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Paying with Polymer:
Developing Canada's
New Bank Notes

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Paying with Polymer: Developing Canada's New Bank Notes

In this article, author Charles Spencer reviews the complex process of developing the new polymer note series, which represents a dramatic change for Canada. The leading-edge security features made possible by the new substrate, the cost savings of the move to a polymer base and the environmental advantages of these notes are also examined.

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Paying with Polymer: Developing Canada's New Bank Notes

Charles Spencer, Currency Department

- *Canada's new polymer bank notes are an important change—the product of an exceptional marriage between design and technology.*
- *The key objective of any new note series is to support confidence in bank notes by staying ahead of counterfeiters, and the new notes contain leading-edge security features that make them among the most advanced in the world.*
- *Development and testing of the new materials and features was a complex process, requiring the support of many stakeholders and suppliers in Canada and abroad. The new notes will also require considerable adaptation of equipment that handles cash in Canada.*
- *Polymer notes will not only be more difficult to counterfeit, but will generate substantial savings for the Bank of Canada and for Canada's cash system, as well as reducing the environmental impact of bank notes.*

Despite the popularity of other means of payment, such as credit and debit cards, and electronic transfers, bank notes remain an important way for Canadians to pay for goods and services. Indeed, the total value of bank notes outstanding continues to grow in line with the overall growth of the economy and reached \$57.9 billion at the end of 2010.

The issue of any new note series directly affects individual Canadians, retailers and participants in the cash-handling system. The note series being launched in 2011 will have a particularly striking impact, since it features a polymer substrate—the material on which bank notes are printed. Canadian bank notes have incorporated technical innovations in the past: multicoloured printing in the 1970s, a colour-shifting security feature applied on bank notes in the 1980s, and features in the substrate in the 2000s. But the change to a new base material, together with the unique security features that it makes possible, is arguably the most dramatic innovation yet. It will be noticed by every Canadian and will also require more than the usual amount of adaptation by financial institutions, retailers and other organizations that handle cash.

What Is Different about the New Notes?

This is the first time that a series of Canadian bank notes will be printed on any material but paper.¹ Bank notes printed on polymer are already in circulation elsewhere. Internationally, the first non-paper notes were produced on a polyethylene material called

¹ In the mid-1990s, the Bank issued 100,000 experimental \$5 notes of the then-current *Birds of Canada* series printed on a substrate consisting of a polymer core with paper on each side to assess their durability. The supplier could not produce the material on a sufficient scale, however, and the Bank discontinued the project.

Tyvek® and issued in three countries in the early 1980s,² but the issues were not successful. Canada's new notes are being printed on Guardian®, a biaxial-oriented polypropylene substrate manufactured by Securrency International of Australia. Guardian® has been used successfully for one or more denominations in 32 countries since it was pioneered by the Reserve Bank of Australia beginning in 1988.

Canada's new notes are unlike other polymer notes, however. In addition to the security provided by the clear "windows" used in most polymer notes to capitalize on the substrate's transparency, notes in the *Polymer* series are the first to have a stripe of holographic foil. The images on the foil, which is placed in a large vertical window, are large, brilliant and complex, and the details and colours can be seen clearly from both sides of the note. A second, smaller window contains a frosted area that, when viewed against a single-point light source, shows a circle of numbers matching the note's value.³ Traditional security features, such as fine-line printing (which produces even sharper images on polymer than on paper) and the intaglio process for printing raised ink, give the new notes a unique look and feel. The new notes also carry innovative features designed to be "seen" only by note-handling equipment to ensure that these machines can authenticate the notes.

The five denominations will each be the same dominant colour as in past series, to help people quickly identify each denomination

The *Polymer* series also retains the features contained in the current *Canadian Journey* series to help the blind and partially sighted to identify notes.⁴ These features—large numerals against contrasting backgrounds, dominant colour schemes, codes that can be read by an electronic reader supplied to the blind, and a system of raised dots in a different pattern for each denomination—were assessed in an independent study commissioned by the Bank in 2008, after the *Canadian Journey* series had been in circulation for several years. The assessment, conducted by the University of Waterloo in collaboration with the Canadian National Institute for the Blind, concluded that the suite of features effectively met the needs of users with a range of visual impairment.⁵ Two areas for improvement were suggested, and both have been addressed in the new notes. The electronic reader will now work on both ends of the notes and, thanks to the characteristics of the polymer substrate, the raised dots will last longer in circulation.



