Banknote dimensions and orientation: user requirements

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1. Introduction

Recently, two central banks reduced their banknotes’ dimensions, i.e. the central banks of Malaysia (2004) and Mauritania (2004), while the central bank of Switzerland announced to do so in 2010. Currency News stated that the 5 and 10 euro banknotes are smaller than the lowest and second lowest denominations of the French, German and Spanish banknote series [4]. In fact, the 5 euro is among the smallest banknotes worldwide (Figure 1).

There proves to be a limit, though, to the trend towards smaller banknote sizes observed since the earliest issue of banknotes, i.e. once banknotes become too small to be accepted by teller or sorting machines.

![Recent issued small banknotes: the 5 Euro banknote, the 5 Kuna banknote (Croatia) and the 200 Escudo banknote (Cape Verde).](image)

**Figure 1.**

Recent issued small banknotes: the 5 Euro banknote, the 5 Kuna banknote (Croatia) and the 200 Escudo banknote (Cape Verde). In 1999, Cape Verde started the issue of vertical banknotes (Model 3 according to Figure 2: portrait style on the reverse side).

The smallest banknote size in the former EMU-countries was the ITL 1000 banknote: 112 mm x 61 mm. There are also small Chinese banknotes in circulation in 2006: the smallest measures 114 mm x 52 mm (1 Jiao, 1980).

As reasons for reducing their banknotes’ dimensions, it was cited that this would facilitate ‘easier handling’ (Malaysia) [9] and minimise ‘wear and tear in the wallet’ (Switzerland) [6]. From the Swiss information we may further read:

> ’However, the format of the banknotes will once again be slightly reduced: in particular, the gradation of length will be considerably smaller. This will optimise general proportions, and the banknotes will even better satisfy the current and future requirements with regard to machine processing. In addition, costs can be cut at the production, packaging, storage and transportation stages’.

[6]

It seems that central banks seek to ensure that their banknotes’ dimensions match the requirements of today’s customers. But what are these requirements?
Figure 2.
Overview of four possible combinations of the different orientations of a banknote front/reverse (landscape or portrait). The provided data refers to the Euro Design Contest 1996. In total 44 designs were made [2].

**Orientation**

Directly related to dimensions is another design parameter: the orientation. And here the same questions may be asked: what are the requirements for banknote orientation? Figure 2 describes four different models. In Annex 1 - 4 different examples are given of ‘portrait’ oriented designs.

### 2. Customer requirements (banknote dimensions and orientation)

The guiding principle in developing new banknotes should be that the resulting paper currency must satisfy today’s - and even better, tomorrow’s - stakeholder requirements. Over time, these requirements will change. Central banks’ new role in cash cycles may lead to a review of banknote dimensions. The introduction of outsourcing or new technologies like third-party sorting (e.g. DNB in 2005), multi-denomination and multi-dimension processing (e.g. by Bundesbank in 2007) and increased use of cash recycling machines are calling for efficient banknote dimensions. Worldwide, the architecture of tomorrow’s banknote series will be characterised by small dimensions and uniform note heights.

Also for the visually handicapped better solutions seem to be in the offing.

The requirements of primary users and customers as regards banknote dimensions can be narrowed down to at least 5 sets:

1. Notes should fit inside wallets,
2. Notes should easily feed into banknote acceptors,
3. Notes should meet the need of the visually handicapped,
4. Notes should preclude counterfeiting (e.g. by bleaching),
5. Notes should permit easy processing by central banks and third parties, like professional cash handlers

Other stakeholder requirements relate to:

6. Logistics of new and re-circulated banknotes
7. Banknote production
8. Design (scaling aspects)
**Requirement 1 - Notes should fit inside wallets**

The Dutch were accustomed to a standard note height of 76 mm and to 6 mm length increments between two consecutive Dutch guilder banknotes. A banknote series consisting of various lengths and heights, such as the euro banknotes series, was therefore new to them.

At the BPC/General Meeting in Prague in 2002 the Bundesbank reported: ‘However, complaints were voiced about the size of the banknotes from the EUR 50 note upwards because they no longer fit in existing wallets or purses’ [3]. Later, in 2004, a survey conducted by DNB showed that the Dutch also consider the euro 100 note too large (height 82 mm) for a standard wallet and the euro 5 note too small (height 62 mm) [5].

