THE WASSENAAR ARRANGEMENT

ON

EXPORT CONTROLS FOR CONVENTIONAL ARMS

AND

DUAL-USE GOODS AND TECHNOLOGIES

LIST OF DUAL-USE GOODS AND TECHNOLOGIES

AND

MUNITIONS LIST

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* This Corrigendum is issued to correct the following:
5.E.1.a. – "required" has been deleted after "Technology";
5.E.1.b.1. – "required" has been moved from *before* to *after* "Technology";
2.B.1.b.2.d. and Sensitive List 1.C.7.d. – reference to year of deletion inserted.

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These Lists reflect the agreements recorded in Appendix 5 to the Initial Elements, dated 19 December 1995, and all subsequent amendments, including those approved by the Plenary Meeting (6-8 December 2016).

DUAL-USE LIST

Note 1 *Terms in "quotations" are defined terms. Refer to 'Definitions of Terms used in these Lists' annexed to this List.*

Note 2 *In some instances chemicals are listed by name and CAS number. The list applies to chemicals of the same structural formula (including hydrates) regardless of name or CAS number. CAS numbers are shown to assist in identifying a particular chemical or mixture, irrespective of nomenclature. CAS numbers cannot be used as unique identifiers because some forms of the listed chemical have different CAS numbers, and mixtures containing a listed chemical may also have different CAS numbers.*

GENERAL TECHNOLOGY NOTE

The export of "technology" which is "required" for the "development", "production" or "use" of items controlled in the Dual-Use List is controlled according to the provisions in each Category. This "technology" remains under control even when applicable to any uncontrolled item.

Controls do not apply to that "technology" which is the minimum necessary for the installation, operation, maintenance (checking) or repair of those items which are not controlled or whose export has been authorised.

Note *This does not release such "technology" controlled in entries 1.E.2.e. & 1.E.2.f. and 8.E.2.a. & 8.E.2.b.*

Controls do not apply to "technology" "in the public domain", to "basic scientific research" or to the minimum necessary information for patent applications.

GENERAL SOFTWARE NOTE

The Lists do not control "software" which is any of the following:

1. Generally available to the public by being:
   a. Sold from stock at retail selling points without restriction, by means of:
      1. Over-the-counter transactions;
      2. Mail order transactions;
      3. Electronic transactions; or
      4. Telephone call transactions; and

   b. Designed for installation by the user without further substantial support by the supplier;

   Note *Entry 1 of the General Software Note does not release "software" controlled by Category 5 - Part 2 ("Information Security").*

2. "In the public domain"; or

3. The minimum necessary "object code" for the installation, operation, maintenance (checking) or repair of those items whose export has been authorised.

   Note *Entry 3 of the General Software Note does not release "software" controlled by Category 5 - Part 2 ("Information Security").*

GENERAL "INFORMATION SECURITY" NOTE

"Information security" items or functions should be considered against the provisions in Category 5 - Part 2, even if they are components, "software" or functions of other items.

1. A. SYSTEMS, EQUIPMENT AND COMPONENTS

1. A. 1. Components made from fluorinated compounds, as follows:

a. Seals, gaskets, sealants or fuel bladders, specially designed for "aircraft" or aerospace use, made from more than 50 % by weight of any of the materials specified by 1.C.9.b. or 1.C.9.c.;

b. Not used since 2015

c. Not used since 2015

1. A. 2. "Composite" structures or laminates, having any of the following:

a. Consisting of an organic "matrix" and materials specified by 1.C.10.c., 1.C.10.d. or 1.C.10.e.; or

b. Consisting of a metal or carbon "matrix", and any of the following:
   1. Carbon "fibrous or filamentary materials" having all of the following:
      a. A "specific modulus" exceeding 10.15 x 10^6 m; and
      b. A "specific tensile strength" exceeding 17.7 x 10^4 m; or
   2. Materials specified by 1.C.10.c.

Note 1 *1.A.2. does not apply to "composite" structures or laminates, made from epoxy resin impregnated carbon "fibrous or filamentary materials", for the repair of "civil aircraft" structures or laminates, having all of the following:*
a. An area not exceeding 1 m^2;
b. A length not exceeding 2.5 m; and
c. A width exceeding 15 mm.

Note 2 *1.A.2. does not apply to semi-finished items, specially designed for purely civilian applications as follows:*
a. Sporting goods;
b. Automotive industry;
c. Machine tool industry;
d. Medical applications.

Note 3 *1.A.2.b.1. does not apply to semi-finished items containing a maximum of two dimensions of interwoven filaments and specially designed for applications as follows:*
a. Metal heat-treatment furnaces for tempering metals;
b. Silicon boule production equipment.

Note 4 *1.A.2. does not apply to finished items specially designed for a specific application.*

1. A. 3. Manufactures of non-"fusible" aromatic polyimides in film, sheet, tape or ribbon form having any of the following:

a. A thickness exceeding 0.254 mm; or
b. Coated or laminated with carbon, graphite, metals or magnetic substances.

Note *1.A.3. does not apply to manufactures when coated or laminated with copper and designed for the production of electronic printed circuit boards.*

N.B. *For "fusible" aromatic polyimides in any form, see 1.C.8.a.3.*

1. A. 4. Protective and detection equipment and components, not specially designed for military use, as follows:

a. Full face masks, filter canisters and decontamination equipment therefor, designed or modified for defence against any of the following, and specially designed components therefor:

Note *1.A.4.a. includes Powered Air Purifying Respirators (PAPR) that are designed or modified for defence against agents or materials, listed in 1.A.4.a.*

Technical Notes

For the purposes of 1.A.4.a.:
1. Full face masks are also known as gas masks.
2. Filter canisters include filter cartridges.

1. A. 4. a. 1. "Biological agents";
2. 'Radioactive materials';
3. Chemical warfare (CW) agents; or
4. "Riot control agents", including:
   a. α-Bromobenzeneacetonitrile, (Bromobenzyl cyanide) (CA) (CAS 5798-79-8);
   b. [(2-chlorophenyl) methylene] propanedinitrile, (o-Chlorobenzylidenemalononitrile) (CS) (CAS 2698-41-1);
   c. 2-Chloro-1-phenylethanone, Phenylacyl chloride(ω-chloroacetophenone) (CN) (CAS 532-27-4);
   d. Dibenz-(b,f)-1,4-oxazephine, (CR) (CAS 257-07-8);
   e. 10-Chloro-5,10-dihydrophenarsazine, (Phenarsazine chloride), (Adamsite), (DM) (CAS 578-94-9);
   f. N-Nonanoylmorpholine, (MPA) (CAS 5299-64-9);

b. Protective suits, gloves and shoes, specially designed or modified for defence against any of the following:
1. "Biological agents";
2. 'Radioactive materials'; or
3. Chemical warfare (CW) agents;

c. Detection systems, specially designed or modified for detection or identification of any of the following, and specially designed components therefor:
1. "Biological agents";
2. 'Radioactive materials'; or
3. Chemical warfare (CW) agents.

1. A. 4. d. Electronic equipment designed for automatically detecting or identifying the presence of "explosives" residues and utilising 'trace detection' techniques (e.g., surface acoustic wave, ion mobility spectrometry, differential mobility spectrometry, mass spectrometry).

Technical Note
'Trace detection' is defined as the capability to detect less than 1 ppm vapour, or 1 mg solid or liquid.

Note 1 *1.A.4.d. does not apply to equipment specially designed for laboratory use.*

Note 2 *1.A.4.d. does not apply to non-contact walk-through security portals.*

Note *1.A.4. does not apply to:*
a. Personal radiation monitoring dosimeters;
b. Occupational health or safety equipment limited by design or function to protect against hazards specific to residential safety or civil industries, including:
1. mining;
2. quarrying;
3. agriculture;
4. pharmaceutical;
5. medical;
6. veterinary;
7. environmental;
8. waste management;
9. food industry.

Technical Notes
1. 1.A.4. includes equipment and components that have been identified, successfully tested to national standards or otherwise proven effective, for the detection of or defence against 'radioactive materials', "biological agents", chemical warfare agents, 'simulants' or "riot control agents", even if such equipment or components are used in civil industries such as mining, quarrying, agriculture, pharmaceuticals, medical, veterinary, environmental, waste management, or the food industry.
2. 'Simulant': A substance or material that is used in place of toxic agent (chemical or biological) in training, research, testing or evaluation.
3. For the purposes of 1.A.4., 'radioactive materials' are those selected or modified to increase their effectiveness in producing casualties in humans or animals, degrading equipment or damaging crops or the environment.

1. A. 5. Body armour and components therefor, as follows:

a. Soft body armour not manufactured to military standards or specifications, or to their equivalents, and specially designed components therefor;

b. Hard body armour plates providing ballistic protection equal to or less than level IIIA (NIJ 0101.06, July 2008) or national equivalents.

N.B.1. *For "fibrous or filamentary materials" used in the manufacture of body armour, see entry 1.C.10.*

N.B.2. *For body armour manufactured to military standards or specifications, see entry ML13.d.*

Note 1 *1.A.5. does not apply to body armour when accompanying its user for the user's own personal protection.*

Note 2 *1.A.5. does not apply to body armour designed to provide frontal protection only from both fragment and blast from non-military explosive devices.*

Note 3 *1.A.5. does not apply to body armour designed to provide protection only from knife, spike, needle or blunt trauma.*

1. A. 6. Equipment, specially designed or modified for the disposal of improvised explosive devices, as follows, and specially designed components and accessories therefor:
   a. Remotely operated vehicles;
   b. 'Disruptors';

   Technical Note
   'Disruptors' – Devices specially designed for the purpose of preventing the operation of an explosive device by projecting a liquid, solid or frangible projectile.

   N.B. *For equipment specially designed for military use for the disposal of improvised explosive devices, see also ML4.*

   Note *1.A.6. does not apply to equipment when accompanying its operator .*

1. A. 7. Equipment and devices, specially designed to initiate charges and devices containing "energetic materials", by electrical means, as follows:
   a. Explosive detonator firing sets designed to drive explosive detonators specified by 1.A.7.b.
   b. Electrically driven explosive detonators as follows:
      1. Exploding bridge (EB);
      2. Exploding bridge wire (EBW);
      3. Slapper;
      4. Exploding foil initiators (EFI).

      Technical Notes
      1. The word initiator or igniter is sometimes used in place of the word detonator.
      2. For the purpose of 1.A.7.b. the detonators of concern all utilise a small electrical conductor (bridge, bridge wire, or foil) that explosively vaporises when a fast, high-current electrical pulse is passed through it. In non-slapper types, the exploding conductor starts a chemical detonation in a contacting high explosive material such as PETN (pentaerythritoltetranitrate). In slapper detonators, the explosive vaporisation of the electrical conductor drives a flyer or slapper across a gap, and the impact of the slapper on an explosive starts a chemical detonation. The slapper in some designs is driven by magnetic force. The term exploding foil detonator may refer to either an EB or a slapper-type detonator.

   N.B. *For equipment and devices specially designed for military use see the Munitions List.*

1. A. 8. Charges, devices and components, as follows:
   a. 'Shaped charges' having all of the following:
      1. Net Explosive Quantity (NEQ) greater than 90 g; and
      2. Outer casing diameter equal to or greater than 75 mm;
   b. Linear shaped cutting charges having all of the following, and specially designed components therefor:
      1. An explosive load greater than 40 g/m; and
      2. A width of 10 mm or more;
   c. Detonating cord with explosive core load greater than 64 g/m;
   d. Cutters, other than those specified by 1.A.8.b., and severing tools, having a NEQ greater than 3.5 kg.

   Note *The only charges and devices specified in 1.A.8. are those containing "explosives" listed in the Annex to Category 1 and mixtures thereof.*

   Technical Note
   'Shaped charges' are explosive charges shaped to focus the effects of the explosive blast.

1. B. TEST, INSPECTION AND PRODUCTION EQUIPMENT

1. B. 1. Equipment for the production or inspection of "composite" structures or laminates specified by 1.A.2. or "fibrous or filamentary materials" specified by 1.C.10., as follows, and specially designed components and accessories therefor:
   a. Filament winding machines, of which the motions for positioning, wrapping and winding fibres are coordinated and programmed in three or more 'primary servo positioning' axes, specially designed for the manufacture of "composite" structures or laminates, from "fibrous or filamentary materials";
   b. 'Tape-laying machines', of which the motions for positioning and laying tape are coordinated and programmed in five or more 'primary servo positioning' axes, specially designed for the manufacture of "composite" airframe or missile structures;

      Technical Note
      For the purposes of 1.B.1.b., 'tape-laying machines' have the ability to lay one or more 'filament bands' limited to widths greater than 25.4 mm and less than or equal to 304.8 mm, and to cut and restart individual 'filament band' courses during the laying process.
   c. Multidirectional, multidimensional weaving machines or interlacing machines, including adapters and modification kits, specially designed or modified for weaving, interlacing or braiding fibres for "composite" structures;

      Technical Note
      For the purposes of 1.B.1.c., the technique of interlacing includes knitting.
   d. Equipment specially designed or adapted for the production of reinforcement fibres, as follows:
      1. Equipment for converting polymeric fibres (such as polyacrylonitrile, rayon, pitch or polycarbosilane) into carbon fibres or silicon carbide fibres, including special equipment to strain the fibre during heating;
      2. Equipment for the chemical vapour deposition of elements or compounds, on heated filamentary substrates, to manufacture silicon carbide fibres;
      3. Equipment for the wet-spinning of refractory ceramics (such as aluminium oxide);
      4. Equipment for converting aluminium containing precursor fibres into alumina fibres by heat treatment;

1. B. 1. e. Equipment for producing prepregs specified by 1.C.10.e. by the hot melt method;

f. Non-destructive inspection equipment specially designed for "composite" materials, as follows:
   1. X-ray tomography systems for three dimensional defect inspection;
   2. Numerically controlled ultrasonic testing machines of which the motions for positioning transmitters or receivers are simultaneously coordinated and programmed in four or more axes to follow the three dimensional contours of the component under inspection;

g. 'Tow-placement machines', of which the motions for positioning and laying tows are coordinated and programmed in two or more 'primary servo positioning' axes, specially designed for the manufacture of "composite" airframe or missile structures.

Technical Note

For the purposes of 1.B.1.g., 'tow-placement machines' have the ability to place one or more 'filament bands' having widths less than or equal to 25.4 mm, and to cut and restart individual 'filament band' courses during the placement process.

Technical Notes

1. *For the purposes of 1.B.1., 'primary servo positioning' axes control, under computer program direction, the position of the end effector (i.e., head) in space relative to the work piece at the correct orientation and direction to achieve the desired process.*
2. *For the purposes of 1.B.1., a 'filament band' is a single continuous width of fully or partially resin-impregnated tape, tow or fibre. Fully or partially resin-impregnated 'filament bands' include those coated with dry powder that tacks upon heating.*

1. B. 2. Equipment for producing metal alloys, metal alloy powder or alloyed materials, specially designed to avoid contamination and specially designed for use in one of the processes specified by 1.C.2.c.2.

1. B. 3. Tools, dies, moulds or fixtures, for "superplastic forming" or "diffusion bonding" titanium, aluminium or their alloys, specially designed for the manufacture of any of the following:
   a. Airframe or aerospace structures;
   b. "Aircraft" or aerospace engines; or
   c. Specially designed components for structures specified by 1.B.3.a. or for engines specified by 1.B.3.b..

1. C. MATERIALS

Technical Note

Metals and alloys

Unless provision to the contrary is made, the words 'metals' and 'alloys' cover crude and semi-fabricated forms, as follows:

Crude forms

Anodes, balls, bars (including notched bars and wire bars), billets, blocks, blooms, brickets, cakes, cathodes, crystals, cubes, dice, grains, granules, ingots, lumps, pellets, pigs, powder, rondelles, shot, slabs, slugs, sponge, sticks;

1. C. *Technical Note cont.*

Semi-fabricated forms (whether or not coated, plated, drilled or punched):

a. Wrought or worked materials fabricated by rolling, drawing, extruding, forging, impact extruding, pressing, graining, atomising, and grinding, i.e.: angles, channels, circles, discs, dust, flakes, foils and leaf, forging, plate, powder, pressings and stampings, ribbons, rings, rods (including bare welding rods, wire rods, and rolled wire), sections, shapes, sheets, strip, pipe and tubes (including tube rounds, squares, and hollows), drawn or extruded wire;

b. Cast material produced by casting in sand, die, metal, plaster or other types of moulds, including high pressure castings, sintered forms, and forms made by powder metallurgy.

The object of the control should not be defeated by the export of non-listed forms alleged to be finished products but representing in reality crude forms or semi-fabricated forms.

1. C. 1. Materials specially designed for use as absorbers of electromagnetic waves, or intrinsically conductive polymers, as follows:

a. Materials for absorbing frequencies exceeding 2×10^8 Hz but less than 3×10^{12} Hz;

Note 1 *1.C.1.a. does not apply to:*

a. Hair type absorbers, constructed of natural or synthetic fibres, with non-magnetic loading to provide absorption;

b. Absorbers having no magnetic loss and whose incident surface is non-planar in shape, including pyramids, cones, wedges and convoluted surfaces;

c. Planar absorbers, having all of the following:

1. Made from any of the following:

a. Plastic foam materials (flexible or non-flexible) with carbon-loading, or organic materials, including binders, providing more than 5% echo compared with metal over a bandwidth exceeding ±15% of the centre frequency of the incident energy, and not capable of withstanding temperatures exceeding 450 K (177° C); or

b. Ceramic materials providing more than 20% echo compared with metal over a bandwidth exceeding ±15% of the centre frequency of the incident energy, and not capable of withstanding temperatures exceeding 800 K (527°C);

Technical Note

Absorption test samples for 1.C.1.a. Note 1.c.1. should be a square at least 5 wavelengths of the centre frequency on a side and positioned in the far field of the radiating element.

2. Tensile strength less than 7×10^6 N/m^2; and

3. Compressive strength less than 14×10^6 N/m^2;

d. Planar absorbers made of sintered ferrite, having all of the following:

1. A specific gravity exceeding 4.4; and

2. A maximum operating temperature of 548 K (275°C).

Note 2 *Nothing in Note 1 releases magnetic materials to provide absorption when contained in paint.*

1. C. 1. b. Materials for absorbing frequencies exceeding 1.5 x 10^{14} Hz but less than 3.7 x 10^{14} Hz and not transparent to visible light;

Note *1.C.1.b. does not apply to materials, specially designed or formulated for any of the following applications:*
a. "Laser" marking of polymers; or
b. "Laser" welding of polymers.

1. C. 1. c. Intrinsically conductive polymeric materials with a 'bulk electrical conductivity' exceeding 10,000 S/m (Siemens per metre) or a 'sheet (surface) resistivity' of less than 100 ohms/square, based on any of the following polymers:
1. Polyaniline;
2. Polypyrrole;
3. Polythiophene;
4. Poly phenylene-vinylene; or
5. Poly thienylene-vinylene.

Technical Note
'Bulk electrical conductivity' and 'sheet (surface) resistivity' should be determined using ASTM D-257 or national equivalents.

Note *1.C.1.c. does not apply to materials in a liquid form.*

1. C. 2. Metal alloys, metal alloy powder and alloyed materials, as follows:

Note *1.C.2. does not apply to metal alloys, metal alloy powder and alloyed materials, specially formulated for coating purposes.*

Technical Notes
1. *The metal alloys in 1.C.2. are those containing a higher percentage by weight of the stated metal than of any other element.*
2. *'Stress-rupture life' should be measured in accordance with ASTM standard E-139 or national equivalents.*
3. *'Low cycle fatigue life' should be measured in accordance with ASTM Standard E-606 'Recommended Practice for Constant-Amplitude Low-Cycle Fatigue Testing' or national equivalents. Testing should be axial with an average stress ratio equal to 1 and a stress-concentration factor (K_t) equal to 1. The average stress is defined as maximum stress minus minimum stress divided by maximum stress.*

1. C. 2. a. Aluminides, as follows:
1. Nickel aluminides containing a minimum of 15% by weight aluminium, a maximum of 38% by weight aluminium and at least one additional alloying element;
2. Titanium aluminides containing 10% by weight or more aluminium and at least one additional alloying element;

1. C. 2. b. Metal alloys, as follows, made from the powder or particulate material specified by 1.C.2.c.:
1. Nickel alloys having any of the following:
a. A 'stress-rupture life' of 10,000 hours or longer at 923 K (650°C) at a stress of 676 MPa; or
b. A 'low cycle fatigue life' of 10,000 cycles or more at 823 K (550°C) at a maximum stress of 1,095 MPa;

1. C. 2. b. 2. Niobium alloys having any of the following:
   a. A 'stress-rupture life' of 10,000 hours or longer at 1,073 K (800°C) at a stress of 400 MPa; or
   b. A 'low cycle fatigue life' of 10,000 cycles or more at 973 K (700°C) at a maximum stress of 700 MPa;

   3. Titanium alloys having any of the following:
      a. A 'stress-rupture life' of 10,000 hours or longer at 723 K (450°C) at a stress of 200 MPa; or
      b. A 'low cycle fatigue life' of 10,000 cycles or more at 723 K (450°C) at a maximum stress of 400 MPa;

   4. Aluminium alloys having any of the following:
      a. A tensile strength of 240 MPa or more at 473 K (200°C); or
      b. A tensile strength of 415 MPa or more at 298 K (25°C);

   5. Magnesium alloys having all of the following:
      a. A tensile strength of 345 MPa or more; and
      b. A corrosion rate of less than 1 mm/year in 3% sodium chloride aqueous solution measured in accordance with ASTM standard G-31 or national equivalents;

1. C. 2. c. Metal alloy powder or particulate material, having all of the following:

   1. Made from any of the following composition systems:
      Technical Note
      X in the following equals one or more alloying elements.

      a. Nickel alloys (Ni-Al-X, Ni-X-Al) qualified for turbine engine parts or components, i.e. with less than 3 non-metallic particles (introduced during the manufacturing process) larger than 100 µm in 10^9 alloy particles;
      b. Niobium alloys (Nb-Al-X or Nb-X-Al, Nb-Si-X or Nb-X-Si, Nb-Ti-X or Nb-X-Ti);
      c. Titanium alloys (Ti-Al-X or Ti-X-Al);
      d. Aluminium alloys (Al-Mg-X or Al-X-Mg, Al-Zn-X or Al-X-Zn, Al-Fe-X or Al-X-Fe); or
      e. Magnesium alloys (Mg-Al-X or Mg-X-Al);

1. C. 2. c. 2. Made in a controlled environment by any of the following processes:
   a. "Vacuum atomisation";
   b. "Gas atomisation";
   c. "Rotary atomisation";
   d. "Splat quenching";
   e. "Melt spinning" and "comminution";
   f. "Melt extraction" and "comminution";
   g. "Mechanical alloying"; or
   h. "Plasma atomisation"; and

1. C. 2. c. 3. Capable of forming materials specified by 1.C.2.a. or 1.C.2.b.;

1. C. 2. d. Alloyed materials having all of the following:
   1. Made from any of the composition systems specified by 1.C.2.c.1.;
   2. In the form of uncomminuted flakes, ribbons or thin rods; and
   3. Produced in a controlled environment by any of the following:
      a. "Splat quenching";
      b. "Melt spinning"; or
      c. "Melt extraction";

1. C. 3. Magnetic metals, of all types and of whatever form, having any of the following:

a. Initial relative permeability of 120,000 or more and a thickness of 0.05 mm or less;

Technical Note
Measurement of initial relative permeability must be performed on fully annealed materials.

b. Magnetostrictive alloys having any of the following:
1. A saturation magnetostriction of more than 5×10^{-4}; or
2. A magnetomechanical coupling factor (k) of more than 0.8; or

c. Amorphous or 'nanocrystalline' alloy strips, having all of the following:
1. A composition having a minimum of 75% by weight of iron, cobalt or nickel;
2. A saturation magnetic induction (B_S) of 1.6 T or more; and
3. Any of the following:
a. A strip thickness of 0.02 mm or less; or
b. An electrical resistivity of 2×10^{-4} ohm cm or more.

Technical Note
'Nanocrystalline' materials in 1.C.3.c. are those materials having a crystal grain size of 50 nm or less, as determined by X-ray diffraction.

1. C. 4. Uranium titanium alloys or tungsten alloys with a "matrix" based on iron, nickel or copper, having all of the following:

a. A density exceeding 17.5 g/cm^3;
b. An elastic limit exceeding 880 MPa;
c. An ultimate tensile strength exceeding 1,270 MPa; and
d. An elongation exceeding 8%.

1. C. 5. "Superconductive" "composite" conductors in lengths exceeding 100 m or with a mass exceeding 100 g, as follows:

a. "Superconductive" "composite" conductors containing one or more niobium-titanium 'filaments', having all of the following:
1. Embedded in a "matrix" other than a copper or copper-based mixed "matrix"; and
2. Having a cross-section area less than 0.28×10^{-4} mm^2 (6 µm in diameter for circular 'filaments');

b. "Superconductive" "composite" conductors consisting of one or more "superconductive" 'filaments' other than niobium-titanium, having all of the following:
1. A "critical temperature" at zero magnetic induction exceeding 9.85 K (-263.31°C); and
2. Remaining in the "superconductive" state at a temperature of 4.2 K (-268.96°C) when exposed to a magnetic field oriented in any direction perpendicular to the longitudinal axis of conductor and corresponding to a magnetic induction of 12 T with critical current density exceeding 1,750 A/mm^2 on overall cross-section of the conductor.

1. C. 5. c. "Superconductive" "composite" conductors consisting of one or more "superconductive" 'filaments', which remain "superconductive" above 115 K (-158.16°C).