Face of \$100, *Polymer* series

Not every element of our bank notes needed to change. In designing the new series, a conscious decision was made to retain those elements that worked well in earlier series. The notes are therefore the same size, to minimize their impact on note-handling equipment, and the five denominations will each be the same dominant colour as in past series, to help people quickly identify each denomination.

Why a New Series and Why Now?

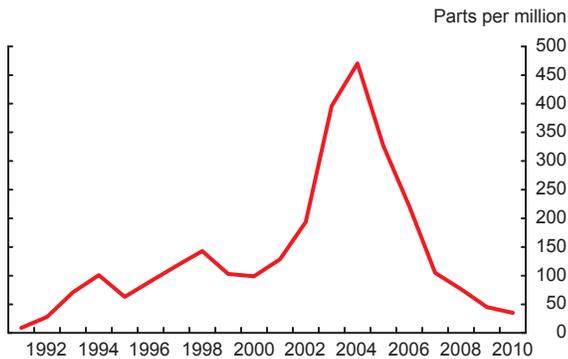
Recent history has demonstrated the importance of staying ahead of counterfeiters. As **Chart 1** illustrates, counterfeiting in Canada increased dramatically between 2001 and 2004, to levels that were very high by Canadian and international standards. Media coverage of counterfeiting was widespread, and Canadians' confidence, particularly in high-denomination bank notes, was put at risk. In some regions in 2002, almost one in ten Canadian retailers displayed a sign indicating that they did not accept \$100 bills, counterfeits of which had triggered the problem in 2001. The Bank responded with a concerted strategy focused on more security in bank notes, training retailers to recognize genuine notes, working with law enforcement to deter counterfeiting, and improving the quality of genuine notes in circulation. This strategy, supported by the release of the current *Canadian Journey* note series with its holographic

- 2 Costa Rica and Haiti issued notes on Tyvek®; the Isle of Man issued one denomination on Tyvek® marketed by its printer Bradbury Wilkinson as "Bradvek" (Eu, Chiew and Straus 2008).
- 3 Hold the note close to your eye and look through the frosted window at a single-point light source, such as a pot light or a household (incandescent) light bulb. Note that it is dangerous to shine a laser pointer through the window into your eye.

- 4 The development of features for the blind and partially sighted is described in Samuel (2009–10).
- 5 The executive summary of the assessment is available on the CNIB website at <http://www.cnib.ca/eng/cnib_document_library/research/final_report_summary_for_cnib_website.doc>.

stripe and other key security features, brought counterfeiting down to the current low level, and almost all retailers are again prepared to accept all denominations of bank notes.

Chart 1: Counterfeit Canadian bank notes passed, 1991–2010



Note: Parts per million is the number of counterfeit bank notes detected in one year for each million genuine bank notes in circulation.

Because counterfeiting techniques are advancing more rapidly than in the past, Canada, like many other countries, expects to issue new bank note series more frequently

Three key lessons from this experience were applied in planning for the next generation of Canadian bank notes. First, a new note series with further improvements in resistance to counterfeiting would be developed and issued *before* a counterfeiting problem arose, because it can be cheaper and more effective to prevent a problem than to fix it. Indeed, confidence in bank notes, once lost, is not easily regained; although 99 per cent of retailers now accept \$10 notes,⁶ the perception persists that these notes are “difficult to spend.” Second, because counterfeiting techniques are advancing more rapidly than in the past, Canada, like many other countries, expects to issue new bank note series more frequently. The *Polymer* series is being launched just short of eight years after the first notes of the striped *Canadian Journey* series were issued in 2004. Third, new notes must be significant improvements over their pre-

⁶ Results of the Bank’s semi-annual survey of retailers are available at <<http://www.bankofcanada.ca/banknotes>>. Follow the links to the Audience-Specific Resources and select Retailers, then Surveys.

decessors. The new security features incorporated in the first versions of the \$10 and \$5 *Canadian Journey* designs were quickly simulated by counterfeiters. In retrospect, the Bank had not invested enough in advanced security features to keep pace with counterfeiters.⁷

With these lessons in mind, the team tasked with developing the new series was given a dual objective: develop new designs with significantly more security, and issue the first note in 2011 with the remainder of the series to follow within two years.

