

Used Goods, New Risks: Mitigating Proliferation Impacts of the Global Secondary Market

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Abstract

Economic, technological, and social trends have led to rapid growth in the market for used and remanufactured goods, and with it, a potential threat: the export of used, dual-use commodities that could contribute to the development of Weapons of Mass Destruction (WMDs). Export control requirements apply to WMD-related commodities even beyond first sale, but knowledge of these requirements is sometimes lost as commodities are sold and resold—and many “outdated” products can still contribute to a WMD development program. As such, the secondary market for listed commodities may pose proliferation risks and export control challenges that may not be well understood. While measures may exist to mitigate the risks posed by the secondary market, those measures may not have been systematically integrated into export enforcement and outreach programs and secondary market resellers may not be aware of the requirements associated with exporting these commodities. This article summarizes the findings of a study that was performed to assess the secondary market to (1) identify dual-use commodities that present a higher risk for resale in secondary markets and (2) outline approaches for relevant authorities to address gaps in existing outreach, training, and enforcement programs. While the initial analysis focused on the United States’ export control system, the corresponding European Union export control numbers and multilateral export control regime references

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have been added for completeness.

Keywords

Compliance, dual-use, export control, industry, multilateral export control regimes, procurement, proliferation, refurbished, secondary market, United States, used

Introduction

Economic, technological, and social trends are changing the way consumers think about used commodities. Many consumers are now more willing to consider used or remanufactured goods, and simultaneously, new technological innovations are making it more cost-effective to recycle used commodities and easier to find buyers. Together, these changes have led to rapid growth in the secondary market and, along with it, a new potential threat: the export of used, dual-use commodities that could contribute to the development of Weapons of Mass Destruction (WMDs).

While the export of WMD-related commodities is expected to be regulated throughout the commodities' lifetimes, knowledge of those export control requirements is sometimes lost as commodities are sold and resold. Replacing older, used products with newer and better technologies does not necessarily mean that the "outdated" products cannot still contribute to a WMD development program. As such, the secondary market for listed commodities may pose proliferation risks and export control challenges that may not be well understood. Furthermore, while measures may exist to mitigate the risks posed by the secondary market, those measures may not have been systematically integrated into export enforcement and outreach programs, and secondary market resellers may not be aware of the requirements associated with exporting these commodities. Considering these challenges, this article summarizes the findings of a study assessing the secondary market to (1) identify dual-use commodities that present a higher risk for resale in secondary markets, and (2) outline approaches for relevant authorities to address gaps in existing outreach, training, and enforcement programs.

What is the Secondary Market and How Does it Relate to Export Controls?

To fully understand the secondary market for listed commodities, it was necessary to first define the term listed commodities of interest for the secondary market. The authors did this by defining and constraining two key terms: (1) secondary market and (2) listed commodities.² Considering those definitions, the following sections discuss the legal controls for used listed commodities, the challenges posed by the secondary market, and a review of the research that has already been done in this area.

The authors defined the secondary market as the post-retail market for selling used, unwanted

2 Authors' interviews, Seattle, January-March 2019.

goods. These goods can be reused, remanufactured, or, in some cases, disposed (e.g., scrap).³ Unused goods sold as excess, or surplus, are excluded. One important source of secondary market goods is the original buyers, who may come from industry, academia, or government. Often, they resell their used goods by connecting directly with a buyer. However, sometimes sellers want or need assistance to sell used commodities and may rely on a facilitator. Facilitators help connect sellers to new buyers and can include general and specialty resellers, auction houses (brick-and-mortar and online), scrap or recycling companies, and e-commerce sites. These organizations might connect the buyer and seller (e.g., Craigslist or eBay) or take full or partial ownership of the item to resell it (e.g., furniture consignment). Original equipment manufacturers (OEMs) and distributors are included in this definition when selling used dual-use commodities.

The international export control regime is complex, and defining the term listed commodity is therefore equally complex. Multilateral nonproliferation regimes and arrangements identify the dual-use commodities and technology covered by export controls, while national governments are responsible for implementing the rules and regulations to prevent their proliferation to WMD programs. The U.S. Government controls the export of various physical commodities and technical data for reasons related to national security, foreign policy, nonproliferation of WMD, international obligations, and other reasons. Various U.S. agencies enumerate and set controls for different types of commodities and export-related activities, including the U.S. Department of State (military commodities), Department of Commerce (dual-use commodities), Department of Energy (nuclear technology), Nuclear Regulatory Commission (nuclear materials and equipment), and the Treasury Department (finances and embargos). This article focuses on WMD-related dual-use commodities under the jurisdiction of the U.S. Department of Commerce, specifically those commodities that are important for the development, production, testing, or use of WMDs, but that also have commercial applications. Despite this article's focus on U.S. laws, there exists corresponding control language in the European Union (EU) and multilateral export control regimes (MECRs). The authors have annotated other controls (i.e., EU & MECR) only when they differ.

The U.S. Department of Commerce's (DOC) Bureau of Industry and Security (BIS) maintains the Commerce Control List (CCL) (15 CFR 774) within the Export Administration Regulations (EAR), which includes items (e.g., commodities, software, and technology) subject to the export licensing authority of BIS. For the purposes of this article, the authors will focus on commodities. Commodities are identified by a five character alpha-numeric designation called an Export Control Classification Number (ECCN). An ECCN is made up of four sections, the "Heading," "License Requirements," "License Exceptions," and "List of Items Controlled." Under each ECCN, BIS describes the items controlled, and it is common for one ECCN to include many similar or related commodities. For this article, the term ECCN refers to the five character parent designation (e.g., 1C354) while the term listed commodity refers to a discrete item controlled on the CCL. In this report, the term "listed" preceding a commodity name (e.g., "listed mass spectrometer") indicates that the item meets the control specifications enumerated

3 Remanufacturing describes the process in which a recovered good, or core, is transformed through cleaning, testing, and other operations into a product that is tested and certified to meet technical or safety specifications and has a warranty similar to that of a new product. Different industries sometimes apply other terms, such as refurbishing, reconditioning, or rebuilding, to describe essentially the same process.

in the CCL.⁴ The process used to select commodities of interest for this article is described in the next section. This article does not consider non-listed commodities destined for proscribed end-uses, such as a used tanker truck destined for use in a missile program.⁵

Consistent with multilateral arrangements, U.S. export control laws do not distinguish between new and used commodities. If a used commodity still meets the control specifications, it is still listed. The EAR states, in the Code of Federal Regulations (CFR) Chapter 15 Section 774 (15 CFR 774) Supplement No. 3 (d), that “the specifications in the [CCL] apply equally to new or used goods. In the case of used goods, an evaluation by [BIS] may be carried out in order to assess whether the goods are capable of meeting the relevant specifications.”⁶ No public documentation exists regarding how this assessment is conducted or the criteria that need to be met. For example, if a machine tool meets the control specifications under ECCN 2B001 but does not function or needs minor repairs, no published guidance exists to help the owner determine applicable export controls, aside from seeking a determination from the DOC. This article assumes that any item that meets the control specifications, when new, is listed, regardless of whether a used version can still meet those specifications.

Secondary markets, particularly e-commerce markets, challenge the enforcement of export control regulations on listed commodities. Zilinskas and Mauger (2015) capture this well:

“E-marketplaces...create a niche by providing visibility and a degree of legitimacy for small and specialized vendors to sell products abroad. ... In the past, companies wishing to enter foreign markets would have to send out expensive trade delegations to demonstrate their products in person. The harnessing of the Internet for commerce, notably through e-marketplaces, has reduced the necessity of doing so. The rise in export control cases involving these spaces raise concerns that e-marketplaces permit would-be proliferators ‘to find suppliers who will not ask so many questions.’ Importantly, these low-profile actors are able to sell secondhand products through e-marketplace websites.”⁷

In comparison to OEMs, secondhand sellers may not be knowledgeable about the products they sell or aware of the export control requirements that may apply, putting them at greater risk of unintentionally exporting a listed commodity without a required export license. Additionally, some resellers are at even greater risk, such as liquidation companies who may have limited

4 Listed commodities do not always require a license for export. The need for a license is determined based on the country of destination, end-use, and end-user. Therefore, the authors use the word “listed” to indicate that the commodity meets the control specifications enumerated on the Commerce Control List.