Technical Note
For the purpose of 1.C.5., 'filaments' may be in wire, cylinder, film, tape or ribbon form.

1. C. 6. Fluids and lubricating materials, as follows:

a. Not used since 2015

b. Lubricating materials containing, as their principal ingredients, any of the following:
   1. Phenylene or alkylphenylene ethers or thio-ethers, or their mixtures, containing more than two ether or thio-ether functions or mixtures thereof; or
   2. Fluorinated silicone fluids with a kinematic viscosity of less than 5,000 mm^2/s (5,000 centistokes) measured at 298 K (25°C);

c. Damping or flotation fluids having all of the following:
   1. Purity exceeding 99.8%;
   2. Containing less than 25 particles of 200 µm or larger in size per 100 ml; and
   3. Made from at least 85% of any of the following:
      a. Dibromotetrafluoroethane (CAS 25497-30-7, 124-73-2, 27336-23-8);
      b. Polychlorotrifluoroethylene (oily and waxy modifications only); or
      c. Polybromotrifluoroethylene;

d. Fluorocarbon electronic cooling fluids having all of the following:
   1. Containing 85% by weight or more of any of the following, or mixtures thereof:
      a. Monomeric forms of perfluoropolyalkylether-triazines or perfluoroaliphatic-ethers;
      b. Perfluoroalkylamines;
      c. Perfluorocycloalkanes; or
      d. Perfluoroalkanes;
   2. Density at 298 K (25°C) of 1.5 g/ml or more;
   3. In a liquid state at 273 K (0°C); and
   4. Containing 60% or more by weight of fluorine.

   Note *1.C.6.d. does not apply to materials specified and packaged as medical products.*

1. C. 7. Ceramic powders, ceramic-"matrix" "composite" materials and 'precursor materials', as follows:

a. Ceramic powders of titanium diboride (TiB_2) (CAS 12045-63-5) having total metallic impurities, excluding intentional additions, of less than 5,000 ppm, an average particle size equal to or less than 5 µm and no more than 10% of the particles larger than 10 µm;

b. Not used since 2016

c. Ceramic-"matrix" "composite" materials as follows:
   1. Ceramic-ceramic "composite" materials with a glass or oxide-"matrix" and reinforced with any of the following:

1. C. 7. c. 1. a. Continuous fibres made from any of the following materials:
   1. Al_2O_3 (CAS 1344-28-1); or
   2. Si-C-N; or

   Note *1.C.7.c.1.a. does not apply to "composites" containing fibres with a tensile strength of less than 700 MPa at 1,273 K (1,000°C) or tensile creep resistance of more than 1% creep strain at 100 MPa load and 1,273 K (1,000°C) for 100 hours.*

1. C. 7. c. 1. b. Fibres being all of the following:
   1. Made from any of the following materials:
      a. Si-N;
      b. Si-C;
      c. Si-Al-O-N; or
      d. Si-O-N; and
   2. Having a "specific tensile strength" exceeding 12.7 x 10^3m;

1. C. 7. c. 2. Ceramic-"matrix" "composite" materials with a "matrix" formed of carbides or nitrides of silicon, zirconium or boron;

   N.B. *For items previously listed under 1.C.7.c. see 1C.7.c.1.b.*

1. C. 7. d. Not used since 2016

   N.B. *For items previously listed under 1.C.7.d. see 1.C.7.c.2.*

1. C. 7. e. 'Precursor materials' specially designed for the "production" of materials specified by 1.C.7.c., as follows:
   1. Polydiorganosilanes;
   2. Polysilazanes;
   3. Polycarbosilazanes;

   Technical Note

   For the purposes of 1.C.7., 'precursor materials' are special purpose polymeric or metallo-organic materials used for the "production" of silicon carbide, silicon nitride, or ceramics with silicon, carbon and nitrogen.

1. C. 7. f. Not used since 2016

   N.B. *For items previously listed under 1.C.7.f. see 1.C.7.c.1.a.*

1. C. 8. Non-fluorinated polymeric substances as follows:
   a. Imides as follows:
      1. Bismaleimides;
      2. Aromatic polyamide-imides (PAI) having a 'glass transition temperature (Tg)' exceeding 563 K (290°C);
      3. Aromatic polyimides having a 'glass transition temperature (Tg)' exceeding 505 K (232°C);
      4. Aromatic polyetherimides having a 'glass transition temperature (T_g)' exceeding 563 K (290° C);

      Note *1.C.8.a. applies to the substances in liquid or solid "fusible" form, including resin, powder, pellet, film, sheet, tape, or ribbon.*

      N.B. *For non-"fusible" aromatic polyimides in film, sheet, tape, or ribbon form, see 1.A.3.*

1. C. 8. b. Not used since 2014

c. Not used since 2006

d. Polyarylene ketones;

e. Polyarylene sulphides, where the arylene group is biphenylene, triphenylene or combinations thereof;

f. Polybiphenylenethersulphone having a 'glass transition temperature (Tg)' exceeding 563 K (290° C).

Technical Notes

1. *The 'glass transition temperature (Tg)' for 1.C.8.a.2. thermoplastic materials, 1.C.8.a.4. materials and 1.C.8.f. materials is determined using the method described in ISO 11357-2 (1999) or national equivalents.*
2. *The 'glass transition temperature (Tg)' for 1.C.8.a.2. thermosetting materials and 1.C.8.a.3. materials is determined using the 3-point bend method described in ASTM D 7028-07 or equivalent national standard. The test is to be performed using a dry test specimen which has attained a minimum of 90% degree of cure as specified by ASTM E 2160-04 or equivalent national standard, and was cured using the combination of standard- and post-cure processes that yield the highest Tg.*

1. C. 9. Unprocessed fluorinated compounds as follows:

a. Not used since 2015
b. Fluorinated polyimides containing 10% by weight or more of combined fluorine;
c. Fluorinated phosphazene elastomers containing 30% by weight or more of combined fluorine.

1. C. 10. "Fibrous or filamentary materials" as follows:

Technical Notes

1. *For the purpose of calculating "specific tensile strength", "specific modulus" or specific weight of "fibrous or filamentary materials" in 1.C.10.a., 1.C.10.b., 1.C.10.c. or 1.C.10.e.1.b., the tensile strength and modulus should be determined by using Method A described in ISO 10618 (2004) or national equivalents.*
2. *Assessing the "specific tensile strength", "specific modulus" or specific weight of non-unidirectional "fibrous or filamentary materials" (e.g., fabrics, random mats or braids) in 1.C.10. is to be based on the mechanical properties of the constituent unidirectional monofilaments (e.g., monofilaments, yarns, rovings or tows) prior to processing into the non-unidirectional "fibrous or filamentary materials".*

1. C. 10. a. Organic "fibrous or filamentary materials", having all of the following:
   1. "Specific modulus" exceeding 12.7 x 10^6 m; and
   2. "Specific tensile strength" exceeding 23.5 x 10^4 m;

   Note *1.C.10.a. does not apply to polyethylene.*

b. Carbon "fibrous or filamentary materials", having all of the following:
   1. "Specific modulus" exceeding 14.65 x 10^6 m; and
   2. "Specific tensile strength" exceeding 26.82 x 10^4 m;

Note *1.C.10.b. does not apply to:*

a. "Fibrous or filamentary materials", for the repair of "civil aircraft" structures or laminates, having all of the following:

1. An area not exceeding 1 m^2;

2. A length not exceeding 2.5 m; and

3. A width exceeding 15 mm.

b. Mechanically chopped, milled or cut carbon "fibrous or filamentary materials" 25.0 mm or less in length.

1. C. 10. c. Inorganic "fibrous or filamentary materials", having all of the following:

1. "Specific modulus" exceeding 2.54 x 10^6 m; and
2. Melting, softening, decomposition or sublimation point exceeding 1,922 K (1,649°C) in an inert environment;

Note *1.C.10.c. does not apply to:*

a. Discontinuous, multiphase, polycrystalline alumina fibres in chopped fibre or random mat form, containing 3% by weight or more silica, with a "specific modulus" of less than 10 x 10^6 m;

b. Molybdenum and molybdenum alloy fibres;

c. Boron fibres;

d. Discontinuous ceramic fibres with a melting, softening, decomposition or sublimation point lower than 2,043 K (1,770°C) in an inert environment.

1. C. 10. d. "Fibrous or filamentary materials", having any of the following:

1. Composed of any of the following:
   a. Polyetherimides specified by 1.C.8.a; or
   b. Materials specified by 1.C.8.d. to 1.C.8.f.; or
2. Composed of materials specified by 1.C.10.d.1.a. or 1.C.10.d.1.b. and "commingled" with other fibres specified by 1.C.10.a., 1.C.10.b. or 1.C.10.c.;

1. C. 10. e. Fully or partially resin-impregnated or pitch-impregnated "fibrous or filamentary materials" (prepregs), metal or carbon-coated "fibrous or filamentary materials" (preforms) or "carbon fibre preforms", having all of the following:

1. Having any of the following:
   a. Inorganic "fibrous or filamentary materials" specified by 1.C.10.c.; or
   b. Organic or carbon "fibrous or filamentary materials", having all of the following:
      1. "Specific modulus" exceeding 10.15 x 10^6 m; and
      2. "Specific tensile strength" exceeding 17.7 x 10^4 m; and
2. Having any of the following:
   a. Resin or pitch, specified by 1.C.8. or 1.C.9.b.;
   b. 'Dynamic Mechanical Analysis glass transition temperature (DMA T_g)' equal to or exceeding 453 K (180°C) and having a phenolic resin; or
   c. 'Dynamic Mechanical Analysis glass transition temperature (DMA T_g)' equal to or exceeding 505 K (232°C) and having a resin or pitch, not specified by 1.C.8. or 1.C.9.b., and not being a phenolic resin;

Note 1 *Metal or carbon-coated "fibrous or filamentary materials" (preforms) or "carbon fibre preforms", not impregnated with resin or pitch, are specified by "fibrous or filamentary materials" in 1.C.10.a., 1.C.10.b. or 1.C.10.c.*

Note 2 *1.C.10.e. does not apply to:*

a. Epoxy resin "matrix" impregnated carbon "fibrous or filamentary materials" (prepregs) for the repair of "civil aircraft" structures or laminates, having all of the following;

1. An area not exceeding 1 m^2;

2. A length not exceeding 2.5 m; and

3. A width exceeding 15 mm;

b. Fully or partially resin-impregnated or pitch-impregnated mechanically chopped, milled or cut carbon "fibrous or filamentary materials" 25.0 mm or less in length when using a resin or pitch other than those specified by 1.C.8. or 1.C.9.b.

Technical Note

The 'Dynamic Mechanical Analysis glass transition temperature (DMA T_g)' for materials specified by 1.C.10.e. is determined using the method described in ASTM D 7028-07, or equivalent national standard, on a dry test specimen. In the case of thermoset materials, degree of cure of a dry test specimen shall be a minimum of 90% as defined by ASTM E 2160-04 or equivalent national standard.

1. C. 11. Metals and compounds, as follows:

a. Metals in particle sizes of less than 60 µm whether spherical, atomised, spheroidal, flaked or ground, manufactured from material consisting of 99% or more of zirconium, magnesium and alloys thereof;

Note *The metals or alloys specified by 1.C.11.a. also refer to metals or alloys encapsulated in aluminium, magnesium, zirconium or beryllium.*

Technical Note

The natural content of hafnium in the zirconium (typically 2% to 7%) is counted with the zirconium.

b. Boron or boron alloys, with a particle size of 60 µm or less, as follows:

1. Boron with a purity of 85% by weight or more;
2. Boron alloys with a boron content of 85% by weight or more;

Note *The metals or alloys specified by 1.C.11.b. also refer to metals or alloys encapsulated in aluminium, magnesium, zirconium or beryllium.*

c. Guanidine nitrate (CAS 506-93-4);

d. Nitroguanidine (NQ) (CAS 556-88-7).

N.B. *See ML8.c.5.b. for metal powders mixed with other substances to form a mixture formulated for military purposes.*

1. C. 12. Materials as follows:

Technical Note

These materials are typically used for nuclear heat sources.

1. C. 12. a. Plutonium in any form with a plutonium isotopic assay of plutonium-238 of more than 50% by weight;

Note *1.C.12.a. does not apply to:*
a. Shipments with a plutonium content of 1 g or less;
b. Shipments of 3 "effective grams" or less when contained in a sensing component in instruments.

b. "Previously separated" neptunium-237 in any form.

Note *1.C.12.b. does not apply to shipments with a neptunium-237 content of 1 g or less.*

1. D. SOFTWARE

1. "Software" specially designed or modified for the "development", "production" or "use" of equipment specified by 1.B.
2. "Software" for the "development" of organic "matrix", metal "matrix" or carbon "matrix" laminates or "composites".
3. "Software" specially designed or modified to enable equipment to perform the functions of equipment specified by 1.A.4.c. or 1.A.4.d.

1. E. TECHNOLOGY

1. E. 1. "Technology" according to the General Technology Note for the "development" or "production" of equipment or materials specified by 1.A.2. to 1.A.5., 1.A.6.b., 1.A.7., 1.B. or 1.C.

1. E. 2. Other "technology" as follows:
a. "Technology" for the "development" or "production" of polybenzothiazoles or polybenzoxazoles;
b. "Technology" for the "development" or "production" of fluoroelastomer compounds containing at least one vinylether monomer;
c. "Technology" for the design or "production" of the following ceramic powders or non-"composite" ceramic materials:
1. Ceramic powders having all of the following:
a. Any of the following compositions:
1. Single or complex oxides of zirconium and complex oxides of silicon or aluminium;
2. Single nitrides of boron (cubic crystalline forms);
3. Single or complex carbides of silicon or boron; or
4. Single or complex nitrides of silicon;

b. Any of the following total metallic impurities (excluding intentional additions):
1. Less than 1,000 ppm for single oxides or carbides; or
2. Less than 5,000 ppm for complex compounds or single nitrides; and

c. Being any of the following:
1. Zirconia (CAS 1314-23-4) with an average particle size equal to or less than 1 µm and no more than 10% of the particles larger than 5 µm; or
2. Other ceramic powders with an average particle size equal to or less than 5 µm and no more than 10% of the particles larger than 10 µm;

1. E. 2. c. 2. Non-"composite" ceramic materials composed of the materials specified by 1.E.2.c.1.;
<u>Note</u> *1.E.2.c.2. does not apply to "technology" for abrasives.*

1. E. 2. d. Not used since 2014

e. "Technology" for the installation, maintenance or repair of materials specified by 1.C.1.;

f. "Technology" for the repair of "composite" structures, laminates or materials specified by 1.A.2. or 1.C.7.c.;

<u>Note</u> *1.E.2.f. does not apply to "technology" for the repair of "civil aircraft" structures using carbon "fibrous or filamentary materials" and epoxy resins, contained in "aircraft" manufacturers' manuals.*

1. E. 2. g. "Libraries" specially designed or modified to enable equipment to perform the functions of equipment specified by 1.A.4.c. or 1.A.4.d.

ANNEX

LIST - "EXPLOSIVES"

1. ADNBF (aminodinitrobenzofuroxan or 7-amino-4,6-dinitrobenzofurazane-1-oxide) (CAS 97096-78-1);
2. BNCP (cis-bis (5-nitrotetrazolato) tetra amine-cobalt (III) perchlorate) (CAS 117412-28-9);
3. CL-14 (diamino dinitrobenzofuroxan or 5,7-diamino-4,6-dinitrobenzofurazane-1-oxide) (CAS 117907-74-1);
4. CL-20 (HNIW or Hexanitrohexaazaisowurtzitane) (CAS 135285-90-4); chlathrates of CL-20;
5. CP (2-(5-cyanotetrazolato) penta amine-cobalt (III) perchlorate) (CAS 70247-32-4);
6. DADE (1,1-diamino-2,2-dinitroethylene, FOX7) (CAS 145250-81-3);
7. DATB (diaminotrinitrobenzene) (CAS 1630-08-6);
8. DDFP (1,4-dinitrodifurazanopiperazine);
9. DDPO (2,6-diamino-3,5-dinitropyrazine-1-oxide, PZO) (CAS 194486-77-6);
10. DIPAM (3,3′-diamino-2,2′,4,4′,6,6′-hexanitrobiphenyl or dipicramide) (CAS 17215-44-0);
11. DNGU (DINGU or dinitroglycoluril) (CAS 55510-04-8);
12. Furazans as follows:
    a. DAAOF (diaminoazoxyfurazan);
    b. DAAzF (diaminoazofurazan) (CAS 78644-90-3);
13. HMX and derivatives, as follows:
    a. HMX (Cyclotetramethylenetetranitramine, octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazine, 1,3,5,7-tetranitro-1,3,5,7-tetraza-cyclooctane, octogen or octogene) (CAS 2691-41-0);
    b. difluoroaminated analogs of HMX;
    c. K-55 (2,4,6,8-tetranitro-2,4,6,8-tetraazabicyclo [3,3,0]-octanone-3, tetranitrosemiglycouril or keto-bicyclic HMX) (CAS 130256-72-3);
14. HNAD (hexanitroadamantane) (CAS 143850-71-9);
15. HNS (hexanitrostilbene) (CAS 20062-22-0);
16. Imidazoles as follows:
    a. BNNII (Octahydro-2,5-bis(nitroimino)imidazo [4,5-d]imidazole);
    b. DNI (2,4-dinitroimidazole) (CAS 5213-49-0);
    c. FDIA (1-fluoro-2,4-dinitroimidazole);
    d. NTDNIA (N-(2-nitrotriazolo)-2,4-dinitroimidazole);
    e. PTIA (1-picryl-2,4,5-trinitroimidazole);
17. NTNMH (1-(2-nitrotriazolo)-2-dinitromethylene hydrazine);
18. NTO (ONTA or 3-nitro-1,2,4-triazol-5-one) (CAS 932-64-9);
19. Polynitrocubanes with more than four nitro groups;
20. PYX (2,6-Bis(picrylamino)-3,5-dinitropyridine) (CAS 38082-89-2);
21. RDX and derivatives, as follows:
    a. RDX (cyclotrimethylenetrinitramine, cyclonite, T4, hexahydro-1,3,5-trinitro-1,3,5-triazine, 1,3,5-trinitro-1,3,5-triaza-cyclohexane, hexogen or hexogene) (CAS 121-82-4);
    b. Keto-RDX (K-6 or 2,4,6-trinitro-2,4,6-triazacyclohexanone) (CAS 115029-35-1);
22. TAGN (triaminoguanidinenitrate) (CAS 4000-16-2);
23. TATB (triaminotrinitrobenzene) (CAS 3058-38-6);
24. TEDDZ (3,3,7,7-tetrabis(difluoroamine) octahydro-1,5-dinitro-1,5-diazocine);

LIST - "EXPLOSIVES" cont.

25. Tetrazoles as follows:
    a. NTAT (nitrotriazol aminotetrazole);
    b. NTNT (1-N-(2-nitrotriazolo)-4-nitrotetrazole);
26. Tetryl (trinitrophenylmethylnitramine) (CAS 479-45-8);
27. TNAD (1,4,5,8-tetranitro-1,4,5,8-tetraazadecalin) (CAS 135877-16-6);
28. TNAZ (1,3,3-trinitroazetidine) (CAS 97645-24-4);
29. TNGU (SORGUYL or tetranitroglycoluril) (CAS 55510-03-7);
30. TNP (1,4,5,8-tetranitro-pyridazino[4,5-d]pyridazine) (CAS 229176-04-9);
31. Triazines as follows:
    a. DNAM (2-oxy-4,6-dinitroamino-s-triazine) (CAS 19899-80-0);
    b. NNHT (2-nitroimino-5-nitro-hexahydro-1,3,5-triazine) (CAS 130400-13-4);
32. Triazoles as follows:
    a. 5-azido-2-nitrotriazole;
    b. ADHTDN (4-amino-3,5-dihydrazino-1,2,4-triazole dinitramide) (CAS 1614-08-0);
    c. ADNT (1-amino-3,5-dinitro-1,2,4-triazole);
    d. BDNTA ((bis-dinitrotriazole)amine);
    e. DBT (3,3′-dinitro-5,5-bi-1,2,4-triazole) (CAS 30003-46-4);
    f. DNBT (dinitrobistriazole) (CAS 70890-46-9);
    g. Not used since 2011
    h. NTDNT (1-N-(2-nitrotriazolo) 3,5-dinitrotriazole);
    i. PDNT (1-picryl-3,5-dinitrotriazole);
    j. TACOT (tetranitrobenzotriazolobenzotriazole) (CAS 25243-36-1);
33. "Explosives" not listed elsewhere in this list having a detonation velocity exceeding 8,700 m/s, at maximum density, or a detonation pressure exceeding 34 GPa (340 kbar);
34. Not used since 2013
35. Nitrocellulose (containing more than 12.5% nitrogen) (CAS 9004-70-0);
36. Nitroglycol (CAS 628-96-6);
37. Pentaerythritol tetranitrate (PETN) (CAS 78-11-5);
38. Picryl chloride (CAS 88-88-0);
39. 2,4,6-Trinitrotoluene (TNT) (CAS 118-96-7);
40. Nitroglycerine (NG) (CAS 55-63-0);
41. Triacetone Triperoxide (TATP) (CAS 17088-37-8);
42. Guanidine nitrate (CAS 506-93-4);
43. Nitroguanidine (NQ) (CAS 556-88-7);
44. DNAN (2,4-dinitroanisole) (CAS 119-27-7);
45. TEX (4,10-Dinitro-2,6,8,12-tetraoxa-4,10-diazaisowurtzitane);
46. GUDN (Guanylurea dinitramide) FOX-12 (CAS 217464-38-5);
47. Tetrazines as follows:
    a. BTAT (Bis(2,2,2-trinitroethyl)-3,6-diaminotetrazine);
    b. LAX-112 (3,6-diamino-1,2,4,5-tetrazine-1,4-dioxide);
48. Energetic ionic materials melting between 343 K (70°C) and 373 K (100°C) and with detonation velocity exceeding 6,800 m/s or detonation pressure exceeding 18 GPa (180 kbar);
49. BTNEN (Bis(2,2,2-trinitroethyl)-nitramine) (CAS 19836-28-3);
50. FTDO (5,6-(3',4'-furazano)- 1,2,3,4-tetrazine-1,3-dioxide).

2. A. SYSTEMS, EQUIPMENT AND COMPONENTS

N.B. *For quiet running bearings, see ML9 on the Munitions List.**

2. A. 1. Anti-friction bearings and bearing systems, as follows, and components therefor:

Note *2.A.1. does not apply to balls with tolerances specified by the manufacturer in accordance with ISO 3290 as grade 5 or worse.*

a. Ball bearings and solid roller bearings, having all tolerances specified by the manufacturer in accordance with ISO 492 Tolerance Class 4 (or national equivalents), or better, and having both 'rings' and 'rolling elements', made from monel or beryllium;

Note *2.A.1.a. does not apply to tapered roller bearings.*

Technical Notes

1. *'Ring' - annular part of a radial rolling bearing incorporating one or more raceways (ISO 5593:1997).*
2. *'Rolling element'- ball or roller which rolls between raceways (ISO 5593:1997).*

b. Not used since 2010

c. Active magnetic bearing systems using any of the following:
   1. Materials with flux densities of 2.0 T or greater and yield strengths greater than 414 MPa;
   2. All-electromagnetic 3D homopolar bias designs for actuators; or
   3. High temperature (450 K (177°C) and above) position sensors.

2. B. TEST, INSPECTION AND PRODUCTION EQUIPMENT

Technical Notes

1. *Secondary parallel contouring axes, (e.g., the w-axis on horizontal boring mills or a secondary rotary axis the centre line of which is parallel to the primary rotary axis) are not counted in the total number of contouring axes. Rotary axes need not rotate over 360°. A rotary axis can be driven by a linear device (e.g., a screw or a rack-and-pinion).*
2. *For the purposes of 2.B., the number of axes which can be co-ordinated simultaneously for "contouring control" is the number of axes along or around which, during processing of the workpiece, simultaneous and interrelated motions are performed between the workpiece and a tool. This does not include any additional axes along or around which other relative motions within the machine are performed, such as:*
   a. *Wheel-dressing systems in grinding machines;*
   b. *Parallel rotary axes designed for mounting of separate workpieces;*
   c. *Co-linear rotary axes designed for manipulating the same workpiece by holding it in a chuck from different ends.*

* The Russian Federation and Ukraine view this list as a reference list drawn up to help in the selection of dual-use goods which could contribute to the indigenous development, production or enhancement of conventional munitions capabilities.

Technical Notes contd.