This criticism is understandable given a small study of typically European wallet sizes. From this study it appears that a 70 – 75 mm note height best fits a European wallet (typical dimensions: (length) x (width) = (200 - 250 mm) x (90 - 120 mm) [10].

Inside a wallet, a banknote seems to need around 20 mm additional room to allow for skewing and positioning (see Figure 3). This indicates a maximum note height of around 70 - 73 mm.

Notes not fitting properly inside a wallet will develop more wear and tear along the edges. In the experience of DNB’s banknote sorting department, the high euro banknote denominations, especially the 100 euro one, show more tears than the lower denominations.

**Requirement 2 - Notes should easily feed into banknote acceptors**

As far as is known, banknote acceptors take no landscape or Long Edge First (LEF) oriented notes, but only portrait or Short Edge First (SEF) notes (Figure 4). In the case of ATMs, banknotes must be fed landscape-wise, but more recently introduced machines also take notes inserted portrait-wise.

The usual feeding instructions for euro banknotes are 1) push the note to the left and 2) push the note forward (Figures 5a and 5b), and often lead to confusion. The note may be rejected, upon which the customer, now grown insecure, will proceed to re-insert the note, but this time in a different orientation. A uniform note height, however, would simplify feeding instructions to a mere: Just push the note forward! Moreover, with one note height, notes would be less likely to skew [7,9]

To come to the public’s aid, the banknote designers may need to study the design of, e.g., hotel room keys and telephone cards [9].

**Orientation study**

Bureau Mijksenaar made in 2005 - on request of DNB - a study to banknote orientation from the point of view of the users of banknote acceptors [7]. Some of the findings are reported below.

A banknote can be fed into a banknote acceptor on 8 different ways as is shown in Figure 6.
Figure 4.
Banknotes are fed ‘vertically’ into banknote acceptors. Example of car park ticket machines at Copenhagen Airport (2005).

Figure 5.
The lack of uniformity of size between the various euro banknote denominations may lead to delays at banknote acceptors. The public is instructed to push the note forward and to push the note to the left like in vending machine (a) and like the banknote acceptors as used by the subway system of Amsterdam (b). In 2006 additional instructions appeared on the vending machines of the public transport in Frankfurt telling to feed the euro banknotes in the centre (‘Banknoten mittig einführen’) (c). Pictures a and b are made in 2005, c in 2006 [8].

Figure 6.
There are in all 8 feeding options to insert a banknote in a banknote acceptor: 4 different horizontal and 4 different vertical feed methods.
Figure 7
How to recognize the correct feeding direction? The user must:
a) Keep the banknote horizontal so that denomination figures and other information are upside up.
b) If necessary, turn the banknote over, so that the front side comes up, which shows – in this dummy design - the large figure denomination in the upper right-hand corner and the unprinted watermark zone on the left-hand side.
c) Turn the banknote to the left - anti clock wise - until the large figure denomination is in the upper left-hand corner, the unprinted watermark zone at the lower side, and the reading direction is down-up.
d) Place the banknote in the slot while keeping it as much as possible to the left and at 90° (required for most terminals), after smoothing out any bent corners and edges.

Figure 7 describes the common way how the public will feed a banknote into a banknote acceptor. As said, feeding the machines often leads to confusion. The problem here is the lack of standardisation. A structural solution would therefore be to arrive at an international agreement on one, uniform feeding direction for all means of payment. While there appears to be no ‘natural’ turning direction, feeding a banknote with the large denomination first seems more ‘natural’ than the other way around. This problem, too, would be solved if the feeding direction were indicated on the banknote proper. If this feature is provided on what to all users is clearly the front side of a banknote, a reference to this feature on the back of the banknotes will probably not be necessary.

Figure 8.
Left: study of Paul Mijksenaar to different pictograms to indicate the feeding direction.
Right: optimal design concept for feeding banknote acceptors, including an arrow pictogram. More study is needed.
Starting point of the study is that the provision of visual bill feeding ‘cues’ on banknotes is to be preferred to instructions on the payment terminal. In determining the correct feeding direction, the user must:
1) be able to tell the front of the banknote from the back,
2) find out whether the banknote must be fed long side first or short side first and face up or face down,
3) find out in what direction the banknote must be turned,
4) find out at what side of the slot opening the banknote must be inserted (on the left side).
Requirement 3 – Optimal length increment for to mark difference between two denominations (for the blind)

Blind people may discriminate between the different denominations on the basis of:
1) Tactile information,
2) Differences in size.