The Next Generation Bank Notes Project

Research and development

Planning for the Next Generation Bank Notes Project began less than a year after the last denomination of the *Canadian Journey* series was issued. It built on the research and development capability that the Bank had marshalled while preparing the *Canadian Journey* series. Between 2001 and 2004, the Bank had assembled a small team of physicists, chemists, engineers and other technical experts, who rigorously evaluated the features available from the bank note industry, and who were capable of developing new security features where gaps existed in what the market offered. In the first phase of the Next Generation Project, this team was harnessed to analyze the present and potential counterfeiting threats to Canadian bank notes and to assess appropriate security features and substrates for possible use in the new series. Specific targets were established for the number of new features needed to assist the public, retailers, machines and the central bank in verifying bank notes. Many potential features from the bank note industry were evaluated, and several technologies were developed in-house in collaboration with industry partners. Indeed, one product from this research program was a patented machine-readable feature that has been commercialized by a partner and will see its first use in the new Canadian polymer notes.

Later phases saw extensive testing of alternatives, in some cases using methods developed by Bank staff. For example, a project to evaluate different technical

⁷ The original *Canadian Journey* \$10 and \$5 notes were upgraded in 2005 and 2006, respectively, and now bear the same holographic stripe and other security features as their higher-denomination counterparts. For a full description of the *Canadian Journey* series and its development, see Moxley, Meubus and Brown (2007).

approaches to intaglio printing (a process that has been used for centuries to produce the distinctive raised ink felt on bank notes) reached conclusions that surprised the security printing industry and led directly to decisions on the layout of designs in the *Polymer* series. Much of the rigour of these studies came from their large scale, from innovative methods that allowed laboratory testing of how well test notes could be distinguished from counterfeits, and from standardized tests to predict how notes would stand up to the wear and tear of handling in circulation. Establishing the manufacturing and printing processes also required extensive testing. In fact, by the time the first notes in the *Polymer* series were printed for circulation, almost 15 million test notes had been produced.

The test methods used will be an important legacy for the development of future note series. Of course, the ultimate test of bank notes occurs when they go into circulation, and the Bank will be closely monitoring the performance of the *Polymer* series notes for years after they are issued.

The new series also benefited from close collaboration with leading peers in the bank note field: mainly other central banks. For example, the Bank of Canada is a member of the Four Nations Group, along with the Reserve Bank of Australia, the Bank of England and the Banco de México. The group shares research results, compares notes on development projects and collaborates on the testing of security features for future bank notes. Work with this group and with other international organizations contributed directly to the development of the new series.

Once the technical analysis was complete, a formal process was used to select the combination of security features and substrate for the new series of notes. The Bank's requirements for a bank note configuration suitable for Canada were provided to a number of leading firms in the bank note industry, and the proposed solutions were subjected to a thorough technical, security and financial evaluation. The combination of polymer substrate and associated security features was found to meet the selection criteria best.

It is essential that business arrangements for bank notes ensure the reliable supply of materials and services throughout the life of a bank note series. A contract was negotiated with Note Printing Australia (NPA), a wholly owned subsidiary of the Reserve Bank of Australia (the Australian central bank) for the supply of polymer substrate and associated security features. The substrate itself will be supplied to NPA by the Australian company Securrency International, and the notes will be printed in Canada by two private sector

security printers, Canadian Bank Note Company Ltd. and BA International Inc., both based in Ottawa.

Organization

In 2006, the Bank took the unusual step of publicly announcing its intention to issue a new note series starting in 2011. The dual objectives of increased security and a deadline helped the project's decision-making process. The project's organization built on that developed for the *Canadian Journey* series and followed best practices in project management, with a formal governance structure, explicit staffing and financial resources earmarked in the Bank's medium-term plans, and clear delineation of roles and responsibilities for all the staff involved. As a result, another legacy of the project has been an improved template for the future organization of such exercises.

Stakeholders were consulted to ensure that their needs were understood, and, where appropriate, some were actively engaged in the development process

The involvement of stakeholders was key to the project's organization. Following their delivery to the Bank from its two private sector printers, new bank notes enter a circulation system that reaches every corner of Canada. Along the way, they are dispensed by bank tellers and by 58,000 automated teller machines,⁸ processed by machines operating at up to 70,000 notes per hour, and accepted by vending machines, ticket dispensers and self-service checkouts of all kinds. They must also be accepted and easily verified by people, including the blind and partially sighted, bank tellers, and cashiers at retail outlets. Law-enforcement officers must be able to establish forensically that the notes are genuine. All these stakeholders were consulted to ensure that their needs were understood, and, where appropriate, some were actively engaged in the development process. For example, manufacturers of the equipment used by financial institutions, armoured carriers and retailers to process and verify bank notes were consulted on a confidential basis and given the opportunity to provide input on note design and to adapt their equipment before the new notes were issued. Likewise, financial institutions and armoured carriers participated in the preparation of plans for introducing the new notes into circulation,