3. *Axis nomenclature shall be in accordance with International Standard ISO 841:2001, Industrial automation systems and integration - Numerical control of machines - Coordinate system and motion nomenclature.*
4. *For the purposes of this Category a "tilting spindle" is counted as a rotary axis.*
5. *'Stated "unidirectional positioning repeatability"' may be used for each machine tool model as an alternative to individual machine tests, and is determined as follows:*
   a. *Select five machines of a model to be evaluated;*
   b. *Measure the linear axis repeatability (R↑,R↓) according to ISO 230-2:2014 and evaluate "unidirectional positioning repeatability" for each axis of each of the five machines;*
   c. *Determine the arithmetic mean value of the "unidirectional positioning repeatability"-values for each axis of all five machines together. These arithmetic mean values of "unidirectional positioning repeatability" ($\overline{UPR}$) become the stated value of each axis for the model ($\overline{UPR}_x$, $\overline{UPR}_y$, ...)*
   d. *Since the Category 2 list refers to each linear axis there will be as many 'stated "unidirectional positioning repeatability"'-values as there are linear axes;*
   e. *If any axis of a machine model not specified by 2.B.1.a. to 2.B.1.c. has a 'stated "unidirectional positioning repeatability"' equal to or less than the specified "unidirectional positioning repeatability" of each machine tool model plus 0.7 µm, the builder should be required to reaffirm the accuracy level once every eighteen months.*
6. *For the purposes of 2.B., measurement uncertainty for the "unidirectional positioning repeatability" of machine tools, as defined in the International Standard ISO 230-2:2014 or national equivalents, shall not be considered.*
7. *For the purpose of 2.B., the measurement of axes shall be made according to test procedures in 5.3.2. of ISO 230-2:2014. Tests for axes longer than 2 meters shall be made over 2 m segments. Axes longer than 4 m require multiple tests (e.g., two tests for axes longer than 4 m and up to 8 m, three tests for axes longer than 8 m and up to 12 m), each over 2 m segments and distributed in equal intervals over the axis length. Test segments are equally spaced along the full axis length, with any excess length equally divided at the beginning, in between, and at the end of the test segments. The smallest "unidirectional positioning repeatability"-value of all test segments is to be reported.*

2. B. 1. Machine tools and any combination thereof, for removing (or cutting) metals, ceramics or "composites", which, according to the manufacturer's technical specification, can be equipped with electronic devices for "numerical control", as follows:

   Note 1 *2.B.1. does not apply to special purpose machine tools limited to the manufacture of gears. For such machines, see 2.B.3.*

   Note 2 *2.B.1. does not apply to special purpose machine tools limited to the manufacture of any of the following:*
   a. *Crank shafts or cam shafts;*
   b. *Tools or cutters;*
   c. *Extruder worms;*
   d. *Engraved or facetted jewellery parts; or*
   e. *Dental prostheses.*

Note 3 *A machine tool having at least two of the three turning, milling or grinding capabilities (e.g., a turning machine with milling capability), must be evaluated against each applicable entry 2.B.1.a., b. or c.*

N.B. *For optical finishing machines, see 2.B.2.*

2. B. 1. a. Machine tools for turning having two or more axes which can be coordinated simultaneously for "contouring control" having any of the following:

1. "Unidirectional positioning repeatability" equal to or less (better) than 0.9 µm along one or more linear axis with a travel length less than 1.0 m; or
2. "Unidirectional positioning repeatability" equal to or less (better) than 1.1 µm along one or more linear axis with a travel length equal to or greater than 1.0 m;

Note 1 *2.B.1.a. does not apply to turning machines specially designed for producing contact lenses, having all of the following:*

a. Machine controller limited to using ophthalmic based "software" for part programming data input; and
b. No vacuum chucking.

Note 2 *2.B.1.a. does not apply to bar machines (Swissturn), limited to machining only bar feed thru, if maximum bar diameter is equal to or less than 42 mm and there is no capability of mounting chucks. Machines may have drilling and/or milling capabilities for machining parts with diameters less than 42 mm.*

2. B. 1. b. Machine tools for milling having any of the following:

1. Three linear axes plus one rotary axis which can be coordinated simultaneously for "contouring control" having any of the following:
   a. "Unidirectional positioning repeatability" equal to or less (better) than 0.9 µm along one or more linear axis with a travel length less than 1.0 m; or
   b. "Unidirectional positioning repeatability" equal to or less (better) than 1.1 µm along one or more linear axis with a travel length equal to or greater than 1.0 m;
2. Five or more axes which can be coordinated simultaneously for "contouring control" having any of the following:
   a. "Unidirectional positioning repeatability" equal to or less (better) than 0.9 µm along one or more linear axis with a travel length less than 1.0 m;
   b. "Unidirectional positioning repeatability" equal to or less (better) than 1.4 µm along one or more linear axis with a travel length equal to or greater than 1 m and less than 4 m; or
   c. "Unidirectional positioning repeatability" equal to or less (better) than 6.0 µm along one or more linear axis with a travel length equal to or greater than 4 m;
   d. Not used since 2016

2. B. 1. b. 3. A "unidirectional positioning repeatability" for jig boring machines, equal to or less (better) than 1.1 µm along one or more linear axis; or

2. B. 1. b. 4. Fly cutting machines having all of the following:
   a. Spindle "run-out" and "camming" less (better) than 0.0004 mm TIR; and
   b. Angular deviation of slide movement (yaw, pitch and roll) less (better) than 2 seconds of arc, TIR, over 300 mm of travel;

2. B. 1. c. Machine tools for grinding having any of the following:
   1. Having all of the following:
      a. "Unidirectional positioning repeatability" equal to or less (better) than 1.1 µm along one or more linear axis; and
      b. Three or more axes which can be coordinated simultaneously for "contouring control"; or
   2. Five or more axes which can be coordinated simultaneously for "contouring control" having any of the following:
      a. "Unidirectional positioning repeatability" equal to or less (better) than 1.1 µm along one or more linear axis with a travel length less than 1 m;
      b. "Unidirectional positioning repeatability" equal to or less (better) than 1.4 µm along one or more linear axis with a travel length equal to or greater than 1 m and less than 4 m; or
      c. "Unidirectional positioning repeatability" equal to or less (better) than 6.0 µm along one or more linear axis with a travel length equal to or greater than 4 m.

   Note *2.B.1.c. does not apply to grinding machines as follows:*
   a. Cylindrical external, internal, and external-internal grinding machines, having all of the following:
      1. Limited to cylindrical grinding; and
      2. Limited to a maximum workpiece capacity of 150 mm outside diameter or length.
   b. Machines designed specifically as jig grinders that do not have a z-axis or a w-axis, with a "unidirectional positioning repeatability" less (better) than 1.1 µm.
   c. Surface grinders.

2. B. 1. d. Electrical discharge machines (EDM) of the non-wire type which have two or more rotary axes which can be coordinated simultaneously for "contouring control";

2. B. 1. e. Machine tools for removing metals, ceramics or "composites", having all of the following:
   1. Removing material by means of any of the following:
      a. Water or other liquid jets, including those employing abrasive additives;
      b. Electron beam; or
      c. "Laser" beam; and
   2. At least two rotary axes having all of the following:
      a. Can be coordinated simultaneously for "contouring control"; and
      b. A positioning "accuracy" of less (better) than 0.003°;

2. B. 1. f. Deep-hole-drilling machines and turning machines modified for deep-hole-drilling, having a maximum depth-of-bore capability exceeding 5 m.

2. B. 2. Numerically controlled optical finishing machine tools equipped for selective material removal to produce non-spherical optical surfaces having all of the following characteristics:

a. Finishing the form to less (better) than 1.0 µm;
b. Finishing to a roughness less (better) than 100 nm rms;
c. Four or more axes which can be coordinated simultaneously for "contouring control"; and
d. Using any of the following processes:
   1. 'Magnetorheological finishing (MRF)';
   2. 'Electrorheological finishing (ERF)';
   3. 'Energetic particle beam finishing';
   4. 'Inflatable membrane tool finishing; or
   5. 'Fluid jet finishing'.

Technical Notes

For the purposes of 2.B.2.:

1. *'MRF' is a material removal process using an abrasive magnetic fluid whose viscosity is controlled by a magnetic field.*
2. *'ERF' is a removal process using an abrasive fluid whose viscosity is controlled by an electric field.*
3. *'Energetic particle beam finishing' uses Reactive Atom Plasmas (RAP) or ion-beams to selectively remove material.*
4. *'Inflatable membrane tool finishing' is a process that uses a pressurized membrane that deforms to contact the workpiece over a small area.*
5. *'Fluid jet finishing' makes use of a fluid stream for material removal.*

2. B. 3. "Numerically controlled" or manual machine tools, and specially designed components, controls and accessories therefor, specially designed for the shaving, finishing, grinding or honing of hardened (R_C = 40 or more) spur, helical and double-helical gears with a pitch diameter exceeding 1,250 mm and a face width of 15% of pitch diameter or larger finished to a quality of AGMA 14 or better (equivalent to ISO 1328 class 3).

2. B. 4. Hot "isostatic presses" having all of the following, and specially designed components and accessories therefor:

a. A controlled thermal environment within the closed cavity and a chamber cavity with an inside diameter of 406 mm or more; and
b. Having any of the following:
   1. A maximum working pressure exceeding 207 MPa;
   2. A controlled thermal environment exceeding 1,773 K (1,500°C); or
   3. A facility for hydrocarbon impregnation and removal of resultant gaseous degradation products.

Technical Note

The inside chamber dimension is that of the chamber in which both the working temperature and the working pressure are achieved and does not include fixtures. That dimension will be the smaller of either the inside diameter of the pressure chamber or the inside diameter of the insulated furnace chamber, depending on which of the two chambers is located inside the other.

N.B. *For specially designed dies, moulds and tooling see 1.B.3., 9.B.9. and ML18. of the Munitions List.**

2. B. 5. Equipment specially designed for the deposition, processing and in-process control of inorganic overlays, coatings and surface modifications, as follows, for substrates specified in column 2, by processes shown in column 1 in the Table following 2.E.3.f., and specially designed automated handling, positioning, manipulation and control components therefor:

a. Chemical vapour deposition (CVD) production equipment having all of the following:
   1. A process modified for one of the following:
      a. Pulsating CVD;
      b. Controlled nucleation thermal deposition (CNTD); or
      c. Plasma enhanced or plasma assisted CVD; and
   2. Having any of the following:
      a. Incorporating high vacuum (equal to or less than 0.01 Pa) rotating seals; or
      b. Incorporating *in situ* coating thickness control;

2. B. 5. b. Ion implantation production equipment having beam currents of 5 mA or more;

c. Electron beam physical vapour deposition (EB-PVD) production equipment incorporating power systems rated for over 80 kW and having any of the following:
   1. A liquid pool level "laser" control system which regulates precisely the ingots feed rate; or
   2. A computer controlled rate monitor operating on the principle of photo-luminescence of the ionised atoms in the evaporant stream to control the deposition rate of a coating containing two or more elements;

d. Plasma spraying production equipment having any of the following:
   1. Operating at reduced pressure controlled atmosphere (equal to or less than 10 kPa measured above and within 300 mm of the gun nozzle exit) in a vacuum chamber capable of evacuation down to 0.01 Pa prior to the spraying process; or
   2. Incorporating *in situ* coating thickness control;

e. Sputter deposition production equipment capable of current densities of 0.1 mA/mm^2 or higher at a deposition rate of 15 µm/h or more;

f. Cathodic arc deposition production equipment incorporating a grid of electromagnets for steering control of the arc spot on the cathode;

g. Ion plating production equipment capable of *in situ* measurement of any of the following:
   1. Coating thickness on the substrate and rate control; or
   2. Optical characteristics.

   Note *2.B.5.a., 2.B.5.b., 2.B.5.e., 2.B.5.f. and 2.B.5.g. do not apply to chemical vapour deposition, cathodic arc, sputter deposition, ion plating or ion implantation equipment, specially designed for cutting or machining tools.*

* The Russian Federation and Ukraine view this list as a reference list drawn up to help in the selection of dual-use goods which could contribute to the indigenous development, production or enhancement of conventional munitions capabilities.

2. B. 6. Dimensional inspection or measuring systems, equipment and "electronic assemblies", as follows:

a. Computer controlled or "numerically controlled" Coordinate Measuring Machines (CMM), having a three dimensional (volumetric) maximum permissible error of length measurement ($E_{0,MPE}$) at any point within the operating range of the machine (i.e., within the length of axes) equal to or less (better) than 1.7 + L/1,000 µm (L is the measured length in mm), according to ISO 10360-2 (2009);

Technical Note
The $E_{0,MPE}$ of the most accurate configuration of the CMM specified by the manufacturer (e.g., best of the following: probe, stylus length, motion parameters, environment) and with "all compensations available" shall be compared to the 1.7 + L/1,000 µm threshold.

2. B. 6. b. Linear and angular displacement measuring instruments, as follows:

1. 'Linear displacement' measuring instruments having any of the following:

Note *Interferometer and optical-encoder displacement measuring systems containing a "laser" are only specified in 2.B.6.b.1.c.*

Technical Note
For the purpose of 2.B.6.b.1., 'linear displacement' means the change of distance between the measuring probe and the measured object.

a. Non-contact type measuring systems with a "resolution" equal to or less (better) than 0.2 µm within a measuring range up to 0.2 mm;

b. Linear Variable Differential Transformer (LVDT) systems having all of the following:

1. Having any of the following:

a. "Linearity" equal to or less (better) than 0.1% measured from 0 to the 'full operating range', for LVDTs with a 'full operating range' up to and including ± 5 mm; or

b. "Linearity" equal to or less (better) than 0.1% measured from 0 to 5 mm for LVDTs with a 'full operating range' greater than ± 5 mm; and

2. Drift equal to or less (better) than 0.1% per day at a standard ambient test room temperature ±1 K;

Technical Note
For the purposes of 2.B.6.b.1.b., 'full operating range' is half of the total possible linear displacement of the LVDT. For example, LVDTs with a 'full operating range' up to and including ± 5 mm can measure a total possible linear displacement of 10 mm.

2. B. 6. b. 1. c. Measuring systems having all of the following:
   1. Containing a "laser";
   2. A "resolution" over their full scale of 0.200 nm or less (better); and
   3. Capable of achieving a "measurement uncertainty" equal to or less (better) than (1.6 + L/2,000) nm (L is the measured length in mm) at any point within a measuring range, when compensated for the refractive index of air and measured over a period of 30 seconds at a temperature of 20±0.01°C; or

2. B. 6. b. 1. d. "Electronic assemblies" specially designed to provide feedback capability in systems specified by 2.B.6.b.1.c.;

   Note *2.B.6.b.1. does not apply to measuring interferometer systems, with an automatic control system that is designed to use no feedback techniques, containing a "laser" to measure slide movement errors of machine-tools, dimensional inspection machines or similar equipment.*

2. B. 6. b. 2. Angular displacement measuring instruments having an angular position "accuracy" equal to or less (better) than 0.00025°;

   Note *2.B.6.b.2. does not apply to optical instruments, such as autocollimators, using collimated light (e.g., "laser" light) to detect angular displacement of a mirror.*

2. B. 6. c. Equipment for measuring surface roughness (including surface defects), by measuring optical scatter with a sensitivity of 0.5 nm or less (better).

   Note *2.B.6. includes machine tools, other than those specified by 2.B.1., that can be used as measuring machines if they meet or exceed the criteria specified for the measuring machine function.*

2. B. 7. "Robots" having any of the following characteristics and specially designed controllers and "end-effectors" therefor:

   a. Capable in real time of full three-dimensional image processing or full three-dimensional 'scene analysis' to generate or modify "programs" or to generate or modify numerical program data;

      Technical Note
      The 'scene analysis' limitation does not include approximation of the third dimension by viewing at a given angle, or limited grey scale interpretation for the perception of depth or texture for the approved tasks (2 1/2 D).

   b. Specially designed to comply with national safety standards applicable to potentially explosive munitions environments;

      Note *2.B.7.b. does not apply to "robots" specially designed for paint-spraying booths.*

   c. Specially designed or rated as radiation-hardened to withstand greater than 5×10^3 Gy (Si) without operational degradation; or

   d. Specially designed to operate at altitudes exceeding 30,000 m.

2. B. 8. Assemblies or units, specially designed for machine tools, or dimensional inspection or measuring systems and equipment, as follows:

a. Linear position feedback units having an overall "accuracy" less (better) than (800 + (600 x L/1,000)) nm (L equals the effective length in mm);

N.B. For "laser" systems see also 2.B.6.b.1.c. and d.

b. Rotary position feedback units having an "accuracy" less (better) than 0.00025°;

N.B. For "laser" systems see also 2.B.6.b.2.

Note 2.B.8.a. and 2.B.8.b. apply to units, which are designed to determine the positioning information for feedback control, such as inductive type devices, graduated scales, infrared systems or "laser" systems.

c. "Compound rotary tables" and "tilting spindles", capable of upgrading, according to the manufacturer's specifications, machine tools to or above the levels specified by 2.B.

2. B. 9. Spin-forming machines and flow-forming machines, which, according to the manufacturer's technical specification, can be equipped with "numerical control" units or a computer control and having all of the following:

a. Three or more axes which can be coordinated simultaneously for "contouring control"; and

b. A roller force more than 60 kN.

Technical Note

For the purpose of 2.B.9., machines combining the function of spin-forming and flow-forming are regarded as flow-forming machines.

2. C. MATERIALS - None

2. D. SOFTWARE

1. "Software", other than that specified by 2.D.2., as follows:

a. "Software" specially designed or modified for the "development" or "production" of equipment specified by 2.A. or 2.B.;

b. "Software" specially designed or modified for the "use" of equipment specified by 2.A.1.c., 2.B.1., or 2.B.3. to 2.B.9.

Note 2.D.1. does not apply to part programming "software" that generates "numerical control" codes for machining various parts.

2. D. 2. "Software" for electronic devices, even when residing in an electronic device or system, enabling such devices or systems to function as a "numerical control" unit, capable of co-ordinating simultaneously more than 4 axes for "contouring control".

Note1 2.D.2. does not apply to "software" specially designed or modified for the operation of items not specified by Category 2.

Note 2 2.D.2. does not apply to "software" for items specified by 2.B.2. See 2.D.1. and 2.D.3. for "software" for items specified by 2.B.2.

Note 3 2.D.2. does not apply to "software" that is exported with, and the minimum necessary for the operation of, items not specified by Category 2.

2. D. 3. "Software", designed or modified for the operation of equipment specified by 2.B.2., that converts optical design, workpiece measurements and material removal functions into "numerical control" commands to achieve the desired workpiece form.

2. E. TECHNOLOGY

2. E. 1. "Technology" according to the General Technology Note for the "development" of equipment or "software" specified by 2.A., 2.B. or 2.D.

Note *2.E.1. includes "technology" for the integration of probe systems into coordinate measurement machines specified by 2.B.6.a.*

2. E. 2. "Technology" according to the General Technology Note for the "production" of equipment specified by 2.A. or 2.B.

2. E. 3. Other "technology", as follows:

a. "Technology" for the "development" of interactive graphics as an integrated part in "numerical control" units for preparation or modification of part programs;

b. "Technology" for metal-working manufacturing processes, as follows:

1. "Technology" for the design of tools, dies or fixtures specially designed for any of the following processes:
   a. "Superplastic forming";
   b. "Diffusion bonding"; or
   c. "Direct-acting hydraulic pressing";

2. Technical data consisting of process methods or parameters as listed below used to control:
   a. "Superplastic forming" of aluminium alloys, titanium alloys or "superalloys":
      1. Surface preparation;
      2. Strain rate;
      3. Temperature;
      4. Pressure;
   b. "Diffusion bonding" of "superalloys" or titanium alloys:
      1. Surface preparation;
      2. Temperature;
      3. Pressure;
   c. "Direct-acting hydraulic pressing" of aluminium alloys or titanium alloys:
      1. Pressure;
      2. Cycle time;
   d. "Hot isostatic densification" of titanium alloys, aluminium alloys or "superalloys":
      1. Temperature;
      2. Pressure;
      3. Cycle time;

2. E. 3. c. "Technology" for the "development" or "production" of hydraulic stretch-forming machines and dies therefor, for the manufacture of airframe structures;

2. E. 3. d. "Technology" for the "development" of generators of machine tool instructions (e.g., part programs) from design data residing inside "numerical control" units;

2. E. 3. e. "Technology" for the "development" of integration "software" for incorporation of expert systems for advanced decision support of shop floor operations into "numerical control" units;

2. E. 3. f. "Technology" for the application of inorganic overlay coatings or inorganic surface modification coatings (specified in column 3 of the following table) to non-electronic substrates (specified in column 2 of the following table), by processes specified in column 1 of the following table and defined in the Technical Note.

N.B. *This Table should be read to specify the "technology" for a particular 'Coating Process' only when the Resultant Coating in column 3 is in a paragraph directly across from the relevant 'Substrate' under column 2. For example, Chemical Vapour Deposition (CVD) 'coating process' technical data are included for the application of 'silicides' to 'Carbon-carbon, Ceramic and Metal "matrix" "composites" substrates, but are not included for the application of 'silicides' to 'Cemented tungsten carbide (16), Silicon carbide (18)' substrates. In the second case, the resultant coating is not listed in the paragraph under column 3 directly across from the paragraph under column 2 listing 'Cemented tungsten carbide (16), Silicon carbide (18)'.*

TABLE - DEPOSITION TECHNIQUES

1. Coating Process (1)*	2. Substrate	3. Resultant Coating
A. Chemical Vapour Deposition (CVD)	"Superalloys"	Aluminides for internal passages
	Ceramics (19) and Low-expansion glasses (14)	Silicides Carbides Dielectric layers (15) Diamond Diamond-like carbon (17)
	Carbon-carbon, Ceramic and Metal "matrix" "composites"	Silicides Carbides Refractory metals Mixtures thereof (4) Dielectric layers (15) Aluminides Alloyed aluminides (2) Boron nitride
	Cemented tungsten carbide (16), Silicon carbide (18)	Carbides Tungsten Mixtures thereof (4) Dielectric layers (15)
	Molybdenum and Molybdenum alloys	Dielectric layers (15)
	Beryllium and Beryllium alloys	Dielectric layers (15) Diamond Diamond-like carbon (17)
	Sensor window materials (9)	Dielectric layers (15) Diamond Diamond-like carbon (17)

* The numbers in parenthesis refer to the Notes following this Table.

TABLE - DEPOSITION TECHNIQUES

1. Coating Process (1)	2. Substrate	3. Resultant Coating
B. Thermal-Evaporation Physical Vapour Deposition (TE-PVD)		
B.1. Physical Vapour Deposition (PVD): Electron-Beam (EB-PVD)	"Superalloys"	Alloyed silicides Alloyed aluminides (2) MCrAlX (5) Modified zirconia (12) Silicides Aluminides Mixtures thereof (4)
	Ceramics (19) and Low-expansion glasses (14)	Dielectric layers (15)
	Corrosion resistant steel (7)	MCrAlX (5) Modified zirconia (12) Mixtures thereof (4)
	Carbon-carbon, Ceramic and Metal "matrix" "composites"	Silicides Carbides Refractory metals Mixtures thereof (4) Dielectric layers (15) Boron nitride
	Cemented tungsten carbide (16), Silicon carbide (18)	Carbides Tungsten Mixtures thereof (4) Dielectric layers (15)
	Molybdenum and Molybdenum alloys	Dielectric layers (15)
	Beryllium and Beryllium alloys	Dielectric layers (15) Borides Beryllium
	Sensor window materials (9)	Dielectric layers (15)
	Titanium alloys (13)	Borides Nitrides

TABLE - DEPOSITION TECHNIQUES

1.	Coating Process (1)	2.	Substrate	3.	Resultant Coating
B.2.	Ion assisted resistive heating Physical Vapour Deposition (PVD) (Ion Plating)		Ceramics (19) and Low-expansion glasses (14)		Dielectric layers (15) Diamond-like carbon (17)
			Carbon-carbon, Ceramic and Metal "matrix" "composites"		Dielectric layers (15)
			Cemented tungsten carbide (16), Silicon carbide		Dielectric layers (15)
			Molybdenum and Molybdenum alloys		Dielectric layers (15)
			Beryllium and Beryllium alloys		Dielectric layers (15)
			Sensor window materials (9)		Dielectric layers (15) Diamond-like carbon (17)
B.3.	Physical Vapour Deposition (PVD): "Laser" Vaporization		Ceramics (19) and Low-expansion glasses (14)		Silicides Dielectric layers (15) Diamond-like carbon (17)
			Carbon-carbon, Ceramic and Metal "matrix" "composites"		Dielectric layers (15)
			Cemented tungsten carbide (16), Silicon carbide		Dielectric layers (15)
			Molybdenum and Molybdenum alloys		Dielectric layers (15)
			Beryllium and Beryllium alloys		Dielectric layers (15)
			Sensor window materials (9)		Dielectric layers (15) Diamond-like carbon

TABLE - DEPOSITION TECHNIQUES

1.	Coating Process (1)	2. Substrate	3. Resultant Coating
B.4.	Physical Vapour Deposition (PVD): Cathodic Arc Discharge	"Superalloys"	Alloyed silicides Alloyed aluminides (2) MCrAlX (5)
		Polymers (11) and Organic "matrix" "composites"	Borides Carbides Nitrides Diamond-like carbon (17)
C.	Pack cementation (see A above for out-of-pack cementation) (10)	Carbon-carbon, Ceramic and Metal "matrix" "composites"	Silicides Carbides Mixtures thereof (4)
		Titanium alloys (13)	Silicides Aluminides Alloyed aluminides (2)
		Refractory metals and alloys (8)	Silicides Oxides
D.	Plasma spraying	"Superalloys"	MCrAlX (5) Modified zirconia (12) Mixtures thereof (4) Abradable Nickel-Graphite Abradable materials containing Ni-Cr-Al Abradable Al-Si-Polyester Alloyed aluminides (2)
		Aluminium alloys (6)	MCrAlX (5) Modified zirconia (12) Silicides Mixtures thereof (4)
		Refractory metals and alloys (8)	Aluminides Silicides Carbides

TABLE - DEPOSITION TECHNIQUES

1.	Coating Process (1)	2. Substrate	3. Resultant Coating
D.	(continued)	Corrosion resistant steel (7)	MCrAlX (5) Modified zirconia (12) Mixtures thereof (4)
		Titanium alloys (13)	Carbides Aluminides Silicides Alloyed aluminides (2) Abradable Nickel-Graphite Abradable materials containing Ni-Cr-Al Abradable Al-Si-Polyester
E.	Slurry Deposition	Refractory metals and alloys (8)	Fused silicides Fused aluminides except for resistance heating elements
		Carbon-carbon, Ceramic and Metal "matrix" "composites"	Silicides Carbides Mixtures thereof (4)
F.	Sputter Deposition	"Superalloys"	Alloyed silicides Alloyed aluminides (2) Noble metal modified aluminides (3) MCrAlX (5) Modified zirconia (12) Platinum Mixtures thereof (4)
		Ceramics and Low-expansion glasses (14)	Silicides Platinum Mixtures thereof (4) Dielectic layers (15) Diamond-like carbon (17)

TABLE - DEPOSITION TECHNIQUES

1. Coating Process (1)	2. Substrate	3. Resultant Coating
F. (continued)	Titanium alloys (13)	Borides Nitrides Oxides Silicides Aluminides Alloyed aluminides (2) Carbides
	Carbon-carbon, Ceramic and Metal "matrix" "composites"	Silicides Carbides Refractory metals Mixtures thereof (4) Dielectric layers (15) Boron nitride
	Cemented tungsten carbide (16), Silicon carbide (18)	Carbides Tungsten Mixtures thereof (4) Dielectric layers (15) Boron nitride
	Molybdenum and Molybdenum alloys	Dielectric layers (15)
	Beryllium and Beryllium alloys	Borides Dielectric layers (15) Beryllium
	Sensor window materials (9)	Dielectric layers (15) Diamond-like carbon (17)
	Refractory metals and alloys (8)	Aluminides Silicides Oxides Carbides

TABLE - DEPOSITION TECHNIQUES

1.	Coating Process (1)	2.	Substrate	3.	Resultant Coating
G.	Ion Implantation		High temperature bearing steels		Additions of Chromium Tantalum or Niobium (Columbium)
			Titanium alloys (13)		Borides Nitrides
			Beryllium and Beryllium alloys		Borides
			Cemented tungsten carbide (16)		Carbides Nitrides

TABLE - DEPOSITION TECHNIQUES - NOTES

1. The term 'coating process' includes coating repair and refurbishing as well as original coating.

2. The term 'alloyed aluminide coating' includes single or multiple-step coatings in which an element or elements are deposited prior to or during application of the aluminide coating, even if these elements are deposited by another coating process. It does not, however, include the multiple use of single-step pack cementation processes to achieve alloyed aluminides.