5 Tatsuya Kanemitsu, “Trader Arrested for Export Violation [Sic] to North Korea,” *Global Trade Compliance*, May 19, 2009, <<http://japantradecompliance.blogspot.com/2009/05/trader-arrested-for-export-violaiton-to.html>>.

6 United States Department of Commerce, Bureau of Industry and Security, 15 CFR 774 Supplement No. 3 (d), January 6, 2020, <<https://www.bis.doc.gov/index.php/documents/regulations-docs/2345-774-10-24-18/file>>.

7 Raymond A. Zilinskas and Philippe Mauger, “Biotechnology E-Commerce: A Disruptive Challenge to Biological Arms Control.” *CNS Occasional Papers*, Vol. 21 (May 7, 2015), <<https://www.nonproliferation.org/biotechnology-e-commerce-a-disruptive-challenge-to-biological-arms-control/>>.

experience with the commodities being sold and who may not be able to differentiate between an honest and dishonest declaration of end-use.

Further, cases involving the unlicensed export of dual-use commodities are difficult to prosecute. In comparison with military commodities, where the intent is clear, the dual-use nature of many non-military commodities introduces reasonable doubt.⁸ While cases involving the secondary market resale of military commodities have been successfully prosecuted, the authors' interviews indicated that prosecuting cases involving the secondary market resale of dual-use commodities is typically more difficult.⁹ The secondary market introduces additional challenges to establishing intent because secondary market sellers are often less familiar with the products being sold and may not understand the potential dual applications of the listed commodities they sell. Nonetheless, experts cite examples, domestically and internationally, of successful cases involving used listed dual-use commodities.¹⁰ However, in these cases intent was easier to establish because the exporter could not deny knowledge that the destination country or end-user was inappropriate. These challenges to prosecution highlight the importance of outreach to the secondary market regarding listed commodities.

Another challenge to the secondary market as it relates to export controls is the presence of a specific type of company – the facilitator. Facilitators offer a private platform (often e-marketplaces in the modern secondary market) to connect buyers and sellers without the need for facilitators to take ownership of any commodities. While the facilitator makes it easier and faster for parties to connect, they also do not assume any legal liability for an export violation since they do not assume ownership of the commodity. As one expert summarized, “generally speaking, the [e-marketplace] has immunity in the United States...because it does not control the items. Ultimately, the legal responsibility falls on the buyer and/or seller...”¹¹

8 Military-related commodities, also called defense articles, are enumerated in the U.S. Munitions List (USML) (22 CFR 121) and regulated by the International Traffic in Arms Regulations (ITAR) overseen by the U.S. Department of State's Directorate of Defense Trade Controls.

9 Gregory Kutz, “Internet Sales: Undercover Purchases on Ebay and Craigslist Reveal a Market for Sensitive and Stolen U.S. Military Items,” U.S. Government Accountability Office, April 10, 2008, <<https://www.gao.gov/new.items/d08644t.pdf>>.

10 Domestic Prosecution Example: See 1.) United States District Court in the Northern District of Illinois, Eastern Division, Indictment: United States of America v. Hsien-Tai Tsai aka Alex Tsai, October 23, 2012, <<http://dig.abcllocal.go.com/wls/documents/alex-tsai-complaint.pdf>>. The defendants illegally exported used rotary grinding machines to Taiwan; and 2.) Department of Commerce, Bureau of Export Administration, “Action Affecting Export Privileges; TAL Industries, Inc.; In the Matter of: TAL Industries, Inc.,” Federal Register/ Vol. 66, No. 00, Wednesday, May 23, 2001, <<https://www.govinfo.gov/content/pkg/FR-2001-05-23/pdf/01-13024.pdf>>. The U.S. Department of Commerce reached a settlement with TAL Industries on charges of conspiracy to violate the EAR, misrepresentation and concealment, and violating conditions of ten export licenses. TAL Industries sought to acquire secondhand listed machine tools for the purposes of manufacturing military systems. For examples of international prosecutions, see 1) See Stephanie, Lieggi, Robert Shaw, and Masako Toki, “Taking Control: Stopping North Korean WMD-Related Procurement.” *Bulletin of the Atomic Scientists*, Vol. 66, No. 5 (September 2010): pp. 21–34. In this case, Tadao Morita was found guilty in Japan for violating export controls for attempting to illegally export used tanker trucks (not dual-use) to North Korea.

11 National Research Council, “The Global Movement and Tracking of Chemical Manufacturing Equipment: A Workshop Summary,” edited by Kathryn Hughes and Joe Alper (Washington, DC: The National Academies Press, 2014).

Some facilitators have instituted systems and procedures on their platform to flag trades that may potentially violate U.S. regulations.¹² However, the sheer volume of trade and limited incentives mean that many facilitators are unlikely to concern themselves with export control requirements, absent regulatory changes to their responsibility. This article does not attempt to analyze or recommend changes to U.S. regulations with regards to facilitators but aims instead to highlight some of the challenges for export controls in the secondary market. The first step to highlighting these challenges is understanding which listed commodities are of interest to the secondary market. This will be addressed in the next section.

Despite the challenges discussed above, the authors did not find a systematic assessment of the utility of secondhand dual-use commodities. While expert assertions and documented cases suggested individual secondhand commodities can be and have been used, the entire secondary market and its potential contributions of listed WMD commodities have not been systematically evaluated.^{13,14} The closest study to such an assessment was performed by Stewart et. al., which analysed the manufacturing base for 26 proliferation-sensitive items.¹⁵ Specifically, the study identified commodities suspected to have a secondhand or surplus market.¹⁶ However, the study led by Stewart does not explain or justify its categorization, making it difficult for others to validate their methodology. Stewart's study excludes many key dual-use commodities including machine tools, but it is a worthy first step.

Several papers examine listed commodities on e-commerce sites, but they focus on new or surplus commodities rather than used commodities.¹⁷ Zilinskas and Mauger highlight secondhand vendors for biological process equipment but they do not offer a comprehensive study. Further, the cases mentioned above and statements from subject matter experts demonstrate the continued value of secondhand dual-use commodities for civilian and military applications. Given the noted limitations of previous work, this article aims to provide a comprehensive review of all WMD-related dual-use commodities to identify those of high interest to the secondary market.

12 For example, eBay has developed the eBay Listing Violation Identification System (eLVIS), which is a keyword-based system for flagging potential violations of various regulations, including ITAR, FDA, etc.

13 See Lucy Walker, "Countdown to Zero," 2010; and U.S. China Security Review Commission, "Compilation of Hearings Before the U.S. China Security Review Commission," Washington, DC, U.S. Government Printing Office, 2002.

14 Based on expertise and experience of the authors and subject matter experts in general.

15 Ian Stewart, Andrea Viski, and Nicholas Gillard, "The Manufacturing Base for Proliferation-Sensitive Items," Paper presented at the Institute of Nuclear Material Management Annual Conference, 2018.

16 Autoclaves, bellows-sealed valves, beryllium, calcium, capacitors, carbon fiber, controlled-atmosphere furnaces, flash x-ray devices, flow-forming machines, frequency inverters, high-strength aluminum, high-strength materials, high-speed cameras, heavy water, isostatic presses, maraging steel, mass spectrometers, neutron detectors, pressure transducers, radiation-shielded windows, reactor internals, reactor pressure vessels, remote manipulators, triggered spark gaps, vacuum pumps, and zirconium.

17 Ian Stewart, "Procurement of Pressure Transducer Via Ebay from China," Centre for Science and Security Studies, King's College London, September 24, 2014, <<https://www.kcl.ac.uk/news/procurement-of-pressure-transducer-via-ebay-from-china>>; Raymond A. Zilinskas and Philippe Mauger, "Biotechnology E-Commerce: A Disruptive Challenge to Biological Arms Control." *CNS Occasional Papers*, Vol. 21 (May 7, 2015), <<https://www.nonproliferation.org/biotechnology-e-commerce-a-disruptive-challenge-to-biological-arms-control/>>.

