



# 2017 Minerals Yearbook

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## NIOBIUM [ADVANCE RELEASE]

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# NIObIUM

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Domestic survey data and tables were prepared by Robin C. Kaiser, statistical assistant.

In 2017, U.S. niobium apparent consumption (measured in contained niobium) was 7,820 metric tons (t), an increase of 16% compared with a revised 6,730 t in 2016 (table 1). No domestic mine production of niobium ore was reported. The niobium content of world mine production was 69,100 t, 19% greater than that in the previous year (tables 1, 4). The United States imported 9,370 t of niobium contained in niobium-bearing metal, alloys, ores, and concentrates, an increase of 14% compared with a revised 8,250 t in 2016 (table 1). In the same period, the United States exported 1,490 t of niobium contained in niobium-bearing alloys, ores, and concentrates, essentially unchanged from that in 2016. World trade of niobium materials included ferroniobium and niobium metal, ores and concentrates, and scrap. Ferroniobium was the leading traded niobium material. The leading end use of niobium was as an alloying element in carbon steel, followed by high-strength low-alloy (HSLA) and stainless steels (table 2).

## Legislation and Government Programs

Niobium was first added to the U.S. Government stockpile in 1943 (as columbite ore), and the U.S. Congress designated niobium as a strategic and critical material in 1946 by means of the Strategic and Critical Materials Stock Piling Act as amended through P.L. 79–520, July 23, 1946 (DeMille, 1947, p. 135). The Defense Logistics Agency Strategic Materials (DLA Strategic Materials), U.S. Department of Defense, did not designate niobium materials for disposal from the National Defense Stockpile under its fiscal year 2018 Annual Materials Plan (Defense Logistics Agency Strategic Materials, 2017a); however, DLA Strategic Materials designated a maximum quantity of 209 t of ferroniobium for acquisition (Defense Logistics Agency Strategic Materials, 2017b).

## Production

Globally, pyrochlore is the leading mineral mined for niobium. Niobium minerals are typically converted to ferroniobium and other value-added products at the mine site. The primary marketable niobium materials are ferroniobium and niobium metal, ore, and oxide. Niobium resources in the United States are of low grade and not commercially recoverable at current prices. As a result, domestic supply has been a concern during every national military emergency since World War I. In 2017, no domestic niobium mine production was reported. Recycled materials and stocks were the only domestic sources of niobium.

NioCorp Developments Ltd. (Centennial, CO), a resource company developing a niobium deposit in Elk Creek, NE, announced two process developments that were expected to lower the operating expenses as well as the environmental footprint of the Elk Creek project. The company significantly reduced the amount of water needed for the niobium

recovery and purification process and successfully converted waste neutralization and acid regeneration solids, which were previously planned for disposal, into neutralizing agents and process reagents for the production operations (NioCorp Developments Ltd., 2017a). In June, NioCorp published the results of a revised NI 43–101 feasibility study for the Elk Creek project (NioCorp Developments Ltd., 2017b). NioCorp announced that commercial production might begin in 2021, with a planned production rate of 7,060 metric tons per year (t/yr) of ferroniobium during the expected mine life of 32 years (NioCorp Developments Ltd., 2017c). With the feasibility study complete and the U.S. Clean Water Act Section 404 permit for the project waterline secured, NioCorp planned to accelerate the project financing efforts and continue ongoing efforts to secure the remaining government permits required prior to the onset of construction (NioCorp Developments Ltd., 2017b).

## Consumption

Domestic consumption data for niobium materials were developed by the USGS by means of the “Columbium (Niobium) and Tantalum,” “Consolidated Consumers,” and “Specialty Ferroalloys” surveys. For niobium materials, no consumers responded to the “Columbium (Niobium) and Tantalum” canvass, 11 responded to the “Consolidated Consumers” canvass, and 2 responded to the “Specialty Ferroalloys” canvass.

Total apparent domestic consumption of niobium (measured in contained niobium) was 7,820 t in 2017, a 16% increase compared with that in 2016 (table 2). Reading Alloys, Inc. [a Robeson, PA, subsidiary of AMETEK Specialty Metal Products (United Kingdom)], ATI Specialty Alloys and Components (Pittsburgh, PA), Global Advanced Metals Pty Ltd. (GAM) (Waltham, MA), and H.C. Starck Inc. (Newton, MA) consumed niobium feed materials to produce intermediate niobium materials used in industrial manufacturing processes and products. Ferroniobium, the most commonly traded niobium material, was typically consumed in the production of HSLA steel. Other uses included the fabrication of nonferrous and niobium alloys and production of niobium carbides and chemicals.

