

**2022 Biennial Report
to Congress as Required by the
Coin Modernization, Oversight,
and Continuity Act of 2010
(Public Law 111-302)**



United States Mint
Department of the Treasury

2022

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Background

The United States Mint (Mint) has three primary missions: it mints and issues circulating coins; produces and distributes numismatic items; and provides security and asset protection. Since 1996, the Mint's operations have been funded through the Public Enterprise Fund (PEF) (31 U.S.C. 5136). The operations of the Mint are divided into two major lines of business, or components: circulating coinage and numismatic products. Finances for circulating coinage and numismatic products are accounted for separately. Receipts from circulating coinage operations are not used to fund numismatic operations, and receipts from numismatic operations are not used to fund circulating coinage operations.

The Mint generates revenue through the issuance of circulating coins to the Federal Reserve Banks (FRBs), the sale of numismatic products to the public, and the sale of bullion coins to authorized purchasers. The difference between the face value of circulating coins and the full cost of producing the coins is called seigniorage, which is transferred periodically to the Treasury General Fund to help finance the national debt. The Mint submits annual audited financial statements to the Secretary of the Treasury (Secretary) and to the Congress in support of the operations of the PEF.

The Coin Modernization, Oversight, and Continuity Act of 2010 (Act) authorizes the Secretary to conduct research and development (R&D) on alternative metallic materials for all circulating coins with the goal of finding methods to reduce 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 Mint submitted its first biennial report in December 2012. Subsequent to that initial report, four others were submitted—in 2014, 2016, 2018, and 2020. This report is the sixth biennial report produced as required by the Act.

In each report, including this one, the Mint provides options for reducing costs, thereby improving revenue, through changing the metal composition of circulating coins, but to date, Congress has not authorized the Mint to take any action based on the Mint's recommendations.

Executive Summary

During the past two years, the Mint has continued research and development of alternative metals for modernizing coins and improving general production. Those efforts are aimed at finding alternative compositions that will be less costly and seamless¹ to the general public, coin handling industry, and vending machine operations/usage.

At this time, the Mint has identified one solution that could be ready to implement approximately one year after an authorization by Congress, as well as a few other compositions that future testing may determine to yield even more cost savings.

The alternative 80/20 cupronickel has completed testing and is ready to be authorized for production. Once authorized, it will go through final validation and preparations to start full production for the 5-cent (nickel), 10-cent (dime), 25-cent (quarter dollar), and 50-cent (half dollar) coins. This alternative metal would be seamless, and would improve revenue. If this alternative metal had been available for production in 2022, the Mint estimates that it could have increased seigniorage by an estimated \$12 million.

Additionally, the Mint is researching two forms of C99750² that show promise as a seamless alternative metal for coining. That research is ongoing and may yield additional savings in the future.

The Mint has also continued to research alternatives to the copper-plated penny. While the alternative metals so far may not yield any cost savings, the current penny composition has only one identified supplier capable of providing planchets³ for production. Having a single supplier is a significant risk, one the Mint recommends Congress consider when reviewing possible future legislation.

The Mint continues to support efforts that would allow the Mint to implement alternative metals when certain criteria are met. Legislation such as the Coin Metal Modification Authorization and Cost Savings Act (H.R. 1789 and S. 672 in the 117th Congress) would grant the Mint authority to act on its R&D for seamless solutions when they offer cost savings and have minimal adverse impact on the public and stakeholders.

In addition to alternative metal R&D, the Mint also researched production improvements, with a modified coin design and planchet upset to improve die life. So far, these tests have not yet resulted in effective process improvements. Further details on production improvements are included in section B of the appendix.

Finally, the biennial report is also required to provide the status of coin production costs and cost trends for such production. FY 2022 unit costs are higher than those reported in our 2020 biennial report. The unit cost for both pennies and nickels remained above face value for the 17th consecutive Fiscal Year. FRB orders for new coins decreased in FY 2021 and FY 2022. Since FY 2020, costs of supplies and materials for the production of the Nation's coins have increased significantly. The average price of copper, nickel, and zinc, the primary metals in each coin, have increased each year, resulting in an overall increase in the cost of metal for each denomination.