Identifying and Prioritizing Used Listed Commodities

The authors developed a preliminary research methodology based on principles of qualitative research using in-depth interviews and open-source research techniques. Acknowledging the variety of commodities included on the CCL, the authors intentionally narrowed the scope of commodities to appropriately focus interviews with subject matter experts (SMEs). Given that scope, the authors developed criteria that would identify the listed commodities of interest for the secondary market. SME interviews were the primary means of collecting data for the analysis. The following paragraphs describe the analysis scope, the research design, and criteria for assessing interest to the secondary market.

This analysis focused on commodities under the jurisdiction of the U.S. DOC as outlined in the CCL of the EAR (15 CFR 774), specifically commodities important for WMD development, production, testing, or use but that also have legitimate civilian applications. The authors have included the corresponding Export Control Number (ECN) from the European Union's Dual-Use Control List and MECR paragraphs when they differ.

The CCL includes hundreds of commodities, not all of which are applicable to WMDs (e.g., 0A980 "Horses by sea"). Each commodity on the CCL has one or multiple Reasons for Control, some of which are WMD-related.¹⁸ The authors selected commodities, for which the Reasons for Control included the following:

- Nuclear nonproliferation;
- Chemical and biological weapons;
- Missile technology.

Additionally, it should be noted that, while this analysis has a domestic focus, the CCL also includes listed commodities which are derived from multilateral export control regime lists issued by the Nuclear Suppliers Group (dual-use list), Missile Technology Control Regime, Australia Group, and the Chemical Weapons Convention.

Since one ECCN can represent many controlled commodities, the authors carefully reviewed each ECCN entry in order to identify the associated "List of Items Controlled." In cases where the "List of Items Controlled" included an item and its parts, the authors did not break it out into two commodities, as that level of detail was beyond the scope of the preliminary article.

Additionally, the authors excluded software and technology (ECCNs in Groups D and E within

18 A complete list of the *Reasons for Control* is available in 15 CFR Part 738, CCL Overview and the Country Chart, Department of Commerce, Bureau of Export Administration, <<https://www.bis.doc.gov/index.php/documents/regulation-docs/2254-part-738-commerce-control-list-overview-and-the-country-chart-1/file>>.

the CCL structure).¹⁹ This exclusion is a practical matter: the authors focused only on physical commodities traded through a secondary market. The authors also excluded commodities subject to another agency's jurisdiction (e.g., 0A002 Propulsion equipment for nuclear reactors, which is subject to U.S. Department of State International Traffic Arms Regulations; EU ECN ML17.g).

Based on all these considerations, the team identified 496 discrete WMD-related commodities under 175 ECCNs. To prioritize the most important listed commodities for analysis, the authors began by defining several criteria to transparently assess which listed commodities are of interest to the secondary market.²⁰ Those criteria included the following:

Reusability: Is the commodity reusable? A commodity's reusability is important for identifying used listed commodities sold on the secondary market. This criterion was designed to have a Yes-No answer. Listed commodities assessed to be Not Reusable were excluded from further consideration.

Likelihood of Reuse: What is the likelihood that the commodity will be reused? The criterion Likelihood of Reuse closely follows the Reusability criterion. However, assessing the likelihood of reuse required specific framing boundaries to determine whether the used listed commodity would be desirable for WMD development, production, testing, or use. To maintain consistency in responses, the likelihood of reuse was assessed using three characteristics: 1) need for modification for reuse, 2) ease of modification for reuse, and 3) degraded performance when reused.

*Ability to Distinguish from Non-Listed Commodities:*²¹ Is it possible to easily distinguish a listed commodity from non-listed commodities? Listed commodities can be difficult to distinguish from non-listed commodities without specific knowledge of the listed and non-listed models of the commodity. It was not possible to identify any fixed commodity characteristics that make certain commodities easier to distinguish as listed or non-listed. However, consideration of the following characteristics assisted in assessing this criterion and excluding some commodities from further consideration: 1) consistency between ECCN and OEM language, and 2) analysis requirements for distinguishing list and non-listed commodities.

Frequency on the New Market: What is the frequency of the listed commodity on the new market? Frequency on the New Market is another criterion defined for identifying listed

19 Technology refers to information necessary for the development, production, use, operation, installation, maintenance, repair, overhaul, or refurbishing (or other terms specified in ECCNs on the CCL that control "technology") of an item.

20 For an example of these criteria applied to a high-interest listed commodity, see the section focused on Machine Tools.

21 This criterion is included to address the second objective of this study: to identify gaps in current research, outreach, training, and enforcement for export controls on the secondary market. Industry and the enforcement community do not have the technical capability to distinguish some listed commodities from non-listed commodities, particularly when destructive analysis or other technical analysis is required. Therefore, those commodities were excluded as a practical matter, as any recommendations generated from this analysis would not be useful to industry or the enforcement community.

commodities of interest to the secondary market. Some listed commodities are rare on the new market, and, therefore, not likely to be sold on the secondary market. Quantitative analysis of the actual frequency of listed commodities in the secondary market is beyond the scope of this preliminary article. Instead, the authors used listed commodities' export frequency as a proxy to extrapolate the frequency of listed commodities on the secondary market. The team determined export frequency was the only way to approximate the trade in listed commodities since their domestic trade is not well documented. Listed commodities with a low or rare occurrence on the new market were excluded from this analysis.

Demonstrated Presence on the Secondary Market: Has the listed commodity been observed on the secondary market? The authors understand that the criterion – Demonstrated Presence on the Secondary Market – is closely related to Likelihood of Reuse. However, this criterion is important, because in a few cases, the SMEs had experience with listed commodities on the secondary market that had been reused in ways similar to WMD applications. In these cases, the SMEs assessed these commodities to be of greater interest to the secondary market, even when the other criteria above may have indicated otherwise.

Other Considerations: Are there regulatory or institutional considerations that make the listed commodity of particular interest to the secondary market?

Once the authors had identified the listed commodities of interest to the secondary market, they further prioritized those commodities by assessing each commodity on a scale (high, medium, low) based on common characteristics of listed commodities and used items in general that are present on the secondary market. Characteristics of high-interest listed commodities include:

- Value Retention: Commodities that retain their value relatively well;
- Quality Retention: Commodities that retain their quality or performance;
- Expensive when New: Commodities that are relatively expensive when bought new. The seller may want to recoup initial expenses and the buyer may be looking for a deal;
- Adaptable: Commodities that may be adaptable to other working conditions and applications; they are not specifically designed to meet the buyer's needs;
- Presence on the Secondary Market: Commodities that have a large secondary market (i.e., numerous resellers, multiple instances, known cases);

Medium and low-interest listed commodities were identified in relation to the above characteristics for high-interest listed commodities. Commodities that were less expensive when new, with a medium secondary market (fewer resellers, and fewer verified cases) were considered medium interest. Finally, the team defined low-interest commodities as those with little to no known secondary market.

Finally, using the criteria and characteristics discussed above, the authors conducted interviews with 11 SMEs with expertise in broad areas such as biological and chemical production equipment, nuclear commodities, missile commodities, industrial equipment, and with specific

technical expertise, including graphite and mass spectrometers.²² The authors additionally performed open-source research to further exclude some commodities from consideration and identify which listed commodities are of greatest interest to the secondary market. The results of applying that methodology are provided in the next section.

Results: Which Commodities are of Greatest Interest to the Secondary Market?

A total of 496 commodities under 175 ECCNs were considered. The authors excluded 258 commodities (127 ECCNs) for the following reasons:

- Not reusable (163 commodities);
- Unlikely to be reused (33 commodities);
- Rarely on the new market (37 commodities);
- Indistinguishable from non-listed commodities (25 commodities).