## Prices

Niobium materials were not openly traded on exchanges. Purchase contracts were confidential between buyer and seller. Based on U.S. Census Bureau data for 2017, the average unit value of traded (imported plus exported) niobium-containing materials was \$31.20 per kilogram for niobium oxide; \$20.69 per kilogram for niobium-containing ores and concentrates, including tantalum ores and synthetic concentrates; and \$19.83 per kilogram for ferroniobium (table 1).

## Foreign Trade

According to the U.S. Census Bureau, in 2017 the United States exported niobium materials valued at \$33.5 million (a decrease of 14% from that in 2016) and imported niobium materials valued at \$376 million (an 8% increase from the revised value in 2016) (table 3). Traded niobium materials included ferroniobium and niobium concentrates, metal, ores, and oxide. In 2017, Brazil continued to be the leading supplier of ferroniobium and niobium metal and oxides (table 3). Mexico and Canada continued to be the leading destinations of United States ferroniobium exports.

## World Industry Structure

In 2017, world production of niobium contained in cassiterite, columbite-tantalite, loparite, and pyrochlore concentrates was estimated to be 69,100 t (table 4), an increase of 19% compared with that in 2016. World production of ferroniobium, in terms of niobium content, was 59,500 t, 11% more than that in 2016 (table 5). Brazil and Canada were the leading producers of ferroniobium (table 5) and niobium mineral concentrates (table 4), accounting for more than 99% of global ferroniobium production and 98% of global niobium mineral concentrates production. In Brazil, the leading producers were Companhia Brasileira de Metalurgia e Mineração (CBMM) and Niobras Mineração Ltda. [a subsidiary of China Molybdenum Co., Ltd. (China)]. In Canada, the leading producer was Niobec (a subsidiary of Magris Resources Inc.).

Niobium ore was primarily mined in Brazil, Canada, China, and countries in the Great Lakes region of Africa. Niobium ore was typically beneficiated to concentrates containing about 55% to 60% niobium oxide ( $\text{Nb}_2\text{O}_5$ ) (Roskill Information Services Ltd., 2013, p. 9). Concentrates were further processed to produce ferroniobium or niobium metal and oxides. Ferroniobium, the leading commercial niobium-containing material, typically contained about 66% niobium (Roskill Information Services Ltd., 2013, p. 12).

## World Review

**Australia.**—Australian Zirconia Ltd. (a wholly owned subsidiary of Alkane Resources Ltd.) changed its name to Australian Strategic Materials NL (ASM). ASM was developing the Dubbo project (formerly called the Dubbo Zirconia project) in New South Wales and announced that the project was ready for construction with all State and Federal licenses in place. In June, ASM reported proven reserves of 18.9 million metric tons (Mt) of niobium-bearing trachyte ore with an average grade of 0.44%  $\text{Nb}_2\text{O}_5$  and updated resources of 75.2 Mt with an average grade of 0.44%  $\text{Nb}_2\text{O}_5$ . ASM projected that the Dubbo project would produce 1,970 t/yr of niobium contained in ferroniobium (65% niobium content) (Alkane Resources Ltd., 2017, p. 14). At yearend, the company was focused on securing funding for construction of the project.

**Brazil.**—In July, the Government of Brazil implemented a new mining code to replace mining legislation that had been in place since the 1960s (Camargo and Assalve, 2017). Under the new regulations, the Departamento Nacional de Produção Mineral was replaced by the newly created Agência Nacional

de Mineração. In addition, the new regulations proposed an increase in niobium royalties from 2% to 3% to be calculated based on gross revenue of the company. The National Congress of Brazil ratified the new legislation in November, and the new royalty rates were expected to go into effect at the beginning of 2018 (Camargo and others, 2017; Spring, 2017).