3. The term 'noble metal modified aluminide' coating includes multiple-step coatings in which the noble metal or noble metals are laid down by some other coating process prior to application of the aluminide coating.

4. The term 'mixtures thereof' includes infiltrated material, graded compositions, co-deposits and multilayer deposits and are obtained by one or more of the coating processes specified in the Table.

5. 'MCrAlX' refers to a coating alloy where M equals cobalt, iron, nickel or combinations thereof and X equals hafnium, yttrium, silicon, tantalum in any amount or other intentional additions over 0.01% by weight in various proportions and combinations, except:
   a. CoCrAlY coatings which contain less than 22% by weight of chromium, less than 7% by weight of aluminium and less than 2 weight percent of yttrium;
   b. CoCrAlY coatings which contain 22 to 24% by weight of chromium, 10 to 12% by weight of aluminium and 0.5 to 0.7% by weight of yttrium; or
   c. NiCrAlY coatings which contain 21 to 23% by weight of chromium, 10 to 12% by weight of aluminium and 0.9 to1.1% by weight of yttrium.

6. The term 'aluminium alloys' refers to alloys having an ultimate tensile strength of 190 MPa or more measured at 293 K (20°C).

7. The term 'corrosion resistant steel' refers to AISI (American Iron and Steel Institute) 300 series or equivalent national standard steels.

8. 'Refractory metals and alloys' include the following metals and their alloys: niobium (columbium), molybdenum, tungsten and tantalum.

9. 'Sensor window materials', as follows: alumina, silicon, germanium, zinc sulphide, zinc selenide, gallium arsenide, diamond, gallium phosphide, sapphire and the following metal halides: sensor window materials of more than 40 mm diameter for zirconium fluoride and hafnium fluoride.

TABLE - DEPOSITION TECHNIQUES – NOTES

10. Category 2 does not include "technology" for single-step pack cementation of solid airfoils.

11. 'Polymers', as follows: polyimide, polyester, polysulphide, polycarbonates and polyurethanes.

12. 'Modified zirconia' refers to additions of other metal oxides (e.g., calcia, magnesia, yttria, hafnia, rare earth oxides) to zirconia in order to stabilise certain crystallographic phases and phase compositions. Thermal barrier coatings made of zirconia, modified with calcia or magnesia by mixing or fusion, are not included.

13. 'Titanium alloys' refers only to aerospace alloys having an ultimate tensile strength of 900 MPa or more measured at 293 K (20°C).

14. 'Low-expansion glasses' refers to glasses which have a coefficient of thermal expansion of 1×10^{-7} K^{-1} or less measured at 293 K (20°C).

15. 'Dielectric layers' are coatings constructed of multi-layers of insulator materials in which the interference properties of a design composed of materials of various refractive indices are used to reflect, transmit or absorb various wavelength bands. Dielectric layers refers to more than four dielectric layers or dielectric/metal "composite" layers.

16. 'Cemented tungsten carbide' does not include cutting and forming tool materials consisting of tungsten carbide/(cobalt, nickel), titanium carbide/(cobalt, nickel), chromium carbide/nickel-chromium and chromium carbide/nickel.

17. "Technology" for depositing diamond-like carbon on any of the following is not included:
magnetic disk drives and heads, equipment for the manufacture of disposables, valves for faucets, acoustic diaphragms for speakers, engine parts for automobiles, cutting tools, punching-pressing dies, office automation equipment, microphones, medical devices or moulds, for casting or moulding of plastics, manufactured from alloys containing less than 5% beryllium.

18. 'Silicon carbide' does not include cutting and forming tool materials.

19. Ceramic substrates, as used in this entry, does not include ceramic materials containing 5% by weight, or greater, clay or cement content, either as separate constituents or in combination.

TABLE - DEPOSITION TECHNIQUES - TECHNICAL NOTE

Processes specified in Column 1 of the Table are defined as follows:

a. Chemical Vapour Deposition (CVD) is an overlay coating or surface modification coating process wherein a metal, alloy, "composite", dielectric or ceramic is deposited upon a heated substrate. Gaseous reactants are decomposed or combined in the vicinity of a substrate resulting in the deposition of the desired elemental, alloy or compound material on the substrate. Energy for this decomposition or chemical reaction process may be provided by the heat of the substrate, a glow discharge plasma, or "laser" irradiation.

N.B.1 CVD includes the following processes: directed gas flow out-of-pack deposition, pulsating CVD, controlled nucleation thermal deposition (CNTD), plasma enhanced or plasma assisted CVD processes.

N.B.2 Pack denotes a substrate immersed in a powder mixture.

N.B.3 The gaseous reactants used in the out-of-pack process are produced using the same basic reactions and parameters as the pack cementation process, except that the substrate to be coated is not in contact with the powder mixture.

b. Thermal Evaporation-Physical Vapour Deposition (TE-PVD) is an overlay coating process conducted in a vacuum with a pressure less than 0.1 Pa wherein a source of thermal energy is used to vaporize the coating material. This process results in the condensation, or deposition, of the evaporated species onto appropriately positioned substrates.

The addition of gases to the vacuum chamber during the coating process to synthesize compound coatings is an ordinary modification of the process.

The use of ion or electron beams, or plasma, to activate or assist the coating's deposition is also a common modification in this technique. The use of monitors to provide in-process measurement of optical characteristics and thickness of coatings can be a feature of these processes.

Specific TE-PVD processes are as follows:

1. Electron Beam PVD uses an electron beam to heat and evaporate the material which forms the coating;
2. Ion Assisted Resistive Heating PVD employs electrically resistive heating sources in combination with impinging ion beam(s) to produce a controlled and uniform flux of evaporated coating species;
3. "Laser" Vaporization uses either pulsed or continuous wave "laser" beams to vaporize the material which forms the coating;

TABLE - DEPOSITION TECHNIQUES - TECHNICAL NOTE

Processes specified in Column 1 of the Table - continued:

b. 4. Cathodic Arc Deposition employs a consumable cathode of the material which forms the coating and has an arc discharge established on the surface by a momentary contact of a ground trigger. Controlled motion of arcing erodes the cathode surface creating a highly ionized plasma. The anode can be either a cone attached to the periphery of the cathode, through an insulator, or the chamber. Substrate biasing is used for non line-of-sight deposition.

N.B. This definition does not include random cathodic arc deposition with non-biased substrates.

5. Ion Plating is a special modification of a general TE-PVD process in which a plasma or an ion source is used to ionize the species to be deposited, and a negative bias is applied to the substrate in order to facilitate the extraction of the species from the plasma. The introduction of reactive species, evaporation of solids within the process chamber, and the use of monitors to provide in-process measurement of optical characteristics and thicknesses of coatings are ordinary modifications of the process.

c. Pack Cementation is a surface modification coating or overlay coating process wherein a substrate is immersed in a powder mixture (a pack), that consists of:

1. The metallic powders that are to be deposited (usually aluminium, chromium, silicon or combinations thereof);
2. An activator (normally a halide salt); and
3. An inert powder, most frequently alumina.

The substrate and powder mixture is contained within a retort which is heated to between 1,030 K (757°C) and 1,375 K (1,102°C) for sufficient time to deposit the coating.

d. Plasma Spraying is an overlay coating process wherein a gun (spray torch) which produces and controls a plasma accepts powder or wire coating materials, melts them and propels them towards a substrate, whereon an integrally bonded coating is formed. Plasma spraying constitutes either low pressure plasma spraying or high velocity plasma spraying.

N.B.1 Low pressure means less than ambient atmospheric pressure.

N.B.2 High velocity refers to nozzle-exit gas velocity exceeding 750 m/s calculated at 293 K (20°C) at 0.1 MPa.

TABLE - DEPOSITION TECHNIQUES - TECHNICAL NOTE

Processes specified in Column 1 of the Table - continued:

e. Slurry Deposition is a surface modification coating or overlay coating process wherein a metallic or ceramic powder with an organic binder is suspended in a liquid and is applied to a substrate by either spraying, dipping or painting, subsequent air or oven drying, and heat treatment to obtain the desired coating.

f. Sputter Deposition is an overlay coating process based on a momentum transfer phenomenon, wherein positive ions are accelerated by an electric field towards the surface of a target (coating material). The kinetic energy of the impacting ions is sufficient to cause target surface atoms to be released and deposited on an appropriately positioned substrate.

N.B.1 The Table refers only to triode, magnetron or reactive sputter deposition which is used to increase adhesion of the coating and rate of deposition and to radio frequency (RF) augmented sputter deposition used to permit vaporisation of non-metallic coating materials.

N.B.2 Low-energy ion beams (less than 5 keV) can be used to activate the deposition.

g. Ion Implantation is a surface modification coating process in which the element to be alloyed is ionized, accelerated through a potential gradient and implanted into the surface region of the substrate. This includes processes in which ion implantation is performed simultaneously with electron beam physical vapour deposition or sputter deposition.

TABLE - DEPOSITION TECHNIQUES - STATEMENT OF UNDERSTANDING

It is understood that the following technical information, accompanying the table of deposition techniques, is for use as appropriate.

1. Technical information for pretreatments of the substrates listed in the Table, as follows:
   a. Chemical stripping and cleaning bath cycle parameters, as follows:
      1. Bath composition
         a. For the removal of old or defective coatings, corrosion product or foreign deposits;
         b. For preparation of virgin substrates;
      2. Time in bath;
      3. Temperature of bath;
      4. Number and sequences of wash cycles;

   b. Visual and macroscopic criteria for acceptance of the cleaned part;

   c. Heat treatment cycle parameters, as follows:
      1. Atmosphere parameters, as follows:
         a. Composition of the atmosphere;
         b. Pressure of the atmosphere;
      2. Temperature for heat treatment;
      3. Time of heat treatment;

   d. Substrate surface preparation parameters, as follows:
      1. Grit blasting parameters, as follows:
         a. Grit composition;
         b. Grit size and shape;
         c. Grit velocity;
      2. Time and sequence of cleaning cycle after grit blast;
      3. Surface finish parameters;
      4. Application of binders to promote adhesion;

   e. Masking technique parameters, as follows:
      1. Material of mask;
      2. Location of mask;

2. Technical information for in situ quality assurance techniques for evaluation of the coating processes listed in the Table, as follows:
   a. Atmosphere parameters, as follows:
      1. Composition of the atmosphere;
      2. Pressure of the atmosphere;
   b. Time parameters;
   c. Temperature parameters;
   d. Thickness parameters;
   e. Index of refraction parameters;
   f. Control of composition;

3. Technical information for post deposition treatments of the coated substrates listed in the Table, as follows:
   a. Shot peening parameters, as follows:
      1. Shot composition;
      2. Shot size;
      3. Shot velocity;

TABLE - DEPOSITION TECHNIQUES - STATEMENT OF UNDERSTANDING

3. b. Post shot peening cleaning parameters;
   c. Heat treatment cycle parameters, as follows:
      1. Atmosphere parameters, as follows:
         a. Composition of the atmosphere;
         b. Pressure of the atmosphere;
      2. Time-temperature cycles;
   d. Post heat treatment visual and macroscopic criteria for acceptance of the coated substrates;

4. Technical information for quality assurance techniques for the evaluation of the coated substrates listed in the Table, as follows:
   a. Statistical sampling criteria;
   b. Microscopic criteria for:
      1. Magnification;
      2. Coating thickness uniformity;
      3. Coating integrity;
      4. Coating composition;
      5. Coating and substrates bonding;
      6. Microstructural uniformity;
   c. Criteria for optical properties assessment (measured as a function of wavelength):
      1. Reflectance;
      2. Transmission;
      3. Absorption;
      4. Scatter;

5. Technical information and parameters related to specific coating and surface modification processes listed in the Table, as follows:
   a. For Chemical Vapour Deposition (CVD):
      1. Coating source composition and formulation;
      2. Carrier gas composition;
      3. Substrate temperature;
      4. Time-temperature-pressure cycles;
      5. Gas control and part manipulation;
   b. For Thermal Evaporation - Physical Vapour Deposition (PVD):
      1. Ingot or coating material source composition;
      2. Substrate temperature;
      3. Reactive gas composition;
      4. Ingot feed rate or material vaporisation rate;
      5. Time-temperature-pressure cycles;
      6. Beam and part manipulation;
      7. "Laser" parameters, as follows:
         a. Wave length;
         b. Power density;
         c. Pulse length;
         d. Repetition ratio;
         e. Source;

TABLE - DEPOSITION TECHNIQUES - STATEMENT OF UNDERSTANDING

5. c. For Pack Cementation:
   1. Pack composition and formulation;
   2. Carrier gas composition;
   3. Time-temperature-pressure cycles;

   d. For Plasma Spraying:
   1. Powder composition, preparation and size distributions;
   2. Feed gas composition and parameters;
   3. Substrate temperature;
   4. Gun power parameters;
   5. Spray distance;
   6. Spray angle;
   7. Cover gas composition, pressure and flow rates;
   8. Gun control and part manipulation;

   e. For Sputter Deposition:
   1. Target composition and fabrication;
   2. Geometrical positioning of part and target;
   3. Reactive gas composition;
   4. Electrical bias;
   5. Time-temperature-pressure cycles;
   6. Triode power;
   7. Part manipulation;

   f. For Ion Implantation:
   1. Beam control and part manipulation;
   2. Ion source design details;
   3. Control techniques for ion beam and deposition rate parameters;
   4. Time-temperature-pressure cycles;

   g. For Ion Plating:
   1. Beam control and part manipulation;
   2. Ion source design details;
   3. Control techniques for ion beam and deposition rate parameters;
   4. Time-temperature-pressure cycles;
   5. Coating material feed rate and vaporisation rate;
   6. Substrate temperature;
   7. Substrate bias parameters.

3. A. SYSTEMS, EQUIPMENT AND COMPONENTS

Note 1 *The status of equipment and components described in 3.A., other than those described in 3.A.1.a.3. to 3.A.1.a.10., 3.A.1.a.12. or 3.A.1.a.14., which are specially designed for or which have the same functional characteristics as other equipment is determined by the status of the other equipment.*

Note 2 *The status of integrated circuits described in 3.A.1.a.3. to 3.A.1.a.9., 3.A.1.a.12. or 3.A.1.a.14. which are unalterably programmed or designed for a specific function for another equipment is determined by the status of the other equipment.*

N.B. *When the manufacturer or applicant cannot determine the status of the other equipment, the status of the integrated circuits is determined in 3.A.1.a.3. to 3.A.1.a.9., 3.A.1.a.12. and 3.A.1.a.14.*

3. A. 1. Electronic items as follows:

a. General purpose integrated circuits, as follows:

Note 1 *The status of wafers (finished or unfinished), in which the function has been determined, is to be evaluated against the parameters of 3.A.1.a.*

Note 2 *Integrated circuits include the following types:*
- *"Monolithic integrated circuits";*
- *"Hybrid integrated circuits";*
- *"Multichip integrated circuits";*
- *"Film type integrated circuits", including silicon-on-sapphire integrated circuits;*
- *"Optical integrated circuits";*
- *"Three dimensional integrated circuits";*
- *"Monolithic Microwave Integrated Circuits" ("MMICs").*

3. A. 1. a. 1. Integrated circuits designed or rated as radiation hardened to withstand any of the following:

a. A total dose of 5 x 10^3 Gy (Si) or higher;

b. A dose rate upset of 5 x 10^6 Gy (Si)/s or higher; or

c. A fluence (integrated flux) of neutrons (1 MeV equivalent) of 5 x 10^{13} n/cm^2 or higher on silicon, or its equivalent for other materials;

Note *3.A.1.a.1.c. does not apply to Metal Insulator Semiconductors (MIS).*

3. A. 1. a. 2. "Microprocessor microcircuits", "microcomputer microcircuits", microcontroller microcircuits, storage integrated circuits manufactured from a compound semiconductor, analogue-to-digital converters, integrated circuits that contain analogue-to-digital converters and store or process the digitized data, digital-to-analogue converters, electro-optical or "optical integrated circuits" designed for "signal processing", field programmable logic devices, custom integrated circuits for which either the function is unknown or the status of the equipment in which the integrated circuit will be used is unknown, Fast Fourier Transform (FFT) processors, Electrical Erasable Programmable Read-Only Memories (EEPROMs), flash memories, Static Random-Access Memories (SRAMs) or Magnetic Random Access Memories (MRAMs), having any of the following:

3. A. 1. a. 2. a. Rated for operation at an ambient temperature above 398 K (+125°C);
b. Rated for operation at an ambient temperature below 218 K (-55°C); or
c. Rated for operation over the entire ambient temperature range from 218 K (-55°C) to 398 K (+125°C);

Note *3.A.1.a.2. does not apply to integrated circuits for civil automobile or railway train applications.*

3. A. 1. a. 3. "Microprocessor microcircuits", "microcomputer microcircuits" and microcontroller microcircuits, manufactured from a compound semiconductor and operating at a clock frequency exceeding 40 MHz;

Note *3.A.1.a.3. includes digital signal processors, digital array processors and digital coprocessors.*

3. A. 1. a. 4. Not used since 2010

3. A. 1. a. 5. Analogue-to-Digital Converter (ADC) and Digital-to-Analogue Converter (DAC) integrated circuits, as follows:

a. ADCs having any of the following:
1. A resolution of 8 bit or more, but less than 10 bit, with an output rate greater than 1.3 giga samples per second (GSPS);
2. A resolution of 10 bit or more, but less than 12 bit, with an output rate greater than 600 mega samples per second (MSPS);
3. A resolution of 12 bit or more, but less than 14 bit, with an output rate greater than 400 mega samples per second (MSPS);
4. A resolution of 14 bit or more, but less than 16 bit, with an output rate greater than 250 mega samples per second (MSPS); or
5. A resolution of 16 bit or more with an output rate greater than 65 mega samples per second (MSPS);

N.B. *For integrated circuits that contain analogue-to-digital converters and store or process the digitized data, see 3.A.1.a.14.*

Technical Notes

1. *A resolution of n bit corresponds to a quantisation of 2^n levels.*
2. *The number of bits in the output word is equal to the resolution of the ADC.*
3. *The output rate is the maximum output rate of the converter, regardless of architecture or oversampling.*
4. *For 'multiple channel ADCs', the outputs are not aggregated and the output rate is the maximum output rate of any single channel.*
5. *For 'interleaved ADCs' or for 'multiple channel ADCs' that are specified to have an interleaved mode of operation, the outputs are aggregated and the output rate is the maximum combined total output rate of all of the outputs.*

Technical Notes cont.

6. *Vendors may also refer to the output rate as sampling rate, conversion rate or throughput rate. It is often specified in megahertz (MHz) mega words per second or mega samples per second (MSPS).*
7. *For the purpose of measuring output rate, one sample per second is equivalent to one hertz or one output word per second.*
8. *'Multiple channel ADCs' are defined as devices which integrate more than one ADC, designed so that each ADC has a separate analogue input.*
9. *'Interleaved ADCs' are defined as devices which have multiple ADC units that sample the same analogue input at different times such that when the outputs are aggregated, the analogue input has been effectively sampled and converted at a higher sampling rate.*

3. A. 1. a. 5. b. Digital-to-Analogue Converters (DAC) having any of the following:

1. A resolution of 10 bit or more with an 'adjusted update rate' of greater than 3,500 MSPS; or
2. A resolution of 12 bit or more with an 'adjusted update rate' of greater than 1,250 MSPS and having any of the following:
   a. A settling time less than 9 ns to 0.024% of full scale from a full scale step; or
   b. A 'Spurious Free Dynamic Range' (SFDR) greater than 68 dBc (carrier) when synthesizing a full scale analogue signal of 100 MHz or the highest full scale analogue signal frequency specified below 100 MHz;

Technical Notes

1. *'Spurious Free Dynamic Range' (SFDR) is defined as the ratio of the RMS value of the carrier frequency (maximum signal component) at the input of the DAC to the RMS value of the next largest noise or harmonic distortion component at its output.*
2. *SFDR is determined directly from the specification table or from the characterisation plots of SFDR versus frequency.*
3. *A signal is defined to be full scale when its amplitude is greater than -3 dBfs (full scale).*
4. *'Adjusted update rate' for DACs:*
   a. *For conventional (non-interpolating) DACs, the 'adjusted update rate' is the rate at which the digital signal is converted to an analogue signal and the output analogue values are changed by the DAC. For DACs where the interpolation mode may be bypassed (interpolation factor of one), the DAC should be considered as a conventional (non-interpolating) DAC.*

Technical Notes cont.

4. b. For interpolating DACs (oversampling DACs), the 'adjusted update rate' is defined as the DAC update rate divided by the smallest interpolating factor. For interpolating DACs, the 'adjusted update rate' may be referred to by different terms including:
- *input data rate*
- *input word rate*
- *input sample rate*
- *maximum total input bus rate*
- *maximum DAC clock rate for DAC clock input.*

3. A. 1. a. 6. Electro-optical and "optical integrated circuits", designed for "signal processing" and having all of the following:
   a. One or more than one internal "laser" diode;
   b. One or more than one internal light detecting element; and
   c. Optical waveguides;

3. A. 1. a. 7. Field programmable logic devices having any of the following:
   a. A maximum number of single-ended digital input/outputs of greater than 700; or
   b. An 'aggregate one-way peak serial transceiver data rate' of 500 Gb/s or greater;

Note 3.A.1.a.7.includes:
- *Simple Programmable Logic Devices (SPLDs)*
- *Complex Programmable Logic Devices (CPLDs)*
- *Field Programmable Gate Arrays (FPGAs)*
- *Field Programmable Logic Arrays (FPLAs)*
- *Field Programmable Interconnects (FPICs)*

N.B. For integrated circuits having field programmable logic devices that are combined with an analogue-to-digital converter, see 3.A.1.a.14.

Technical Notes

1. Maximum number of digital input/outputs in 3.A.1.a.7.a. is also referred to as maximum user input/outputs or maximum available input/ outputs, whether the integrated circuit is packaged or bare die.

2. 'Aggregate one-way peak serial transceiver data rate' is the product of the peak serial one-way transceiver data rate times the number of transceivers on the FPGA.

3. A. 1. a. 8. Not used since 1999

9. Neural network integrated circuits;

10. Custom integrated circuits for which the function is unknown, or the status of the equipment in which the integrated circuits will be used is unknown to the manufacturer, having any of the following:
   a. More than 1,500 terminals;
   b. A typical "basic gate propagation delay time" of less than 0.02 ns; or
   c. An operating frequency exceeding 3 GHz;

3. A. 1. a. 11. Digital integrated circuits, other than those described in 3.A.1.a.3. to 3.A.1.a.10. and 3.A.1.a.12., based upon any compound semiconductor and having any of the following:
   a. An equivalent gate count of more than 3,000 (2 input gates); or
   b. A toggle frequency exceeding 1.2 GHz;

12. Fast Fourier Transform (FFT) processors having a rated execution time for an N-point complex FFT of less than (N $\log_2$ N)/20,480 ms, where N is the number of points;

Technical Note
When N is equal to 1,024 points, the formula in 3.A.1.a.12. gives an execution time of 500 μs.

3. A. 1. a. 13. Direct Digital Synthesizer (DDS) integrated circuits having any of the following:
   a. A Digital-to-Analogue Converter (DAC) clock frequency of 3.5 GHz or more and a DAC resolution of 10 bit or more, but less than 12 bit; or
   b. A DAC clock frequency of 1.25 GHz or more and a DAC resolution of 12 bit or more;

Technical Note
The DAC clock frequency may be specified as the master clock frequency or the input clock frequency.

