2018 Biennial Report to the Congress

as required by

The Coin Modernization, Oversight, and Continuity Act of 2010 (Public Law 111-302)

United States Mint

Department of the Treasury

April 2019

1. Background

The Coin Modernization, Oversight, and Continuity Act (CMOCA) of 2010, Public Law 111-302 (Act), authorizes the Secretary of the Treasury (Secretary) to conduct research and development (R&D) on alternative metallic materials for all circulating coins with the goal of reducing production costs. The Act also requires the Secretary to provide a biennial report to Congress on the status of coin production costs, cost trends for such production, and possible new metallic material or technologies for the production of circulating coinage.

The United States Mint (Mint), a bureau of the Department of the Treasury, submitted its first biennial report in December 2012, a second biennial report in December 2014, and a third for the year 2016, in June 2017. This report is the fourth biennial report produced as required by the Act.

2. Summary

The Mint manufactures new circulating coins, which supplement Federal Reserve Bank (FRB) coin inventories and meet the needs of commerce through the Nation's banking system. Typically, the Mint's annual production of new circulating coins is the net difference between total demand for circulating coins and total deposits received by the FRB from the banking system. The FRB buys new coins from the Mint at face value. The difference between the face value and the Mint's manufacturing cost is known as seigniorage. The Mint transfers seigniorage to the Treasury General Fund to help reduce the national debt.

3. Production Cost Comparison

Fiscal year (FY) 2018 unit costs are higher than those reported in our 2016 Biennial report. The unit costs for FY 2018 are: pennies (2.06 cents), nickels (7.53 cents), dimes (3.73 cents), and quarters (8.87 cents). The unit cost for both pennies and nickels remained above face value for the thirteenth consecutive fiscal year. While Federal Reserve orders for new coin decreased in FY 2017, orders decreased further in FY 2018. FY 2017 circulating coin shipments to the FRB decreased by 2.2 billion units (13.7 percent) to a total 14.1 billion coins compared to FY 2016. FY 2018 circulating coin shipments to the FRB of 13.7 billion units decreased by 400 million units (2.8 percent) compared to FY 2017.

UNIT COST OF PRODUCING AND DISTRIBUTING COINS BY DENOMINATION

2018	One-Cent	Five-Cent	Dime	Quarter-Dollar
Cost of Goods Sold	$0.0178	$0.0659	$0.0323	$0.0778
Selling, General & Administrative	$0.0025	$0.0085	$0.0045	$0.0099
Distribution to FRB	$0.0003	$0.0009	$0.0005	$0.0010
Total Unit cost	$0.0206	$0.0753	$0.0373	$0.0887

2017	One-Cent	Five-Cent	Dime	Quarter-Dollar
Cost of Goods Sold	$0.0156	$0.0564	$0.0284	$0.0711
Selling, General & Administrative	$0.0024	$0.0088	$0.0045	$0.0103
Distribution to FRB	$0.0002	$0.0008	$0.0004	$0.0010
Total Unit cost	$0.0182	$0.0660	$0.0333	$0.0824

2016	One-Cent	Five-Cent	Dime	Quarter-Dollar
Cost of Goods Sold	$0.0131	$0.0551	$0.0269	$0.0672
Selling, General & Administrative	$0.0017	$0.0071	$0.0034	$0.0080
Distribution to FRB	$0.0002	$0.0010	$0.0005	$0.0011
Total Unit cost	$0.0150	$0.0632	$0.0308	$0.0763

4. Research and Development

The Act authorizes the Secretary to conduct R&D on "possible new metallic materials or technologies for the production of circulating coins." The Act also specifies that before the second anniversary of its enactment, and biennially thereafter, the Secretary shall submit a report to Congress, analyzing production costs for each circulating coin, cost trends for such production, and possible new metallic materials or technologies for the production of circulating coins.

The Mint has performed diligent research for the last eight years to identify materials that satisfy the requirements of the Act, eliminating from consideration those that do not. As a result, the Mint has narrowed the wide field of elements and metallic alloys to several potential "seamless" alloys (meaning they would require no changes to coin-accepting equipment, but offer incremental savings), and a small number of potential "co-circulate" alternatives (meaning they would offer greater material savings, but coin-accepting equipment would require changes for the new coins to co-circulate with current coins) that would only see use in the 5-cent coin or in the 5-cent and dime coins.

In December 2012, the Mint delivered to the Congress the first (Phase I) biennial report in which it outlined six potential alloys to replace the current material. During the Phase II study, the Mint determined several of those materials not to be feasible for U.S. coinage. In December 2014, the Mint delivered the second (Phase II) biennial report, which detailed the results of testing and evaluation of the initial alternatives and contained recommendations to further research a refined set of alternative materials. Phase III of the study involved more testing and evaluation to refine the identified alternatives along with research and development to identify other unique possibilities. This report provides an update on the Mint's study to identify and evaluate potentially seamless and co-circulate alternatives.