Mineração Taboca S.A. [a subsidiary of MINSUR S.A. (Peru)] operated the Pitinga-Pirapora Mine complex in the State of Amazonas. Following expansion of its tantalum-niobium ore flotation plant and ferroalloy processing and smelting facilities in 2016, Taboca increased its niobium and tantalum ferroalloy production by 77% to 3,250 t of total ferroalloys in 2017 (MINSUR S.A., 2018, p. 24).

**Canada.**—NioBay Metals Inc. announced new assay results for the James Bay niobium project in northern Ontario (NioBay Metals Inc., 2017b). The results validated historical data and confirmed the presence of high niobium grades in the James Bay niobium deposit. NioBay reported initial mineral resource estimates in accordance with NI 43-101 standards of 23.1 Mt of indicated niobium resources with a grade of 0.53%  $\text{Nb}_2\text{O}_5$  and 23.0 Mt of inferred resources with a grade of 0.51%  $\text{Nb}_2\text{O}_5$  (NioBay Metals Inc., 2017c). As of June, the company's exploration permit with the Ministry of Northern Development and Mines of Ontario for proposed exploration drilling at James Bay was on temporary hold (NioBay Metals Inc., 2017a).

**China.**—In January, China reduced its export tariff on a number of ferroalloys in an effort to boost the country's exports. The tariff on ferroniobium was reduced by 5% to 15% (Metal Bulletin, 2017). In December, China announced an additional reduction of 5% on the export tariff for ferroniobium, to 10%, which was expected to go into effect in 2018 (Argus Metals International, 2017). China exported 213 t of ferroniobium in 2017, 40% less than that in 2016 (IHS Markit Inc., 2018).

**Malawi.**—Mkango Resources Ltd. (Canada) announced that it identified new zones of high-grade niobium at the Thambani project in southern Malawi. Assay results from 85 rock samples showed niobium grades of up to 6%  $\text{Nb}_2\text{O}_5$  (Mkango Resources Ltd., 2017a). The new areas of high-grade mineralization were identified from high radiometric and magnetic anomalies in airborne geophysical surveys conducted in 2016. In August, the Government of Malawi granted a 2-year renewal of Mkango's Thambani exclusive exploration license (Mkango Resources Ltd., 2017b).

**Russia.**—LLC Lovozero GOK produced loparite mineral concentrates at the Lovozero Mine in the Murmansk region (Ministry of Economic Development of the Murmansk Region, 2018, p. 2). All loparite concentrate produced by Lovozero was consumed by JSC Solikamsk Magnesium Works, which produced ferroniobium and niobium compounds at the Solikamsk facility (Ministry of Natural Resources and Ecology of the Russian Federation, 2016, p. 263; JSC Solikamsk Magnesium Works, 2017, p. 12–14).

**Tanzania.**—In July, the Parliament of Tanzania enacted a new mining bill, which entitled the Government to a minimum of 16% shareholding in all mining projects in Tanzania. In addition, the Government of Tanzania announced that it would not issue any new mining licenses until all existing licenses with foreign investors were reviewed (Ng'wanakilala, 2017).

Cradle Resources Ltd. (Australia), which was developing the Panda Hill niobium project in southwestern Tanzania, announced that it completed the front-end engineering and design and selected a contractor for the construction of the proposed Panda Hill niobium mine. At yearend, Cradle was focused on securing funding for construction of the project. The Panda Hill niobium project was owned by Panda Hill Tanzania Ltd., a 50–50 joint venture between Cradle and Tremont Investments Ltd. When complete, the Panda Hill complex was expected to produce 5,400 t/yr of contained niobium as ferroniobium over an approximate mine life of 30 years (Cradle Resources Ltd., 2017, p. 2–3).

## Outlook

Currently, operating niobium mines have adequate reserves to meet global demand for the foreseeable future. The steel industry is the largest consumer of niobium (mainly in HSLA steel), and niobium content of HSLA steel is greatest in developed countries, suggesting that niobium use in steel could increase in developing nations (Roskill Information Services Ltd., 2013, p. 197–213). Potential new sources of niobium are typically associated with the production of other mineral deposits with niobium as a byproduct. Several potential new niobium sources were in development during 2017, including the Dubbo, Elk Creek, and Panda Hill projects in Australia, the United States, and Tanzania, respectively. However, these projects were not expected to come into production in 2018, and thus no significant change in production distribution is anticipated.

