. the fluorescent fibres. The distribution and length of the fibres are specified in the POR Origination/Proof Print, just as e.g. special security pigments.

It is also possible to add new requirements, like quality control requirements (e.g. small register marks, measuring points).

The POR Origination/Proof Print should specify the production of the proof print. Is it done on the real production machines or is it done on proof presses, e.g. mini Orlof intaglio? Should it be printed on the real paper sheets, using the large production presses? A test of 10,000 sheets could be specified, which may be produced in a single day. The POR document should specify the tests to be performed, e.g. durability tests, public perception tests, tests by the visually impaired and counterfeit resistance tests. In case of the guilder notes the Board was offered some reproductions made of the full note, to have an impression of the counterfeit resistance of the new printing proof.

The origination phase results in reference notes to be used as follow-me notes for the mass production. These reference notes specify all the properties of the final notes. Probably there are still some improvements possible on these reference notes.

POR Pilot production and issuance
The third POR prescribes the production of zero production run (or proof production or pilot production). Again, the number of sheets, production speed, quality control, testing procedure etc. should be specified by the principal.

If this zero production run is successful, the mass production phase may start, the phase in which, among other things, the final reference prints - complete and progressive - are produced. The plate numbering system - if there is one - is typical of the pilot production requirements. Numbering schemes are typical of the Technical Specifications. Once test notes with the final specifications are available, manufacturers of banknote handling machines and banknote sensors may be invited to adjust and test their equipment.

Other items may also be specified in this document, like a Very Important Persons (VIP) series of 100 notes with low banknote numbers and the delivery of two sheets to the banknote museum. This document also describes the specimen notes to be made and the materials to be prepared for the press conference, including a technical description of the final banknote, which could be used in a catalogue.
6. Role and position of the designer

Figure 6 provides a schematic view of the position of the graphic designer in the new banknote project. In this example, the graphic designer is subcontracted, as is the case in Switzerland, Denmark, Canada and as used to be the case in the Netherlands.

![Diagram of the position of the graphic designer in a new banknote project organisation.](image)

The project manager is responsible for the project’s milestones. The graphic designer can only be held responsible for the work agreed with the project manager and not for achieving deliverables that she or he cannot influence. If both parties arrive at an agreement, the designer will be obliged to deliver the agreed work on time. The designer cannot take - or give - instruction orders to foil manufacturers, paper mills, originators or any other party involved in the project. The graphic designer has no ‘business’ agreements with any of the other parties. Of course, if requested so by the project manager, the designer will comment on sketches, samples, prints or any other design material prepared by one of the other parties.

To keep clear responsibilities, the ordering of semi-finished products like paper, foil or thread is not done by the central bank, but by the contractor (originator).

Apart from attending meetings that enhance communication efficiency, the designer prefers to spend her or his time on the actual designing. The PORs should be the only documents used for instructing the graphic designer, the papermaker, the printer and all other parties involved. The designer will appreciate this, since the instructions of the client are fixed and will not change over-and-over again. This will reduce the design loops. But also the supplier will appreciate such a clear and detailed assignment of the client.

Aesthetic responsibility of graphic designer

To come to a successful final new banknote, the graphic designer must be involved in the preparation of the production process down to the very last correction. The graphic designer has to watch over the aesthetics of the new note until the very last detail.

Working instructions

The communication between the designer and central bank’s project manager is achieved by so-termed ‘work instructions’. DNB had good experiences using this tool during the development of new guilder banknotes (1981 - 1997). Usually, the designer takes the initiative towards such a package of instructions. The project manager asks the supplier for a time and cost planning scheme. After being agreed on, the package goes in the pipeline. So work
instructions are agreed work package descriptions by the contractor, which clearly show how the responsibilities are distributed (see Figure 7). Work instructions differ in this respect from the PORs (although they, too, may refer to requirements).

The work instructions have a formal/legal status, since they are also part of the budget control.