Figure 9
Euro Cash Test device (from CareTec). Blind people usually determine a banknote’s denomination by folding the note and checking the braille section or a simple tactile mark. Only the banknote length is used for this device. For an optimal use of this method, two consecutive notes must differ at least 6 mm in length from each other (= 3 mm effective use). Irregular length increments in a note series are suboptimal for this tool.
According to CareTec around 500,000 Cash Test devices are spread among the European blind (web site information: 5 August 2006).

In 1999 the Euro Group of the European Blind Union interviewed 300 visually impaired people in Belgium, Germany and Spain. This evaluation of Euro Series reported [1]:
- Comparing only lengths used by 81 %
- Both length and width used by 54 %
- Mix up of notes:
  - 5 and 10 euro: 13 %
  - 10 and 20 euro: 11 %
  - 20 and 50 euro: 23 %

To be able to determine notes quickly, the blind are best served by a distinct length difference between the most commonly used notes, i.e. the 5, 10, 20 and 50 euro notes. The Dutch blind asked DNB in 2005 for [10]:
- Better tactile features on all denominations
- A greater length difference between the notes they use daily (mainly 10 and 20 euro)

In the Danish banknote series (5 denominations), there is a 10 mm length difference between two consecutive denominations, just as was the case for the last French banknotes series. In the new series of Swiss banknotes, the length increment between two consecutive banknotes will measure 7 mm, instead of the present 11 mm (to be issued in 2010). The new Mexican notes will introduce on their new series also a length increment per denomination of 7 mm (issue in 2007) [12]. In Pakistan the new 2005- series has a length increment of 8 mm and a standard note height of 65 mm.
**Requirement 4 - Notes should preclude counterfeiting (e.g. by bleaching)**

US dollar notes are counterfeited by bleaching and reprinting these notes with a higher value, mainly in Columbia. This is possible because all denominations are identically dimensioned and tinted. Moreover, their watermarks are of a quality that offers little protection against bleaching. Counterfeiters can thus forge a USD banknote by bleaching it and printing a higher value where the original denomination used to be indicated. In fact, the only protection against bleaching provided for by the USD design is offered by the altering position of the security thread running from left to right across the portrait.

Also euro counterfeits suffer recently from bleaching processes: bleached Nigerian banknotes are used as a basis to print euro counterfeits.

To overcome bleaching within a banknote series, the following measures can be done:

- a length increment between the denominations,
- a width increment between the denominations,
- special paper tint per denomination,
- different designs for paper features like watermark, threads, fibres, foil, iridescent bands,
- different positions of paper features like watermark, thread, fibres, foil, iridescent bands.

**Requirement 5 – Minimum and maximum note height for banknote processing machines**

Small banknote sizes often pose processing problems for sorting machines. Euro 5 notes in particular are notorious for this. The ideal minimum note height for banknote processing would be 65 mm, and the ideal maximum note height around 90 mm, given banknote sorters’ experience that the euro 100, 200 and 500 notes are close to the maximum height that the average sorting machine can handle.

The changed role of central banks in cash cycles will in the short term lead to the introduction of multi-denomination processing. Other trends projected for the near future will be the outsourcing of banknote sorting to third parties, like CIT companies, and the increased use of cash recycling machines. Also in light of these developments, a standard note height would enhance efficiency.

**Requirement 6 – Logistics of new and circulated notes**

The use of different banknote dimensions creates inefficiencies in banknote packaging and storage logistics. From a logistical point of view, a banknote series should ideally be dimensioned on the basis of a standard pallet size.

Many central banks prefer a content of 10,000 banknotes per cardboard box, in 10 bundles of, 1000 banknotes each, face up or down when seen from the top. The only way to fill a box with fit banknotes while maintaining a distinct dimensional difference between length and height of the box is by aligning the bundles in two rows (see Figure 10). The banknote box should be so dimensioned that it provides slack space for misaligned banknote stacks, packaging material (e.g. dog-ears of shrink film) and box construction variances (differences in cardboard thickness are negligible). On the other hand, slack space should be moderate so as to preclude instability and wandering of the bundles during transportation.