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TABLE 1  
 SALIENT NIOBIUM STATISTICS<sup>1</sup>

	2013	2014	2015	2016	2017
United States:					
Exports:					
Niobium ores and concentrates, gross weight metric tons	110	60	73	14	7
Synthetic concentrates, gross weight do.	61	200	138	379	113
Tantalum ores and concentrates, gross weight do.	204	225	98	162	109
Niobium-containing ores and concentrates, <sup>2</sup> Nb content do.	53	60	42	64	26
Ferroniobium, Nb content do.	382	1,050	1,390	1,410	1,460
Total exports, Nb content do.	435	1,110	1,430	1,480	1,490
Imports for consumption:					
Niobium ores and concentrates, gross weight do.	8	2	--	1	1
Synthetic concentrates, gross weight do.	--	--	--	9	15
Tantalum ores and concentrates, gross weight do.	655	897	730	675	1,010
Niobium-containing ores and concentrates, <sup>2</sup> Nb content do.	75	101	82	77 <sup>r</sup>	115
Niobium metal, Nb content <sup>3</sup> do.	1,360	1,870	886	1,240 <sup>r</sup>	1,530
Niobium oxide, Nb content <sup>e</sup> do.	997	1,020	983	855	895
Ferroniobium, Nb content <sup>e</sup> do.	6,140	8,120	6,570	6,080	6,830
Total imports, Nb content do.	8,580	11,100	8,520	8,250 <sup>r</sup>	9,370
Reported consumption, Nb content:					
Raw materials do.	W	W	W	W	W
Ferroniobium and nickel niobium do.	7,500	8,210	7,510	7,370	7,510
Apparent consumption, Nb content do.	8,140	10,000	7,080	6,730 <sup>r</sup>	7,820
Value: <sup>4</sup>					
Niobium ores and concentrates dollars per kilogram	17.15	14.94	7.59	7.83	20.69
Niobium oxide do.	43.47	37.04	36.19	33.66	31.20
Ferroniobium do.	27.29	25.78	24.27	20.56 <sup>r</sup>	19.83
World, production of niobium concentrates, Nb content metric tons	59,700 <sup>r</sup>	69,000 <sup>r</sup>	65,500 <sup>r</sup>	58,300 <sup>r</sup>	69,100 <sup>c</sup>

<sup>e</sup>Estimated. <sup>r</sup>Revised. do. Ditto. W Withheld to avoid disclosing company proprietary data. -- Zero.

<sup>1</sup>Table includes data available through April 9, 2019. Data are rounded to no more than three significant digits, except values; may not add to totals shown.

<sup>2</sup>Includes natural and synthetic niobium-containing ores and concentrates. Nb content of ores and concentrates was estimated assuming the following Nb<sub>2</sub>O<sub>5</sub> contents: 30% in niobium ore, 16% in synthetic concentrates, and 16% in tantalum ore. Nb<sub>2</sub>O<sub>5</sub> is 69.904% Nb.

<sup>3</sup>Includes niobium and articles made of niobium.

<sup>4</sup>Weighted average value of imported plus exported materials.

Sources: U.S. Census Bureau and U.S. Geological Survey.

TABLE 2  
 REPORTED CONSUMPTION, BY END USE, INDUSTRY STOCKS OF FERRONIUM AND  
 NICKEL NIOBIUM, AND GOVERNMENT STOCKS BY MATERIAL IN THE UNITED STATES<sup>1</sup>

(Metric tons, niobium content)

	2016	2017
End use:		
Steel:		
Carbon	1,180	1,170
Stainless and heat-resisting	615	689
Full alloy	(2)	(2)
High-strength low-alloy	680	719
Electric	(2)	(2)
Tool	(2)	(2)
Unspecified	3,100	3,090
Total	5,580	5,670
Superalloys	1,770	1,820
Alloys (excluding steels and superalloys)	21	20
Grand total	<u>7,370</u>	<u>7,510</u>
Stocks, December 31:		
Consumer	390	393
Producer <sup>3</sup>	W	W
Total	390	393
National Defense Stockpile, total uncommitted inventory by material:		
Ferroniobium	39 <sup>r</sup>	104
Niobium metal ingots	10 <sup>r</sup>	10

<sup>r</sup>Revised. W Withheld to avoid disclosing company proprietary data.