7. Working with a customer based POR will lead to new security features

A Programme of Requirements built on a stakeholders’ approach will lead to new, knowledge-driven design concepts for new banknotes. The POR will provide the requirements from a customer point of view and will be problem setting. Some examples to demonstrate this statement [5]:
- if the reverse side of a banknote is checked, it is only after a few seconds → place all public features on the front (and e.g. all retail features on the reverse),
- the silver foil stripes are often perceived as too complex → create inside the stripe a silver or gold coloured area for the public hologram and design the other foil elements in a transparent, coloured area,
- public is using a former level 3 feature (ISARD) to check the authenticity of the euro notes by using their fingernails → develop a scratch patch feature,
- banknote automates require a single note height → split the series in notes for daily use and notes for hoarding. The notes for daily use could have a single note height and a vertical, portrait style orientation, while the notes for hoarding could have a larger note height and a horizontal or landscape orientation and receive a higher security,
- today many people carry mobile telephones with cameras → develop new public features for detection using a mobile telephone camera.

Analyse: set a maximum to the number of security features
Today’s market offers many security features. Public feedback has made it clear that the public want 2 to 3 features and certainly no more than 6. So be careful with statements like ‘the more locks on the door the better’. Introducing
more than six public security features would mean ignoring the public’s preference for just a few solid and understandable public security features. It may even be argued that the public does not want to check any features at all! They just want to use the notes, trust them and leave the verification to the retailer and the banks. So, a limitation to the number of security features from a customer point of view is necessary.

At the Currency Conference 2007, the ECB presented the requested number of security features for the next series of euro banknotes, the so called ES2 (Table 2). The ‘security mix’ referred to in Table 2 is part of the necessary policymaking at a higher ‘target-means’ level.

<table>
<thead>
<tr>
<th>User group</th>
<th>Number</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 1 Public</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Level 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A) Retailers – human</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>B) Retailers - automatic device, C) Third-party sorting machines</td>
<td>At least 4</td>
<td></td>
</tr>
<tr>
<td>Level 3 Sorting machines central bank</td>
<td>4 to 6</td>
<td>2 or 3 in substrate and 2 or 3 applied in printing works</td>
</tr>
</tbody>
</table>

Table 2. Overview of the requested security features in the Euro Series 2 [18].

To introduce a new series of banknotes based only on new Public Security Features (PSF) is a risky policy; a gradual approach, using an improved version of the best PSF of the previous series is best practice. The strategy for selecting the six PSF for a new series of banknotes could be based on a gradual approach. Existing features with a high public awareness should be cherished as gold, since it is proven that it is very hard to familiarise the public with new security features. This principle is illustrated in Figure 8.

Figure 8. Example of the gradual approach applied to the selection of 6 PSF for the new series: 2 - 4 public features are retained from the previous series and 2 - 4 new features are added.

PSF = Public Security Feature(s)

The next step is to specify the features. The features that are retained could be selected from the ranking resulting from the public opinion polls. They should, of course, be improved. Enhancement of, e.g., the intaglio printing by means of the new Computer to Intaglio Plate (CtIP) instead of chemical etching will improve the quality of the intaglio printing in several ways. The new features should preferably be innovations, but could also be taken from other, foreign successful banknotes. Keep communication and marketing aspects into account when selecting a completely new feature. Balance the features e.g. between feel, look and tilt.

Long term view
Over the years, over the decades, the number of security features in a banknote tends to grow. Public features are kept because the public is familiar with them; to issue a new banknote without a watermark seems impossible. The same trend is observed in case of features for the retailer (level 2a and 2b). It will be very hard to delete e.g. the UV-feature from the notes, since the UV-lamps are so widely spread and commonly used.

Level 3 and 4 features may be replaced more easily. The scan- and screen traps for example, introduced in the 1970s (see Appendix 5), are more-and-more replaced by counterfeit deterrence features.
For these reasons DNB set a maximum to the total number of security features in a new banknote in the early 1990s. This maximum was set at 20 [1].

If no long term view is developed, the number of features in a banknote will grow, particularly when the life cycle of security features in banknotes is becoming shorter to an average of 10 - 20 years. Especially for features using a detection device (UV, IR, magnetism) a long-term planning scheme should be made. Plan in advance what features will go when, and when their follow-up is foreseen [19].

8. Conclusions

8.1 Working with POR leads to shorter development time, to a higher design quality and to better informed staff.

8.2 Creating an adequate Programme of Requirements is not a waste of time. The composition of the POR is in fact already part of the design process.