¹ “Seamless” means the alternative metal will result in no discernible difference to the general public and minimal adverse impact to other stakeholders like the coin handling equipment or vending industry.

² C99750 is an alternative metal alloy comprised of copper, nickel, zinc, and manganese.

³ Planchets are the blank rounds, or disks, that are pressed into coins.

Analysis of Alternatives Metals for Coin Production⁴

The below table provides data on the alternative metals tested between 2020 and 2022.

Table 1 - Revenue, Status, Benefits, and Risks of Alternative Metal Options

Alternative Metal Option	Est. Increased Revenue per Year, Based on 2022 Production Levels	Status	Benefits	Risks
80/20 Cupronickel (5¢, 10¢, 25¢, 50¢)	\$12,000,000	<ul style="list-style-type: none"> Completed large-scale production test in 2015. During 2020-2022, tested one supplier's additional samples to confirm improved bonding process and avoid corrugation of metal layers. 	<ul style="list-style-type: none"> All tests to date have shown this alternative is seamless. This particular version of the alloy is not commercially available off the shelf, so it is more resistant to counterfeiting. Existing suppliers can still be used without significant changes to their operations. Compatible with Mint coin manufacturing operations. 	<ul style="list-style-type: none"> Testing to validate seamlessness was conducted in 2015. Once authorized, the Mint will conduct final validation testing to verify both cupronickel suppliers continue to maintain seamless expectations for coin processors and the vending industry during large-scale production.
Original C99750T-M (5¢, 10¢, 25¢, 50¢)	\$51,000,000	<ul style="list-style-type: none"> Discontinued research on this alloy and shifted to Low and High Mn versions of this alloy. See next two rows of chart. 	<ul style="list-style-type: none"> Potentially seamless. This particular version of the alloy is not commercially available off the shelf, so it is more resistant to counterfeiting. Compatible with Mint coin manufacturing operations. 	<ul style="list-style-type: none"> Strip manufacturing issues may exist (hot rolling, strip bonding, etc.) Large-scale testing would be needed with both cupronickel suppliers to verify that this alloy remains fully seamless for coin processors and the vending industry during large-scale production. Discernible color difference to cupronickel.
C99750T-M (Low Mn) (5¢, 10¢, 25¢, 50¢)	\$12,900,000	<ul style="list-style-type: none"> Received 5¢ blanks for small-scale testing in 2022. Seamless validation, to include Coin Acceptor Manufacturers (Scheduled completion- 2nd Qtr. FY23). Assuming testing is successful and further investigating is warranted, order blanks for 10¢ and 25¢ small-scale testing prior to first large-scale production test. 	<ul style="list-style-type: none"> Potentially seamless. This particular version of the alloy is not commercially available off the shelf, so it is more resistant to counterfeiting. Compatible with Mint coin manufacturing operations. More metal cost savings than 80/20 cupronickel. 	<ul style="list-style-type: none"> Discernible color/appearance differences to existing cupronickel may still exist. Strip manufacturing issues may exist. To be determined. Large-scale testing is still needed with both cupronickel suppliers to verify that this alloy remains fully seamless for coin processors and the vending industry during large-scale production.
C99750T-M (High Mn) (5¢, 10¢, 25¢, 50¢)	\$24,200,000	<ul style="list-style-type: none"> Received 5¢ blanks for small-scale testing in 2022. Seamless validation, to include Coin Acceptor Manufacturers (Scheduled completion- 2nd Qtr. FY23). Assuming testing is successful and further investigating is warranted, order blanks for 10¢ and 25¢ small-scale testing prior to first-large-scale production test. 	<ul style="list-style-type: none"> Potentially seamless. This version of the alloy is not commercially available off the shelf, so it is more resistant to counterfeiting. Compatible with Mint coin manufacturing operations. More metal cost savings than 80/20 cupronickel. 	<ul style="list-style-type: none"> Discernible color/appearance differences to existing cupronickel may still exist. Strip manufacturing issues may exist. To be determined. Large-scale testing is still needed with both cupronickel suppliers to verify that this alloy remains fully seamless for coin processors and the vending industry during large-scale production.

⁴ Please see appendix, section A, for more technically focused details.