3. A. 1. a. 14. Integrated circuits that perform all of the following:
   a. Analogue-to-digital conversions meeting any of the following:
      1. A resolution of 8 bit or more, but less than 10 bit, with an input sample rate greater than 1.3 giga samples per second (GSPS);
      2. A resolution of 10 bit or more, but less than 12 bit, with an input sample rate greater than 1.0 giga samples per second (GSPS);
      3. A resolution of 12 bit or more, but less than 14 bit, with an input sample rate greater than 1.0 giga samples per second (GSPS);
      4. A resolution of 14 bit or more, but less than 16 bit, with an input sample rate greater than 400 mega samples per second (MSPS); or
      5. A resolution of 16 bit or more with an input sample rate greater than 180 mega samples per second (MSPS); and
   b. Any of the following:
      1. Storage of digitized data; or
      2. Processing of digitized data;

N.B.1. For analogue-to-digital converter integrated circuits see 3.A.1.a.5.a.

N.B.2. For field programmable logic devices see 3.A.1.a.7.

3. A. 1. b. Microwave or millimetre wave items, as follows:

Technical Notes

1. *For purposes of 3.A.1.b., the parameter peak saturated power output may also be referred to on product data sheets as output power, saturated power output, maximum power output, peak power output, or peak envelope power output.*
2. *For purposes of 3.A.1.b.1., 'vacuum electronic devices' are electronic devices based on the interaction of an electron beam with an electromagnetic wave propagating in a vacuum circuit or interacting with radio-frequency vacuum cavity resonators. 'Vacuum electronic devices' include klystrons, travelling-wave tubes, and their derivatives.*

1. 'Vacuum electronic devices' and cathodes, as follows:

Note 1 *3.A.1.b.1. does not apply to 'vacuum electronic devices' designed or rated for operation in any frequency bands and having all of the following:*

a. Does not exceed 31.8 GHz; and

b. Is "allocated by the ITU" for radio-communications services, but not for radio-determination.

Note 2 *3.A.1.b.1. does not apply to non-"space-qualified" 'vacuum electronic devices' having all of the following:*

a. An average output power equal to or less than 50 W; and

b. Designed or rated for operation in any frequency band and having all of the following:

1. Exceeds 31.8 GHz but does not exceed 43.5 GHz; and

2. Is "allocated by the ITU" for radio-communications services, but not for radio-determination.

3. A. 1. b. 1. a. Travelling-wave 'vacuum electronic devices', pulsed or continuous wave, as follows:

1. Devices operating at frequencies exceeding 31.8 GHz;
2. Devices having a cathode heater with a turn on time to rated RF power of less than 3 seconds;
3. Coupled cavity devices, or derivatives thereof, with a "fractional bandwidth" of more than 7% or a peak power exceeding 2.5 kW;
4. Devices based on helix, folded waveguide, or serpentine waveguide circuits, or derivatives thereof, having any of the following:
   a. An "instantaneous bandwidth" of more than one octave, and average power (expressed in kW) times frequency (expressed in GHz) of more than 0.5;
   b. An "instantaneous bandwidth" of one octave or less, and average power (expressed in kW) times frequency (expressed in GHz) of more than 1;
   c. Being "space-qualified"; or
   d. Having a gridded electron gun;
5. Devices with a "fractional bandwidth" greater than or equal to 10%, with any of the following:
   a. An annular electron beam;
   b. A non-axisymmetric electron beam; or
   c. Multiple electron beams;

3. A. 1. b. 1. b. Crossed-field amplifier 'vacuum electronic devices' with a gain of more than 17 dB;

c. Thermionic cathodes designed for 'vacuum electronic devices' producing an emission current density at rated operating conditions exceeding 5 A/cm² or a pulsed (non-continuous) current density at rated operating conditions exceeding 10 A/cm^2;

d. 'Vacuum electronic devices' with the capability to operate in a 'dual mode'.

Technical Note
'Dual mode' means the 'vacuum electronic device' beam current can be intentionally changed between continuous-wave and pulsed mode operation by use of a grid and produces a peak pulse output power greater than the continuous-wave output power.

3. A. 1. b. 2. "Monolithic Microwave Integrated Circuit" ("MMIC") amplifiers that are any of the following:

N.B. For "MMIC" amplifiers that have an integrated phase shifter see 3.A.1.b.12.

a. Rated for operation at frequencies exceeding 2.7 GHz up to and including 6.8 GHz with a "fractional bandwidth" greater than 15%, and having any of the following:
   1. A peak saturated power output greater than 75 W (48.75 dBm) at any frequency exceeding 2.7 GHz up to and including 2.9 GHz;
   2. A peak saturated power output greater than 55 W (47.4 dBm) at any frequency exceeding 2.9 GHz up to and including 3.2 GHz;
   3. A peak saturated power output greater than 40 W (46 dBm) at any frequency exceeding 3.2 GHz up to and including 3.7 GHz; or
   4. A peak saturated power output greater than 20 W (43 dBm) at any frequency exceeding 3.7 GHz up to and including 6.8 GHz;

b. Rated for operation at frequencies exceeding 6.8 GHz up to and including 16 GHz with a "fractional bandwidth" greater than 10%, and having any of the following:
   1. A peak saturated power output greater than 10W (40 dBm) at any frequency exceeding 6.8 GHz up to and including 8.5 GHz; or
   2. A peak saturated power output greater than 5W (37 dBm) at any frequency exceeding 8.5 GHz up to and including 16 GHz;

c. Rated for operation with a peak saturated power output greater than 3 W (34.77 dBm) at any frequency exceeding 16 GHz up to and including 31.8 GHz, and with a "fractional bandwidth" of greater than 10%;

d. Rated for operation with a peak saturated power output greater than 0.1n W (-70 dBm) at any frequency exceeding 31.8 GHz up to and including 37 GHz;

3. A. 1. b. 2. e. Rated for operation with a peak saturated power output greater than 1 W (30 dBm) at any frequency exceeding 37 GHz up to and including 43.5 GHz, and with a "fractional bandwidth" of greater than 10%;

f. Rated for operation with a peak saturated power output greater than 31.62 mW (15 dBm) at any frequency exceeding 43.5 GHz up to and including 75 GHz, and with a "fractional bandwidth" of greater than 10%;

g. Rated for operation with a peak saturated power output greater than 10 mW (10 dBm) at any frequency exceeding 75 GHz up to and including 90 GHz, and with a "fractional bandwidth" of greater than 5%; or

h. Rated for operation with a peak saturated power output greater than 0.1 nW (-70 dBm) at any frequency exceeding 90 GHz;

Note 1 *Not used since 2010*

Note 2 *The status of the MMIC whose rated operating frequency includes frequencies listed in more than one frequency range, as defined by 3.A.1.b.2.a. through 3.A.1.b.2.h., is determined by the lowest peak saturated power output threshold.*

Note 3 *Notes 1 and 2 in 3.A. mean that 3.A.1.b.2. does not apply to MMICs if they are specially designed for other applications, e.g., telecommunications, radar, automobiles.*

3. A. 1. b. 3. Discrete microwave transistors that are any of the following:

a. Rated for operation at frequencies exceeding 2.7 GHz up to and including 6.8 GHz and having any of the following:

1. A peak saturated power output greater than 400 W (56 dBm) at any frequency exceeding 2.7 GHz up to and including 2.9 GHz;
2. A peak saturated power output greater than 205 W (53.12 dBm) at any frequency exceeding 2.9 GHz up to and including 3.2 GHz;
3. A peak saturated power output greater than 115 W (50.61 dBm) at any frequency exceeding 3.2 GHz up to and including 3.7 GHz; or
4. A peak saturated power output greater than 60 W (47.78 dBm) at any frequency exceeding 3.7 GHz up to and including 6.8 GHz;

b. Rated for operation at frequencies exceeding 6.8 GHz up to and including 31.8 GHz and having any of the following:

1. A peak saturated power output greater than 50 W (47 dBm) at any frequency exceeding 6.8 GHz up to and including 8.5 GHz;
2. A peak saturated power output greater than 15 W (41.76 dBm) at any frequency exceeding 8.5 GHz up to and including 12 GHz;
3. A peak saturated power output greater than 40 W (46 dBm) at any frequency exceeding 12 GHz up to and including 16 GHz; or
4. A peak saturated power output greater than 7 W (38.45 dBm) at any frequency exceeding 16 GHz up to and including 31.8 GHz;

3. A. 1. b. 3. c. Rated for operation with a peak saturated power output greater than 0.5 W (27 dBm) at any frequency exceeding 31.8 GHz up to and including 37 GHz;

d. Rated for operation with a peak saturated power output greater than 1 W (30 dBm) at any frequency exceeding 37 GHz up to and including 43.5 GHz; or

e. Rated for operation with a peak saturated power output greater than 0.1 nW (-70 dBm) at any frequency exceeding 43.5 GHz;

Note 1 *The status of a transistor whose rated operating frequency includes frequencies listed in more than one frequency range, as defined by 3.A.1.b.3.a. through 3.A.1.b.3.e., is determined by the lowest peak saturated power output threshold.*

Note 2 *3.A.1.b.3. includes bare dice, dice mounted on carriers, or dice mounted in packages. Some discrete transistors may also be referred to as power amplifiers, but the status of these discrete transistors is determined by 3.A.1.b.3.*

3. A. 1. b. 4. Microwave solid state amplifiers and microwave assemblies/modules containing microwave solid state amplifiers, that are any of the following:

a. Rated for operation at frequencies exceeding 2.7 GHz up to and including 6.8 GHz with a "fractional bandwidth" greater than 15%, and having any of the following:

1. A peak saturated power output greater than 500 W (57 dBm) at any frequency exceeding 2.7 GHz up to and including 2.9 GHz;
2. A peak saturated power output greater than 270 W (54.3 dBm) at any frequency exceeding 2.9 GHz up to and including 3.2 GHz;
3. A peak saturated power output greater than 200 W (53 dBm) at any frequency exceeding 3.2 GHz up to and including 3.7 GHz; or
4. A peak saturated power output greater than 90 W (49.54 dBm) at any frequency exceeding 3.7 GHz up to and including 6.8 GHz;

b. Rated for operation at frequencies greater than 6.8 GHz up to and including 31.8 GHz with a "fractional bandwidth" greater than 10%, and having any of the following:

1. A peak saturated power output greater than 70 W (48.54 dBm) at any frequency exceeding 6.8 GHz up to and including 8.5 GHz;
2. A peak saturated power output greater than 50 W (47 dBm) at any frequency exceeding 8.5 GHz up to and including 12 GHz;
3. A peak saturated power output greater than 30 W (44.77 dBm) at any frequency exceeding 12 GHz up to and including 16 GHz; or
4. A peak saturated power output greater than 20 W (43 dBm) at any frequency exceeding 16 GHz up to and including 31.8 GHz;

c. Rated for operation with a peak saturated power output greater than 0.5 W (27 dBm) at any frequency exceeding 31.8 GHz up to and including 37 GHz;

3. A. 1. b. 4. d. Rated for operation with a peak saturated power output greater than 2 W (33 dBm) at any frequency exceeding 37 GHz up to and including 43.5 GHz, and with a "fractional bandwidth" of greater than 10%;

e. Rated for operation at frequencies exceeding 43.5 GHz and having any of the following:
1. A peak saturated power output greater than 0.2 W (23 dBm) at any frequency exceeding 43.5 GHz up to and including 75 GHz, and with a "fractional bandwidth" of greater than 10%;
2. A peak saturated power output greater than 20 mW (13 dBm) at any frequency exceeding 75 GHz up to and including 90 GHz, and with a "fractional bandwidth" of greater than 5%; or
3. A peak saturated power output greater than 0.1 nW (-70 dBm) at any frequency exceeding 90 GHz; or

3. A. 1. b. 4. f. Not used since 2016

N.B.1. For "MMIC" amplifiers see 3.A.1.b.2.

N.B.2. For 'transmit/receive modules' and 'transmit modules' see 3.A.1.b.12.

Note 1 Not used since 2010

Note 2 The status of an item whose rated operating frequency includes frequencies listed in more than one frequency range, as defined by 3.A.1.b.4.a. through 3.A.1.b.4.e., is determined by the lowest peak saturated power output threshold.

3. A. 1. b. 5. Electronically or magnetically tunable band-pass or band-stop filters, having more than 5 tunable resonators capable of tuning across a 1.5:1 frequency band (f_{max}/f_{min}) in less than 10 µs and having any of the following:
a. A band-pass bandwidth of more than 0.5% of centre frequency; or
b. A band-stop bandwidth of less than 0.5% of centre frequency;

6. Not used since 2003

7. Converters and harmonic mixers, that are any of the following:
a. Designed to extend the frequency range of "signal analysers" beyond 90 GHz;
b. Designed to extend the operating range of signal generators as follows:
1. Beyond 90 GHz;
2. To an output power greater than 100 mW (20 dBm) anywhere within the frequency range exceeding 43.5 GHz but not exceeding 90 GHz;
c. Designed to extend the operating range of network analysers as follows:
1. Beyond 110 GHz;
2. To an output power greater than 31.62 mW (15 dBm) anywhere within the frequency range exceeding 43.5 GHz but not exceeding 90 GHz;
3. To an output power greater than 1 mW (0 dBm) anywhere within the frequency range exceeding 90 GHz but not exceeding 110 GHz; or

3. A. 1. b. 7. d. Designed to extend the frequency range of microwave test receivers beyond 110 GHz.

3. A. 1. b. 8. Microwave power amplifiers containing 'vacuum electronic devices' specified by 3.A.1.b.1. and having all of the following:
a. Operating frequencies above 3 GHz;
b. An average output power to mass ratio exceeding 80 W/kg; and
c. A volume of less than 400 cm^3;

Note 3.A.1.b.8. does not apply to equipment designed or rated for operation in any frequency band which is "allocated by the ITU" for radio-communications services, but not for radio-determination.

3. A. 1. b. 9. Microwave Power Modules (MPMs) consisting of, at least, a travelling-wave 'vacuum electronic device', a "Monolithic Microwave Integrated Circuit" ("MMIC") and an integrated electronic power conditioner and having all of the following:
a. A 'turn-on time' from off to fully operational in less than 10 seconds;
b. A volume less than the maximum rated power in Watts multiplied by 10 cm^3/W; and
c. An "instantaneous bandwidth" greater than 1 octave ($f_{max.} > 2f_{min,}$) and having any of the following:
1. For frequencies equal to or less than 18 GHz, an RF output power greater than 100 W; or
2. A frequency greater than 18 GHz;

Technical Notes
1. To calculate the volume in 3.A.1.b.9.b., the following example is provided: for a maximum rated power of 20 W, the volume would be: 20 W x 10 cm^3/W = 200 cm^3.
2. The 'turn-on time' in 3.A.1.b.9.a. refers to the time from fully-off to fully operational, i.e., it includes the warm-up time of the MPM.

3. A. 1. b. 10. Oscillators or oscillator assemblies, specified to operate with a single sideband (SSB) phase noise, in dBc/Hz, less (better) than $-(126 + 20\log_{10}F - 20\log_{10}f)$ anywhere within the range of 10 Hz ≤ F ≤ 10 kHz;

Technical Note
In 3.A.1.b.10., F is the offset from the operating frequency in Hz and f is the operating frequency in MHz.

3. A. 1. b. 11. "Frequency synthesizer" "electronic assemblies" having a "frequency switching time" as specified by any of the following:
a. Less than 143 ps;
b. Less than 100 µs for any frequency change exceeding 2.2 GHz within the synthesized frequency range exceeding 4.8 GHz but not exceeding 31.8 GHz;
c. Not used since 2016
d. Less than 500 µs for any frequency change exceeding 550 MHz within the synthesized frequency range exceeding 31.8 GHz but not exceeding 37 GHz;
e. Less than 100 µs for any frequency change exceeding 2.2 GHz within the synthesized frequency range exceeding 37 GHz but not exceeding 90 GHz; or
f. Not used since 2016

3. A. 1. b. 11. g. Less than 1 ms within the synthesized frequency range exceeding 90 GHz;

N.B. For general purpose "signal analysers", signal generators, network analysers and microwave test receivers, see 3.A.2.c., 3.A.2.d., 3.A.2.e. and 3.A.2.f., respectively.

3. A. 1. b. 12. 'Transmit/receive modules', 'transmit/receive MMICs', 'transmit modules', and 'transmit MMICs', rated for operation at frequencies above 2.7 GHz and having all of the following:

a. A peak saturated power output (in watts), P_{sat}, greater than 505.62 divided by the maximum operating frequency (in GHz) squared [P_{sat}>505.62 W*GHz^2/f_{GHz}^2] for any channel;

b. A "fractional bandwidth" of 5% or greater for any channel;

c. Any planar side with length d (in cm) equal to or less than 15 divided by the lowest operating frequency in GHz [d ≤ 15cm*GHz*N/f_{GHz}] where N is the number of transmit or transmit/receive channels; and

d. An electronically variable phase shifter per channel.

Technical Notes

1. *A 'transmit/receive module': is a multifunction "electronic assembly" that provides bi-directional amplitude and phase control for transmission and reception of signals.*
2. *A 'transmit module': is an "electronic assembly" that provides amplitude and phase control for transmission of signals.*
3. *A 'transmit/receive MMIC': is a multifunction "MMIC" that provides bi-directional amplitude and phase control for transmission and reception of signals.*
4. *A 'transmit MMIC': is a "MMIC" that provides amplitude and phase control for transmission of signals.*
5. *2.7 GHz should be used as the lowest operating frequency (f_{GHz}) in the formula in 3.A.1.b.4.12.c. for transmit/receive or transmit modules that have a rated operation range extending downward to 2.7 GHz and below [d≤15cm*GHz*N/2.7 GHz].*
6. *3.A.1.b.12. applies to 'transmit/receive modules' or 'transmit modules' with or without a heat sink. The value of d in 3.A.1.b.12.c. does not include any portion of the 'transmit/receive module' or 'transmit module' that functions as a heat sink.*
7. *'Transmit/receive modules', or 'transmit modules', or 'transmit/receive MMICs' or 'transmit MMICs' may or may not have N integrated radiating antenna elements where N is the number of transmit or transmit/receive channels.*

3. A. 1. c. Acoustic wave devices as follows and specially designed components therefor:

1. Surface acoustic wave and surface skimming (shallow bulk) acoustic wave devices, having any of the following:

a. A carrier frequency exceeding 6 GHz;

3. A. 1. c. 1. b. A carrier frequency exceeding 1 GHz, but not exceeding 6 GHz and having any of the following:
   1. A 'frequency side-lobe rejection' exceeding 65 dB;
   2. A product of the maximum delay time and the bandwidth (time in µs and bandwidth in MHz) of more than 100;
   3. A bandwidth greater than 250 MHz; or
   4. A dispersive delay of more than 10 µs; or

   c. A carrier frequency of 1 GHz or less and having any of the following:
   1. A product of the maximum delay time and the bandwidth (time in µs and bandwidth in MHz) of more than 100;
   2. A dispersive delay of more than 10 µs; or
   3. A 'frequency side-lobe rejection' exceeding 65 dB and a bandwidth greater than 100 MHz;

   Technical Note
   'Frequency side-lobe rejection' is the maximum rejection value specified in data sheet.

3. A. 1. c. 2. Bulk (volume) acoustic wave devices which permit the direct processing of signals at frequencies exceeding 6 GHz;

   3. Acoustic-optic "signal processing" devices employing interaction between acoustic waves (bulk wave or surface wave) and light waves which permit the direct processing of signals or images, including spectral analysis, correlation or convolution;

   Note *3.A.1.c. does not apply to acoustic wave devices that are limited to a single band pass, low pass, high pass or notch filtering, or resonating function.*

3. A. 1. d. Electronic devices and circuits containing components, manufactured from "superconductive" materials, specially designed for operation at temperatures below the "critical temperature" of at least one of the "superconductive" constituents and having any of the following:
   1. Current switching for digital circuits using "superconductive" gates with a product of delay time per gate (in seconds) and power dissipation per gate (in watts) of less than 10^{-14} J; or
   2. Frequency selection at all frequencies using resonant circuits with Q-values exceeding 10,000;

3. A. 1. e. High energy devices as follows:
   1. 'Cells' as follows:
      a. 'Primary cells' having an 'energy density' exceeding 550 Wh/kg at 20°C;
      b. 'Secondary cells' having an 'energy density' exceeding 350 Wh/kg at 20°C;

      Technical Notes
      1. For the purpose of 3.A.1.e.1., 'energy density' (Wh/kg) is calculated from the nominal voltage multiplied by the nominal capacity in ampere-hours (Ah) divided by the mass in kilograms. If the nominal capacity is not stated, energy density is calculated from the nominal voltage squared then multiplied by the discharge duration in hours divided by the discharge load in Ohms and the mass in kilograms.

Technical Notes (cont.)

2. *For the purpose of 3.A.1.e.1., a 'cell' is defined as an electrochemical device, which has positive and negative electrodes, an electrolyte, and is a source of electrical energy. It is the basic building block of a battery.*
3. *For the purpose of 3.A.1.e.1.a., a 'primary cell' is a 'cell' that is not designed to be charged by any other source.*
4. *For the purpose of 3.A.1.e.1.b., a 'secondary cell' is a 'cell' that is designed to be charged by an external electrical source.*

Note *3.A.1.e. does not apply to batteries, including single-cell batteries.*

3. A. 1. e. 2. High energy storage capacitors as follows:

a. Capacitors with a repetition rate of less than 10 Hz (single shot capacitors) and having all of the following:
   1. A voltage rating equal to or more than 5 kV;
   2. An energy density equal to or more than 250 J/kg; and
   3. A total energy equal to or more than 25 kJ;
b. Capacitors with a repetition rate of 10 Hz or more (repetition rated capacitors) and having all of the following:
   1. A voltage rating equal to or more than 5 kV;
   2. An energy density equal to or more than 50 J/kg;
   3. A total energy equal to or more than 100 J; and
   4. A charge/discharge cycle life equal to or more than 10,000;

N.B. *See also the Munitions List.*

3. A. 1. e. 3. "Superconductive" electromagnets and solenoids, specially designed to be fully charged or discharged in less than one second and having all of the following:

Note *3.A.1.e.3. does not apply to "superconductive" electromagnets or solenoids specially designed for Magnetic Resonance Imaging (MRI) medical equipment.*

a. Energy delivered during the discharge exceeding 10 kJ in the first second;
b. Inner diameter of the current carrying windings of more than 250 mm; and
c. Rated for a magnetic induction of more than 8 T or "overall current density" in the winding of more than 300 A/mm^2;

3. A. 1. e. 4. Solar cells, cell-interconnect-coverglass (CIC) assemblies, solar panels, and solar arrays, which are "space-qualified", having a minimum average efficiency exceeding 20% at an operating temperature of 301 K (28°C) under simulated 'AM0' illumination with an irradiance of 1,367 Watts per square meter (W/m^2);

Technical Note
'AM0', or 'Air Mass Zero', refers to the spectral irradiance of sun light in the earth's outer atmosphere when the distance between the earth and sun is one astronomical unit (AU).

3. A. 1. f. Rotary input type absolute position encoders having an "accuracy" equal to or less (better) than 1.0 second of arc and specially designed encoder rings, discs or scales therefor;

3. A. 1. g. Solid-state pulsed power switching thyristor devices and 'thyristor modules', using either electrically, optically, or electron radiation controlled switch methods and having any of the following:

1. A maximum turn-on current rate of rise (di/dt) greater than 30,000 A/µs and off-state voltage greater than 1,100 V; or
2. A maximum turn-on current rate of rise (di/dt) greater than 2,000 A/µs and having all of the following:
   a. An off-state peak voltage equal to or greater than 3,000 V; and
   b. A peak (surge) current equal to or greater than 3,000 A;

Note 1 *3.A.1.g. includes:*
- *Silicon Controlled Rectifiers (SCRs)*
- *Electrical Triggering Thyristors (ETTs)*
- *Light Triggering Thyristors (LTTs)*
- *Integrated Gate Commutated Thyristors (IGCTs)*
- *Gate Turn-off Thyristors (GTOs)*
- *MOS Controlled Thyristors (MCTs)*
- *Solidtrons*

Note 2 *3.A.1.g. does not apply to thyristor devices and 'thyristor modules' incorporated into equipment designed for civil railway or "civil aircraft" applications.*

Technical Note
For the purposes of 3.A.1.g., a 'thyristor module' contains one or more thyristor devices.

3. A. 1. h. Solid-state power semiconductor switches, diodes, or 'modules', having all of the following:

1. Rated for a maximum operating junction temperature greater than 488 K (215°C);
2. Repetitive peak off-state voltage (blocking voltage) exceeding 300 V; and
3. Continuous current greater than 1 A;

Note 1 *Repetitive peak off-state voltage in 3.A.1.h. includes drain to source voltage, collector to emitter voltage, repetitive peak reverse voltage and peak repetitive off-state blocking voltage.*

Note 2 *3.A.1.h. includes:*
- *Junction Field Effect Transistors (JFETs)*
- *Vertical Junction Field Effect Transistors (VJFETs)*
- *Metal Oxide Semiconductor Field Effect Transistors (MOSFETs)*
- *Double Diffused Metal Oxide Semiconductor Field Effect Transistor (DMOSFET)*
- *Insulated Gate Bipolar Transistor (IGBT)*
- *High Electron Mobility Transistors (HEMTs)*
- *Bipolar Junction Transistors (BJTs)*
- *Thyristors and Silicon Controlled Rectifiers (SCRs)*
- *Gate Turn-Off Thyristors (GTOs)*
- *Emitter Turn-Off Thyristors (ETOs)*
- *PiN Diodes*
- *Schottky Diodes*

Note 3 *3.A.1.h. does not apply to switches, diodes, or 'modules', incorporated into equipment designed for civil automobile, civil railway, or "civil aircraft" applications.*

Technical Note
For the purposes of 3.A.1.h., 'modules' contain one or more solid-state power semiconductor switches or diodes.