The outer box dimensions of 400 mm x 300 mm are optimal for both the standard Euro pallet (1200 mm x 800 mm) and the standard half-Euro pallet (600 mm x 800 mm). Efficient logistics indicate an optimum note length of 140 mm:

\[
300 \text{ mm} - (2 \times 5 \text{ mm cardboard thickness}) - 2 \text{ mm construction variance} = 288 \text{ mm}
\]

Hence, for each row 144 mm is available.

\[
144 \text{ mm} - 2 \text{ mm stacking variance} - 2 \text{ mm packaging material for bundles} = 140 \text{ mm}
\]

Following the same line of reason, a banknote’s optimum height would be 74 mm:

\[
400 \text{ mm} - (2 \times 5 \text{ mm cardboard thickness}) - 2 \text{ mm construction variance} = 388 \text{ mm}
\]

Hence, for each line (388/5 =) 77.6 mm is available.

\[
77 - 2 \text{ mm stacking variance} - 1 \text{ mm}^* \text{ packaging material for bundles} = 74 \text{ mm}
\]

(* flaps are usually not on the long side of the bundles due to packaging constraints).
Figure 10.
(a) a box with 10 bundles of banknotes (seen from above)
(b) when sorted banknotes are stacked, some degree of misalignment is unavoidable, both height-wise and length-wise.
(c) ECB cross border packaging standard for (used) banknotes. Carton boxes on a half euro pallet.

Requirement 7 – Optimal sizes for banknote production

Figure 11 shows the maximum sheet size for KBA super format printing machines (820 mm x 700 mm). Allowing for margins, the maximum nominal sheet size would be 800 mm x 660 mm. With 10 rows on one sheet this would lead to a note height of 66 mm; 9 rows: 73 mm. Taken a minimum length of 124 mm, this would lead to 6.45 columns. Taken a maximum of 6 columns, this would mean a note length of 133 mm.

Figure 11.
A sheet with printed banknotes based on the maximum sheet size for KBA super format machines: (length) x (width) = 820 mm x 700 mm. The margin for the gripper or ‘head’ side of the sheet is usually 25 mm. The margin at the bottom or ‘tail’ side of the sheet is usually 15 mm. The requisite left- and right-hand side margins are usually 10 mm.
Requirement 8 – Design

For banknote designers a banknote series with both a length and a width increment is more difficult to design (main image, texts, other standard elements). Especially with many denominations, as is the case with the euro banknote series (7 denominations), scaling problems will arise as is shown in Figure 12. A standard note height will help to overcome such scaling problems and will probably bring – from an aesthetic point of view – higher appreciated banknotes.

Figure 12.
Scaling problems with euro banknotes. The denomination figures in the 500 are free of background printing, while in the euro 5 there is competition between the numeral 5 and the arch.

3. International benchmarking and trend watching

Now that the requirements of customers and other stakeholders are identified, let us have a look at four main global trends in banknote dimensioning:

1) Banknote dimensions are - in general - decreasing.
2) In the past 25 years, many countries switched to a uniform note height (while some introduced variation in note height).
3) Several countries issuing banknotes series with uniform heights proceeded to increase the length increments between denominations. Some countries with a large length increment announced to reduce these increments (e.g. Switzerland, Denmark).
4) Banknote series with a uniform note height have larger length differences between denominations.