Of the 496 commodities considered, 226 commodities (48 ECCNs) were identified as listed commodities of interest to the secondary market: 30 commodities (7 ECCNs) are high interest, 11 commodities (8 ECCNs) are medium interest, and 197 commodities (33 ECCNs) are low interest. The specific commodities in each group are provided in the following list:

High-Interest Listed Commodities²³

Listed commodities of high interest for the secondary market include the following commodities:

- Machine tools (2B001.a-d; N1B2a-d*) (2B201.a-c; N1B2a-c)
- Mass spectrometers (3A233.a-d; N3B6)
- Chemical process equipment (2B350; A, applies to entire entry)
 - Chemical reactors (2B350.a)
 - Agitators (2B350.b)

22 Authors' interviews with SMEs, Seattle and Richland, January-March 2019.

23 The ECN and MECR correlations were sourced from the UK control list, which is the basis of the EU control list. Many non-EU countries use the EU list as the basis of their control lists. The authors would like to thank Tye Blackburn and William Szymanski (PNNL) for their effort to manually correlate ECCNs to ECNs. The notation in this section is as follows: Commodity Description (ECCN/ECN; ECN only if different than ECCN; MECR). MECR codes reference the originating regime by an initial code letter. If the code is followed by an asterisk (*) the source text should be referred to for full details. The originating regime notation is as follows: "A" for Australia Group; "C" for Chemical Weapons Convention; "M" for Missile Technology Control Regime; and "N" for Nuclear Suppliers Group Dual-Use List.

- Tanks (2B350.c)
- Heat exchangers (2B350.d)
- Distillation or absorption columns (2B350.e)
- Valves (2B350.g)
- Multi-walled piping (2B350.h)
- Pumps (2B350.i)
- Vacuum pumps (2B231; N3A8)
- Bellows seal valves (2A226; N3A3)
- Biological process equipment (2B352; A, applies to entire entry)
 - Fermenters (2B352.b)
 - Centrifugal separators (2B352.c)
 - Cross flow filtration equipment (2B352.d)
 - Steam sterilizable freeze-drying equipment (2B352.e)
 - Protective and containment equipment (2B352.f)
 - Aerosol testing chambers (2B352.g)
 - Aerosol challenge testing chambers (2B352.h)
 - Spraying and fogging systems (2B352.i)

Medium-Interest Listed Commodities

Listed commodities of medium interest for the secondary market include the following commodities:

- Protective and detection equipment (1A004.a; N6A2*) (1A004.b; N6A1*) (1A004.c; A*)
- Toxic gas monitoring systems (2B351.a, 2B351.b; A)
- Analog-to-digital converter (3A002.h; no MECR exists)
- Accelerators (3A101.b; M15B5)
- Frequency changers (3A225; N3A1)
- High-voltage DC power supplies (3A226; N3A5) (3A227; N3A6)
- High-speed pulse generators (3A230; N5B6)

Low-Interest Listed Commodities

Listed commodities of low interest for the secondary market include the following commodities:

- Biological Materials
 - Human pathogens, zoonosis, toxins (1C351; A) (105 materials)
 - Genetic elements, genetically modified organisms (1C353; A) (6 organisms)

- Plant pathogens (1C354; A) (23 pathogens)
- Metals
 - Aluminum alloys (1C002.b.4; N2C13*) (1C202.a; N2C1)
 - Titanium alloys (1C002.b.3; N2C13*) (1C202.b; N2C13)
 - Tungsten (1C117.a; M6C7) (1C226; N2C14)
 - Hafnium (1C231; N2C8)
 - Zirconium (1C234; N2C15)
 - Molybdenum (1C117.b; M6C7)
 - Depleted uranium (1A290; no EU ECN or MECR exists)
- Graphite (1C298; EU ECN 0C004; no MECR exists)
- Superconducting solenoidal electromagnets (3A001.e.3, 3A201.b; N6A4)
- Gravity meters (6A007; M12A3*) (6A107; M12A3)
- Radiation-shielded windows (1A227; N1A1)
- Composites production equipment (various)²⁴
- Furnaces (2B105; M6B4) (2B226; N1B4) (2B227.a-c; N1B7)
- Remote manipulators (2B225; N1A4)
- Cameras (various)²⁵
- Lasers (various)²⁶
- Accelerometers (7A001; M9A3*, M9A5)
- Drone production facilities (9B610; no EU ECN or MECR exists)

Understanding High Interest Listed Commodities on the Secondary Market

As discussed in the Results section above, a prioritization of listed commodities of interest to the secondary market is a key outcome of this study. Beyond the prioritized list, the authors performed detailed analysis on several of the high-interest listed commodity groups to identify trends, conclusions, and recommendations for actions and further research. While the authors did not perform detailed analysis on all the medium- and low-interest commodity groups, some

24 Composites production equipment (1B001.a; M6B1a*, N3B4) (1B001.b; M6B1b*) (1B001.c; M6B1c*) (1B101.a; M6B1a; N3B4*) (1B101.b; M6B1b) (1B201; N3B4).

25 Cameras (6A003.a.3, 6A003.a.4, 6A003.a.6; N5B3*) (6A203.a-c; N5B3).

26 Lasers (6A005.a.2-3; N3A2b*) (6A005.b.2.a, 6A005.b.2.b; N3A2a*; N3A2b*) (6A005.b.4; N3A2a*) (6A005.b.6.a, 6A005.b.6.b, 6A005.b.6.c, 6A005.b.6.d; N3A2c*) (6A005.c.2.a, 6A005.c.2.b; N3A2f) (6A005.d.3.c; N3A2g*) (6A005.d.4.c; N3A2h) (6A005.a.4, 6A005.c.1.a, 6A005.c.1.b, 6A005.d.2; no MECR exists) (6A205.a, 6A205.f; no EU ECN or MECR exists) (6A205.b; EU ECN 6A205.a; N3A2b) (6A205.c; 6A205.f; N3A2c) (6A205.d; 6A205.b; N3A2d) (6A205.e; 6A205.c; N3A2e) (6A205.g; 6A205.d; N2A2g).

of these commodity groups did yield interesting preliminary analysis, which can be provided upon request.

The paragraphs below identify the key characteristics for high-interest listed commodities of interest for the secondary market and provide a detailed analysis of the commodities identified as high-interest. The authors also identified key characteristics for excluding many listed commodities from further consideration and identified several cross-cutting trends related to listed commodities on the secondary market, also included in the subsections below.

It is important to note that the companies identified in the following sections are for illustrative purposes only to demonstrate that there are listed commodities on the secondary market potentially sold by these companies. The authors did not attempt to evaluate or comment on the export control compliance programs of these companies. The objective of this article is to raise awareness of the potential export of listed commodities on the secondary market without an export license, and the analysis below should not imply wrongdoing by any of the companies mentioned.

Listed Commodities of High Interest

High-interest listed commodities to the secondary market were generally identified as: reusable; having a high likelihood of reuse; distinguishable from non-listed commodities; and frequently sold or observed on secondary markets. The following characteristics likely increase the desirability of buying or selling a commodity on the secondary market that could be used for a WMD application. This list of characteristics is not exhaustive and each of the characteristics may not apply to all high-interest listed commodities, but it does provide a quick reference for understanding which listed commodities may be relevant for the secondary market.

- **High Resale Value:** These commodities are expensive because they are usually specialized. Some are specially designed, making them less useable in other applications. Despite the specialized nature of these commodities, when a company chooses to replace a piece of equipment, they will often attempt to sell the old piece of equipment to recoup some of their costs;
- **Can be Remanufactured or Refurbished:**²⁷ In addition to commodities that retain their quality, commodities that can be refurbished or upgraded are also of high interest to the secondary market. This is particularly true for commodities containing smaller parts and electronics, where replacing a degraded component can extend the life of the larger commodity, similar to replacing parts in a car;
- **Adaptable:** These commodities are adaptable to other working conditions and applications.

27 While often used interchangeably, *remanufactured* and *refurbished* have very different meanings. According to the U.S. International Trade Commission, “Remanufacturing is an industrial process that restores end-of-life goods to their original working condition.” On the other hand, refurbishing is a less robust process, where some maintenance and testing may be performed, but the commodity is not usually disassembled.

They are not specifically designed to meet only the original buyer's needs.

Machine Tools

Finding: The potential to remanufacture previously unlisted machine tools to meet or exceed control criteria is a serious issue that may require additional research.

Commodities referenced in this section include:

- 2B001.a-d, 2B201.a-c: Machine tools including turning machines, milling machines, grinding machines, and electrical discharge machines.