8.3 Banknote design driven by a stakeholders’ approach - instead of a production oriented approach - will lead to a Programme of Requirements based on customer requirements. This will lead to new design concepts, including new concepts for security features.

8.4 Banknote design traditions will counteract a central bank’s stakeholders’ approach to creating a new banknote.

8.5 Write requirements as detailed as possible. Be sharp.

8.6 Certification ISO 9001 does not guarantee the quality of the banknote design; rather, it certifies that consistent business processes are being applied.

8.7 Long-term planning of security features using a detection device is essential to keep the total number of security features within bounds.

8.8 The introduction of ‘work instructions’ between central bank and supplier will help to achieve project objectives like design quality, time planning and budget control.

Acknowledgements

I would like to thank Mr. Fred Collens (DNB) for editing the English text and Dr. Ton Roos (DNB) for his comments.
APPENDIX I
History of Programme of Requirements (DNB)

Ever since the year of its foundation, i.e. 1814, De Nederlandsche Bank (DNB) has commissioned its banknotes from Joh. Enschedé on a commercial basis.

In 1860, DNB issued their second series of banknotes, introducing intaglio. The designer of the intaglio, Mr. F.G. Wagner from Berlin, was selected by a member of the DNB Board. In those days, also other design requirements were determined by the Bank and committed to paper: ‘1) an extremely fine artistic engraving, either with a vignette or something else, by an artist who stands out for his sophisticated style. 2) an engraving produced on guilloching or die-stamping machines, which achieve a degree of fineness which the hand cannot hope to trace. 3) typography, with its typical difficulties for hand-copyists.’ This list could be seen as a very first Programme of Requirements (POR) [10, page 9 and 10].

In the 1920s, the Bank changed its policy and became even more active, especially in the area of papermaking. The direct involvement of DNB with the design is mentioned in a report of 1 December 1920: ‘The paper producer declared to be prepared to make the shadows in the watermark more subtle.’ [20]. A POR dedicated to the paper was prepared by DNB. There were no customer requirements yet, as the document was production-oriented, specifying, e.g., the paper weight, machine direction, the strength and composition of the fibres (40-60 % cotton and 60 – 40 % flax) [21].

In 1962, a POR for a new 10 guilder note was written, one and a half A4 pages long. This time DNB also specified the printing part of the note, e.g. intaglio print with ‘a portrait as most important anti-counterfeiting element’ [22]. The POR prepared in 1965 for the first time contained a design philosophy: ‘The banknote should have the appearance of a full banknote and should as such be clearly more valuable and handled more carefully than the well-known 2.50 guilder notes.’ The designer was allowed to suggest the paper tint. ‘A thread in the paper, coloured fibres or planchettes eceteras is not required.’ The document included 2 pages [23].

In 1978, the requirements for a new series of banknotes were described in a 7-page document. For the first time, DNB listed the customer requirements as well as describing the printing techniques to be applied [24]. In 1981, a Programme of Requirements was made for the new NLG 50 [25]. In the following year, a 45-page follow-up was prepared for the new NLG 250 note [26]. The first national publication - in Dutch - on the methodology of a Programme of Requirements for Banknotes appeared in 1986 [16]. In the years to follow, DNB developed the PORs further [7, 10, 27, 28].
APPENDIX II
Programme of Requirements Design New Banknote X
Content chapter

CONTENT

1. APPROVAL SHEET
2. KEY SHEET
3. CONTENT
4. REFERENCES
5. INTRODUCTION

6. PRESENTATION REQUIREMENTS DESIGN

7. DESIGN POLICY
   7.1 General design policy
   7.2 Design policy of security features

8. COMMUNICATION STRATEGY
   8.1 General communication goals
   8.2 Communication strategy of the public security features

9. COLOUR, DIMENSION AND ORIENTATION

10. TEXTS

11. VALUE RECOGNITION FEATURES
   11.1 General public
   11.2 Visually impaired people
      11.2.1 Low vision
      11.2.2 Colour blind
      11.2.3 Blind
   11.3 Cashiers
   11.4 Central bank