3. A. 2. General purpose "electronic assemblies", modules and equipment, as follows:

a. Recording equipment and oscilloscopes, as follows:

1. Not used since 2013
2. Not used since 2013
3. Not used since 2013
4. Not used since 2013
5. Not used since 2015

N.B. *For waveform digitizers and transient recorders, see 3.A.2.h.*

3. A. 2. a. 6. Digital data recorders having all of the following:

a. A sustained 'continuous throughput' of more than 6.4 Gbit/s to disk or solid-state drive memory; and
b. A processor that performs analysis of radio frequency signal data while it is being recorded;

Technical Notes
1. *For recorders with a parallel bus architecture, the 'continuous throughput' rate is the highest word rate multiplied by the number of bits in a word.*
2. *'Continuous throughput' is the fastest data rate the instrument can record to disk or solid-state drive memory without the loss of any information while sustaining the input digital data rate or digitizer conversion rate.*

3. A. 2. a. 7. Real-time oscilloscopes having a vertical root-mean-square (rms) noise voltage of less than 2% of full-scale at the vertical scale setting that provides the lowest noise value for any input 3dB bandwidth of 60 GHz or greater per channel;

Note *3.A.2.a.7. does not apply to equivalent-time sampling oscilloscopes.*

3. A. 2. b. Not used since 2009

3. A. 2. c. "Signal analysers" as follows:

1. "Signal analysers" having a 3 dB resolution bandwidth (RBW) exceeding 10 MHz anywhere within the frequency range exceeding 31.8 GHz but not exceeding 37 GHz;
2. "Signal analysers" having Displayed Average Noise Level (DANL) less (better) than –150 dBm/Hz anywhere within the frequency range exceeding 43.5 GHz but not exceeding 90 GHz;
3. "Signal analysers" having a frequency exceeding 90 GHz;
4. "Signal analysers" having all of the following:
   a. "Real-time bandwidth" exceeding 170 MHz; and
   b. Having any of the following:
      1. 100% probability of discovery, with less than a 3 dB reduction from full amplitude due to gaps or windowing effects, of signals having a duration of 15 µs or less; or
      2. A "frequency mask trigger" function with 100% probability of trigger (capture) for signals having a duration of 15 µs or less;

   Technical Notes

   1. Probability of discovery in 3.A.2.c.4.b.1. is also referred to as probability of intercept or probability of capture.

   2. For the purposes of 3.A.2.c.4.b.1., the duration for 100% probability of discovery is equivalent to the minimum signal duration necessary for the specified level measurement uncertainty.

   Note *3.A.2.c.4. does not apply to those "signal analysers" using only constant percentage bandwidth filters (also known as octave or fractional octave filters).*

3. A. 2. c. 5. Not used since 2016

3. A. 2. d. Signal generators having any of the following:

1. Specified to generate pulse-modulated signals having all of the following, anywhere within the frequency range exceeding 31.8 GHz but not exceeding 37 GHz:
   a. 'Pulse duration' of less than 25 ns; and
   b. On/off ratio equal to or exceeding 65 dB;
2. An output power exceeding 100 mW (20 dBm) anywhere within the frequency range exceeding 43.5 GHz but not exceeding 90 GHz;
3. A "frequency switching time" as specified by any of the following:
   a. Not used since 2012
   b. Less than 100 µs for any frequency change exceeding 2.2 GHz within the frequency range exceeding 4.8 GHz but not exceeding 31.8 GHz;
   c. Not used since 2014
   d. Less than 500 µs for any frequency change exceeding 550 MHz within the frequency range exceeding 31.8 GHz but not exceeding 37 GHz; or

3. A. 2. d. 3. e. Less than 100 µs for any frequency change exceeding 2.2 GHz within the frequency range exceeding 37 GHz but not exceeding 90 GHz;

f. Not used since 2014

3. A. 2. d. 4. Single sideband (SSB) phase noise, in dBc/Hz, specified as being any of the following:

a. Less (better) than $-(126+20 \log_{10}F-20 \log_{10}f)$ anywhere within the range of 10 Hz $\leq$ F $\leq$10 kHz anywhere within the frequency range exceeding 3.2 GHz but not exceeding 90 GHz; or

b. Less (better) than $-(206 - 20\log_{10}f)$ anywhere within the range of 10 kHz < F $\leq$ 100 kHz anywhere within the frequency range exceeding 3.2 GHz but not exceeding 90 GHz; or

Technical Note

In 3.A.2.d.4., F is the offset from the operating frequency in Hz and f is the operating frequency in MHz.

3. A. 2. d. 5. A maximum frequency exceeding 90 GHz;

Note 1 *For the purpose of 3.A.2.d., signal generators include arbitrary waveform and function generators.*

Note 2 *3.A.2.d. does not apply to equipment in which the output frequency is either produced by the addition or subtraction of two or more crystal oscillator frequencies, or by an addition or subtraction followed by a multiplication of the result.*

Technical Notes

1. *The maximum frequency of an arbitrary waveform or function generator is calculated by dividing the sample rate, in samples/second, by a factor of 2.5.*
2. *For the purposes of 3.A.2.d.1.a., 'pulse duration' is defined as the time interval from the point on the leading edge that is 50% of the pulse amplitude to the point on the trailing edge that is 50 % of the pulse amplitude.*

3. A. 2. e. Network analysers having any of the following:

1. An output power exceeding 31.62 mW (15 dBm) anywhere within the operating frequency range exceeding 43.5 GHz but not exceeding 90 GHz;
2. An output power exceeding 1 mW (0 dBm) anywhere within the operating frequency range exceeding 90 GHz but not exceeding 110 GHz;
3. 'Nonlinear vector measurement functionality' at frequencies exceeding 50 GHz but not exceeding 110 GHz; or

Technical Note

'Nonlinear vector measurement functionality' is an instrument's ability to analyse the test results of devices driven into the large-signal domain or the non-linear distortion range.

4. A maximum operating frequency exceeding 110 GHz;

3. A. 2. f. Microwave test receivers having all of the following:
   1. A maximum operating frequency exceeding 110 GHz; and
   2. Being capable of measuring amplitude and phase simultaneously;

3. A. 2. g. Atomic frequency standards being any of the following:
   1. "Space-qualified";
   2. Non-rubidium and having a long-term stability less (better) than 1×10^{-11}/month; or
   3. Non-"space-qualified" and having all of the following:
      a. Being a rubidium standard;
      b. Long-term stability less (better) than 1×10^{-11}/month; and
      c. Total power consumption of less than 1 Watt;

3. A. 2. h. "Electronic assemblies", modules or equipment, specified to perform all of the following:
   1. Analogue-to-digital conversions meeting any of the following:
      a. A resolution of 8 bit or more, but less than 10 bit, with an input sample rate greater than 1.3 billion samples per second;
      b. A resolution of 10 bit or more, but less than 12 bit, with an input sample rate greater than 1.0 billion samples per second;
      c. A resolution of 12 bit or more, but less than 14 bit, with an input sample rate greater than 1.0 billion samples per second;
      d. A resolution of 14 bit or more but less than 16 bit, with an input sample rate greater than 400 million samples per second; or
      e. A resolution of 16 bit or more with an input sample rate greater than 180 million samples per second; and
   2. Any of the following:
      a. Output of digitized data;
      b. Storage of digitized data; or
      c. Processing of digitized data;

   N.B. *Digital data recorders, oscilloscopes, "signal analysers", signal generators, network analysers and microwave test receivers, are specified by 3.A.2.a.6., 3.A.2.a.7., 3.A.2.c., 3.A.2.d., 3.A.2.e. and 3.A.2.f., respectively.*

   Technical Note
   For multiple-channel "electronic assemblies" or modules, control status is determined by the highest single-channel specified performance.

   Note *3.A.2.h. includes ADC cards, waveform digitizers, data acquisition cards, signal acquisition boards and transient recorders.*

3. A. 3. Spray cooling thermal management systems employing closed loop fluid handling and reconditioning equipment in a sealed enclosure where a dielectric fluid is sprayed onto electronic components using specially designed spray nozzles that are designed to maintain electronic components within their operating temperature range, and specially designed components therefor.

3. B. TEST, INSPECTION AND PRODUCTION EQUIPMENT

3. B. 1. Equipment for the manufacturing of semiconductor devices or materials, as follows and specially designed components and accessories therefor:

a. Equipment designed for epitaxial growth as follows:

1. Equipment designed or modified to produce a layer of any material other than silicon with a thickness uniform to less than ± 2.5% across a distance of 75 mm or more;

Note 3.B.1.a.1. includes atomic layer epitaxy (ALE) equipment.

2. Metal Organic Chemical Vapour Deposition (MOCVD) reactors designed for compound semiconductor epitaxial growth of material having two or more of the following elements: aluminium, gallium, indium, arsenic, phosphorus, antimony, or nitrogen;
3. Molecular beam epitaxial growth equipment using gas or solid sources;

3. B. 1. b. Equipment designed for ion implantation and having any of the following:

1. Not used since 2012
2. Being designed and optimized to operate at a beam energy of 20 keV or more and a beam current of 10 mA or more for hydrogen, deuterium or helium implant;
3. Direct write capability;
4. A beam energy of 65 keV or more and a beam current of 45 mA or more for high energy oxygen implant into a heated semiconductor material "substrate"; or
5. Being designed and optimized to operate at a beam energy of 20 keV or more and a beam current of 10 mA or more for silicon implant into a semiconductor material "substrate" heated to 600°C or greater;

3. B. 1. c. Not used since 2015

3. B. 1. d. Not used since 2011

3. B. 1. e. Automatic loading multi-chamber central wafer handling systems having all of the following:

1. Interfaces for wafer input and output, to which more than two functionally different 'semiconductor process tools' specified by 3.B.1.a.1., 3.B.1.a.2., 3.B.1.a.3. or 3.B.1.b. are designed to be connected; and
2. Designed to form an integrated system in a vacuum environment for 'sequential multiple wafer processing';

Note 3.B.1.e. does not apply to automatic robotic wafer handling systems specially designed for parallel wafer processing.

Technical Notes

1. *For the purpose of 3.B.1.e., 'semiconductor process tools' refers to modular tools that provide physical processes for semiconductor production that are functionally different, such as deposition, implant or thermal processing.*
2. *For the purpose of 3.B.1.e., 'sequential multiple wafer processing' means the capability to process each wafer in different 'semiconductor process tools', such as by transferring each wafer from one tool to a second tool and on to a third tool with the automatic loading multi-chamber central wafer handling systems.*

3. B. 1. f. Lithography equipment as follows:

1. Align and expose step and repeat (direct step on wafer) or step and scan (scanner) equipment for wafer processing using photo-optical or X-ray methods and having any of the following:
   a. A light source wavelength shorter than 193 nm; or
   b. Capable of producing a pattern with a 'Minimum Resolvable Feature size' (MRF) of 45 nm or less;

   Technical Note
   The 'Minimum Resolvable Feature size' (MRF) is calculated by the following formula:

$$MRF = \frac{\text{(an exposure light source wavelength in nm) x (K factor)}}{\text{numerical aperture}}$$

where the K factor = 0.35

3. B. 1. f. 2. Imprint lithography equipment capable of producing features of 45 nm or less;

Note *3.B.1.f.2. includes:*
- *Micro contact printing tools*
- *Hot embossing tools*
- *Nano-imprint lithography tools*
- *Step and flash imprint lithography (S-FIL) tools*

3. B. 1. f. 3. Equipment specially designed for mask making having all of the following:
   a. A deflected focused electron beam, ion beam or "laser" beam; and
   b. Having any of the following:
      1. A full-width half-maximum (FWHM) spot size smaller than 65 nm and an image placement less than 17 nm (mean + 3 sigma); or
      2. Not used since 2015
      3. A second-layer overlay error of less than 23 nm (mean + 3 sigma) on the mask;

3. B. 1. f. 4. Equipment designed for device processing using direct writing methods, having all of the following:
   a. A deflected focused electron beam; and
   b. Having any of the following:
      1. A minimum beam size equal to or smaller than 15 nm; or
      2. An overlay error less than 27 nm (mean + 3 sigma);

3. B. 1. g. Masks and reticles, designed for integrated circuits specified by 3.A.1.;

3. B. 1. h. Multi-layer masks with a phase shift layer not specified by 3.B.1.g. and having any of the following:
   1. Made on a mask "substrate blank" from glass specified as having less than 7 nm/cm birefringence; or
   2. Designed to be used by lithography equipment having a light source wavelength less than 245 nm;

   Note *3.B.1.h. does not apply to multi-layer masks with a phase shift layer designed for the fabrication of memory devices not specified by 3.A.1.*

3. B. 1. i. Imprint lithography templates designed for integrated circuits specified by 3.A.1.

3. B. 2. Test equipment specially designed for testing finished or unfinished semiconductor devices as follows and specially designed components and accessories therefor:
   a. For testing S-parameters of transistor devices at frequencies exceeding 31.8 GHz;
   b. Not used since 2004
   c. For testing microwave integrated circuits specified by 3.A.1.b.2.

3. C. MATERIALS

3. C. 1. Hetero-epitaxial materials consisting of a "substrate" having stacked epitaxially grown multiple layers of any of the following:
   a. Silicon (Si);
   b. Germanium (Ge);
   c. Silicon Carbide (SiC); or
   d. "III/V compounds" of gallium or indium.

   Note *3.C.1.d. does not apply to a "substrate" having one or more P-type epitaxial layers of GaN, InGaN, AlGaN, InAlN, InAlGaN, GaP, GaAs, AlGaAs, InP, InGaP, AlInP or InGaAlP, independent of the sequence of the elements, except if the P-type epitaxial layer is between N-type layers.*

3. C. 2. Resist materials as follows and "substrates" coated with the following resists:
   a. Resists designed for semiconductor lithography as follows:
      1. Positive resists adjusted (optimised) for use at wavelengths less than 245 nm but equal to or greater than 15 nm;
      2. Resists adjusted (optimised) for use at wavelengths less than 15 nm but greater than 1 nm;
   b. All resists designed for use with electron beams or ion beams, with a sensitivity of 0.01 µcoulomb/mm^2 or better;
   c. Not used since 2012
   d. All resists optimised for surface imaging technologies;
   e. All resists designed or optimised for use with imprint lithography equipment specified by 3.B.1.f.2. that use either a thermal or photo-curable process.

3. C. 3. Organo-inorganic compounds as follows:
   a. Organo-metallic compounds of aluminium, gallium or indium, having a purity (metal basis) better than 99.999%;
   b. Organo-arsenic, organo-antimony and organo-phosphorus compounds, having a purity (inorganic element basis) better than 99.999%.

   Note *3.C.3. only applies to compounds whose metallic, partly metallic or non-metallic element is directly linked to carbon in the organic part of the molecule.*

3. C. 4. Hydrides of phosphorus, arsenic or antimony, having a purity better than 99.999%, even diluted in inert gases or hydrogen.

   Note *3.C.4. does not apply to hydrides containing 20% molar or more of inert gases or hydrogen.*

3. C. 5. Silicon carbide (SiC), gallium nitride (GaN), aluminium nitride (AlN) or aluminium gallium nitride (AlGaN) semiconductor "substrates", or ingots, boules, or other preforms of those materials, having resistivities greater than 10,000 ohm-cm at 20°C.

3. C. 6. "Substrates" specified in 3.C.5. with at least one epitaxial layer of silicon carbide, gallium nitride, aluminium nitride or aluminium gallium nitride.

3. D. SOFTWARE

3. D. 1. "Software" specially designed for the "development" or "production" of equipment specified by 3.A.1.b. to 3.A.2.h. or 3.B.

3. D. 2. "Software" specially designed for the "use" of equipment specified by 3.B.1.a. to f. or 3.B.2.

3. D. 3. 'Physics-based' simulation "software" specially designed for the "development" of lithographic, etching or deposition processes for translating masking patterns into specific topographical patterns in conductors, dielectrics or semiconductor materials.

Technical Note
'Physics-based' in 3.D.3. means using computations to determine a sequence of physical cause and effect events based on physical properties (e.g., temperature, pressure, diffusion constants and semiconductor materials properties).

Note *Libraries, design attributes or associated data for the design of semiconductor devices or integrated circuits are considered as "technology".*

3. D. 4. "Software" specially designed for the "development" of equipment specified by 3.A.3.

3. E. TECHNOLOGY

3. E. 1. "Technology" according to the General Technology Note for the "development" or "production" of equipment or materials specified by 3.A, 3.B or 3.C;

Note 1 *3.E.1. does not apply to "technology" for equipment or components specified by 3.A.3.*

Note 2 *3.E.1. does not apply to "technology" for integrated circuits specified by 3.A.1.a.3. to 3.A.1.a.12., having all of the following:*
a. Using "technology" at or above 0.130 µm; and
b. Incorporating multi-layer structures with three or fewer metal layers.

3. E. 2. "Technology" according to the General Technology Note other than that specified by 3.E.1. for the "development" or "production" of a "microprocessor microcircuit", "microcomputer microcircuit" or microcontroller microcircuit core, having an arithmetic logic unit with an access width of 32 bits or more and any of the following features or characteristics:

3. E. 2. a. A 'vector processor unit' designed to perform more than two calculations on floating-point vectors (one-dimensional arrays of 32-bit or larger numbers) simultaneously;

Technical Note

A 'vector processor unit' is a processor element with built-in instructions that perform multiple calculations on floating-point vectors (one-dimensional arrays of 32-bit or larger numbers) simultaneously, having at least one vector arithmetic logic unit and vector registers of at least 32 elements each.

b. Designed to perform more than four 64-bit or larger floating-point operation results per cycle; or

c. Designed to perform more than eight 16-bit fixed-point multiply-accumulate results per cycle (e.g., digital manipulation of analogue information that has been previously converted into digital form, also known as digital "signal processing").

Note 1 *3.E.2. does not apply to "technology" for multimedia extensions.*

Note 2 *3.E.2. does not apply to "technology" for micro-processor cores, having all of the following:*

a. Using "technology" at or above 0.130 µm; and

b. Incorporating multi-layer structures with five or fewer metal layers.

Note 3 *3.E.2. includes "technology" for the "development" or "production" of digital signal processors and digital array processors.*

3. E. 3. Other "technology" for the "development" or "production" of the following:

a. Vacuum microelectronic devices;

b. Hetero-structure semiconductor electronic devices such as high electron mobility transistors (HEMT), hetero-bipolar transistors (HBT), quantum well and super lattice devices;

Note *3.E.3.b. does not apply to "technology" for high electron mobility transistors (HEMT) operating at frequencies lower than 31.8 GHz and hetero-junction bipolar transistors (HBT) operating at frequencies lower than 31.8 GHz.*

c. "Superconductive" electronic devices;

d. Substrates of films of diamond for electronic components;

e. Substrates of silicon-on-insulator (SOI) for integrated circuits in which the insulator is silicon dioxide;

f. Substrates of silicon carbide for electronic components;

g. 'Vacuum electronic devices' operating at frequencies of 31.8 GHz or higher.

4. COMPUTERS

Note 1 *Computers, related equipment and "software" performing telecommunications or "local area network" functions must also be evaluated against the performance characteristics of Category 5 – Part 1 (Telecommunications).*

Note 2 *Control units which directly interconnect the buses or channels of central processing units, "main storage" or disk controllers are not regarded as telecommunications equipment described in Category 5 – Part 1 (Telecommunications).*

N.B. *For the status of "software" specially designed for packet switching, see Category 5.D.1. (Telecommunications).*

Note 3 *Not used since 2015*

4. A. SYSTEMS, EQUIPMENT AND COMPONENTS

4. A. 1. Electronic computers and related equipment, having any of the following and "electronic assemblies" and specially designed components therefor:

a. Specially designed to have any of the following:

1. Rated for operation at an ambient temperature below 228 K (-45°C) or above 358 K (85°C); or

Note *4.A.1.a.1. does not apply to computers specially designed for civil automobile, railway train or "civil aircraft" applications.*

2. Radiation hardened to exceed any of the following specifications:

a. Total Dose 5×10^3 Gy (Si);
b. Dose Rate Upset 5×10^6 Gy (Si)/s; or
c. Single Event Upset 1×10^{-8} Error/bit/day.

Note *4.A.1.a.2. does not apply to computers specially designed for "civil aircraft" applications.*

4. A. 1. b. Not used since 2009

4. A. 2. Not used since 2003

4. A. 3. "Digital computers", "electronic assemblies", and related equipment therefor, as follows and specially designed components therefor:

Note 1 *4.A.3. includes the following:*
- *'Vector processors';*
- *Array processors;*
- *Digital signal processors;*
- *Logic processors;*
- *Equipment designed for "image enhancement".*

Note 2 *The status of the "digital computers" and related equipment described in 4.A.3. is determined by the status of other equipment or systems provided:*

a. The "digital computers" or related equipment are essential for the operation of the other equipment or systems;

b. The "digital computers" or related equipment are not a "principal element" of the other equipment or systems; and

N.B.1 *The status of "signal processing" or "image enhancement" equipment specially designed for other equipment with functions limited to those required for the other equipment is determined by the status of the other equipment even if it exceeds the "principal element" criterion.*

Note 2 cont.

N.B.2 For the status of "digital computers" or related equipment for telecommunications equipment, see Category 5 – Part 1 (Telecommunications).

c. The "technology" for the "digital computers" and related equipment is determined by 4.E.

4. A. 3. a. Not used since 2011

b. "Digital computers" having an 'Adjusted Peak Performance' ('APP') exceeding 16 Weighted TeraFLOPS (WT);

c. "Electronic assemblies" specially designed or modified for enhancing performance by aggregation of processors so that the 'APP' of the aggregation exceeds the limit specified by 4.A.3.b.;

Note 1 4.A.3.c. applies only to "electronic assemblies" and programmable interconnections not exceeding the limit specified by 4.A.3.b. when shipped as unintegrated "electronic assemblies".

Note 2 4.A.3.c. does not apply to "electronic assemblies" specially designed for a product or family of products whose maximum configuration does not exceed the limit specified by 4.A.3.b.

4. A. 3. d. Not used since 2001

e. Not used since 2015

N.B. For "electronic assemblies", modules or equipment, performing analogue-to-digital conversions, see 3.A.2.h.

f. Not used since 1998

g. Equipment specially designed for aggregating the performance of "digital computers" by providing external interconnections which allow communications at unidirectional data rates exceeding 2.0 Gbyte/s per link.

Note 4.A.3.g. does not apply to internal interconnection equipment (e.g., backplanes, buses), passive interconnection equipment, "network access controllers" or "communications channel controllers".

4. A. 4. Computers as follows and specially designed related equipment, "electronic assemblies" and components therefor:

a. "Systolic array computers";
b. "Neural computers";
c. "Optical computers".

4. A. 5. Systems, equipment, and components therefor, specially designed or modified for the generation, command and control, or delivery of "intrusion software".

4. B. TEST, INSPECTION AND PRODUCTION EQUIPMENT - None

4. C. MATERIALS – None

4. D. SOFTWARE

Note *The status of "software" for equipment described in other Categories is dealt with in the appropriate Category.*

4. D. 1. "Software" as follows:

a. "Software" specially designed or modified for the "development" or "production" of equipment or "software" specified by 4.A. or 4.D.

b. "Software", other than that specified by 4.D.1.a., specially designed or modified for the "development" or "production" of equipment as follows:
1. "Digital computers" having an 'Adjusted Peak Performance' ('APP') exceeding 8.0 Weighted TeraFLOPS (WT);
2. "Electronic assemblies" specially designed or modified for enhancing performance by aggregation of processors so that the 'APP' of the aggregation exceeds the limit in 4.D.1.b.1.

4. D. 2. Not used since 2014

4. D. 3. Not used since 2009

4. D. 4. "Software" specially designed or modified for the generation, command and control, or delivery of "intrusion software".

4. E. TECHNOLOGY

4. E. 1. "Technology" as follows:

a. "Technology" according to the General Technology Note, for the "development", "production" or "use" of equipment or "software" specified by 4.A. or 4.D.

b. "Technology" according to the General Technology Note, other than that specified by 4.E.1.a., for the "development" or "production" of equipment as follows:
1. "Digital computers" having an 'Adjusted Peak Performance' ('APP') exceeding 8.0 Weighted TeraFLOPS (WT);
2. "Electronic assemblies" specially designed or modified for enhancing performance by aggregation of processors so that the 'APP' of the aggregation exceeds the limit in 4.E.1.b.1.

c. "Technology" for the "development" of "intrusion software".

TECHNICAL NOTE ON 'ADJUSTED PEAK PERFORMANCE' ('APP')

'APP' is an adjusted peak rate at which "digital computers" perform 64-bit or larger floating point additions and multiplications.

Abbreviations used in this Technical Note

n	number of processors in the "digital computer"
i	processor number (i,...n)
t_i	processor cycle time ($t_i = 1/F_i$)
F_i	processor frequency
R_i	peak floating point calculating rate
W_i	architecture adjustment factor

'APP' is expressed in Weighted TeraFLOPS (WT), in units of 10^{12} adjusted floating point operations per second.