<sup>1</sup>Table includes data available through April 9, 2019. Data are rounded to no more than three significant digits; may not add to totals shown.

<sup>2</sup>Included with "Steel, unspecified."

<sup>3</sup>Ferroniobium only.

TABLE 3  
U.S. FOREIGN TRADE IN NIOBIUM, BY CLASS<sup>1</sup>

HTS <sup>2</sup> code	Class	2016		2017		Principal destinations and sources in 2017 (gross weight in kilograms and values in thousand dollars)
		Gross weight (kilograms)	Value (thousands)	Gross weight (kilograms)	Value (thousands)	
Exports:						
2615.90.3000	Synthetic concentrates	379,000	\$6,030	113,000	\$3,300	China 67,900, \$1,660; Germany 16,200, \$620; Hong Kong 14,100, \$372; Mexico 12,400, \$586.
2615.90.6030	Niobium ores and concentrates	14,300	103	7,460	165	India 2,190, \$47; United Kingdom 2,010, \$21; China 1,400, \$37; Chile 980, \$28.
2615.90.6060	Tantalum ores and concentrates <sup>3</sup>	162,000	7,300	109,000	3,840	Austria 38,200, \$245; Germany 27,900, \$1,230; Thailand 24,900, \$1,390; China 15,000, \$754.
7202.93.0000	Ferromiobium	2,180,000	25,500	2,250,000	26,200	Mexico 1,280,000, \$13,999; Canada 970,000, \$12,200; Peru 1,550, \$17.
	Total exports	XX	38,900	XX	33,500	
Imports for consumption:						
2615.90.3000	Synthetic concentrates	9,150	46	14,900	1,970	Germany 14,900, \$1,970; Mexico 17, \$3.
2615.90.6030	Niobium ores and concentrates	1,160	18	1,120	12	China 1,120, \$12.
2615.90.6060	Tantalum ores and concentrates <sup>3</sup>	675,000	37,300	1,010,000	39,500	Rwanda 465,000, \$16,800; Australia 198,000, \$8,190; Mozambique 105,000, \$3,620.
2825.90.1500	Oxide	1,220,000	41,200	1,280,000	39,900	Brazil 449,000, \$15,000; Russia 287,000, \$7,370; Thailand 216,000, \$5,710.
	Total ores, concentrates, and oxides	XX	78,500	XX	81,400	
Ferromiobium:						
7202.93.4000	Silicon < 0.4%	1,060,000 <sup>r</sup>	33,500 <sup>r</sup>	561,000	22,000	Brazil 321,000, \$13,700; Germany 230,000, \$8,030; Russia 5,000, \$126.
7202.93.8000	Other	8,280,000 <sup>r</sup>	178,000 <sup>r</sup>	9,950,000	205,000	Brazil 6,390,000, \$127,000; Canada 3,550,000, \$77,100; Germany 3,390, \$68.
	Total ferromiobium	9,350,000 <sup>r</sup>	211,000 <sup>r</sup>	10,500,000	227,000	
8112.92.4000	Unwrought, powders <sup>4</sup>	1,240,000 <sup>r</sup>	59,300 <sup>r</sup>	1,530,000	68,100	Brazil 1,290,000, \$55,800; Russia 83,600, \$3,350; Switzerland 63,900, \$2,550.
	Total imports	XX	349,000 <sup>r</sup>	XX	376,000	

<sup>r</sup>Revised. XX Not applicable.<sup>1</sup>Table includes data available through April 9, 2019. Data are rounded to no more than three significant digits; may not add to totals shown.<sup>2</sup>Harmonized Tariff Schedule of the United States.<sup>3</sup>Tantalum ores and concentrates may contain niobium. To estimate Nb content, it was assumed that tantalum ores and concentrates contain 16.0% Nb<sub>2</sub>O<sub>5</sub>. The Nb content of Nb<sub>2</sub>O<sub>5</sub> is 69.904%.<sup>4</sup>Niobium waste and scrap is included in 8112.92.0600 along with other materials. Niobium other than powders, unwrought, and waste and scrap is included in 8112.99.9000 along with other materials.

Sources: U.S. Census Bureau and U.S. Geological Survey.