Table 1 - Revenue, Status, Benefits, and Risks of Alternative Metal Options (continued)

Alternative Metal Option	Est. Increased Revenue per Year, Based on 2022 Production Levels ⁵	Status	Benefits	Risks
Nickel-Steel (10¢, 25¢, 50¢)	N/A	<ul style="list-style-type: none"> Discontinued as of 2022. 	<ul style="list-style-type: none"> Potentially seamless for 10¢, 25¢, and 50¢. This version of the alloy is not commercially available off the shelf, so it is more resistant to counterfeiting. 	<ul style="list-style-type: none"> This alloy is not seamless for 5¢ coins. Market research identified there are no existing large capacity suppliers capable of providing this alternative metal in form that can be made into coins. Limited recyclability. High probability of significant strip manufacturing issues that must be overcome prior to transitioning into production. High probability that Mint manufacturing operations must be modified (die coating, high temperature annealing, blank prep/lubrication, etc.). The seamless nature of this alternative metal may be adversely impacted by extremely high and/or extremely low ambient temperatures.
Copper Plated Steel (CPS) (1¢)	Potential for decreased revenue	<ul style="list-style-type: none"> Small-scale tests will be completed by 2023. Large-scale testing is on hold. 	<ul style="list-style-type: none"> Potentially seamless. The current penny has only one supplier of planchets. This alternative opens use of multiple suppliers for a more robust and secure pipeline. No adverse impacts to Mint penny manufacture (no die coatings, no evidence of premature die failures, normal circulating stamping tonnage, etc.). 	<ul style="list-style-type: none"> Potential for greater costs than current copper plated zinc (CPZ). CPS blank capacity insufficient to supply Mint forecasted penny demand. Production scale stamping may uncover issues with die fatigue failures, die wear, CPS planchet incompatibility with existing stamping practices. To be determined if large-scale testing occurs.

⁵ Savings estimate based on 2022 data both on costs per unit and 2022 annual volume for all affected denominations combined. See Appendix for more information.

Details of Research and Development⁶ 2020-2022

Further Improvements for 80/20

Ongoing testing identified that one of the two suppliers for 80/20 had provided dime and quarter coils with excessive corrugation.⁷ In 2020, this supplier made improvements to their strip bonding processes to address this corrugation and supplied the Mint with improved dime and quarter coin blanks for limited stamping trials and analysis. Testing validated that the improved bonding reduced corrugation to a level comparable to the alloy currently used in circulated coins and is acceptable. This alternative metal option is ready for Congress to authorize for implementation. If this alternative metal had been used for production in 2022, it would have produced an estimated additional \$12 million in seigniorage for the Treasury General Fund.

If Congress chooses to implement this alternative metal, the Mint will need approximately one year for final validation of large-scale production before starting production for general circulation in the following calendar year.

C99750T-M

In 2020, the Mint and one of its suppliers developed a test matrix to validate whether this alloy would be seamless across strip manufacturing tolerance ranges for thickness and composition. The supplier manufactured 21 C99750 alloy test lots with varying chemical compositions and blank thickness, and the Mint confirmed that C99750T-M would indeed be seamless.

Because of the golden hue of this alloy, the Mint explored developing C99750 alloy variants with similar visual appearance as 75/25 cupronickel, as well as seamless for EMS, weight, and dimensions.

Also in 2022, the C99750 supplier submitted 14 sample color lots to the Mint for internal testing. After testing, two C99750 alloy variants were selected for further evaluation: C99750T-M (low manganese) and C99750T-M (high manganese). Monolithic nickel blanks in these two alloy variants were recently received and are now undergoing testing. Once testing of the blanks is completed, one C99750 alloy variant will be selected for manufactured dime and quarter testing in larger quantities to confirm seamlessness and analyze manufacturability and associated costs.

Once the more desirable alloy is selected, large-scale production testing will be conducted in 2024. Assuming testing is successful, one of these two alternative metals will be ready for full production by 2027.

Based on 2022 production quantities and dollars, C99750T-M (low manganese) could improve seigniorage by an estimated \$12.9 million per year, and C99750T-M (high manganese) could improve seigniorage by an estimated \$24.2 million per year.

⁶ Expounded technical details for all listed alternative metals are available in the appendix.