A. Alternative Materials

The materials that underwent more extensive evaluation during this period are:

- 80/20: A variation on the present cupronickel (75% copper (Cu)/25% nickel (Ni)), with more Cu, less Ni, and some manganese (Mn). Nominal composition of 77% Cu, 20% Ni, and 3% Mn.

- C99750T-M: A leaner potentially seamless alloy developed jointly with the National Institute of Standards and Technology (NIST), which contains less Cu and Ni and substitutes zinc (Zn) and Mn. Nominal composition 50.75% Cu, 14% Ni, 33% Zn, and 2.1% Mn. This alloy represents what we believe to be the leanest or lowest material cost possible. It also maintains the key seamless characteristics of electromagnetic signature (EMS) and color.

- Nickel Steel: A monolithic alloy developed by the Mint, which is austenitic (not attracted to magnets) and a less expensive co-circulate alternative to stainless steel. Nickel content is 25%, with the balance being lower cost iron and some manganese.

- Nickel Plated Silicon Steel: An alternative to the commonly used nickel or multi-ply plated steels in the world. This option could provide a co-circulate alternative with a distinguishable EMS and therefore more security than other commonly available plated steel coins.

A cost comparison table provided as attachment 1 estimates the material cost, total unit cost, and annual savings versus current coin compositions. The unit cost projections and resultant annual savings are very sensitive to fluctuations in metal cost and production volumes[1] so the estimates should be used as relative or directional and not budgetary.

With the prior research and the work accomplished this period, the following table summarizes the identified potential alternatives:

[1] Since a portion of the unit costs are distributed fixed production costs, overhead, and General & Administrative, changes in annual coin volumes can significantly affect the unit cost and projected savings.

Alternative	Seamless/Co-Circulate	Denominations	Testing Status
80/20	Potentially Seamless	5¢, 10¢, and 25¢	Full First Article qualifications complete with external validation by three coin acceptor manufacturers (CAMs).
C99750T-M	Potentially Seamless	5¢, 10¢, and 25¢	Small scale testing completed with samples validated by three external CAMs. Larger scale tests would be required to confirm production capable and confirm seamless.
Multi-ply Plated Steel (MPPS)	Co-Circulate	5¢ and 10¢	Large pre-production scale testing completed, would need First Article qualification.
Nickel Plated Steel (NPS)	Co-Circulate	5¢ and 10¢	Large pre-production scale testing completed, would need First Article qualification.
R52 Stainless (monolithic)	Co-Circulate	5¢ only	Small scale feasibility testing completed with limited external CAM testing.
Nickel Plated Silicon Steel	Co-Circulate	5¢ and 10¢	Small scale feasibility testing completed with limited external CAM testing.
Nickel Steel (monolithic)	Co-Circulate	5¢ only	Small scale feasibility testing completed with limited external CAM testing.

The first two materials in the above chart are potentially seamless materials, meaning that they are intended to work in current coin-accepting and handling equipment without modification. Extensive testing has been conducted on 80/20 monolithic 5-cent, and 80/20 clad 10-cent and 25-

cent denominations (half-dollar coins were not tested [2]) including comprehensive 1st Article qualification of both current strip suppliers and both circulating production facilities. In addition, the Mint conducted testing with three major CAMs to validate that the 80/20 is seamless with current U.S. cupronickel and cupronickel clad coins. The test used the CAMs' equipment. The C99750T-M material is potentially seamless for the 5-cent piece. It has the same EMS, dimensions, and piece weight as the current material. It is also a potentially seamless replacement for the cladding material of the dime, quarter-dollar, and half-dollar. Given that the major portion of clad coins is the copper core, the material savings from a change in the cladding composition are not significant. More development work is needed along with larger scale testing to establish C99750T-M as a viable seamless alternative; this is expected to take two years.

The remaining materials in the summary are co-circulate alternatives, meaning they do not have the same EMS, or piece weight, as that of the current U.S. coinage material. Co-circulate materials offer greater material savings, but would require modifications to coin-accepting and handling equipment.

The co-circulated materials listed—NPS, MPPS, and R52 Stainless—have been tested and evaluated, and details have been provided in earlier reports. The last two were alternatives developed by the Mint.

Nickel Steel is a lower cost alternative to stainless steel that was tested earlier. It is also austenitic (non-magnetic) with superior wear and corrosion resistance as compared to the current 5-cent. Its EMS and the monolithic construction mean it would be appropriate only for the 5-cent coin[3]. The Mint determined that Nickel Steel is viable for coining based on small scale testing. More extensive testing would be required to fully assess its coinability and production capability. It does not exhibit the mottled or orange peel appearance associated with the R52 stainless steel alternative tested earlier.