Outline of 'APP' calculation method

1. For each processor i, determine the peak number of 64-bit or larger floating point operations, FPO_i, performed per cycle for each processor in the "digital computer".

Note In determining FPO, include only 64-bit or larger floating point additions and/or multiplications. All floating point operations must be expressed in operations per processor cycle; operations requiring multiple cycles may be expressed in fractional results per cycle. For processors not capable of performing calculations on floating point operands of 64-bit or more, the effective calculating rate R is zero.

2. Calculate the floating point rate R for each processor $R_i = FPO_i/t_i$

3. Calculate 'APP' as 'APP' = $W_1 \times R_1 + W_2 \times R_2 + \ldots + W_n \times R_n$.

4. For 'vector processors', $W_i = 0.9$. For non-'vector processors', $W_i = 0.3$.

Note 1 For processors that perform compound operations in a cycle, such as addition and multiplication, each operation is counted.

Note 2 For a pipelined processor the effective calculating rate R is the faster of the pipelined rate, once the pipeline is full, or the non-pipelined rate.

Note 3 The calculating rate R of each contributing processor is to be calculated at its maximum value theoretically possible before the 'APP' of the combination is derived. Simultaneous operations are assumed to exist when the computer manufacturer claims concurrent, parallel, or simultaneous operation or execution in a manual or brochure for the computer.

TECHNICAL NOTE ON 'ADJUSTED PEAK PERFORMANCE' ('APP')

Note 4 Do not include processors that are limited to input/output and peripheral functions (e.g., disk drive, communication and video display) when calculating 'APP'.

Note 5 'APP' values are not to be calculated for processor combinations (inter)connected by "Local Area Networks", Wide Area Networks, I/O shared connections/devices, I/O controllers and any communication interconnection implemented by "software".

Note 6 'APP' values must be calculated for processor combinations containing processors specially designed to enhance performance by aggregation, operating simultaneously and sharing memory;

Technical Notes

1. *Aggregate all processors and accelerators operating simultaneously and located on the same die.*
2. *Processor combinations share memory when any processor is capable of accessing any memory location in the system through the hardware transmission of cache lines or memory words, without the involvement of any software mechanism, which may be achieved using "electronic assemblies" specified in 4.A.3.c.*

Note 7 A 'vector processor' is defined as a processor with built-in instructions that perform multiple calculations on floating-point vectors (one-dimensional arrays of 64-bit or larger numbers) simultaneously, having at least 2 vector functional units and at least 8 vector registers of at least 64 elements each.

Part 1 - TELECOMMUNICATIONS

Note 1 *The status of components, test and "production" equipment and "software" therefor which are specially designed for telecommunications equipment or systems is determined in Category 5 – Part 1.*

N.B. *For "lasers" specially designed for telecommunications equipment or systems, see 6.A.5.*

Note 2 *"Digital computers", related equipment or "software", when essential for the operation and support of telecommunications equipment described in this Category, are regarded as specially designed components, provided they are the standard models customarily supplied by the manufacturer. This includes operation, administration, maintenance, engineering or billing computer systems.*

5. A. Part 1. SYSTEMS, EQUIPMENT AND COMPONENTS

5. A. 1. Telecommunications systems, equipment, components and accessories, as follows:

a. Any type of telecommunications equipment having any of the following characteristics, functions or features:

1. Specially designed to withstand transitory electronic effects or electromagnetic pulse effects, both arising from a nuclear explosion;
2. Specially hardened to withstand gamma, neutron or ion radiation; or
3. Specially designed to operate outside the temperature range from 218 K (-55°C) to 397 K (124°C);

Note *5.A.1.a.3. applies only to electronic equipment.*

Note *5.A.1.a.2. and 5.A.1.a.3. do not apply to equipment designed or modified for use on board satellites.*

5. A. 1. b. Telecommunication systems and equipment, and specially designed components and accessories therefor, having any of the following characteristics, functions or features:

1. Being underwater untethered communications systems having any of the following:
   a. An acoustic carrier frequency outside the range from 20 kHz to 60 kHz;
   b. Using an electromagnetic carrier frequency below 30 kHz;
   c. Using electronic beam steering techniques; or
   d. Using "lasers" or light-emitting diodes (LEDs), with an output wavelength greater than 400 nm and less than 700 nm, in a "local area network";
2. Being radio equipment operating in the 1.5 MHz to 87.5 MHz band and having all of the following:
   a. Automatically predicting and selecting frequencies and "total digital transfer rates" per channel to optimise the transmission; and

5. A. 1. b. 2. b. Incorporating a linear power amplifier configuration having a capability to support multiple signals simultaneously at an output power of 1 kW or more in the frequency range of 1.5 MHz or more but less than 30 MHz, or 250 W or more in the frequency range of 30 MHz or more but not exceeding 87.5 MHz, over an "instantaneous bandwidth" of one octave or more and with an output harmonic and distortion content of better than -80 dB;

5. A. 1. b. 3. Being radio equipment employing "spread spectrum" techniques, including "frequency hopping" techniques, not specified by 5.A.1.b.4. and having any of the following:

a. User programmable spreading codes; or
b. A total transmitted bandwidth which is 100 or more times the bandwidth of any one information channel and in excess of 50 kHz;

Note *5.A.1.b.3.b. does not apply to radio equipment specially designed for use with any of the following:*
a. Civil cellular radio-communications systems; or
b. Fixed or mobile satellite earth stations for commercial civil telecommunications.

Note *5.A.1.b.3. does not apply to equipment designed to operate at an output power of 1 W or less.*

5. A. 1. b. 4. Being radio equipment employing ultra-wideband modulation techniques having user programmable channelizing codes, scrambling codes or network identification codes and having any of the following:

a. A bandwidth exceeding 500 MHz; or
b. A "fractional bandwidth" of 20% or more;

5. A. 1. b. 5. Being digitally controlled radio receivers having all of the following:

a. More than 1,000 channels;
b. A 'channel switching time' of less than 1 ms;
c. Automatic searching or scanning of a part of the electromagnetic spectrum; and
d. Identification of the received signals or the type of transmitter; or

Note *5.A.1.b.5. does not apply to radio equipment specially designed for use with civil cellular radio-communications systems.*

Technical Note
'Channel switching time': the time (i.e., delay) to change from one receiving frequency to another, to arrive at or within ±0.05% of the final specified receiving frequency. Items having a specified frequency range of less than ±0.05% around their centre frequency are defined to be incapable of channel frequency switching.

5. A. 1. b. 6. Employing functions of digital "signal processing" to provide 'voice coding' output at rates of less than 700 bit/s.

Technical Notes

1. *For variable rate 'voice coding', 5.A.1.b.6. applies to the 'voice coding' output of continuous speech.*
2. *For the purpose of 5.A.1.b.6., 'voice coding' is defined as the technique to take samples of human voice and then convert these samples into a digital signal, taking into account specific characteristics of human speech.*

5. A. 1. c. Optical fibres of more than 500 m in length and specified by the manufacturer as being capable of withstanding a 'proof test' tensile stress of 2×10^9 N/m^2 or more;

N.B. For underwater umbilical cables, see 8.A.2.a.3.

Technical Note

'Proof Test': on-line or off-line production screen testing that dynamically applies a prescribed tensile stress over a 0.5 to 3 m length of fibre at a running rate of 2 to 5 m/s while passing between capstans approximately 150 mm in diameter. The ambient temperature is a nominal 293 K (20 °C) and relative humidity 40%. Equivalent national standards may be used for executing the proof test.

5. A. 1. d. "Electronically steerable phased array antennae" as follows:

1. Rated for operation above 31.8 GHz, but not exceeding 57 GHz, and having an Effective Radiated Power (ERP) equal to or greater than +20 dBm (22.15 dBm Effective Isotropic Radiated Power (EIRP));
2. Rated for operation above 57 GHz, but not exceeding 66 GHz, and having an ERP equal to or greater than +24 dBm (26.15 dBm EIRP);
3. Rated for operation above 66 GHz, but not exceeding 90 GHz, and having an ERP equal to or greater than +20 dBm (22.15 dBm EIRP);
4. Rated for operation above 90 GHz;

Note 5.A.1.d. does not apply to "electronically steerable phased array antennae" for landing systems with instruments meeting ICAO standards covering Microwave Landing Systems (MLS).

5. A. 1. e. Radio direction finding equipment operating at frequencies above 30 MHz and having all of the following, and specially designed components therefor:

1. "Instantaneous bandwidth" of 10 MHz or more; and
2. Capable of finding a Line Of Bearing (LOB) to non-cooperating radio transmitters with a signal duration of less than 1 ms;

5. A. 1. f. Mobile telecommunications interception or jamming equipment, and monitoring equipment therefor, as follows, and specially designed components therefor:

1. Interception equipment designed for the extraction of voice or data, transmitted over the air interface;
2. Interception equipment not specified in 5.A.1.f.1., designed for the extraction of client device or subscriber identifiers (e.g., IMSI, TIMSI or IMEI), signalling, or other metadata transmitted over the air interface;

5. A. 1. f. 3. Jamming equipment specially designed or modified to intentionally and selectively interfere with, deny, inhibit, degrade or seduce mobile telecommunication services and performing any of the following:

a. Simulate the functions of Radio Access Network (RAN) equipment;
b. Detect and exploit specific characteristics of the mobile telecommunications protocol employed (e.g., GSM); or
c. Exploit specific characteristics of the mobile telecommunications protocol employed (e.g., GSM);

4. RF monitoring equipment designed or modified to identify the operation of items specified in 5.A.1.f.1., 5.A.1.f.2. or 5.A.1.f.3.;

Note 5.A.1.f.1. and 5.A.1.f.2. do not apply to any of the following:

a. Equipment specially designed for the interception of analogue Private Mobile Radio (PMR), IEEE 802.11 WLAN;
b. Equipment designed for mobile telecommunications network operators; or
c. Equipment designed for the "development" or "production" of mobile telecommunications equipment or systems.

N.B.1. See also the Munitions List.

N.B.2. For radio receivers see 5.A.1.b.5.

5. A. 1. g. Passive Coherent Location (PCL) systems or equipment, specially designed for detecting and tracking moving objects by measuring reflections of ambient radio frequency emissions, supplied by non-radar transmitters;

Technical Note
Non-radar transmitters may include commercial radio, television or cellular telecommunications base stations.

Note 5.A.1.g. does not apply to any of the following:

a. Radio-astronomical equipment; or
b. Systems or equipment, that require any radio transmission from the target.

5. A. 1. h. Counter Improvised Explosive Device (IED) equipment and related equipment, as follows:

1. Radio Frequency (RF) transmitting equipment, not specified by 5.A.1.f., designed or modified for prematurely activating or preventing the initiation of Improvised Explosive Devices;
2. Equipment using techniques designed to enable radio communications in the same frequency channels on which co-located equipment specified by 5.A.1.h.1. is transmitting.

N.B. See also the Munitions List.

5. A. 1. i. Not used since 2012

N.B. See 5.A.1.f. for items previously specified by 5.A.1.i.

5. A. 1. j. IP network communications surveillance systems or equipment, and specially designed components therefor, having all of the following:
   1. Performing all of the following on a carrier class IP network (e.g., national grade IP backbone):
      a. Analysis at the application layer (e.g., Layer 7 of Open Systems Interconnection (OSI) model (ISO/IEC 7498-1));
      b. Extraction of selected metadata and application content (e.g., voice, video, messages, attachments); and
      c. Indexing of extracted data; and
   2. Being specially designed to carry out all of the following:
      a. Execution of searches on the basis of 'hard selectors'; and
      b. Mapping of the relational network of an individual or of a group of people.

   Note *5.A.1.j. does not apply to systems or equipment, specially designed for any of the following:*
   a. Marketing purpose;
   b. Network Quality of Service (QoS); or
   c. Quality of Experience (QoE).

   Technical Note
   'Hard selectors': data or set of data, related to an individual (e.g., family name, given name, e-mail, street address, phone number or group affiliations).

5. B. Part 1. TEST, INSPECTION AND PRODUCTION EQUIPMENT

5. B. 1. Telecommunication test, inspection and production equipment, components and accessories, as follows:
   a. Equipment and specially designed components or accessories therefor, specially designed for the "development" or "production" of equipment, functions or features, specified by 5.A.1.;

      Note *5.B.1.a. does not apply to optical fibre characterization equipment.*

5. B. 1. b. Equipment and specially designed components or accessories therefor, specially designed for the "development" of any of the following telecommunication transmission or switching equipment:
   1. Not used since 2009
   2. Equipment employing a "laser" and having any of the following:
      a. A transmission wavelength exceeding 1,750 nm; or
      b. Not used since 2015
      c. Not used since 2016
      d. Employing analogue techniques and having a bandwidth exceeding 2.5 GHz; or

         Note *5.B.1.b.2.d. does not apply to equipment specially designed for the "development" of commercial TV systems.*
   3. Not used since 2009
   4. Radio equipment employing Quadrature-Amplitude-Modulation (QAM) techniques above level 1,024.
   5. Not used since 2011

5. C. Part 1. MATERIALS - None

5. D. Part 1. SOFTWARE

5. D. 1. "Software" as follows:
   a. "Software" specially designed or modified for the "development", "production" or "use" of equipment, functions or features, specified by 5.A.1.;
   b. Not used since 2014
   c. Specific "software" specially designed or modified to provide characteristics, functions or features of equipment, specified by 5.A.1. or 5.B.1.;

5. D. 1. d. "Software" specially designed or modified for the "development" of any of the following telecommunication transmission or switching equipment:
   1. Not used since 2009
   2. Equipment employing a "laser" and having any of the following:
      a. A transmission wavelength exceeding 1,750 nm; or
      b. Employing analogue techniques and having a bandwidth exceeding 2.5 GHz; or

         Note 5.D.1.d.2.b. does not apply to "software" specially designed or modified for the "development" of commercial TV systems.
   3. Not used since 2009
   4. Radio equipment employing Quadrature-Amplitude-Modulation (QAM) techniques above level 1,024.

5. E. Part 1. TECHNOLOGY

5. E. 1. "Technology" as follows:
   a. "Technology" according to the General Technology Note for the "development", "production" or "use" (excluding operation) of equipment, functions or features specified by 5.A.1. or "software" specified by 5.D.1.a.;

5. E. 1. b. Specific "technology" as follows:
   1. "Technology" "required" for the "development" or "production" of telecommunications equipment specially designed to be used on board satellites;
   2. "Technology" for the "development" or "use" of "laser" communication techniques with the capability of automatically acquiring and tracking signals and maintaining communications through exoatmosphere or sub-surface (water) media;
   3. "Technology" for the "development" of digital cellular radio base station receiving equipment whose reception capabilities that allow multi-band, multi-channel, multi-mode, multi-coding algorithm or multi-protocol operation can be modified by changes in "software";
   4. "Technology" for the "development" of "spread spectrum" techniques, including "frequency hopping" techniques;

      Note 5.E.1.b.4. does not apply to "technology" for the "development" of any of the following:
      a. Civil cellular radio-communications systems; or
      b. Fixed or mobile satellite earth stations for commercial civil telecommunications.

5. E. 1. c. "Technology" according to the General Technology Note for the "development" or "production" of any of the following:

1. Not used since 2016
2. Equipment employing a "laser" and having any of the following:
   a. A transmission wavelength exceeding 1,750 nm;
   b. Not used since 2015
   c. Not used since 2016
   d. Employing wavelength division multiplexing techniques of optical carriers at less than 100 GHz spacing; or
   e. Employing analogue techniques and having a bandwidth exceeding 2.5 GHz;

   Note *5.E.1.c.2.e. does not apply to "technology" for commercial TV systems.*

N.B. *For "technology" for the "development" or "production" of non-telecommunications equipment employing a "laser", see 6.E.*

5. E. 1. c. 3. Equipment employing "optical switching" and having a switching time less than 1 ms;

5. E. 1. c. 4. Radio equipment having any of the following:
   a. Quadrature-Amplitude-Modulation (QAM) techniques above level 1,024;
   b. Operating at input or output frequencies exceeding 31.8 GHz; or

   Note *5.E.1.c.4.b. does not apply to "technology" for equipment designed or modified for operation in any frequency band which is "allocated by the ITU" for radio-communications services, but not for radio-determination.*

   c. Operating in the 1.5 MHz to 87.5 MHz band and incorporating adaptive techniques providing more than 15 dB suppression of an interfering signal; or

5. E. 1. c. 5. Not used since 2011

5. E. 1. c. 6. Mobile equipment having all of the following:
   a. Operating at an optical wavelength greater than or equal to 200 nm and less than or equal to 400 nm; and
   b. Operating as a "local area network";

5. E. 1. d. "Technology" according to the General Technology Note for the "development" or "production" of "Monolithic Microwave Integrated Circuit" ("MMIC") amplifiers specially designed for telecommunications and that are any of the following:

Technical Note
For purposes of 5.E.1.d., the parameter peak saturated power output may also be referred to on product data sheets as output power, saturated power output, maximum power output, peak power output, or peak envelope power output.

5. E. 1. d. 1. Rated for operation at frequencies exceeding 2.7 GHz up to and including 6.8 GHz with a "fractional bandwidth" greater than 15%, and having any of the following:
   a. A peak saturated power output greater than 75 W (48.75 dBm) at any frequency exceeding 2.7 GHz up to and including 2.9 GHz;
   b. A peak saturated power output greater than 55 W (47.4 dBm) at any frequency exceeding 2.9 GHz up to and including 3.2 GHz;
   c. A peak saturated power output greater than 40 W (46 dBm) at any frequency exceeding 3.2 GHz up to and including 3.7 GHz; or
   d. A peak saturated power output greater than 20 W (43 dBm) at any frequency exceeding 3.7 GHz up to and including 6.8 GHz;

5. E. 1. d. 2. Rated for operation at frequencies exceeding 6.8 GHz up to and including 16 GHz with a "fractional bandwidth" greater than 10%, and having any of the following:
   a. A peak saturated power output greater than 10 W (40 dBm) at any frequency exceeding 6.8 GHz up to and including 8.5 GHz; or
   b. A peak saturated power output greater than 5 W (37 dBm) at any frequency exceeding 8.5 GHz up to and including 16 GHz;

3. Rated for operation with a peak saturated power output greater than 3 W (34.77 dBm) at any frequency exceeding 16 GHz up to and including 31.8 GHz, and with a "fractional bandwidth" of greater than 10%;

4. Rated for operation with a peak saturated power output greater than 0.1n W (-70 dBm) at any frequency exceeding 31.8 GHz up to and including 37 GHz;

5. Rated for operation with a peak saturated power output greater than 1 W (30 dBm) at any frequency exceeding 37 GHz up to and including 43.5 GHz, and with a "fractional bandwidth" of greater than 10%;

6. Rated for operation with a peak saturated power output greater than 31.62 mW (15 dBm) at any frequency exceeding 43.5 GHz up to and including 75 GHz, and with a "fractional bandwidth" of greater than 10%;

7. Rated for operation with a peak saturated power output greater than 10 mW (10 dBm) at any frequency exceeding 75 GHz up to and including 90 GHz, and with a "fractional bandwidth" of greater than 5%; or

8. Rated for operation with a peak saturated power output greater than 0.1 nW (-70 dBm) at any frequency exceeding 90 GHz;

5. E. 1. e. "Technology" according to the General Technology Note for the "development" or "production" of electronic devices and circuits, specially designed for telecommunications and containing components manufactured from "superconductive" materials, specially designed for operation at temperatures below the "critical temperature" of at least one of the "superconductive" constituents and having any of the following:

1. Current switching for digital circuits using "superconductive" gates with a product of delay time per gate (in seconds) and power dissipation per gate (in watts) of less than 10^{-14} J; or

2. Frequency selection at all frequencies using resonant circuits with Q-values exceeding 10,000.

Part 2 - "INFORMATION SECURITY"

Note 1 *Not used since 2015*

Note 2 *Category 5 – Part 2 does not apply to products when accompanying their user for the user's personal use.*

Note 3 *Cryptography Note*

5.A.2., 5.D.2.a.1., 5.D.2.b. and 5.D.2.c.1. do not apply to items as follows:

a. Items meeting all of the following:

1. Generally available to the public by being sold, without restriction, from stock at retail selling points by means of any of the following:

a. Over-the-counter transactions;

b. Mail order transactions;

c. Electronic transactions; or

d. Telephone call transactions;

2. The cryptographic functionality cannot easily be changed by the user;

3. Designed for installation by the user without further substantial support by the supplier; and

4. When necessary, details of the items are accessible and will be provided, upon request, to the appropriate authority in the exporter's country in order to ascertain compliance with conditions described in paragraphs 1. to 3. above;

b. Hardware components or 'executable software', of existing items described in paragraph a. of this Note, that have been designed for these existing items, and meeting all of the following:

1. "Information security" is not the primary function or set of functions of the component or 'executable software';

2. The component or 'executable software' does not change any cryptographic functionality of the existing items, or add new cryptographic functionality to the existing items;

3. The feature set of the component or 'executable software' is fixed and is not designed or modified to customer specification; and

4. When necessary as determined by the appropriate authority in the exporter's country, details of the component or 'executable software', and details of relevant end-items are accessible and will be provided to the authority upon request, in order to ascertain compliance with conditions described above.

Technical Note

For the purpose of the Cryptography Note, 'executable software' means "software" in executable form, from an existing hardware component excluded from 5.A.2. by the Cryptography Note.

Note *'Executable software' does not include complete binary images of the "software" running on an end-item.*

Note to the Cryptography Note:

1. *To meet paragraph a. of Note 3, all of the following must apply:*
   a. *The item is of potential interest to a wide range of individuals and businesses; and*
   b. *The price and information about the main functionality of the item are available before purchase without the need to consult the vendor or supplier. A simple price enquiry is not considered to be a consultation.*
2. *In determining eligibility of paragraph a. of Note 3, national authorities may take into account relevant factors such as quantity, price, required technical skill, existing sales channels, typical customers, typical use or any exclusionary practices of the supplier.*

5. A. Part 2. SYSTEMS, EQUIPMENT AND COMPONENTS

CRYPTOGRAPHIC "INFORMATION SECURITY"

5. A. 2. "Information security" systems, equipment and components, as follows:

N.B. For Global Navigation Satellite Systems (GNSS) receiving equipment containing or employing decryption see 7.A.5., and for related decryption "software" and "technology" see 7.D.5. and 7.E.1.

a. Designed or modified to use 'cryptography for data confidentiality' having 'in excess of 56 bits of symmetric key length, or equivalent', where that cryptographic capability is usable without "cryptographic activation" or has been activated, as follows:
   1. Items having "information security" as a primary function;
   2. Digital communication or networking systems, equipment or components, not specified in paragraph 5.A.2.a.1.;
   3. Computers, other items having information storage or processing as a primary function, and components therefor, not specified in paragraphs 5.A.2.a.1. or 5.A.2.a.2.;

      N.B. For operating systems, see also 5.D.2.a.1. and 5.D.2.c.1.
   4. Items, not specified in paragraphs 5.A.2.a.1. to a.3., where the 'cryptography for data confidentiality' having 'in excess of 56 bits of symmetric key length, or equivalent' meets all of the following:
      a. It supports a non-primary function of the item; and
      b. It is performed by incorporated equipment or "software" that would, as a standalone item, be specified by Category 5 – Part 2.

Technical Notes

1. *For the purposes of 5.A.2.a., 'cryptography for data confidentiality' means "cryptography" that employs digital techniques and performs any cryptographic function other than any of the following:*
   a. *"Authentication";*
   b. *Digital signature;*
   c. *Data integrity;*
   d. *Non-repudiation;*
   e. *Digital rights management, including the execution of copy-protected "software";*
   f. *Encryption or decryption in support of entertainment, mass commercial broadcasts or medical records management; or*
   g. *Key management in support of any function described in paragraph a. to f. above.*

Technical Notes cont.

2. *For the purposes of 5.A.2.a., 'in excess of 56 bits of symmetric key length, or equivalent' means any of the following:*
   a. *A "symmetric algorithm" employing a key length in excess of 56 bits, not including parity bits; or*
   b. *An "asymmetric algorithm" where the security of the algorithm is based on any of the following:*
      1. *Factorisation of integers in excess of 512 bits (e.g., RSA);*
      2. *Computation of discrete logarithms in a multiplicative group of a finite field of size greater than 512 bits (e.g., Diffie-Hellman over Z/pZ); or*
      3. *Discrete logarithms in a group other than mentioned in paragraph b.2. in excess of 112 bits (e.g., Diffie-Hellman over an elliptic curve).*

Note 1 *When necessary as determined by the appropriate authority in the exporter's country, details of items must be accessible and provided to the authority upon request, in order to establish any of the following:*
   a. *Whether the item meets the criteria of 5.A.2.a.1. to a.4.; or*
   b. *Whether the cryptographic capability for data confidentiality specified by 5.A.2.a. is usable without "cryptographic activation".*

Note 2 *5.A.2.a. does not apply to any of the following items, or specially designed "information security" components therefor:*
   a. *Smart cards and smart card 'readers/writers' as follows:*
      1. *A smart card or an electronically readable personal document (e.g., token coin, e-passport) that meets any of the following:*
         a. *The cryptographic capability meets all of the following:*
            1. *It is restricted for use in any of the following:*
               a. *Equipment or systems not described by 5.A.2.a.1. to a.4.;*
               b. *Equipment or systems not using 'cryptography for data confidentiality' having 'in excess of 56 bits of symmetric key length, or equivalent'; or*
               c. *Equipment or systems excluded from 5.A.2.a. by entries b. to f. of this Note; and*
            2. *It cannot be reprogrammed for any other use; or*
         b. *Having all of the following:*
            1. *It is specially designed and limited to allow protection of 'personal data' stored within;*
            2. *Has been, or can only be, personalized for public or commercial transactions or individual identification; and*
            3. *Where the cryptographic capability is not user-accessible;*

Note 2 cont.