⁷ Excessive corrugation is the thickness variation (waviness) of outer clad layers to a degree that adversely affects EMS (electromagnetic signature), which may increase coin rejection rates in vending machines.

Nickel-Steel

During 2020 and 2022, the Mint conducted extensive market research for a supplier who could provide coin blanks for stamping. Unfortunately, a supplier could not be located for the quantities needed for production. Additionally, the Mint determined that the scrap produced during blanking can only be recycled into specialty steels and cannot be melted down and reused for additional coin blanks.

Originally, this alloy showed promise; small-scale evaluations have shown that nickel-steel clad to a copper core to be seamless for the dime, quarter, and half dollar.

However, because of both the complications of recyclability and lack of suppliers, the Mint does not recommend further development of nickel-steel as a seamless alternative.

Copper Plated Steel (CPS) Penny

During 2020 and 2022, development and testing of the CPS penny was conducted in two phases: (1) small-scale test strikes and design verification, and (2) extended large-scale stamping trials. Test strikes were conducted to develop CPS planchet specifications and to identify modifications to current circulating designs for optimal performance when stamping CPS planchets.

During summer 2022, the extended stamping trials were completed, and results suggested that transitioning to CPS penny production would not adversely affect stamping performance, shorten die life, or require coating circulating dies. Further small-scale evaluations are still underway to optimize CPS penny planchet hardness and dimensional specifications.

CPS development also involved conducting market research of existing and potential CPS planchet suppliers. This research revealed that global CPS manufacturing capacity is not sufficient to meet Mint forecasted penny demand. Therefore, under current conditions, CPS can be a viable alternative only as a co-production⁸ option. Additionally, this alternative metal could possibly cost more than the existing penny; as such, this alternative is not anticipated to provide any increase to seigniorage. More research is needed to fully understand the costs for this alternative. However, considering there is currently only one supplier of current penny planchets,⁹ there is a real risk to the supply chain for manufacturing this coin for circulation. Because of the risk to the supply chain, this alternative metal may be worth considering in the future as a co-production option, and therefore worth continued research.

Work is underway to complete optimization, and large-scale production trials will be conducted if determined appropriate.

⁸ Co-production: producing different varieties of the same product in different facilities.

⁹ Current pennies are made from copper-plated zinc. Only one supplier in the global market provides the planchets for penny production.

Production Cost Update for 2020 through 2022

The Act requires a biennial report on the status of coin production costs and cost trends for such production. Table 2 below provides an at-a-glance review of the costs. FY 2022 unit costs are higher than those reported in our 2020 biennial report. The unit costs for FY 2022 are as shown in Table 2: pennies, 2.72 cents; nickels, 10.41 cents; dimes, 5.03 cents; and quarters, 11.09 cents. The unit cost for both pennies and nickels remained above face value for the 17th consecutive FY. FRB orders for new coins decreased in FY 2021 and FY 2022. FY 2021 circulating coin shipments to the FRB decreased by 0.8 billion units (5.0%) to a total of 14.7 billion coins compared to FY 2020. FY 2022 circulating coin shipments to the FRB of 12.1 billion units decreased by 2.6 billion units (17.6%) compared to FY 2021. Further information about production financials can be found in the appendix section C tables.

Since FY 2020, costs of supplies and materials for the production of the Nation’s coins have increased significantly. The average price of copper, nickel, and zinc, which are the primary metals in each coin, have increased each year, resulting in an overall increase in the cost of metal for each denomination. The average daily price for copper per metric tonne increased 57.5% from FY 2020 to FY2022, while nickel and zinc have increased 81.2% and 61.7%, respectively.

Table 2 - Unit Cost of Producing and Distributing Coins by Denomination

2022	One-Cent	Five-Cent	Dime	Quarter-Dollar
Cost of Goods Sold	\$0.0243	\$0.0918	\$0.0442	\$0.0975
Selling, General & Administrative	\$0.0026	\$0.0109	\$0.0054	\$0.0118
Distribution to FRB	\$0.0003	\$0.0014	\$0.0007	\$0.0016
Total Unit cost	\$0.0272	\$0.1041	\$0.0503	\$0.1109