Of the commodities researched, machine tools are some of the most widely reused commodities. Machine tools are reusable, have a high likelihood of reuse, are distinguishable from non-listed commodities, and are frequently sold and observed on secondary markets. See Figure 1 below for a complete elaboration of the research methodology for listed machine tools on the secondary market. Machine tools have a high resale value and can be refurbished, resulting in numerous interested buyers and sellers. Nearly every manufacturing industry uses listed machine tools, including aerospace, automotive, general appliance, electronic, power generating, and defence industries. Large machine tools with wide applications in the aircraft, shipbuilding, and off-road vehicle industry rarely have sufficient accuracy to meet the control criteria and are therefore non-listed.

Research Methodology: Assessing Interest of Used Machine Tools to the Secondary Market

1. Is the commodity reusable? *Yes.*
2. What is the likelihood that the commodity will be reused? *The likelihood of reuse is great, given the high resale value of machine tools and ability to refurbish.*
3. Is it possible to easily distinguish a listed commodity from non-listed commodities? *Yes.*
4. What is the frequency of the listed commodity on the new market? *The frequency of machine tools on the new market is high.*
5. Has the listed commodity been observed on the secondary market? *Yes.*

According to one industry study, the machine tool industry is strong, with consumption totalling USD \$8.142 billion in 2017, up 6.8 percent from the previous year.²⁸ Moreover, the industry has grown dramatically since the early 2000s. Growth was fuelled by increasing international demand. In 2017, 12 of the top 15 countries that consume machine tools increased their consumption from the previous year, and, perhaps most importantly, China raised its 2017 machine tool consumption by USD \$1.780 billion in one year alone, corresponding to an increase of 6.3 percent. Given this strong international demand for machine tools, exports of

28 Gardner Intelligence, "World Machine Tool Survey," 2017, <<https://www.gardnerintelligence.com/report/world-machine-tool>>.

secondhand machine tools, either used or refurbished, is expected to grow as well.

Machine tools' high resale value gives them a high return on investment. In 1992, the U.S. DOC approved 572 export applications containing USD \$454 million worth of machine tools, two of which were valued at USD \$1.8 million each.²⁹ While more recent public data on consumption of listed machine tools is not available, this data from 1992 clearly demonstrates the incentives for buyers to purchase used machine tools. In fact, one machine tool reseller indicated that "buying used can generate a five- or six-figure cost savings since used [machine tools are] typically discounted at more than 30 percent off the original price."³⁰ The current average cost of new listed machine tools is more than USD \$800,000.³¹ Based on these numbers, a buyer could expect to save USD \$240,000 by purchasing a used machine tool instead of a new one.

Used machine tools are available from a variety of sellers including companies specializing in reselling machine tools such as Advanced Machinery, ABL Technology, Asset Exchange, CNC Exchange, and HGR Industrial Surplus, to name a few.^{32,33,34,35,36} In one search, it was found that CNC Exchange, an online retailer specializing in used machine tools, had nine Haas manufactured machine tools for resale that likely meet control specifications.^{37,38} Many companies offer remanufactured tools and services, posing a challenge to export controls related to machine tools and the secondary market. Additionally, with the development and spread of improved control software, it is in some cases possible to remanufacture or modify non-listed machine tools with new control software, allowing the machine to meet the technical specifications on the CCL.³⁹ This means that previously non-listed machine tools could become listed following remanufacturing. The following companies specialize in retrofits and remanufacturing: Hansford Parts and Products, Scott Machinery, and Texas Machine Tool

29 U.S. Congress, Office of Technology Assessment, "Export Controls and Nonproliferation Policy," Government Printing Office, 1994, <http://govinfo.library.unt.edu/ota/Ota_1/DATA/1994/9408.PDF>.

30 "Why Buy a Used HAAS CNC Machine," Machine Tool Bids, February 28, 2017, <<http://blog.machinetoolbids.com/2015/07/09/why-buy-a-used-haas-cnc-machine>>.

31 Authors' interviews with SMEs, Seattle, January-March 2019. Author's interviews with OEMs, Seattle, January 2014.

32 "Advanced Machinery," Advanced Machinery, <<https://advanced-machinery.myshopify.com/>>.

33 "CNC Lathe and Milling Machines – Used Machinery for Sale," ABL Technology, <<http://www.abltechnology.com/en/>>.

34 "Asset Exchange Corporation – Industrial Machine Appraisal, Remarketing, Auctions," Asset Exchange, <<http://www.assetexchangeinc.com/>>.

35 "We Buy, Sell, and Auction Used CNC Machines," CNC Exchange, <<https://www.cncexchange.com/>>.

36 "Used Machinery and Industrial Equipment," HGR Industrial Surplus, <<https://hgrinc.com/>>.

37 "Used Haas CNC Machines," CNC Exchange, <https://www.cncexchange.com/machinery-sale/all-machinery-sale?field_manufacturer_value=Haas>.

38 These machine tools were reviewed by an SME with experience identifying listed machine tools. They indicated that the machine tools were likely listed.

39 Authors' interview with SME, Seattle, March 2019.

International, LLC.^{40,41,42} The possibility to remanufacture machine tools to meet or exceed control specifications requires further consideration but, in any case, the remanufactured machine tool industry is strong and deserves attention. Many companies that use machine tools have exported their used equipment to recoup some of their investment; however, depending on the industry, these companies may not be aware of the requirements associated with exporting these used machine tools, as it is not their normal business model.

Based on the authors' research and SME interviews, a future study should take a deeper look at the market for used machine tools and the technical requirements for upgrading non-listed tools. Further, enforcement outreach should also focus on secondary market for machine tools.

Mass Spectrometers

Finding: While less common than machine tools, mass spectrometers are frequently found on the secondary market.

Finding: A few specific industries (oil and gas, pharmaceuticals) frequently contribute used mass spectrometers to the secondary market. Given the likelihood that these mass spectrometers may be listed commodities and that these industries may not be aware of export control requirements, it may be valuable to understand how these sales are being handled and whether licenses are being appropriately requested for export.

Commodities referenced in this section include:

- 3A233.a-d: Mass spectrometers

Mass spectrometers are used to monitor the performance of uranium enrichment processes and to analyze compounds in nuclear reprocessing facilities. They also have civilian applications in analytical chemistry and the chemical and biomedical industry. Mass spectrometers are reusable, have a high likelihood of reuse, are distinguishable from non-listed commodities, and are frequently sold and observed on secondary markets. Used mass spectrometers have a very high resale value and can be remanufactured.

The global market for new mass spectrometers was valued at USD \$4.6 billion in 2016 and is estimated to reach USD \$7.9 billion by 2023.⁴³ Mass spectrometers rank among the top listed commodities exported from the U.S. each year.⁴⁴ Key manufacturers of mass spectrometers include Agilent Technologies, Inc., Danaher Corporation, Waters Corporation, Bruker

40 "High Precision Machining," Hansford Parts and Products, <<https://hproc.com/>>.

41 "Home | ScottMachinery," Scott Machinery, <<https://www.scottmachinery.com/>>.

42 "Machine Tool Remanufacturer," Texas Machine Tool International, <<http://www.tmiusa.com/remanufacture.html>>.

43 "Mass Spectrometry Market by Technology - Global Opportunity Analysis and Industry Forecast, 2017-2023," Allied Market Research, 2017, <<https://www.alliedmarketresearch.com/mass-spectrometry-market>>.

44 Authors' interviews with SMEs, Seattle, January-March 2019.

Corporation, Thermo Fisher Scientific, Inc., Perkin Elmer, Inc., Shimadzu Corporation, Kore Technologies, Ltd., Dani Instruments S.P.A., and Leco Corporation.

Similar to machine tools, mass spectrometers have a high resale value, thus companies are likely to resell used mass spectrometers to recoup their investment. As a result, many used or refurbished mass spectrometers are sold on e-commerce sites and by the manufacturers themselves. Specialized resellers are limited, but International Equipment Trading LTD and LabX are examples of companies with large supplies of used or refurbished mass spectrometers.^{45,46}

Finally, SMEs noted that some industries generate more used mass spectrometers than others. Specifically, high-value industries, such as oil and gas or pharmaceuticals, typically spare no expense to have the very best and newest equipment. In comparison with most other industries, they are believed to sell used mass spectrometers more frequently.