⁸ Source: Interac

Visual Designs for the *Polymer Series*

New images are not the reason behind a new note series. But the images on bank notes are important to Canadians. They want to see in them a reflection of themselves and a representation of Canada to visitors. New designs and images also help users to distinguish between the different series of bank notes. The face of each denomination in the *Polymer series* carries the same portrait subject as in the *Canadian Journey series*: Her Majesty the Queen and former Prime Ministers Macdonald, Laurier, Borden and Mackenzie King. However, new photographs were selected upon which to base engravings that would fit the overall style of the new notes and that would be visibly different from the previous portraits. The most significant changes are on the reverse of the new notes. Expanding on the process developed for the *Canadian Journey series*, the images on the reverse were chosen after consulting Canadians. “Innovation workshops” were held across the country to generate ideas that would meet the high standards required for bank notes. Participants were asked for ideas that promoted Canadian values, conveyed pride and confidence in Canada, were modern and forward looking and, because bank notes have to last for years, would not become outdated. The results were then tested with other groups drawn from the general public and with academics and other experts in relevant fields.

Designers at Canadian Bank Note Company then produced the detailed illustrations for the five

denominations, the first two of which have already been made public and are reproduced below. Three more designs—“Canadian National Vimy Memorial,” “The *Canadian*” train and “*Canadarm2* and *Dextre*”—will be revealed when the \$20, \$10 and \$5 denominations of the *Polymer series* are unveiled some months before each is issued through 2012–13.



\$100 reverse: Medical Innovation



\$50 reverse: CCGS *Amundsen*, Research Icebreaker

for telling their staff and customers about the new notes, and for returning notes of the previous series to the Bank of Canada. The Bank also sought technical advice from forensic experts at the RCMP. And finally, the Bank tested the public’s willingness to accept a change to polymer: sample notes had an enthusiastic reception from participants in focus groups who found them modern, innovative and exciting.

Counting the Cost: The Business Case

Security from counterfeiting was the primary driver of the Next Generation Project, but bank notes must

also be an efficient means of retail payment. Once the choice of bank note configuration was narrowed down to several alternative substrates and their associated security features, the Bank established that polymer presented a unique opportunity to combine excellent resistance to counterfeiting with economy. The cost savings derive from polymer’s lower vulnerability to soiling and other forms of wear and tear. Polymer notes are expected to last much longer in circulation than conventional paper notes. Experience in other countries has varied—some claim that notes last at least four times longer—but the team estimated conservatively that in the Canadian environment the notes would last at least 2.5 times longer, on average, than their paper equivalents.

Polymer presented a unique opportunity to combine excellent resistance to counterfeiting with economy

The initial cost of the polymer notes is about twice that of paper notes, and thus the Bank's budget for producing bank notes will increase significantly in the short term. However, the longer note life will substantially reduce the need to reprint and replace worn notes. This will result in a saving of at least \$200 million, or more than 25 per cent of the total production costs, over the assumed eight-year life of the series, when compared with the option of achieving a similar level of resistance to counterfeiting by adding new security features to paper-based notes. Indeed, the eight-year cost of the new series will be less than that of the *Canadian Journey* series, but the new notes will offer significantly more protection against counterfeiting.

Polymer notes will also have costs and benefits for the broader cash system outside the Bank of Canada. As noted earlier, each time a new note series is issued, the equipment that accepts, processes or dispenses bank notes must be adapted by financial institutions, cash processors, retailers and others that accept bank notes. The cost of these changes is hard to estimate, but for the *Canadian Journey* series in 2004–06, it may have been in the order of \$25 to \$35 million. It will likely be significantly higher for the conversion to polymer, perhaps as much as \$75 to \$100 million. However, the cash system will benefit in the long run from the change to a polymer substrate. Because polymer notes are expected to last longer, the notes in circulation will be of better quality and will allow more efficient processing by financial institutions and other users. In addition, smaller volumes of worn notes will need to be returned to the Bank of Canada at the end of their useful life. The improved security of the new notes will help to keep counterfeiting low and thus maintain confidence among retailers and consumers.