2021	One-Cent	Five-Cent	Dime	Quarter-Dollar
Cost of Goods Sold	\$0.0181	\$0.0743	\$0.0386	\$0.0843
Selling, General & Administrative	\$0.0026	\$0.0095	\$0.0047	\$0.0106
Distribution to FRB	\$0.0003	\$0.0013	\$0.0006	\$0.0014
Total Unit cost	\$0.0210	\$0.0851	\$0.0439	\$0.0963

2020	One-Cent	Five-Cent	Dime	Quarter-Dollar
Cost of Goods Sold	\$0.0151	\$0.0653	\$0.0326	\$0.0760
Selling, General & Administrative	\$0.0022	\$0.0080	\$0.0042	\$0.0091
Distribution to FRB	\$0.0003	\$0.0009	\$0.0005	\$0.0011
Total Unit cost	\$0.0176	\$0.0742	\$0.0373	\$0.0862

Recommendations

Currently, Congress must pass a law to either specifically make changes to statutory coin composition or provide authority for the Mint to change to an alternative metal under certain conditions.

The Mint recommends granting authority to the Department of the Treasury, specifically the Mint, to act on R&D for seamless solutions that reduce costs and have minimal adverse impact as possible on the public and stakeholders. There is already legislation, introduced both in the 116th and 117th Congresses, that would provide that type of authority (the Coin Metal Modification Authorization and Cost Savings Act, H.R. 1789 and S. 672). Enacting this legislation would allow the Mint to act in real time on various alternative metals. This would help to address market fluctuations in metals; proactively reduce risk of supply chain problems; make counterfeiting coins more difficult; and, most important, reduce costs.

Alternatively, the Mint recommends granting authority to the Department of the Treasury to produce coins with the 80/20 alternative metal for nickels, dimes, quarters, and half-dollar denominations. Based on 2022 production levels, this could increase revenue by approximately \$12 million per year, and it is the one alternative metal that has completed its full research. Once authorized, the Mint would need approximately one year for final supplier validation for large-scale production before starting production for general circulation in the next calendar year.

Appendix

A. Expounding Further on Alternative Materials Research Completed in 2020 through 2022

Table 3 summarizes all identified potential alternatives evaluated by the Mint both during this period as well as past research in prior years, including whether they are seamless or co-circulating, the denominations they are applicable to, and the testing status or readiness for implementation:

Table 3 - All Identified Potential Alternatives (Past and Present) Evaluated by the Mint

Alternative	Seamless/ Co-Circulate	Denominations ¹⁰	Testing Status/ Readiness for Implementation
80/20	Seamless	5¢, 10¢, and 25¢	Full First Article qualifications of Mint production and current supplier capability complete with external validation by three coin acceptor manufacturers (CAMs).
C99750T-M	Potentially Seamless	5¢	Small-scale testing completed with samples validated by three external CAMs. During CY2022 further small-scale testing is underway to optimize alloy color, composition, manufacturability and coin blank dimension specifications. <i>Small-scale testing will follow by large-scale (First Article) testing to confirm capability and confirm seamless.</i>
Copper Plated Steel (CPS)	Seamless	1¢ only	Large-scale tests were completed during CY2022 to determine coining production impacts, determine economic potential, and define planchet specifications. <i>Continuing smaller scale testing to optimize/finalize planchet specifications.</i>
Multi-ply Plated Steel (MPPS)	Co-Circulate	25¢	Large pre-production scale testing completed, would need First Article qualification. <i>No additional testing or evaluation this period.</i>
Nickel Plated Steel (NPS)	Co-Circulate	25¢	Large pre-production scale testing completed, would need First Article qualification. <i>No additional testing or evaluation this period.</i>
Nickel Plated CPZ (Copper Plated Zinc)	Co-Circulate	5¢ and 25¢	Failed large-scale pre-production testing. <i>This alternative was eliminated from further consideration.</i>
R52 Stainless (monolithic)	Co-Circulate	5¢ only	Small-scale feasibility testing completed with limited external CAM testing. <i>No additional testing or evaluation this period.</i>
Nickel Plated Silicon Steel	Co-Circulate	5¢ and 10¢	Small-scale feasibility testing completed with limited external CAM testing. <i>No additional testing or evaluation this period.</i>
Nickel Steel (monolithic/ clad)	Co-Circulate Seamless	5¢ monolithic 10¢, and 25¢	Initial small-scale feasibility testing completed with limited external CAM testing. Market research failed to identify vendors capable of supplying this alloy in sufficient quantities.