It would be valuable for a future study to consider how the oil and gas and pharmaceutical industries are handling the sale of used mass spectrometers and if they are being controlled properly for export.

Chemical Process Equipment

Finding: Industrial trends, high initial investments, and good reusability result in great quantities of specialized chemical process equipment on the secondary market, and this is likely to continue.

Finding: Companies that specialize in the refurbishing and resale of glass-lined chemical processing equipment may be a priority for industry outreach, considering the high percentage of commodities expected to be listed.

Commodities addressed in this section include the following:

- 2B350 a-e, g-i: Chemical process equipment
- 2B231: Vacuum pumps
- 2A226: Bellows valves

The authors identified chemical process equipment as a high-interest commodity group for the secondary market. Specifically, in this article, chemical process equipment refers to ECCN 2B350, which includes chemical reactors, agitators, tanks, heat exchangers, distillation or absorption columns, valves, pumps, and vacuum pumps. Two specific commodities, incinerators (2B350.j) and remotely operated filling equipment (2B350.f), are excluded from this list as they are specially designed and rare even on the new market. The authors have not observed multi-walled piping (2B350.h) for sale independently but assume it is included in the sale of

45 “International Equipment Trading Ltd. – Refurbished Analytical Laboratory Equipment,” International Equipment Trading Ltd., <<https://ietltd.com/>>.

46 “New and Used Laboratory Equipment for Sale, Auctions, Wanted,” LabX, <<https://www.labx.com/>>.

whole plants.⁴⁷ This section also includes vacuum pumps (2B231) and bellows valves (2A226) due to their similar characteristics.⁴⁸

Chemical process equipment is of high interest to the secondary market primarily due to its high probability of reuse given its longevity, durability, and ability to be refurbished. According to several experts, some chemical process equipment is designed to last for decades.⁴⁹ Moreover, the chemical industry witnessed two important trends in recent years: (1) rapid growth focused in Asia where it was not previously located and (2) consolidation, with many companies specializing in the activities they do best and contracting out other tasks. Altogether, these trends mean that the decommissioning and resale of chemical processing equipment is more common, and, consequently, more used specialized chemical processing equipment may be available in the world market.⁵⁰ In fact, this trend is significant enough that the U.S. National Research Council released a report in 2014 stating, “Chemical manufacturing equipment never dies, but rather it comes back to life in some other form with some other use because of the significant initial investment that is made in these items.”⁵¹

The high initial investment for chemical processing equipment also plays a large role in its likelihood of being reused. Even though decontamination and dismantlement can be expensive and time consuming, the return on investment can make the process worthwhile. Multiple resellers, auction houses, and specialty organizations sell or facilitate the sale of used equipment. For example, the Federal Equipment Company provides liquidation and auction services; they have at least 50 glass-lined reactors between 100-20,000 litres for sale on their website.⁵² Companies that specialize in plant dismantlement and relocation usually offer resale or “investment recovery” services.⁵³ In one case, R. Baker and Son recovered USD \$4 million of process equipment by auctioning off components and equipment from a Kimberly Clark pulp mill.⁵⁴ Commodities included heat exchangers, agitators, and pumps, some of which may have been listed.

47 It is not unusual to see entire used chemical processing plants for sale. While double-walled piping is not explicitly described in the description of these plants. It is possible that many of them may include double-walled piping. For more information, see <<http://www.ippe.com/Plants>>.

48 Vacuum pumps are listed for nuclear nonproliferation under 2B231 and for chemical weapons under 2B350. Bellows valves (2A226) are controlled for both chemical weapons and nonproliferation.

49 National Research Council, “The Global Movement and Tracking of Chemical Manufacturing Equipment: A Workshop Summary,” edited by Kathryn Hughes and Joe Alper (Washington, DC: The National Academies Press, 2014).

50 Ibid.

51 Ibid.

52 For example, see <http://fedequip.com/inventory/Reactors/#/?_1=1&filter.custitem_material_of_construction=Glass%20Lined&page=3>.

53 For examples of these companies, see Phoenix Equipment Corporation, <<https://www.phxequip.com/resource-detail.39/process-plant-relocation-can-speed-expansion-save-money.aspx>>.

54 R. Baker and Son, “Procter & Gamble Paper Pulp Mill: Asset Recovery, Decommissioning, Dismantling, Demolition,” <http://www.rbaker.com/full_project.php?project=Procter-Gamble-Paper-Pulp-Mill-Decommissioning>.

As with machine tools and mass spectrometers, a market for repairing and refurbishing chemical process equipment exists. For example, listed chemical processing equipment is often glass-lined, and the glass can develop defects or wear thin after years of use. Some defects of this kind can be repaired using prefabricated repair kits of tantalum or tantalum alloy, or as a last resort the entire surface can be reglassed.⁵⁵ Reglassing is the complex process of repairing old, damaged, or worn glass, returning affected equipment to a like-new state in only a few weeks.⁵⁶ The cost savings is said to be almost 50 percent of the list price of a new vessel. Given the economic incentives for refurbishing chemical processing equipment, several companies responded to this need, including De Dietrich Process Systems, Pfaudler, Empire Reglassing and Equipment, and Glasslined Technologies Inc.^{57,58,59,60}

As mentioned earlier, this article makes no effort to determine whether companies responsible for selling used or refurbished listed chemical processing equipment are aware of the export control requirements associated with this equipment. Naturally, only a small fraction of the equipment sold by companies recovering these investments are likely to be listed commodities. However, companies that infrequently sell refurbished equipment (e.g., reglassed chemical processing equipment) may not be as familiar with export requirements unlike the OEM that have more experience.

Given the strong secondary market for chemical process equipment and the good possibility that listed commodities may exist in that market, outreach to resellers of used or refurbished chemical process equipment and whole processing plants is advised.

Biological Process Equipment

Finding: Biological process equipment has a high likelihood of reuse and has been seen on the secondary market.

Finding: The Do It Yourself (DIY) Bio community is an area where the secondhand market for biological process equipment is likely to continue growing, and for that reason, more outreach may be necessary.

Commodities addressed in this section include the following:

- 2B352.b-i: Biological process equipment

55 For more information on reglassing, see Jennifer Mayo, “What is Reglassing and How Can It Work for You?,” De Dietrich Process Systems, April 13, 2015 <<https://www.ddpsinc.com/blog-0/what-is-reglassing-and-how-can-it-work-for-you>>.

56 Within the commodity group of chemical processing equipment, reaction vessels, agitators, storage tanks, containers, valves, and multi-walled piping can be reglassed.

57 Jennifer Mayo, “What is Reglassing and How Can It Work for You?,” *De Dietrich Process Systems*, April 13, 2015 <<https://www.ddpsinc.com/blog-0/what-is-reglassing-and-how-can-it-work-for-you>>.

58 “Recondition and Reglass,” Pfaudler, <<https://www.pfaudler.com/en/products/recondition-reglass>>.

59 “Reglassing,” Empire Reglassing & Equipment, <<https://www.empirereglassingandequipment.com/>>.

60 “Glasslined Technologies Inc,” <<http://glasslined.us/>>.

The authors identified biological process equipment as a high-interest commodity group for the secondary market. Biological process equipment (ECCN 2B352) includes fermenters, centrifugal separators, cross-flow filtration equipment, steam-serializable freeze-drying and spray-drying equipment, protective and containment equipment, aerosol testing chambers, aerosol challenge testing chambers, inhalation chambers, and spraying and fogging systems. P3 and P4 biological containment facilities (2B352.a) are of low interest as none were observed on the secondary market, likely because they are special ordered by a purchaser. With this exception, all the commodities in ECCN 2B352 are reusable and have a high likelihood of reuse. They are easily identified, have a high frequency on the market, and have been observed for sale on the secondary market.