Introduction of uniform note height
The historical overview in Table 1 shows there really is a trend towards a uniform note height. Table 2 provides an overview of the various note heights of the banknote series introduced in the past 25 years, of which the introduction of the euro in 2002 is the latest.
<table>
<thead>
<tr>
<th>Currency</th>
<th>Year of introduction</th>
<th>Height</th>
<th>Different note length?</th>
</tr>
</thead>
<tbody>
<tr>
<td>USA</td>
<td>1929</td>
<td>66 mm¹</td>
<td>No</td>
</tr>
<tr>
<td>Canada</td>
<td>1954</td>
<td>70 mm</td>
<td>No</td>
</tr>
<tr>
<td>Finland</td>
<td>1955</td>
<td>70 mm</td>
<td>No</td>
</tr>
<tr>
<td>The Netherlands</td>
<td>1965</td>
<td>76 mm</td>
<td>Yes, 6 mm</td>
</tr>
<tr>
<td>Mexico</td>
<td>1969</td>
<td>66 mm</td>
<td>Yes, two lengths 25 mm</td>
</tr>
<tr>
<td>Israel</td>
<td>1970</td>
<td>71 mm</td>
<td>No</td>
</tr>
<tr>
<td>Poland²</td>
<td>1975 – 1995</td>
<td>63 mm</td>
<td>No</td>
</tr>
<tr>
<td>Belgium/Luxembourg</td>
<td>BEF</td>
<td>1980</td>
<td>Yes, 6 mm</td>
</tr>
<tr>
<td>Iceland</td>
<td>1981</td>
<td>70 mm</td>
<td>Yes, 5 mm</td>
</tr>
<tr>
<td>Japan</td>
<td>1984</td>
<td>76 mm</td>
<td>Yes, 5 mm</td>
</tr>
<tr>
<td>Russia</td>
<td>1985</td>
<td>65 mm</td>
<td></td>
</tr>
<tr>
<td>Estonia</td>
<td>1991</td>
<td>69 mm</td>
<td>No</td>
</tr>
<tr>
<td>Argentina</td>
<td>1992</td>
<td>65 mm</td>
<td>No</td>
</tr>
<tr>
<td>France³</td>
<td>1992</td>
<td>80 mm</td>
<td>Yes, 10 mm</td>
</tr>
<tr>
<td>Latvia</td>
<td>1992</td>
<td>65 mm</td>
<td>No</td>
</tr>
<tr>
<td>Australia</td>
<td>1993</td>
<td>65 mm</td>
<td>Yes, 7 mm</td>
</tr>
<tr>
<td>Kyrgyzstan⁴</td>
<td>1993 - 1997</td>
<td>70 mm</td>
<td>No</td>
</tr>
<tr>
<td>Lithuania</td>
<td>1993</td>
<td>65 mm</td>
<td>No</td>
</tr>
<tr>
<td>Macedonia</td>
<td>1993</td>
<td>70 mm</td>
<td>Yes, 3 mm</td>
</tr>
<tr>
<td>South Africa</td>
<td>1993</td>
<td>70 mm</td>
<td>Yes, 6 mm</td>
</tr>
<tr>
<td>Brazil</td>
<td>1994</td>
<td>65 mm</td>
<td>No</td>
</tr>
<tr>
<td>Switzerland</td>
<td>1995</td>
<td>74 mm</td>
<td>Yes, 11 mm</td>
</tr>
<tr>
<td>Malaysia⁵</td>
<td>1996/2004</td>
<td>65 mm</td>
<td>Yes, 5 mm</td>
</tr>
<tr>
<td>Portugal</td>
<td>1996</td>
<td>68 mm</td>
<td>Yes, 7 mm</td>
</tr>
<tr>
<td>Peru</td>
<td>1996</td>
<td>65 mm</td>
<td>No</td>
</tr>
<tr>
<td>Denmark</td>
<td>1997</td>
<td>72 mm</td>
<td>Yes, 10 mm</td>
</tr>
<tr>
<td>Austria</td>
<td>1997</td>
<td>72 mm</td>
<td>Yes, 4 mm</td>
</tr>
<tr>
<td>Hungary</td>
<td>1990</td>
<td>70 mm</td>
<td>No</td>
</tr>
<tr>
<td>Egypt</td>
<td>1998</td>
<td>70 mm</td>
<td>Yes, 5 mm</td>
</tr>
<tr>
<td>Pakistan</td>
<td>2005</td>
<td>65 mm</td>
<td>Yes, 8 mm</td>
</tr>
<tr>
<td>Mexico</td>
<td>2007</td>
<td>66 mm</td>
<td>Yes, 7 mm</td>
</tr>
<tr>
<td>Switzerland⁶</td>
<td>2010</td>
<td>70 mm</td>
<td>Yes, 7 mm</td>
</tr>
</tbody>
</table>

**Average**      |                      | ± 70 mm |                        |

*Table 1.*

Historical overview of central banks introducing uniform note heights. The years of introduction are specified to the best of our knowledge [11]. Several EMU countries changed to a single note height shortly before the introduction of the euro: Austria and France in 1993, and Portugal in 1996.