It should be noted that co-circulating alternatives, materials that were not expected to be seamless, were not evaluated during this period. Co-circulating materials offer greater material savings but would potentially require costly modifications to coin-accepting and handling equipment. Therefore, the focus of development efforts has been, and will continue to be, seamless alternative materials.

¹⁰ Denominations listed in Table 3 are only those included in testing, and may not represent all expected denominations planned for this alternative metal.

Seamless alternative materials are developed to work in current coin-accepting and handling equipment without modification. Listed below are more technical details from engineering about the seamless alternative materials that underwent evaluation during this period:

- **80/20 Cupronickel:** A lean nickel version of the incumbent 75/25 cupronickel alloy. First article testing in 2016 identified that one of two 80/20 suppliers submitted dime and quarter coils exhibiting excessive corrugation. Excessive corrugation is the thickness variation (waviness) of outer clad layers to a degree that adversely affect EMS, possibly increasing coin rejection rates in coin-accepting and handling equipment, thus the need to reprogram these machines.

During 2020, the supplier completed improvements to its strip-bonding processes. Improved bonded dime and quarter coin blanks were supplied to the Mint for limited stamping trials and analysis, which demonstrated that corrugation was reduced to a level comparable to incumbent 75/25 cupronickel clad, and thus acceptable. However, large-scale first article testing will be required to certify the supplier's improved bonding operation as ready for circulating production.

- **C99750T-M:** A leaner potentially seamless alloy developed jointly with the National Institute of Standards and Technology (NIST), which contains less copper and nickel and substitutes zinc (Zn) and manganese (Mn). This alloy represents what may be the leanest, or lowest material cost seamless alternative possible, to replace the current monolithic five-cent coin and clad on higher coin denominations.

During 2020, the Mint and C99750 supplier developed a test matrix to test whether the alloy would be seamless across strip manufacturing tolerance ranges for thickness and composition. The supplier manufactured 21 C99750 alloy test lots (monolithic nickel blanks) with varying chemical compositions and blank thickness. Testing conducted by the Mint demonstrated that C99750T-M would indeed be seamless.

Because of the gold hue of this alloy, the Mint began developing C99750 alloy variants with similar visual appearance as 75/25 cupronickel, as well as seamless for EMS, weight, and dimensions.

During 2022, the C99750 supplier submitted 14 sample color lots for internal testing by the Mint. After testing, two C99750 alloy variants were selected for further evaluation. Monolithic nickel blanks in these two alloy variants were recently received and are now undergoing testing. One C99750 alloy variant will be selected for detailed evaluations of this alloy in clad constructions (dime and quarter) and in larger quantities to confirm seamlessness and better understand manufacturability of the alloy and costs.

- **Nickel-Steel:** An austenitic alloy (not attracted to magnets) developed as a less expensive seamless alternative to cupronickel for clad denomination. Nickel content is 25%, with the balance being lower cost iron and some manganese versus higher cost copper.

Small-scale evaluations have shown that nickel-steel clad to a copper core to be seamless for the dime, quarter, and half dollar. However, extensive market research has failed to identify specialty steel manufacturers/processors capable of supplying this material in sufficient quantities to meet circulating coinage production.

Nickel-steel clad web scrap produced during blanking cannot be recycled back into new nickel-steel alloy because of the presence of copper. Nickel-steel web scrap can be recycled when manufacturing specialty steels; however, further market research is needed to determine whether this industry can accommodate the large amount of nickel steel clad web scrap likely to be produced each year during circulating coin production.

The advantages of this alloy are potentially significant metal cost savings; visual appearance similar to incumbent cupronickel; and counterfeit deterrence. However, several important disadvantages exist:

- Nickel-steel is a seamless alternative for clad denominations only.
- Transitioning to nickel-steel will likely require changes to existing Mint manufacturing operations (e.g., annealing, blank lubrication, die coatings).
- Inability to recycle web scrap back into new nickel steel alloy.
- Most problematic of all, manufacturers do not exist to supply quantities sufficient for circulating production.