The Mint also developed another potentially unique co-circulate alternative – Nickel Plated Silicon Steel. The distinctive conductivity characteristics of silicon steel (also referred to as electrical steel), as compared to the low carbon steel used by other countries as a core material for plated coins, could provide a means of discriminating from the more commonly available nickel or multi-ply plated coins used by many countries. More extensive testing would be required to fully assess its viability.

---

[2] Testing for 80/20 was only completed on the dime and quarter-dollar, given the same clad construction the testing can readily be extrapolated to the half-dollar.

[3] If both denominations were made from the same monolithic material, the larger 5-cent could be counterfeited into the smaller but higher value 10-cent.

B. Production Improvements

The coin striking process is a whole system, no part of which can be changed without affecting another. These aspects include not only die shape and stamping force, but also level of detail, sharpness of transitions, and relief height in the coin's design; overall curvature of the coins' faces; and the upsetting process (which deforms the blank's material to the planchet's rim). The Mint considers these factors in optimizing the coin design.

During this current study, the Mint conceived an optimized system for the 5-cent coining process that can increase die life by modifying upset profiles and practices, as well as changing the geometry of the dies themselves together with subtle changes to the dies' designs that do not negatively affect the approved design or appearance. Specifically, matching planchet upset and die curvatures will reduce coining pressures around the coin edge, producing more uniform normal pressures. This "matched system" would enable coining presses to use less stamping force and still obtain optimal detail in the coins produced using current coinage materials. Less stamping force results in longer die life. Production testing has confirmed the effectiveness of this approach, and larger scale testing is currently in progress. Once completed, these refinements can be incorporated into the standard 5-cent design and testing undertaken to transition the approach to other denominations.

Matching planchet and die curvatures will also be beneficial when considering alternative materials, which in many cases are harder than current cupronickel. Greater hardness increases the coins' wear resistance, but the striking tonnage must be increased to get the same level of detail in the new coins as in the old ones. This greater striking pressure would reduce the die life and increase the stamping process cost. After the upset and die modifications, these harder new materials could be stamped to get the same image detail with the same tonnage as current production.

The Mint saw promising results when the "matched system" was used on the current coinage material, alternative materials, and also with pushback-blanked material (as opposed to conventional blanked material). Beyond that, the optimization also shows great promise with other circulating denominations, whether alternative materials or current materials are used. The Mint contracted with an independent company to perform a study on the formation of the coins' rims in the optimized design. The contractor used a prototype upsetting tool and tested several different profiles and methods of upsetting blanks and determined that a tapered upset with a concave facing formed the best rims of coins, and that tapered upset with a convex facing was nearly as good. Continued testing and evaluation are in progress. Push Back Blanking (PBB) is a blanking process which cuts blanks from coils of material annealed by an external supplier versus the current process of cutting the blanks from the cold rolled coil first (the harder cold-rolled strip facilitates blanking with our conventional blanking process, a special blanking die is necessary for the "softer" annealed strip) and then annealing the blanks internally.

C. Findings and Conclusions

The Mint tested and evaluated both seamless and co-circulate during this period, resulting in the development of two unique co-circulate alternatives. In addition, the Mint continued to develop and evaluate of several concepts to improve the production of circulating coin.

a) Seamless Materials

1. After extensive testing, the Mint determined 80/20 to be a potentially seamless alternative for producing 5-cent (monolithic), 10-cent, and 25-cent (when bonded to a copper core) circulating coins that matches the current materials' key characteristics of EMS, color, and piece weight. The Mint completed qualification of the strip suppliers and the Mint production processes and three major CAMS completed external validation.

2. The Mint tested C99750T-M, a potentially seamless alternative developed by the Mint, on a small scale internally with CAM validation externally. It shows promise of being able to further reduce the material costs while still being able to work in current coin-accepting and -handling equipment without modification. The Mint recommends larger scale testing and development to determine if C99750T-M is a viable seamless alternative.

b) Co-Circulate Materials

1. The Mint developed two unique co-circulate alternatives, Nickel Steel and Nickel Plated Silicon Steel, and completed initial testing to confirm coinability and coin recognition/sorter signature. The Mint recommends larger scale tests to fully evaluate them as viable co-circulate alternatives.

c) Production Improvement

1. Tests involving changing the geometry of the 5-cent dies, together with subtle changes to the dies' designs that do not negatively affect the approved design or appearance, have shown improved die life in production trials. The Mint recommends continued testing with migration to other denominations and incorporation into future designs.

2. The Mint completed structured trials with various rimming profiles on the 5-cent coin. The results show promise and can yield incremental efficiencies in the production of circulating coin and other Mint products, so development work should continue. The Mint recommends small-scale coining trials continue followed by production-scale die life testing. Objective data gathered during these coining trials will be used to develop a

Finite Element Analysis (FEA) model to reduce the need for as many trials in the future and enable the application of the optimization to other Mint products.