12. SECURITY FEATURES
   12.1 Location
   12.2 Public (level 1)
   12.3 Retailer and cashiers (level 2)
   12.4 Central bank (level 3)
   12.5 Anti-copy, anti-reproduction (level 4)
   12.6 Forensic features (level 5)
   12.7 Other security features (e.g. level 0)
   12.8 Public banknote automates
   12.9 Additional police requirements

13. DURABILITY

14. QUALITY CONTROL

15. BANKNOTE PRODUCTION CONSTRAINTS
   15.1 Production processes
   15.2 Tolerances
   15.3 Not allowed
APPENDIX III  
Target-means diagram for a banknote

1. target stably growing economy
   means European System of Central Banks
   De Nederlandsche Bank (in NL)

2. target efficient payments system
   means cash non-cash

3. target trust
   means coins banknotes

4. target only genuine banknotes in circulation cultural expression
   means security features well thought-out design contemporary design

5. target detection of counterfeits product for daily use (‘form follows function’)
   means by sorting system DNB by public and retailers design policy PoR

6. target machine-readable features public features retail features
   means inaccessible for public accessible for public reliable, fast, no discussion

7. target large design freedom large space (25 %) detector telling yes/no maximum 6
   means intrinsic, not visible all features on the front

8. target fast, discreet, easy to use
   means cluster tilt features, cluster look-tough features

Figure 1.
Eight levels in a hierarchical target-means diagram. At level 7 or 8 a second target-means diagram could be inserted, designed to work out the requirement in more detail [16].
APPENDIX IV
The use of space in the euro banknotes

The final perception of security features in a banknote is the result of several design parameters like:
- ‘reading direction’: from the upper left corner to the bottom on the right,
- realistic images (receive more attention as abstract),
- gloss (a foil element receives more attention),
- movement (something that moves receives more attention),
- colour (strong, bright colours receives more attention),
- size of the features,
- …

Unfortunately not much is know about these parameters and the way a banknote designer could make use of them. One of these parameters will also be the size or the dimensions of the feature. In principle a larger feature will receive more attention as a smaller one.

DNB analysis performed in 2004 on the 5 most space-intensive euro series features are provided in Table 1 [29]).

<table>
<thead>
<tr>
<th>Euro Series – Use of space</th>
<th>Dimensions</th>
<th>In %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feature</td>
<td>mm x mm</td>
<td>mm²</td>
</tr>
<tr>
<td>Bridges</td>
<td>105 x 30</td>
<td>3,675</td>
</tr>
<tr>
<td>Ring of Stars</td>
<td>60 x 60</td>
<td>3,600</td>
</tr>
<tr>
<td>SC-Marks</td>
<td></td>
<td>3,475</td>
</tr>
<tr>
<td>Map of Europe</td>
<td>50 x 50</td>
<td>2,500</td>
</tr>
<tr>
<td>Doors/windows</td>
<td>60 x 40</td>
<td>2,400</td>
</tr>
</tbody>
</table>

Table 1.
Overview of the top 5 of most space-intensive features of the euro series of 2002 [29].

Table 1 teaches that there are no public security features in the Top 5, although it may be argued that the ‘doors/windows’ are part of the tactility feature and that the bridges are part of the UV-images on the reverse side. However, it is clear that public features have no ‘space priority’ over theme elements.

Some more light on the use of space for security features is thrown in Table 2, which specifies the space per user group. For the general public only 15 % is reserved. Counterfeit deterrence features are used to fill in ‘background structures’. So may be it is not such a surprise that these level 4 features consumes more than 50 % of the banknote space! Still it may be a surprise for the banknote designers of the first euro series (ES1).

<table>
<thead>
<tr>
<th>Space consumption of Security Features per user group</th>
<th>Space consumption</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level</td>
<td>User</td>
</tr>
<tr>
<td>1</td>
<td>General Public</td>
</tr>
<tr>
<td>2</td>
<td>Retailers, cash handlers</td>
</tr>
<tr>
<td>3</td>
<td>NCBs</td>
</tr>
<tr>
<td>4</td>
<td>Counterfeit deterrence</td>
</tr>
<tr>
<td>5</td>
<td>Forensic</td>
</tr>
</tbody>
</table>

Table 2.
Overview of the space consumption of security features in ES1 by the different security levels.
(Level 4 = 53 % = SC Marks (16 %) + DR Marks (5 %) + Rainbow printing (10.7 %) + Screen traps (8 %) + Grey colour (8 %) + Registered fine lines (3.5 %) + 3 other security features [29].)
In Figure 1 the space consumption by the public security features is shown versus the public knowledge (data used from Table 3). From this analysis it can be concluded that there is no relationship between space consumption and public knowledge of security features [30].