1) US dollar dimensions: (6.14 inch) x (2.61 inch)
2) In 1995, Poland returns from a uniform note height to various heights.
3) Only the FFR 20 was irregular: 140 mm x 75 mm, the other four new denominations had a uniform note height of 80 mm, ranging from 123 mm x 80 mm for the FFR 50 to 153 mm x 80 mm for the FFR 500.
4) In 1997, the central bank of Kyrgyzstan introduced a variable note height.
5) Announced in 2004: all denominations will be of uniform height (i.e. 65 mm) except for the high denominations (still 69 mm).
6) Adaptation to single note height from 74 mm to 70 mm.
### Different note heights

<table>
<thead>
<tr>
<th>Currency</th>
<th>Year of introduction</th>
<th># Den.</th>
<th>Different length range</th>
<th>Length increment</th>
<th>Different height range</th>
<th>Height increment</th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>1980</td>
<td>7</td>
<td>140 -156 mm</td>
<td>Variable</td>
<td>63 - 80 mm</td>
<td>Variable</td>
</tr>
<tr>
<td>Kenya</td>
<td>1980</td>
<td>5</td>
<td>138 - 164 mm</td>
<td>Variable</td>
<td>72 - 86 mm</td>
<td>Variable</td>
</tr>
<tr>
<td>Thailand</td>
<td>1981</td>
<td>5</td>
<td>135 - 162 mm</td>
<td>Variable</td>
<td>68 - 80 mm</td>
<td>Variable</td>
</tr>
<tr>
<td>Sweden</td>
<td>1986</td>
<td>5</td>
<td>120 - 161 mm</td>
<td>Variable</td>
<td>67 - 82 mm</td>
<td>Variable</td>
</tr>
<tr>
<td>Morocco</td>
<td>1987</td>
<td>4</td>
<td>130 - 158 mm</td>
<td>Variable</td>
<td>68 -78 mm</td>
<td>Variable</td>
</tr>
<tr>
<td>Vietnam</td>
<td>1989</td>
<td>7</td>
<td>134 - 151 mm</td>
<td>Variable</td>
<td>64 - 71 mm</td>
<td>Variable</td>
</tr>
<tr>
<td>Norway</td>
<td>1990</td>
<td>5</td>
<td>128 - 160 mm</td>
<td>8 mm</td>
<td>60 - 80 mm</td>
<td>5 mm</td>
</tr>
<tr>
<td>Slovenia</td>
<td>1992</td>
<td>7</td>
<td>132 - 156 mm</td>
<td>Variable</td>
<td>66 - 78 mm</td>
<td>Variable</td>
</tr>
<tr>
<td>Czech Republ.</td>
<td>1993</td>
<td>7</td>
<td>133 - 170 mm</td>
<td>6 or 7 mm</td>
<td>64 - 74 mm</td>
<td>1 or 4 mm</td>
</tr>
<tr>
<td>Slovakia</td>
<td>1993</td>
<td>7</td>
<td>128 - 164 mm</td>
<td>6 mm</td>
<td>65 - 83 mm</td>
<td>3 mm</td>
</tr>
<tr>
<td>Croatia</td>
<td>1993</td>
<td>8</td>
<td>122 - 150 mm</td>
<td>4 mm</td>
<td>61 - 75 mm</td>
<td>2 mm</td>
</tr>
<tr>
<td>UK</td>
<td>1994</td>
<td>4</td>
<td>135 - 157 mm</td>
<td>7 mm</td>
<td>70 - 85 mm</td>
<td>5 mm</td>
</tr>
<tr>
<td>Malta</td>
<td>1994</td>
<td>4</td>
<td>138 - 179 mm</td>
<td>Variable</td>
<td>69 - 76 mm</td>
<td>Variable</td>
</tr>
<tr>
<td>Poland</td>
<td>1995</td>
<td>5</td>
<td>120 - 144 mm</td>
<td>6 mm</td>
<td>60 - 72 mm</td>
<td>3 mm</td>
</tr>
<tr>
<td>Ukraine</td>
<td>1996</td>
<td>8</td>
<td>118 - 136 mm</td>
<td>2 mm</td>
<td>63 - 72 mm</td>
<td>3 mm</td>
</tr>
<tr>
<td>Cyprus</td>
<td>1997</td>
<td>4</td>
<td>140 - 164 mm</td>
<td>8 mm</td>
<td>68 - 80 mm</td>
<td>4 mm</td>
</tr>
<tr>
<td>Cape Verde</td>
<td>2000</td>
<td>5</td>
<td>121 - 148 mm</td>
<td>Variable</td>
<td>62 - 74 mm</td>
<td>Variable</td>
</tr>
<tr>
<td>ESCB</td>
<td>2002</td>
<td>7</td>
<td>120 - 160 mm</td>
<td>6 or 7 mm</td>
<td>62 - 82 mm</td>
<td>5 mm*</td>
</tr>
<tr>
<td><strong>Table 2.</strong></td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>Historical overview of central banks that introduced variable note heights. Year of introduction to the best of our knowledge [11].</td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

*) except for 100, 200 and 500 euro

### Technical trend

Another trend to be observed is the introduction of bands in banknotes, like
- security threads,
- foil stripes,
- iridescent stripes,
- IR areas,
- strokes of additives like fibres or planchettes,
- ...