5¢	Annual Volume	Weight (grams)	Metal Cost	Supplier Fabrication	Metal + Supplier Fab + USM Direct Production	Total Unit Cost	% Savings	Savings Compared to FY-18 5¢ AUDITED 1,306 M Coins	Notes
FY16 5¢ Audited	1,578 M	5.00	$0.0326	$0.0077	$ 0.0444	$ 0.0632	-15.1% To FY15		a
FY17 5¢ Audited	1,306 M	5.00	$0.0344	$0.0077	$ 0.0461	$ 0.0660	4.4% To FY16		b
FY18 5¢ Audited	1,327 M	5.00	$0.0442	$0.0082	$ 0.0562	$ 0.0753	14.1% To FY17		c
80-20Cu-Ni Solid		5.00	$0.0327	$0.0077	$ 0.0444	$ 0.0643	-2.6%	$ 2,220,200	e
Multi-Ply plated steel (p)		4.37	$0.0286		$ 0.0307	$ 0.0506	-23.3%	$ 20,112,400	q
Nickel plated steel (p)		4.40	$0.0282		$ 0.0303	$ 0.0502	-23.9%	$ 20,634,800	q
Rittenhouse 52 Stainless Steel (s)		4.61	$0.0328		$ 0.0375	$ 0.0574	-13.0%	$ 11,231,600	q
Nickel Steel Monolithic -Alt - M (s)		4.61	$0.0156	$0.0077	$ 0.0273	$ 0.0472	-28.5%	$ 24,552,800	e
C99750T-M (s)		5.00	$0.0274	$0.0077	$ 0.0391	$ 0.0590	-10.61%	$ 9,142,000	e

10¢	Annual Volume	Weight (grams)	Metal Cost	Supplier Fabrication	Metal + Supplier Fab + USM Direct Production	Total Unit Cost	% Savings	Savings Compared to FY-18 10¢ AUDITED 2,410 M Coins	
FY16 10¢ Audited	3,134 M	2.27	$0.0130	$0.0071	$ 0.0220	$ 0.0308	-13.% To FY15		a
FY17 10¢ Audited	2,410 M	2.27	$0.0135	$0.0071	$ 0.0228	$ 0.0333	8.1% To FY16		b
FY18 10¢ Audited	2,381 M	2.27	$0.0174	$0.0074	$ 0.0269	$ 0.0373	12.% To FY17		c
80-20 Cu-Ni Clad (cs)		2.27	$0.0132	$0.0071	$ 0.0225	$ 0.0330	-0.9%	$ 723,000	e
Multi-Ply plated steel (p)		2.00	$0.0221		$ 0.0231	$ 0.0319	-4.2%	$ 3,374,000	e
Nickel plated steel (p)		2.00	$0.0131		$ 0.0141	$ 0.0229	-31.2%	$ 25,064,000	e
C99750T-M Clad (cs)		2.27	$0.0125	$0.0071	$ 0.0218	$ 0.0323	-3.00%	$ 2,410,000	e
Plated Silicon Steel ALT - P (p)		2.00	Unable to estimate at this time, would be similar to Nickel plated steel						

25¢	Annual Volume	Weight (grams)	Metal Cost	Supplier Fabrication	Metal + Supplier Fab + USM Direct Production	Total Unit Cost	% Savings	Savings Compared to FY-18 25¢ AUDITED 1,926 M Coins	Notes
FY16 25¢ Audited	2,482 M	5.67	$0.0303	$0.0176	$ 0.0533	$ 0.0763	-9.6% To FY15		a
FY17 25¢ Audited	1,926 M	5.67	$0.0336	$0.0176	$ 0.0568	$ 0.0824	8.% To FY16		b
FY18 25¢ Audited	1,895 M	5.67	$0.0448	$0.0190	$ 0.0677	$ 0.0887	7.6% To FY17		c
80-20 Cu-Ni Clad (cs)		5.67	$0.0330	$0.0176	$ 0.0562	$ 0.0818	-0.7%	$ 1,155,600	e
C99750T-M Clad (cs)		5.67	$0.0310	$0.0176	$ 0.0542	$ 0.0798	-3.16%	$ 5,007,600	e

Notes:
a = FY16 Audited
b = FY17 Audited
c = FY18 Audited
e = Estimate
q = Supplier quote

Assumptions:
> FY18 unit cost data is from Audited FY18.
> U.S. Mint production, G&A and distribution costs are from Audited FY18.
> Volumes are from Audited FY18.
> Savings are calculated against Audited FY18 unit costs and volumes

Key:
(cs)=clad strip
(p)=plated
(s)=strip

ATTACHMENT 1