Figure 1.
Graphical presentation of space consumption by security features versus public knowledge. It can be concluded that there is no relationship between space consumption and public knowledge of security features. For the data used, see Table 3 [30].

<table>
<thead>
<tr>
<th>Security feature</th>
<th>Space in %</th>
<th>Public knowledge in %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Multi-tone and electrotype watermark</td>
<td>7,3</td>
<td>29,3</td>
</tr>
<tr>
<td>2. Iridescent stripe</td>
<td>3,6</td>
<td>5,3</td>
</tr>
<tr>
<td>3. Diffractive foil stripe</td>
<td>2,35</td>
<td>30,4</td>
</tr>
<tr>
<td>4. Diffractive foil patch</td>
<td>2,35</td>
<td>30,4</td>
</tr>
<tr>
<td>5. Optical Variable Ink</td>
<td>1</td>
<td>3,8</td>
</tr>
<tr>
<td>6. Security thread (dark line, micro-text)</td>
<td>0,9</td>
<td>18,7</td>
</tr>
<tr>
<td>7. See through register</td>
<td>0,9</td>
<td>3</td>
</tr>
<tr>
<td>8. Tactile properties (intaglio)</td>
<td>0,9</td>
<td>6,9</td>
</tr>
<tr>
<td>9. Demetallised perforation/text</td>
<td>0,2</td>
<td>--</td>
</tr>
<tr>
<td>10. Mini lettering (0,8 mm)</td>
<td>0,04</td>
<td>--</td>
</tr>
<tr>
<td>11. Overprinting foil by offset inks</td>
<td>--</td>
<td>--</td>
</tr>
</tbody>
</table>

Table 3.
Overview of the public security features of the euro banknotes, their space consumption in % and the corresponding public knowledge scores within the Eurozone, in % in 2004 [29, 31].
APPENDIX V

Examples of requirements for banknote design

Two examples of requirements are provided as they were used by DNB:
1) Watermark (POR Design),
2) Marks for the blind (POR Design),

Requirement 1 - Watermark

The watermark image is generated by means of paper thickness modulation at the paper formation stage on specific paper machines. The watermark is an intrinsic feature.

Design theme
The watermark subject is:
- part of the theme of the new model,
- a realistic image (not abstract or symbolic),
- different from any of the printed subjects used in the design.

Multi-tone watermark including electrotype
- watermark is a registered multi-tone watermark, including an electrotype watermark,
- electrotype watermark will not have a solitary position, but be integrated into the motive.

Multi-tone watermark security
Details: A minimum of 20 % of the surface of the watermark is partly constructed from light and dark details. A major part of this consists of the smallest details, which are about Ø 1 mm. There should be:
- 2 or more light details of Ø 1 mm,
- 2 or more dark details of Ø 1 mm.

These details should be used in the design in such a way that their absence, e.g. in a counterfeit, will cause the watermark to appear quite differently.

Maximum contrast differences from very light to very dark
A minimum of 10 % of the surface of the watermark is filled with a maximum of contrast differences; from very light to very dark. These light-dark shades should be applied at least 3 times over:
- the shortest possible length: circa 2 mm,
- the longest possible length: circa 6 mm.

Electrotype watermark security
An electrotype watermark is a ‘one-tone highlight’. This ‘thread’ watermark will show one light tone if the note is view when held against a light source.
Design: almost every subject can be chosen: numbers, letters and geometrical figures.

Electrotype line width: 0.8 mm – 1.0 mm.

Number of elements in electrotype: The electrotype watermark can be constructed from one, two or three parts. If two or three parts are used - as is the case with denomination numerals - a ‘bridge’ between the two parts is not allowed.

Effective surface electrotype: about 100 mm².

Smallest electrotype detail: Ø 1 mm.