Therefore, the recommendation is to discontinue further development of nickel-steel and focus efforts on developing a seamless C99750 alloy optimized for color, manufacturability, and cost savings.

- **CPS:** An alternative to the copper-plated zinc (CPZ) penny. This alternative could be an option that presents minimal impact to stakeholders, with a similar appearance, seamless dimensions, and weight.

From 2020 to 2022, development and testing of CPS pennies were conducted in two phases—test strikes/design verification (small-scale) and extended stamping trials (large-scale), as delineated by the quantity of test pieces stamped during each phase. Test strikes were conducted to develop CPS planchet specifications and identify modifications to current circulating designs for optimal performance when stamping CPS planchets

Test Strikes and Design Validation (small-scale): Phase one is complete. The phase one development approach was a seamless CPS alternative with a similar weight, diameter, and edge thickness. Achieving specification coin edge thickness at reasonable stamping tonnage (40 metric tons) was the major challenge to producing a CPS penny, because of CPS planchets' thinner gauge and higher hardness. The development approach was that modifying die curvature and lowering design relief would provide the best stamping results. Nonsense master tooling/stamping dies incorporating these modifications were manufactured to support further optimization stamping trials and phase two extended stamping trials (large-scale).

Optimization stamping trials were conducted as part of phase one utilizing nonsense die designs and CPS planchets supplied by five vendors with various upset geometries, steel grades, and whether annealed or not annealed after upset. Stamping trials suggested that acceptable coin edge thickness can be achieved at reasonable tonnage when stamping CPS planchets with optimal dimensional specifications, especially planchet edge thickness.

Extended Stamping Trials: After phase one test strikes, resulting modified nonsense designs were utilized during phase two extended stamping trials (500,000 planchets supplied per vendor) to ascertain stamping performance, retirement modes, need for die coatings, and probable die life.

During summer 2022, extended stamping trials were completed and results suggested that transitioning to CPS penny production would not adversely affect stamping performance, shorten die life, or require coating circulating dies. Further small-scale evaluations are still underway to optimize CPS penny planchet hardness and dimensional specifications.

CPS development also involved conducting market research of existing and potential CPS planchet suppliers. This research revealed that global CPS manufacturing capacity is not sufficient to meet Mint forecasted penny demand. Therefore, under current conditions, CPS can be a viable alternative only as a co-production option.

B. Engineering Assessment Regarding 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.

Penny stamping trials were conducted involving changing die curvatures from spherical to exponential and modifying planchet upset geometry to achieve acceptable design and coin edge fill at lower stamping tonnage. The hypothesis tested was that lowering stamping tonnage would increase fatigue die life (die retired because of cracking/chipping), resulting in fewer dies consumed and less press downtime for die changes. Stamping trials conducted in the coin development room at the Philadelphia Mint did show an approximate 8% stamping tonnage, but no statistically significant die life improvement. Testing was discontinued and penny die curvature/upset geometry modifications were not implemented.

Similar stamping trials were conducted where nickel die curvatures were changed from spherical to exponential curvature to "match" existing nickel planchet upset geometry and thus lower stamping tonnage. Increased die life was realized during stamping trials conducted in the coin development room. However, the 2021 transition to exponential crown for circulating nickel production dies did not yield similar results. Both the Philadelphia and Denver Mints realized a marginal decrease in stamping tonnage, but no comparable increase in fatigue die life. These results suggest that further design optimization is required to increase fatigue die life.

The Mint's Design/Engraving Department has three-dimensional mapped/characterized nickel fatigue failure locations and made subtle die design changes. Controlled stamping trials are currently underway in the Philadelphia coin development room. If successful, these trials will justify expediting production trials in the Coining Departments at the Philadelphia and Denver Mints and transitioning to circulation production starting at the start of 2024. If successful, similar failure mapping, characterization, and design modification techniques will be applied to other denominations as appropriate.

C. Additional Costing Details for FY 2020 through FY 2022

The following tables expound on unit costs from FY 2020 to FY 2022 and compare them to various alternative compositions.