The researchers Zilinskas and Mauger have thoroughly documented the reuse of biological process equipment and their work supports an important conclusion reached by several researchers: most biological process equipment is cheap, widely used, and easily available secondhand.⁶¹ Moreover, it is not uncommon for end-users to repurpose or recondition biological process equipment.⁶² This is particularly true with biotechnology and fermentation industries “where process conditions are generally mild and non-abrasive, and for equipment that has no moving parts.”⁶³ This means that it is common and cost-effective to remanufacture and resell biological process equipment on the secondary market. In fact, a quick search of LabX, one online facilitator specializing in biological process equipment, yielded results for all the commodities listed (aside from P3 and P4 biological containment facilities).

The market for secondhand biological process equipment will continue growing, particularly considering the recent trend known as the “Maker Movement” or “DIY Bio.” New developments in life sciences research launched a paradigm shift regarding where and how such research is performed. Research once conducted by top research institutes and governments can now be conducted at home or in small laboratories by DIY Bio enthusiasts. These small-scale operations do not have support teams to assist them with navigating the legal and regulatory requirements and responsibilities that accompany such research, which presents challenges to enforcement of bio-related laws and regulations. Fortunately, this issue has gained the attention of the U.S. Government, and programs are in place for outreach to the biological research

61 Raymond A. Zilinskas and Philippe Mauger, “Biotechnology E-Commerce: A Disruptive Challenge to Biological Arms Control.” *CNS Occasional Papers*, Vol. 21 (May 7, 2015) <<https://www.nonproliferation.org/biotechnology-e-commerce-a-disruptive-challenge-to-biological-arms-control/>>; Robert Shaw, “Export Controls and the Life Sciences: Controversy or Opportunity?” *EMBO Reports*, Vol. 17, Issue 4 (2016), pp. 474-80, <<https://doi.org/10.15252/embr.201642254>>.

62 Zilinskas and Mauger, “Biotechnology E-Commerce: A Disruptive Challenge to Biological Arms Control.”

63 National Research Council, “The Global Movement and Tracking of Chemical Manufacturing Equipment: A Workshop Summary,” edited by Kathryn Hughes and Joe Alper (Washington, DC: The National Academies Press, 2014).

communities, including the DIY community.^{64,65} The export control community, from large government outreach programs to industry export control offices, can support this outreach by promoting export control awareness among new and existing biological research communities.

Like chemical process equipment, given the strong secondary market for biological process equipment, the growing DIY Bio movement and the good possibility that listed commodities may exist in that market, outreach to resellers of used or refurbished biological process equipment is advised.

Listed Commodities of Medium, Low, and No Interest

The authors identified medium- and low-interest listed commodities based on the same characteristics used for high-interest listed commodities: high likelihood of reuse and frequency on the secondary market. However, these commodities also possessed characteristics that made them less interesting from the perspective of this article, such as lower cost savings, lower likelihood for remanufacturing or refurbishment, lower frequency on the new market, or being indistinguishable from non-listed counterparts. Examples of medium interest commodities include: toxic gas monitoring systems and frequency changers. Low interest commodities include: radiation shielded windows and remote manipulators.

Another important result of this analysis was identifying listed commodities that have no interest for the secondary market. A complete list of these commodities is beyond the scope of this analysis. However, the authors identified the following commodity characteristics that were useful in excluding interest for the secondary market: inability to be reused (i.e., consumable), degraded performance with reuse, or specially designed for a discrete application. Commodities of no interest include: fibrous and filamentary materials, propellants, and high explosives.

Cross-Cutting Issues

The authors identified several issues unique to the secondary market which transcend the individual listed commodity discussion. These topics warrant further discussion.

Recycling of Scrap Metals and Other Materials

Finding: With current recycling processes, most metals cannot be recycled and returned to the composition or performance required for listed commodities. However, consumer and economic trends are changing rapidly in this area, along with innovations in recycling

64 Since 2009, the FBI has made efforts to engage the DIY Bio community, beginning with sponsoring a booth and workshop at the 2009 International Genetic Engineered Machine (iGEM) competition in Cambridge, MA. The engagement has continued since then through sponsorship of several synthetic biology conferences and hosting a number of meetings with the DIY Bio community, including the FBI-sponsored “Bridges” Meeting in San Francisco in 2012.

65 Wolinsky, Howard, “The FBI and Biohackers: An Unusual Relationship: The FBI Has Had Some Success Reaching out to the DIY Biology Community in the USA, but European Biohackers Remain Skeptical of the Intentions of U.S. Law Enforcement.” *EMBO Reports* Vol. 17, Issue 6 (2016), pp. 793-96, <<https://doi.org/10.15252/embr.201642483>>.

technology. Therefore, research should continue in this area.

Finding: Aluminum, titanium, and graphite are the materials most likely to be reused for production of listed commodities.

In general, many materials (especially metals) are reusable and the recycling industry is growing. The United Nations noted that metal reuse (or recycling) needs to dramatically increase to meet the growing demands for critical metals including aluminum, molybdenum, titanium, and tungsten.⁶⁶ However, three necessary conditions must be met for recycling to be feasible:

- 1) A supply of material must exist. Many materials break down with use and cannot be recycled. For example, the titanium pigment found in many paints cannot be easily recovered. On the other hand, some metals retain their mass while in service, making them good candidates for recycling;
- 2) The cost of identifying, collecting, processing, and transporting scrap materials must be low enough to provide a profit margin for an entity that would perform those tasks;
- 3) The quality of recycled materials must be sufficient. In many cases, recycled materials are used in lesser applications because recycling mixed materials dilutes and compromises their composition. This means that some recycled materials may not be ideal for strength-critical areas (e.g., WMD applications), unless it is possible to verify the recycled material's composition. While high-strength metals can be made from scrap, it is only economical when the origin and composition of the metal are known, like with new scrap.

Scrap can be described as either new or old. New scrap is generated during fabrication and manufacturing operations, usually in the form of clippings, stampings, and turnings. These items are usually segregated by material specification and returned to furnace operations where the scrap is matched and melted into a product with the desired composition. The location of new scrap recycling varies: some companies recycle onsite or release it to a contracted recycler, others return it to the source which may be in a foreign country. Old scrap originates when a product of the aforementioned manufacturing process is no longer economical to use (e.g., an old airplane). Unlike new scrap, which is usually recycled directly, old scrap may wait for years until it is recycled and may be mixed with other old scrap materials. As a result, it is more difficult to tell the origin of old scrap and, consequently, more difficult to recycle it to the same standards for composition and strength. The one exception is graphite, for which the recycled properties may be superior to those of its new counterpart, as it relates to WMD applications.⁶⁷ Though recycling of graphite is uncommon, it may be wise to examine innovations and increases in graphite recycling.

66 Thomas E Graedel, Julian Allwood, Jean-Pierre Birat, Barbara K. Reck, Scott F. Sibley, Guido Sonneman, Matthias Buchert, and Christian Hagelueken, "The Recycling Rates of Metals: A Status Report," United Nations Environment Programme, 2011, <<https://www.resourcepanel.org/reports/recycling-rates-metals>>..

67 Juan Liu, Chen Wang, Limin Dong, and Tongxiang Liang, "Study on the Recycling of Nuclear Graphite after Micro-Oxidation," *Nuclear Engineering and Technology*, Vol. 48, Issue 1 (February 2016), pp. 182–88, <<http://www.sciencedirect.com/science/article/pii/S1738573315002041>>.

Future research should focus on those companies recycling new listed scrap and those which claim to produce listed materials from recycled scrap. Advancements in recycling approaches that make the recycling of old scrap more economical at the quality required for WMD applications should be monitored.

Institutional and Regulatory Issues to the Secondary Market

In conducting this analysis, the authors discovered several institutional and regulatory issues relating specifically to the secondary market for some listed commodities. While a thorough analysis of these issues is beyond the scope of this article, an overview of these issues is provided below. These issues may deserve further investigation.

Biological Materials and Awareness of Requirements

Finding: Biological materials may be transferred on the secondary market by researchers who are unaware of the export control requirements but may be more aware of safety-related requirements.

SME interviews indicated that the transfer of secondhand biological materials between people, often researchers, is quite common. However, the materials are usually shared, rather than sold, between people, as part of the scientific method to validate results. Unfortunately, the researchers engaged in these transfers may be more aware of safety-related requirements than export control requirements, meaning that international transfers may be occurring without proper export controls. This topic may warrant further inquiry.