Tolerance: tolerance of the electrotype watermark relative to the multi-tone watermark: +/- 0.1 mm.
**Dimension**
The effective part of the watermark should have a surface of at least 30 mm x 30 mm.

**Location constraints**
- Folding lines will disturb the perception of the watermark. The watermark area should not be placed on the main vertical banknote folding line.
- Wish: watermark position preferably not on horizontal folding line.
- Nominal position of the watermark should at least be 6 mm from the nominal note edges.
- No security thread through the watermark area.
- …

**Perception**
- watermark should be presented in an area kept free from printing elements (except for some 20 % designed overprinting);
- essential perception area of the watermark should not be overprinted with visible colours.

**Partly overprinted**
Up to 20 % of the surface of the watermark is covered by offset and/or intaglio print. The rest of the watermark surface is free from overprinting (e.g. with line patterns).
The watermark is not overprinted with foil printing, silk screen printing or letterpress.
The electrotype watermark should not be overprinted.

The watermark ‘Little Owl’ was developed (in 1991-1992) on the basis of the above watermark requirements. See Figure 1.

![Sketch design of the watermark 'Little Owl' by Jaap Drupsteen (dated 22 February 1991). The circular pattern next to the owl fully fulfills the requirement 'maximum contrast differences from very light to very dark'. These shades should be applied at least 3 times across the longest possible length: circa 6 mm.](image1)

**Requirement 2 - Tactile structures for the blind**

All denominations should have tactile structures for blind users, with a different pattern for each denomination to permit distinction of the different denominations.

**Shapes**
Dot patterns are very suitable for tactile structures. In between the dot patterns light engraved fine intaglio lines may be designed. Tactile structures could also be based on straight lines, wavy lines, V-shaped elements (herringbone), rectangles, circles, triangles or other geometric shapes.
**Location and redundancy**
Tactile patterns should preferably be positioned at the short edge(s) of the banknote so that they can be spotted easily.

**Dimensions and spacing**
The width of the white areas between the intaglio elements should not be too narrow. There must be enough space for the finger tips between the lines: spacing > 1.5 mm. A single element should not be larger than a fingertip.

**Feel of the elements**
Tactile sensation is increased when the lines are - partly - interrupted (broken).

**No Braille**
Braille elements are not feasible as they require a height of 1.4 mm. This height cannot be achieved in banknote printing and, secondly, only a minority of the blind can read Braille.

**Colour**
The choice of colour is basically completely free. To make the structures not too visible, though, there is a preference for using the same intaglio colour as for offset under-print or a colourless intaglio ink.

**Durability**
The tactile structures must be durable to ensure their reliable detection and discrimination also on circulated banknotes.

![Figure 2](image1)
Figure 2.
Tactile areas at the spots where people usually place their fingers to hold the note.
The tactile pattern based on three different types of dots: a mixture of randomly positioned dots with diameters of 1 mm, 0.6 mm and 0.4 mm, a minimum mutual distance of 1.5 mm and a maximum mutual distance of 3 mm.
Dot diameter in Canadian notes (2002): 0.8 mm and 1 mm [32]. Dot diameter in NLG 100 (1992): 1 mm [5].

![Figure 3](image2)
Figure 3.
Tactile patterns used in a study done by Prof. Hubert Dinse. The new CtIP technique may create better tactile patterns, with a higher and steeper relief [33].
References

20. ‘Bezoek van den Secretaris en den Adjunct-Secretaris Mr. V.Buttingha Wichers, aan de Koninklijke Papierfabriek v/h Pannekoek & Co, Heelsum’ internal report, De Nederlandsche Bank, 1 December 1920 - internal document
21. ‘Eischen aan het papier voor de biljetten van f.10,- NED. Bank te stellen’ De Nederlandsche Bank, 23 February 1922 - internal document
22. ‘Concept. Programma van Eisen nieuw f.10. – biljet’ De Nederlandsche Bank, 22 May 1962 - internal document
23. ‘Globaal Programma van Eisen voor een bankbiljet van f.5.’ De Nederlandsche Bank, 5 May 1965 - internal document
24. ‘Technische specificaties voor de nieuwe serie bankbiljetten’ De Nederlandsche Bank, April 1978 - internal document