TABLE 4  
 NIOBIUM: WORLD PRODUCTION OF MINERAL CONCENTRATES, BY COUNTRY OR LOCALITY<sup>1,2</sup>

(Kilograms, niobium content)

Country or locality <sup>3</sup>	2013	2014	2015	2016	2017
Brazil, mineral concentrate <sup>4</sup>	53,756,000	62,055,000	58,852,000 <sup>r</sup>	50,752,000 <sup>r</sup>	60,700,000
Burundi, ore and concentrate	14,000	21,000	10,000	6,200 <sup>r</sup>	17,000 <sup>e</sup>
Canada, pyrochlore concentrate	4,916,000	5,774,000	5,385,000	6,213,000	6,981,000
China, mineral concentrate <sup>e</sup>	15,400	19,600	30,100	35,000 <sup>r</sup>	37,000
Congo (Kinshasa):					
Cassiterite concentrate	76,000 <sup>r</sup>	74,000 <sup>r</sup>	84,000 <sup>r</sup>	120,000 <sup>r</sup>	190,000
Columbite-tantalite concentrate	120,000	200,000 <sup>r</sup>	370,000 <sup>r</sup>	420,000 <sup>r</sup>	380,000
Ethiopia, columbite-tantalite concentrate <sup>e</sup>	3,900	12,000	15,000	16,000	18,000
Mozambique, columbite-tantalite concentrate	3,406 <sup>r</sup>	4,837 <sup>r</sup>	2,735 <sup>r</sup>	4,005 <sup>r</sup>	3,700 <sup>e</sup>
Nigeria, columbite-tantalite concentrate <sup>e</sup>	38,000	52,000	52,000	52,000	44,000
Russia, loparite concentrate	357,002	405,935	439,140	439,209	457,000 <sup>e</sup>
Rwanda:					
Cassiterite concentrate	43,000 <sup>r</sup>	53,000 <sup>r</sup>	34,000 <sup>r</sup>	32,000 <sup>r</sup>	42,000
Columbite-tantalite concentrate	310,000	290,000	210,000	160,000 <sup>r</sup>	220,000
Uganda, ore and concentrate <sup>e</sup>	--	--	1,000	970	1,000
Total	59,700,000 <sup>r</sup>	69,000,000 <sup>r</sup>	65,500,000 <sup>r</sup>	58,300,000 <sup>r</sup>	69,100,000 <sup>e</sup>

<sup>e</sup>Estimated. <sup>r</sup>Revised. -- Zero.

<sup>1</sup>Table includes data available through July 30, 2018. All data are reported unless otherwise noted. Totals and estimated data are rounded to no more than three significant digits; may not add to totals shown.

<sup>2</sup>Figures for all countries and (or) localities represent marketable output.

<sup>3</sup>In addition to the countries and (or) localities listed, Australia, French Guiana, and Malaysia may have produced niobium mineral concentrates, but available information was inadequate to make reliable estimates of output.

<sup>4</sup>Includes columbite-tantalite and pyrochlore.

TABLE 5  
 FERRONIObIUM (FERROCOlUMBIUM): WORLD PRODUCTION, BY COUNTRY OR LOCALITY<sup>1</sup>

(Metric tons, niobium content)

Country or locality <sup>2</sup>	2013	2014	2015	2016	2017
Brazil	46,555	51,737	52,000 <sup>r</sup>	47,300 <sup>r</sup>	52,455
Canada	4,916	5,774	5,385	6,213	6,981
Russia <sup>e</sup>	120 <sup>r</sup>	100 <sup>r</sup>	160 <sup>r</sup>	80 <sup>r</sup>	65
Total	51,600 <sup>r</sup>	57,600 <sup>r</sup>	57,500 <sup>r</sup>	53,600 <sup>r</sup>	59,500 <sup>e</sup>

<sup>e</sup>Estimated. <sup>r</sup>Revised.

<sup>1</sup>Table includes data available through June 12, 2018. All data are reported unless otherwise noted. Totals and estimated data are rounded to no more than three significant digits; may not add to totals shown.

<sup>2</sup>In addition to the countries and (or) localities listed, Austria, China, and Germany may have produced ferroniobium (ferrocolumbium), but available information was inadequate to make reliable estimates of output.