Table 4 - Actual Production Per Year for Nickel, Dime, and Quarter Denominations and Savings Comparisons for Alternative Metals

FIVE-CENT	Annual Volume In Millions	Weight Grams	Per Unit Cost Est	% Savings Compared to FY 2022	Estimated Savings Compared to FY 2022 In Millions
FY 2020 (Actual)	1,598	5.00	\$0.0742		
FY 2021 (Actual)	1,736	5.00	\$0.0851		
FY 2022 (Actual)	1,442	5.00	\$0.1040		
80/20 (CU/Ni)		5.00	\$0.0999	-3.9%	\$5.9
C99750T-M		5.00	\$0.0858	-17.5%	\$26.2
C99750T-M (Low MN Variant)		5.00	\$0.0996	-4.23%	\$6.3
C99750T-M (High MN Variant)		5.00	\$0.0955	-8.17%	\$12.3

TEN-CENT	Annual Volume In Millions	Weight Grams	Per Unit Cost Est	% Savings Compared to FY 2022	Estimated Savings Compared to FY 2022 In Millions
FY 2020 (Actual)	2,801	2.27	\$0.0373		
FY 2021 (Actual)	3,065	2.27	\$0.0438		
FY 2022 (Actual)	2,849	2.27	\$0.0503		
80/20 (CU/Ni)		2.27	\$0.0497	-1.2%	\$1.7
C99750T-M		2.27	\$0.0475	-5.6%	\$8.0
C99750T-M (Low MN Variant)		2.27	\$0.0496	-1.4%	\$2.0
C99750T-M (High MN Variant)		2.27	\$0.0490	-2.6%	\$3.7

QUARTER DOLLAR	Annual Volume In Millions	Weight Grams	Per Unit Cost Est	% Savings Compared to FY 2022	Estimated Savings Compared to FY 2022 In Millions
FY 2020 (Actual)	2,906	5.67	\$0.0862		
FY 2021 (Actual)	2,274	5.67	\$0.0963		
FY 2022 (Actual)	2,426	5.67	\$0.1109		
80/20 (CU/Ni)		5.67	\$0.1091	-1.6%	\$4.4
C99750T-M		5.67	\$0.1040	-6.2%	\$16.7
C99750T-M (Low MN Variant)		5.67	\$0.1090	-1.7%	\$4.6
C99750T-M (High MN Variant)		5.67	\$0.1075	-3.1%	\$8.2

Table 5 - Cost Savings Assessments for Reported 80/20 Cupronickel, and Variations of C99750T-M.

80/20 CUPRONICKEL	Actual Annual Volume In Millions	Per Unit Cost Est. FY 2022	Per Unit Cost Est. 80/20	Estimated Savings Compared to FY 2022 In Millions
Five-Cent	1,442	\$0.1040	\$0.0999	\$5.9
Ten-Cent	2,849	\$0.0503	\$0.0497	\$1.7
Quarter Dollar	2,426	\$0.1109	\$0.1091	\$4.4
Total Savings				\$12.0

C99750T-M	Actual Annual Volume In Millions	Per Unit Cost Est. FY 2022	Per Unit Cost Est. 80/20	Estimated Savings Compared to FY 2022 In Millions
Five-Cent	1,442	\$0.1040	\$0.0858	\$26.2
Ten-Cent	2,849	\$0.0503	\$0.0475	\$8.0
Quarter Dollar	2,426	\$0.1109	\$0.1040	\$16.7
Total Savings				\$50.9

C99750T-M (LOW MN VARIANT)	Actual Annual Volume In Millions	Per Unit Cost Est. FY 2022	Per Unit Cost Est. 80/20	Estimated Savings Compared to FY 2022 In Millions
Five-Cent	1,442	\$0.1040	\$0.0996	\$6.3
Ten-Cent	2,849	\$0.0503	\$0.0496	\$2.0
Quarter Dollar	2,426	\$0.1109	\$0.1090	\$4.6
Total Savings				\$12.9

C99750T-M (HIGH MN VARIANT)	Actual Annual Volume In Millions	Per Unit Cost Est. FY 2022	Per Unit Cost Est. 80/20	Estimated Savings Compared to FY 2022 In Millions
Five-Cent	1,442	\$0.1040	\$0.0955	\$12.3
Ten-Cent	2,849	\$0.0503	\$0.0490	\$3.7
Quarter Dollar	2,426	\$0.1109	\$0.1075	\$8.2
Total Savings				\$24.2

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