Considering the Environment

The change to polymer will also benefit the environment. The Bank commissioned a life-cycle study of bank notes in Canada, which examined the environmental impact of both the *Canadian Journey* series of cotton-based notes and the new polymer notes. The study looked at the notes “from cradle to grave,” starting with the impact of growing cotton for bank

note paper and of producing the raw material for polymer, and ending with the disposal of the shred after worn bank notes are destroyed. The assessment concluded that since fewer replacement notes will be needed over the life of the series, the *Polymer* series would reduce the environmental impact of the manufacturing process and of transporting new notes to financial institutions and worn notes back to the Bank. Furthermore, when the polymer notes reach the end of their useful life and have been verified and destroyed by the Bank, they will be recycled.⁹

Nothing Is Simple: Managing the Risks

To be successful at resisting counterfeiting, bank notes must be at the leading edge of security technology at the time a new series is issued, and they must also work reliably when hundreds of millions of them are printed and put into circulation. Finding the balance between “leading edge” and “still in R&D” is a constant source of risk in any bank note development project. This risk must be reduced by sound testing and evaluation, and by willingness to defer the use of promising technologies if they are not ready for the ultimate test of large-scale production and circulation.

Testing in collaboration with users was a key strategy in smoothing the transition to a new note series

Innovation also requires adaptation by a wide range of bank note users. To assess the implications of the changes, it was important to understand how people and machines use bank notes. Testing in collaboration with users was a key strategy in smoothing the transition to a new note series.

Where can leading-edge projects look for guidance? Because central banks usually undertake the development of a new note series only at intervals of eight years or more, they look to others, as well as to history, to learn. Central banks share their experiences generously with each other, but such projects are large and complex and are often at risk of not meeting their timelines. The success of the *Polymer* series in meeting its target issue dates stemmed from good

⁹ The report of the life-cycle study is available on our website. Go to <http://www.bankofcanada.ca/banknotes> and follow the links to the *Polymer* series.

documentation and corporate memory of the lessons learned in developing the *Canadian Journey* series, the right expertise on the team, sound project management, the full engagement of partners and stakeholders, and a rigorous testing and decision-making process.

Rolling Out the New Series

As this article goes to press, the designs for the first two denominations of the *Polymer* series, the \$100 and the \$50, have been presented to the public,¹⁰ and preparations are well under way to issue the first new \$100 notes into circulation, starting in November 2011. The first \$50 notes will follow in March 2012.

As each denomination is issued, financial institutions will facilitate the changeover to the new polymer notes by collecting *Canadian Journey* notes of that denomination and notes from older series and returning them to the Bank of Canada for verification and destruction. Based on its experience with the *Canadian Journey* series, the Bank expects the new polymer notes to dominate circulation within two years after all the denominations have been issued. The predominance of one note series—the most recent and most secure—benefits retailers and consumers by requiring them to check only one set of security features. Nonetheless, *Canadian Journey* notes, and indeed notes from all earlier series, retain their face value indefinitely.

The biggest changeover will occur in late 2012, when the \$20 denomination is issued. It is used in automated banking machines and represents over half of all current notes in circulation. The *Polymer* series will be completed in 2013 with the issue of the \$10 and \$5 denominations. In all cases, the designs for the notes will be unveiled several months before the issue date, and the Bank will mount a broad communications program, using traditional and new media, to alert retailers and other users so that they can familiarize themselves with the appearance and features of the new notes before encountering them in circulation.

Conclusion

After a long and complex development process, a new note series is being launched in time—before notes from the *Canadian Journey* series are seriously challenged by counterfeiters. The new series employs innovative technology to deliver increased protection

against counterfeiting at a cost lower than that of the *Canadian Journey* series and with major savings when compared with paper-based notes incorporating additional security features. The new series also reduces the environmental impact of bank notes.

At the same time, the Bank continues its broad strategy for maintaining confidence in Canada's bank notes. Public communications and retailer training will ensure that cash handlers are vigilant in checking notes and detecting counterfeits. The Bank will work closely with law-enforcement agencies and the courts to support the apprehension and conviction of counterfeiters. Together with the financial-institution members of the Bank Note Distribution System, the Bank will work to maintain the quality and authenticity of bank notes in circulation.

Public confidence in bank notes rests fundamentally on notes that are as resistant as possible to counterfeiting while being easy for users to identify as genuine. The Bank believes that the new *Polymer* series meets this objective. Neither counterfeiting nor security technology stands still, however, and, to stay ahead of counterfeiters, the research and development team has already begun assessing and developing security features for the next series of bank notes, or upgrades to the *Polymer* series. This research will exploit the further potential of the polymer substrate and will benefit from the approaches, partnerships and processes developed in this project.

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¹⁰ Go to <<http://www.bankofcanada.ca/banknotes>> and follow the links to the *Polymer* series.