Current banknote dimensioning contains a paradox: while banknotes become increasingly smaller, ‘band features’ are requiring more and more space, as indicated in Figure 13, and bands are requiring more and more width: wider security threads – up to 4 mm – and wider foil stripes and iridescent bands.
Figure 13.
Left: Trend in banknote construction: more-and-more bands. A larger length lends itself better to introducing band features than does a larger banknote height.

Figure 14.
A vertical orientation of banknotes creates new design possibilities, e.g. a registered foil stripe with a vertically oriented image (right).
4. Different dimension models for banknote series

This paragraph provides a visual overview of different banknote dimension models of world currencies (USD, JPY and EUR) and several other currencies.

Figure 15.
USD banknote dimensions, unchanged since 1929. Uniform note size (horizontal). The notes shown are USD 1 (issued in 1957), USD 20 (issued in 2004) and USD 100 (issued in 1996).

Figure 16.
Figure 17.
Dimensions of JPY. Issued in 2002 (except JPY 2000). Uniform note height and length increments of 2 or 4 mm.

Figure 18.
The new Swiss banknote series as proposed to be issued in 2010. Smaller note sizes; shorter length increment (from 11 mm to 7 mm).
Figure 19.
Uniform note height, with large (10 mm) length increments for low denominations. High denominations are identically dimensioned.
The Danish 1997 Series come close to this model. However, there is no DKK 2000 note.

Figure 20.
Dimensions of Euro Series 1 (ES1), issued in 2002.
Left: low denominations 5 and 20 (foil stripe, iridescent band).
Right: high denominations 100 and 500 (foil patch, OVI). The high denominations are of uniform height. To facilitate discrimination for the visually handicapped: the 100 euro note bears no tactile marks, the 200 euro note has a horizontal tactile band, and the 500 euro note features a vertical tactile band.
**Figure 21.**
Banknote series breakdown into notes for daily use and notes for non-daily use. Two categories of note heights: one category optimised for daily use in wallets and banknote acceptors (5-10-20-50) and the other category optimised for large-value payments and/or hoarding money: possibility of high security.

**Figure 22.**
Two categories: one (on the left-hand side) for optimal processing by machines, easy recognition by the visually handicapped and better durability, e.g. Econote of G&D (2001), with a long grain and two tear-proofing threads on the longitudinal sides [8], and once for high denominations (on the right-hand side) which have more space for additional security features.
Alternative size systems
On the basis of an analysis of models A, B and C, some alternative size systems might be developed to meet customer requirements. These models are presented as models D en E. The basic principle of these models is that the note series can be divided into notes for daily use and notes for non-daily use. The two models were worked out for the existing euro series of 2002. It may well be wondered whether three denominations for non-daily use is not too much and whether just one high, hoarding denomination would be sufficient.

The largest note length is 156 mm, coming close to the largest notes in the UK (157 mm), Australia (158 mm) and the new Swiss notes (158 mm). The smallest note (124 mm x 72 mm) comes close to the DKK 50 (125 mm x 72 mm).

The length increment between the notes is 8 mm, one of the largest length increments in banknote history and in between the length increments of both the Australian and new Swiss banknote series (7 mm) and Danish banknote series (10mm). The three highest denominations will all be of the same length (156 mm). All denominations, the ones for daily use in particular, feature tactile marks/areas for the visually handicapped.

5. Criteria for selection

Given the variety of dimension models, the ideal model is best selected as demonstrated in Table 3.