Superconducting Solenoidal Electromagnets

Superconducting solenoidal electromagnets (SSEs) may be interesting to the secondary market because the quantity on the market may be much greater than indicated by export license records alone. This potential inconsistency may exist for two reasons: (1) exported SSEs are exempt from license requirements when incorporated into Magnetic Resonance Imaging (MRI) machines, and (2) a market for recycling MRI components does exist, meaning that it is likely that used SSEs are being bought and sold.⁶⁸ A future study could investigate whether SSEs could be repurposed for other applications or if they are sufficiently “specially designed” to limit their application to only MRI machines.

Conclusions and Recommendations

Based on the findings and analysis, select dual-use commodities are valued on the secondary market. The authors recommend the following actions to enable companies and the U.S. enforcement community to ensure secondary market compliance with export control regulations. *The findings from this article should be incorporated into existing and new export control*

68 “Scrap – Sorted, American Metal Market,” <https://search.proquest.com/docview/2038156373?rfr_id=info%3Axri%2Fsid%3Aprimo>.

trainings.

The U.S. government offers a variety of training opportunities for domestic and foreign entities on export controls. These trainings should include a section on the secondary market and, specifically the high-interest listed commodities found on the secondary market. Additional research on high-interest listed commodities could improve identification and targeting of these commodities which could enhance training materials.

Outreach efforts should prioritize specialty resellers and remanufacturers focused on any of the high-interest listed commodities.

While large e-commerce facilitators such as eBay do undoubtedly facilitate the sale of used listed commodities, outreach to these companies is more challenging for two reasons: 1) they typically sell a wider variety of commodities, making it difficult to target outreach and education, and 2) they may have less incentive for compliance, as they have less legal liability.⁶⁹ Therefore, outreach efforts should prioritize specialty resellers (e.g., LabX) and companies refurbishing specialized equipment (e.g., glass-lining companies) for high-interest listed commodities. Outreach should focus on raising awareness of export control regulations and building relationships in case these specialty resellers receive a suspicious inquiry. Enforcement officials can identify and prioritize companies in their area of responsibility using export data and online research. SMEs might be essential in identifying companies for outreach. Further, government outreach efforts can focus on bringing together companies from similar industries, so that companies with well-established compliance programs can help smaller companies in establishing their compliance programs.

Outreach personnel should encourage companies to track export control information for the listed commodities they use.

Companies understand the regulations governing the export of the listed commodities they sell regularly, but they may be less informed about the regulations on the equipment they actually use for manufacturing. Further, outreach efforts usually focus on ensuring companies follow export control regulations for the listed commodities they produce and export. For companies that use listed industrial equipment, outreach should also focus on export control plans for this equipment. This could include recording the ECCN at the time of the original purchase, creating and maintaining a record of each listed commodity they use, and using this information to determine how the listed commodity should be excessed.

OEMs of listed commodities should include ECCNs in technical specifications.

Manufacturers of listed commodities provide the ECCN to a domestic buyer upon request. It should be common practice for manufacturers to include the ECCN down to the subparagraph level (if necessary) in the bill of sales and on the technical specification datasheet. This would help maintain continuity of knowledge regarding the export control regulations governing that

⁶⁹ It should be noted that eBay, in particular, and some of the other facilitators do have well-developed compliance programs and are known to cooperate closely with law enforcement and proactively monitor users and initiated sales.

item.

OEMs should maintain a public list of all listed commodities and corresponding ECCNs.

It was much easier for the authors to identify used listed commodities with a model number. Dell maintains a reference table of ECCNs, Harmonized Tariff Schedule Numbers, and Commodity Classification Automated Tracking System codes.⁷⁰ Companies could consider maintaining a list of all their commodities and the corresponding ECCNs including non-listed commodities.

OEMs should consider adding ECCNs to commodity name plates.

In many industries, commodities are affixed with an information plate containing a variety of information including certifications, technical specification, and manufacturer. For example, pressure vessels are affixed with a National Board Number which can be tracked.⁷¹ However, export control information is rarely attached. If companies included ECCNs on the name plates, resellers and enforcement personnel would have an easier time referencing them.

One of the main arguments for not listing an ECCN is that control lists change over time. This means a commodity meeting control specifications today might be non-listed (EAR99) in a few years as technology and control lists change. Any easy solution could be to list the ECCN and date then a potential seller would know that the commodity was listed at that time. They could then cross reference the CCL from that date with the current version to see if the item meets the current control language. Further, a published official cross reference between MECR, ECN, and other prominent export controls should be publicly available. This is only one potential solution; further research and outreach might be necessary to move forward with this idea.

Regulators should consider providing guidance on best practices, processes, and procedures to help companies excess or dispose of their dual-use commodities securely.

No agreed upon definition of, or guidelines exist for, rendering a listed commodity useless. Specific guidelines for rendering military commodities useless do exist, but no guidelines exist for dual-use commodities. The Wassenaar Arrangement documented “Best Practices for Disposal of Surplus/Demilitarised Military Equipment” provides some information on rendering commodities useless, but the document stops short of providing activities or instructions on how to dispose of military equipment.⁷² Guidance on end-of-life best practices, processes, and procedures from regulators would help companies dispose of their dual-use commodities securely.

70 “Import/Export Compliance,” Dell, <<https://www.dell.com/learn/us/en/uscorp1/import-export>>.

71 National Research Council, “The Global Movement and Tracking of Chemical Manufacturing Equipment: A Workshop Summary,” edited by Kathryn Hughes and Joe Alper (Washington, DC: The National Academies Press, 2014).

72 Secretariat, Wassenaar Arrangement, “Compendium of Best Practice Documents,” Wassenaar Arrangement on Export Controls for Conventional Arms and Dual-Use Goods and Technologies, 2018, <<https://www.wassenaar.org/app/uploads/2019/consolidated/WA-DOC-18-PUB-003-Public-Docs-Vol-III-Comp.-of-Best-Practice-Documents-Dec-18.pdf>>.

The export control community should monitor innovations in materials recycling, particularly if these recycling methods can create recycled materials of a higher quality than new materials.

Presently, new scrap is the only material that could be recycled into listed materials. As recycling practices improve, the importance of certain materials for the secondary market should be revisited. For example, several SMEs stated that that powders cannot be reused. However, studies related to additive manufacturing are changing long-held views regarding powder use and recycling.⁷³ Another example is carbon fibre, another single-use commodity, for which industry is investigating potential technologies to reuse new scrap.

A group of industry leaders in the secondary market should be convened to understand how they think about export control regulations and identify incentives that will encourage secondary market sellers to improve their compliance with export control regulations. Resellers, particularly facilitators, should consider listed commodities as part of their user agreement. For example, eBay prohibits the sale of certain restricted items, which are enforced by monitoring users with a variety of tools, including filters.⁷⁴ Other companies should be encouraged to institute similar procedures, but no general set of best practices currently exists for these secondary market sellers.

In conclusion, economic and technological trends are changing the way consumers think about used commodities. This has led to an expanding secondary market, and with it, the possibility that some used listed commodities are being exported without appropriate export licenses. This article concluded that listed commodities are being resold on the secondary market and identified the commodities of greatest interest to the secondary market. These conclusions are important for the implementation of export control regulations and it is hoped that the findings from this article will be incorporated into current training and outreach programs on export controls.

73 H. P. Tang, M. Qian, N. Liu, X. Z. Zhang, G. Y. Yang, and J. Wang, "Effect of Powder Reuse Times on Additive Manufacturing of Ti-6Al-4V by Selective Electron Beam Melting." *JOM*, Vol. 67, Issue 3 (2015), pp. 555-63, <<https://doi.org/10.1007/s11837-015-1300-4>>; "Recycling Titanium Powder," <<https://www.manufacturingtomorrow.com/news/2018/11/13/recycling-titanium-powder/12517>>.

74 National Research Council, "The Global Movement and Tracking of Chemical Manufacturing Equipment: A Workshop Summary," edited by Kathryn Hughes and Joe Alper (Washington, DC: The National Academies Press, 2014).