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Dimension model</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A1</td>
</tr>
<tr>
<td>1. Fit inside standard wallet</td>
<td>+</td>
</tr>
<tr>
<td>2. Feeding public banknote acceptors</td>
<td>+</td>
</tr>
<tr>
<td>3. Following the trend towards uniform note height</td>
<td>+</td>
</tr>
<tr>
<td>4. Length increment (optimised for the visually handicapped)</td>
<td>--</td>
</tr>
<tr>
<td>5. Practical use by the visually handicapped</td>
<td>--</td>
</tr>
<tr>
<td>6. Logistics, especially pallet/box</td>
<td>++</td>
</tr>
<tr>
<td>7. Sorting aspects</td>
<td>++</td>
</tr>
<tr>
<td>8. Production efficiency</td>
<td>++</td>
</tr>
<tr>
<td>9. Design (scaling problems)</td>
<td>++</td>
</tr>
<tr>
<td>10. Costs of foil stripe</td>
<td>+</td>
</tr>
<tr>
<td>11. ...</td>
<td></td>
</tr>
</tbody>
</table>

A1 = All denominations identically dimensioned, horizontal
A2 = All denominations identically dimensioned, vertical
B1 = Uniform note height, variable length, horizontal
B2 = Uniform note height, variable length, vertical
B3 = Uniform note height, large length increment, horizontal
C = Low and high denominations, different lengths and widths
D = Daily use (4) – Non-daily use (3), both horizontal
E = Daily use (4), vertical – Non-daily use (3), horizontal

Table 3.
Overview of the criteria - and a scoring exercise - to come to the selection of a ‘fit for use’ dimension model.
6. Conclusions

1. Uniform note height is the main trend
A uniform note height is the major trend worldwide. For one, it facilitates handling for operators of all kinds of banknote acceptors. Second, the notes fit better inside wallets. And, finally, a uniform note height would create more space for incorporating ‘bands’ into banknotes, as is the recent trend (foil stripe, iridescent stripe, threads, fibres, magnetic features, …).

2. Vertical position more ergonomic for public use of banknote acceptors
For banknote acceptors, a vertical position of the banknote (‘portrait’ style) is ergonomically better than the traditional horizontal position (‘landscape’ style). Furthermore, a vertical position will create new possibilities for security features (e.g. horizontal foil stripe) and durability.

3. Useful aid for the visually handicapped
The introduction of a uniform note height will help the visually handicapped in that it allows room for:
- distinct length increments between the most frequently used notes, e.g. 7 or 8 mm; 8 mm is preferred, e.g. because of Cash Test device,
- tactile marks on the edges of the most frequently used notes by way of:
  - higher and sharper relief obtained by Computer to Intaglio Plate (CiIP)
  - ‘running of’ intaglio
- free distribution of Cash Test
- …

4. Design
If a series of banknotes exists of more than 4 denominations, from a designer’s point of view a single note height is preferred (to avoid scaling problems).

References

1. ‘Handling the euro with ease and confidence: the needs of the visually impaired people’ EBU Euro Group, Brussels, September 1999
4. ‘Size really does matter!’ Currency News, January 2004
8. De Heij, Hans; ‘Curved banknotes. Can the paper maker help’ power point presentation to BPC Paper Committee, Warsaw, 17 – 20 May 2005
9. Web site Bank Negara Malaysia, 2005

Acknowledgements

Tables 1 and 2 were prepared with the help of Mr. Thomas Stange from the Bundesbank. The idea to split up a banknote series into ‘notes for daily use’ and ‘notes for non-daily use’ (higher security) was conceived by Mr. Thomas Stange and Mr. Hans de Heij.

The paragraph on logistical efficiency was written with the help of Mr. Marco Wind of De Nederlandsche Bank.
ANNEX 1 – SOME HISTORICAL PORTRAIT DESIGNED BANKNOTES

First ‘saved’ paper money Ming - dynasty
China 1375

Japan
1746

Wiener Stadt Banco
1806

Russia
1909

China
1930
ANNEX 2 – SOME RECENT PORTRAIT DESIGNED BANKNOTES

Netherlands
NLG 1986

Sri Lanka
LKR 1991

Spain
ESP 1992

Switzerland
CHF 1995

Israel
NIS 1999

Cape Verde
CVE 2005

Serbia
CSD 2006
ANNEX 3 – SOME PROMOTION AND COMMEMORATIVE BANKNOTES IN PORTRAIT STYLE

Giesecke & DeVrient
2001

Commemorative note
Thailand 2004

Orell Füssli
2005

Kurz
2006
ANNEX 4 – SOME PORTRAIT DESIGNED BANKNOTES
EURO BANKNOTE DESIGN CONTEST 1996

Belgium
Brigitte Matoul,
Benoît Grégoire,
Véronique Boland

Finland
Erik Bruun

France
Roger Pfund

The Netherlands
Inge Madlé

United Kingdom
John Stevenson

The Netherlands
Ootje Oxenaar

Germany
Reinhold Gerstetter