Technical Note
'Personal data' includes any data specific to a particular person or entity, such as the amount of money stored and data necessary for "authentication".

2. *'Readers/writers' specially designed or modified, and limited, for items specified by paragraph a.1. of this Note;*

   Technical Note
   'Readers/writers' include equipment that communicates with smart cards or electronically readable documents through a network.

b. *Cryptographic equipment specially designed and limited for banking use or 'money transactions';*

   Technical Note
   'Money transactions' in 5.A.2. Note 2.b. includes the collection and settlement of fares or credit functions.

c. *Portable or mobile radiotelephones for civil use (e.g., for use with commercial civil cellular radio communication systems) that are not capable of transmitting encrypted data directly to another radiotelephone or equipment (other than Radio Access Network (RAN) equipment), nor of passing encrypted data through RAN equipment (e.g., Radio Network Controller (RNC) or Base Station Controller (BSC));*

d. *Cordless telephone equipment not capable of end-to-end encryption where the maximum effective range of unboosted cordless operation (i.e., a single, unrelayed hop between terminal and home base station) is less than 400 metres according to the manufacturer's specifications;*

e. *Portable or mobile radiotelephones and similar client wireless devices for civil use, that implement only published or commercial cryptographic standards (except for anti-piracy functions, which may be non-published) and also meet the provisions of paragraphs a.2. to a.4. of the Cryptography Note (Note 3 in Category 5 – Part 2), that have been customised for a specific civil industry application with features that do not affect the cryptographic functionality of these original non-customised devices;*

f. *Items, where the "information security" functionality is limited to wireless "personal area network" functionality, meeting all of the following:*
   1. *Implement only published or commercial cryptographic standards; and*
   2. *The cryptographic capability is limited to a nominal operating range not exceeding 30 metres according to the manufacturer's specifications, or not exceeding 100 metres according to the manufacturer's specifications for equipment that cannot interconnect with more than seven devices;*

Note 2 cont.

g. Mobile telecommunications Radio Access Network (RAN) equipment designed for civil use, which also meet the provisions of paragraphs a.2. to a.4. of the Cryptography Note (Note 3 in Category 5 – Part 2), having an RF output power limited to 0.1W (20 dBm) or less, and supporting 16 or fewer concurrent users;

h. Routers, switches or relays, where the "information security" functionality is limited to the tasks of "Operations, Administration or Maintenance" ("OAM") implementing only published or commercial cryptographic standards; or

i. General purpose computing equipment or servers, where the "information security" functionality meets all of the following:

1. Uses only published or commercial cryptographic standards; and

2. Is any of the following:

a. Integral to a CPU that meets the provisions of Note 3 in Category 5 – Part 2;

b. Integral to an operating system that is not specified by 5.D.2.; or

c. Limited to "OAM" of the equipment.

5. A. 2. b. Designed or modified to enable, by means of "cryptographic activation", an item to achieve or exceed the controlled performance levels for functionality specified by 5.A.2.a. that would not otherwise be enabled;

c. Designed or modified to use or perform "quantum cryptography";
Technical Note
"Quantum cryptography" is also known as Quantum Key Distribution (QKD).

d. Designed or modified to use cryptographic techniques to generate channelising codes, scrambling codes or network identification codes, for systems using ultra-wideband modulation techniques and having any of the following:
1. A bandwidth exceeding 500 MHz; or
2. A "fractional bandwidth" of 20% or more;

e. Designed or modified to use cryptographic techniques to generate the spreading code for "spread spectrum" systems, not specified by 5.A.2.d., including the hopping code for "frequency hopping" systems.

NON-CRYPTOGRAPHIC "INFORMATION SECURITY"

5. A. 3. Systems, equipment and components, for non-cryptographic "information security", as follows:

a. Communications cable systems designed or modified using mechanical, electrical or electronic means to detect surreptitious intrusion;

Note 5.A.3.a. applies only to physical layer security. For the purpose of 5.A.3.a., the physical layer includes Layer 1 of the Reference Model of Open Systems Interconnection (OSI) (ISO/IEC 7498-1).

b. Specially designed or modified to reduce the compromising emanations of information-bearing signals beyond what is necessary for health, safety or electromagnetic interference standards.

DEFEATING, WEAKENING OR BYPASSING "INFORMATION SECURITY"

5. A. 4. Systems, equipment and components for defeating, weakening or bypassing "information security", as follows:

a. Designed or modified to perform 'cryptanalytic functions'.

Note 5.A.4.a. includes systems or equipment, designed or modified to perform 'cryptanalytic functions' by means of reverse engineering.

Technical Note
'Cryptanalytic functions' are functions designed to defeat cryptographic mechanisms in order to derive confidential variables or sensitive data, including clear text, passwords or cryptographic keys.

5. B. Part 2. TEST, INSPECTION AND PRODUCTION EQUIPMENT

5. B. 2. "Information security" test, inspection and "production" equipment, as follows:

a. Equipment specially designed for the "development" or "production" of equipment specified by 5.A.2., 5.A.3., 5.A.4. or 5.B.2.b.;

b. Measuring equipment specially designed to evaluate and validate the "information security" functions of equipment specified by 5.A.2., 5.A.3. or 5.A.4., or of "software" specified by 5.D.2.a. or 5.D.2.c.

5. C. Part 2. MATERIALS - None

5. D. Part 2. SOFTWARE

5. D. 2. "Software" as follows:

a. "Software" specially designed or modified for the "development", "production" or "use" of any of the following:
1. Equipment specified by 5.A.2. or "software" specified by 5.D.2.c.1.;
2. Equipment specified by 5.A.3. or "software" specified by 5.D.2.c.2.; or
3. Equipment specified by 5.A.4. or "software" specified by 5.D.2.c.3.;

b. "Software" designed or modified to enable, by means of "cryptographic activation", an item to meet the criteria for functionality specified by 5.A.2.a., that would not otherwise be met;

c. "Software" having the characteristics of, or performing or simulating the functions of, any of the following:
1. Equipment specified by 5.A.2.a., 5.A.2.c., 5.A.2.d. or 5.A.2.e.;
Note 5.D.2.c.1. does not apply to "software" limited to the tasks of "OAM" implementing only published or commercial cryptographic standards.
2. Equipment specified by 5.A.3.; or
3. Equipment specified by 5.A.4.

d. Not used since 2016

N.B. See 5.D.2.b. for items formerly specified in 5.D.2.d.

5. E. Part 2. TECHNOLOGY

5. E. 2. "Technology" as follows:

a. "Technology" according to the General Technology Note for the "development", "production" or "use" of equipment specified by 5.A.2., 5.A.3., 5.A.4. or 5.B.2., or of "software" specified by 5.D.2.a. or 5.D.2.c.;

b. "Technology" to enable, by means of "cryptographic activation", an item to meet the criteria for functionality specified by 5.A.2.a., that would not otherwise be met.

Note 5.E.2. includes "information security" technical data resulting from procedures carried out to evaluate or determine the implementation of functions, features or techniques specified in Category 5 – Part 2.

6. A. SYSTEMS, EQUIPMENT AND COMPONENTS

ACOUSTICS

6. A. 1. Acoustic systems, equipment and components, as follows:

6. A. 1. a. Marine acoustic systems, equipment and specially designed components therefor, as follows:

1. Active (transmitting or transmitting-and-receiving) systems, equipment and specially designed components therefor, as follows:

Note 6.A.1.a.1. does not apply to equipment as follows:

a. Depth sounders operating vertically below the apparatus, not including a scanning function exceeding ± 20°, and limited to measuring the depth of water, the distance of submerged or buried objects or fish finding;

b. Acoustic beacons, as follows:

1. Acoustic emergency beacons;

2. Pingers specially designed for relocating or returning to an underwater position.

6. A. 1. a. 1. a. Acoustic seabed survey equipment as follows:

1. Surface vessel survey equipment designed for seabed topographic mapping and having all of the following:

a. Designed to take measurements at an angle exceeding 20° from the vertical;

b. Designed to measure seabed topography at seabed depths exceeding 600 m;

c. 'Sounding resolution' less than 2; and

d. 'Enhancement' of the depth "accuracy" through compensation for all the following:

1. Motion of the acoustic sensor;

2. In-water propagation from sensor to the seabed and back; and

3. Sound speed at the sensor;

Technical Notes

1. 'Sounding resolution' is the swath width (degrees) divided by the maximum number of soundings per swath.

2. 'Enhancement' includes the ability to compensate by external means.

6. A. 1. a. 1. a. 2. Underwater survey equipment designed for seabed topographic mapping and having any of the following:

Technical Note

The acoustic sensor pressure rating determines the depth rating of the equipment specified by 6.A.1.a.1.a.2.

6. A. 1. a. 1. a. 2. a. Having all of the following:
   1. Designed or modified to operate at depths exceeding 300 m; and
   2. 'Sounding rate' greater than 3,800 m/s; or

   Technical Note
   'Sounding rate' is the product of the maximum speed (m/s) at which the sensor can operate and the maximum number of soundings per swath assuming 100% coverage. For systems that produce soundings in two directions (3D sonars), the maximum of the 'sounding rate' in either direction should be used.

6. A. 1. a. 1. a. 2. b. Survey equipment, not specified by 6.A.1.a.1.a.2.a., having all of the following:
   1. Designed or modified to operate at depths exceeding 100 m;
   2. Designed to take measurements at an angle exceeding 20° from the vertical;
   3. Having any of the following:
      a. Operating frequency below 350 kHz; or
      b. Designed to measure seabed topography at a range exceeding 200 m from the acoustic sensor; and
   4. 'Enhancement' of the depth "accuracy" through compensation of all of the following:
      a. Motion of the acoustic sensor;
      b. In-water propagation from sensor to the seabed and back; and
      c. Sound speed at the sensor.

6. A. 1. a. 1. a. 3. Side Scan Sonar (SSS) or Synthetic Aperture Sonar (SAS), designed for seabed imaging and having all of the following, and specially designed transmitting and receiving acoustic arrays therefor:
   a. Designed or modified to operate at depths exceeding 500 m;
   b. An 'area coverage rate' of greater than 570 m^2/s while operating at the maximum range that it can operate with an 'along track resolution' of less than 15 cm; and
   c. An 'across track resolution' of less than 15 cm;

   Technical Notes
   1. *'Area coverage rate' (m^2/s) is twice the product of the sonar range (m) and the maximum speed (m/s) at which the sensor can operate at that range.*
   2. *'Along track resolution' (cm), for SSS only, is the product of azimuth (horizontal) beamwidth (degrees) and sonar range (m) and 0.873.*
   3. *'Across track resolution' (cm) is 75 divided by the signal bandwidth (kHz).*

6. A. 1. a. 1. b. Systems or transmitting and receiving arrays, designed for object detection or location, having any of the following:
   1. A transmitting frequency below 10 kHz;
   2. Sound pressure level exceeding 224 dB (reference 1 µPa at 1 m) for equipment with an operating frequency in the band from 10 kHz to 24 kHz inclusive;
   3. Sound pressure level exceeding 235 dB (reference 1 µPa at 1 m) for equipment with an operating frequency in the band between 24 kHz and 30 kHz;
   4. Forming beams of less than 1° on any axis and having an operating frequency of less than 100 kHz;
   5. Designed to operate with an unambiguous display range exceeding 5,120 m; or
   6. Designed to withstand pressure during normal operation at depths exceeding 1,000 m and having transducers with any of the following:
      a. Dynamic compensation for pressure; or
      b. Incorporating other than lead zirconate titanate as the transduction element;

6. A. 1. a. 1. c. Acoustic projectors (including transducers), incorporating piezoelectric, magnetostrictive, electrostrictive, electrodynamic or hydraulic elements operating individually or in a designed combination, and having any of the following:

Note 1 *The status of acoustic projectors, including transducers, specially designed for other equipment not specified by 6.A.1. is determined by the status of the other equipment.*

Note 2 *6.A.1.a.1.c. does not apply to electronic sources which direct the sound vertically only, or mechanical (e.g., air gun or vapour-shock gun) or chemical (e.g., explosive) sources.*

Note 3 *Piezoelectric elements specified in 6.A.1.a.1.c. include those made from lead-magnesium-niobate/lead-titanate ($Pb(Mg_{1/3}Nb_{2/3})O_3$-$PbTiO_3$, or PMN-PT) single crystals grown from solid solution or lead-indium-niobate/lead-magnesium niobate/lead-titanate ($Pb(In_{1/2}Nb_{1/2})O_3$–$Pb(Mg_{1/3}Nb_{2/3})O_3$–$PbTiO_3$, or PIN-PMN-PT) single crystals grown from solid solution.*

6. A. 1. a. 1. c. 1. Operating at frequencies below 10 kHz and having any of the following:
   a. Not designed for continuous operation at 100% duty cycle and having a radiated 'free-field Source Level (SL_{RMS})' exceeding (10log(f) + 169.77)dB (reference 1 µPa at 1 m) where f is the frequency in Hertz of maximum Transmitting Voltage Response (TVR) below 10 kHz; or
   b. Designed for continuous operation at 100% duty cycle and having a continuously radiated 'free-field Source Level (SL_{RMS})' at 100% duty cycle exceeding (10log(f) + 159.77)dB (reference 1 µPa at 1 m) where f is the frequency in Hertz of maximum Transmitting Voltage Response (TVR) below 10 kHz; or

Technical Note
The 'free-field Source Level (SL_{RMS})' is defined along the maximum response axis and in the far field of the acoustic projector. It can be obtained from the Transmitting Voltage Response using the following equation: SL_{RMS} = (TVR + 20log V_{RMS}) dB (ref 1µPa at 1 m), where SL_{RMS} is the source level, TVR is the Transmitting Voltage Response and V_{RMS} is the Driving Voltage of the Projector.

6. A. 1. a. 1. c. 2. Not used since 2014

N.B. See 6.A.1.a.1.c.1. for items previously specified in 6.A.1.a.1.c.2.

3. Side-lobe suppression exceeding 22 dB;

6. A. 1. a. 1. d. Acoustic systems and equipment, designed to determine the position of surface vessels or underwater vehicles and having all of the following, and specially designed components therefor:
1. Detection range exceeding 1,000 m; and
2. Determined position error of less than 10 m rms (root mean square) when measured at a range of 1,000 m;

Note 6.A.1.a.1.d. includes:
a. Equipment using coherent "signal processing" between two or more beacons and the hydrophone unit carried by the surface vessel or underwater vehicle;
b. Equipment capable of automatically correcting speed-of-sound propagation errors for calculation of a point.

6. A. 1. a. 1. e. Active individual sonars, specially designed or modified to detect, locate and automatically classify swimmers or divers, having all of the following, and specially designed transmitting and receiving acoustic arrays therefor:
1. Detection range exceeding 530 m;
2. Determined position error of less than 15 m rms (root mean square) when measured at a range of 530 m; and
3. Transmitted pulse signal bandwidth exceeding 3 kHz;

N.B. For diver detection systems specially designed or modified for military use, see the Munitions List.

Note For 6.A.1.a.1.e., where multiple detection ranges are specified for various environments, the greatest detection range is used.

6. A. 1. a. 2. Passive systems, equipment and specially designed components therefor, as follows:
a. Hydrophones having any of the following:

Note The status of hydrophones specially designed for other equipment is determined by the status of the other equipment.

Technical Note
Hydrophones consist of one or more sensing elements producing a single acoustic output channel. Those that contain multiple elements can be referred to as a hydrophone group.

6. A. 1. a. 2. a.

1. Incorporating continuous flexible sensing elements;
2. Incorporating flexible assemblies of discrete sensing elements with either a diameter or length less than 20 mm and with a separation between elements of less than 20 mm;
3. Having any of the following sensing elements:
   a. Optical fibres;
   b. 'Piezoelectric polymer films' other than polyvinylidene-fluoride (PVDF) and its co-polymers {P(VDF-TrFE) and P(VDF-TFE)};
   c. 'Flexible piezoelectric composites';
   d. Lead-magnesium-niobate/lead-titanate (i.e., $Pb(Mg_{1/3}Nb_{2/3})O_3$-$PbTiO_3$, or PMN-PT) piezoelectric single crystals grown from solid solution; <u>or</u>
   e. Lead-indium-niobate/lead-magnesium niobate/lead-titanate (i.e., $Pb(In_{1/2}Nb_{1/2})O_3$–$Pb(Mg_{1/3}Nb_{2/3})O_3$–$PbTiO_3$, or PIN-PMN-PT) piezoelectric single crystals grown from solid solution;
4. A 'hydrophone sensitivity' better than -180 dB at any depth with no acceleration compensation;
5. Designed to operate at depths exceeding 35 m with acceleration compensation; <u>or</u>
6. Designed for operation at depths exceeding 1,000 m;

<u>*Technical Notes*</u>

1. *'Piezoelectric polymer film' sensing elements consist of polarized polymer film that is stretched over and attached to a supporting frame or spool (mandrel).*
2. *'Flexible piezoelectric composite' sensing elements consist of piezoelectric ceramic particles or fibres combined with an electrically insulating, acoustically transparent rubber, polymer or epoxy compound, where the compound is an integral part of the sensing elements.*
3. *'Hydrophone sensitivity' is defined as twenty times the logarithm to the base 10 of the ratio of rms output voltage to a 1 V rms reference, when the hydrophone sensor, without a pre-amplifier, is placed in a plane wave acoustic field with an rms pressure of 1 µPa. For example, a hydrophone of -160 dB (reference 1 V per µPa) would yield an output voltage of 10^{-8} V in such a field, while one of -180 dB sensitivity would yield only 10^{-9} V output. Thus, -160 dB is better than -180 dB.*

6. A. 1. a. 2. b. Towed acoustic hydrophone arrays having any of the following:

<u>*Technical Note*</u>

Hydrophone arrays consist of a number of hydrophones providing multiple acoustic output channels.

6. A. 1. a. 2. b. 1. Hydrophone group spacing of less than 12.5 m or 'able to be modified' to have hydrophone group spacing of less than 12.5 m;
2. Designed or 'able to be modified' to operate at depths exceeding 35 m;

Technical Note
'Able to be modified' in 6.A.1.a.2.b. means having provisions to allow a change of the wiring or interconnections to alter hydrophone group spacing or operating depth limits. These provisions are: spare wiring exceeding 10% of the number of wires, hydrophone group spacing adjustment blocks or internal depth limiting devices that are adjustable or that control more than one hydrophone group.

6. A. 1. a. 2. b.
3. Heading sensors specified by 6.A.1.a.2.d.;
4. Longitudinally reinforced array hoses;
5. An assembled array of less than 40 mm in diameter;
6. Not used since 2007
7. Hydrophone characteristics specified by 6.A.1.a.2.a.; or
8. Accelerometer-based hydro-acoustic sensors specified by 6.A.1.a.2.g.;

6. A. 1. a. 2. c. Processing equipment, specially designed for towed acoustic hydrophone arrays, having "user-accessible programmability" and time or frequency domain processing and correlation, including spectral analysis, digital filtering and beamforming using Fast Fourier or other transforms or processes;

6. A. 1. a. 2. d. Heading sensors having all of the following:
1. An "accuracy" of better than 0.5°; and
2. Designed to operate at depths exceeding 35 m or having an adjustable or removable depth sensing device in order to operate at depths exceeding 35 m;

N.B. *For inertial heading systems, see 7.A.3.c.*

6. A. 1. a. 2. e. Bottom or bay-cable hydrophone arrays having any of the following:
1. Incorporating hydrophones specified by 6.A.1.a.2.a.;
2. Incorporating multiplexed hydrophone group signal modules having all of the following characteristics:
   a. Designed to operate at depths exceeding 35 m or having an adjustable or removable depth sensing device in order to operate at depths exceeding 35 m; and
   b. Capable of being operationally interchanged with towed acoustic hydrophone array modules; or
3. Incorporating accelerometer-based hydro-acoustic sensors specified by 6.A.1.a.2.g.;

6. A. 1. a. 2. f. Processing equipment, specially designed for bottom or bay cable systems, having "user-accessible programmability" and time or frequency domain processing and correlation, including spectral analysis, digital filtering and beamforming using Fast Fourier or other transforms or processes;

6. A. 1. a. 2. g. Accelerometer-based hydro-acoustic sensors having all of the following:
   1. Composed of three accelerometers arranged along three distinct axes;
   2. Having an overall 'acceleration sensitivity' better than 48 dB (reference 1,000 mV rms per 1g);
   3. Designed to operate at depths greater than 35 meters; and
   4. Operating frequency below 20 kHz.

   Note *6.A.1.a.2.g. does not apply to particle velocity sensors or geophones.*

Note *6.A.1.a.2. also applies to receiving equipment, whether or not related in normal application to separate active equipment, and specially designed components therefor.*

Technical Notes
1. *Accelerometer-based hydro-acoustic sensors are also known as vector sensors.*
2. *'Acceleration sensitivity' is defined as twenty times the logarithm to the base 10 of the ratio of rms output voltage to a 1 V rms reference, when the hydro-acoustic sensor, without a preamplifier, is placed in a plane wave acoustic field with an rms acceleration of 1 g (i.e., 9.81 m/s^2).*

6. A. 1. b. Correlation-velocity and Doppler-velocity sonar log equipment, designed to measure the horizontal speed of the equipment carrier relative to the sea bed, as follows:
   1. Correlation-velocity sonar log equipment having any of the following characteristics:
      a. Designed to operate at distances between the carrier and the sea bed exceeding 500 m; or
      b. Having speed "accuracy" better than 1% of speed;
   2. Doppler-velocity sonar log equipment having speed "accuracy" better than 1% of speed.

   Note 1 *6.A.1.b. does not apply to depth sounders limited to any of the following:*
      a. Measuring the depth of water;
      b. Measuring the distance of submerged or buried objects; or
      c. Fish finding.

   Note 2 *6.A.1.b. does not apply to equipment specially designed for installation on surface vessels.*

6. A. 1. c. Not used since 2010

   N.B. *For diver deterrent acoustic systems, see 8.A.2.r.*

OPTICAL SENSORS

6. A. 2. Optical sensors or equipment and components therefor, as follows:
   a. Optical detectors as follows:
      1. "Space-qualified" solid-state detectors as follows:

         Note *For the purpose of 6.A.2.a.1., solid-state detectors include "focal plane arrays".*

6. A. 2. a. 1. a. "Space-qualified" solid-state detectors having all of the following:
   1. A peak response in the wavelength range exceeding 10 nm but not exceeding 300 nm; and
   2. A response of less than 0.1% relative to the peak response at a wavelength exceeding 400 nm;

   b. "Space-qualified" solid-state detectors having all of the following:
   1. A peak response in the wavelength range exceeding 900 nm but not exceeding 1,200 nm; and
   2. A response "time constant" of 95 ns or less;

   c. "Space-qualified" solid-state detectors having a peak response in the wavelength range exceeding 1,200 nm but not exceeding 30,000 nm;

   d. "Space-qualified" "focal plane arrays" having more than 2,048 elements per array and having a peak response in the wavelength range exceeding 300 nm but not exceeding 900 nm.

6. A. 2. a. 2. Image intensifier tubes and specially designed components therefor, as follows:

Note *6.A.2.a.2. does not apply to non-imaging photomultiplier tubes having an electron sensing device in the vacuum space limited solely to any of the following:*
a. A single metal anode; or
b. Metal anodes with a centre to centre spacing greater than 500 µm.

Technical Note
'Charge multiplication' is a form of electronic image amplification and is defined as the generation of charge carriers as a result of an impact ionization gain process. 'Charge multiplication' sensors may take the form of an image intensifier tube, solid state detector or "focal plane array".

6. A. 2. a. 2. a. Image intensifier tubes having all of the following:
   1. A peak response in the wavelength range exceeding 400 nm but not exceeding 1,050 nm;
   2. Electron image amplification using any of the following:
      a. A microchannel plate with a hole pitch (centre-to-centre spacing) of 12 µm or less; or
      b. An electron sensing device with a non-binned pixel pitch of 500 µm or less, specially designed or modified to achieve 'charge multiplication' other than by a microchannel plate; and
   3. Any of the following photocathodes:
      a. Multialkali photocathodes (e.g., S-20 and S-25) having a luminous sensitivity exceeding 350 µA/lm;
      b. GaAs or GaInAs photocathodes; or
      c. Other "III/V compound" semiconductor photocathodes having a maximum "radiant sensitivity" exceeding 10 mA/W;

6. A. 2. a. 2. b. Image intensifier tubes having all of the following:

1. A peak response in the wavelength range exceeding 1,050 nm but not exceeding 1,800 nm;
2. Electron image amplification using any of the following:
   a. A microchannel plate with a hole pitch (centre-to-centre spacing) of 12 µm or less; or
   b. An electron sensing device with a non-binned pixel pitch of 500 µm or less, specially designed or modified to achieve 'charge multiplication' other than by a microchannel plate; and
3. "III/V compound" semiconductor (e.g., GaAs or GaInAs) photocathodes and transferred electron photocathodes, having a maximum "radiant sensitivity" exceeding 15 mA/W;

6. A. 2. a. 2. c. Specially designed components as follows:

1. Microchannel plates having a hole pitch (centre-to-centre spacing) of 12 µm or less;
2. An electron sensing device with a non-binned pixel pitch of 500 µm or less, specially designed or modified to achieve 'charge multiplication' other than by a microchannel plate;
3. "III/V compound" semiconductor (e.g., GaAs or GaInAs) photocathodes and transferred electron photocathodes;

Note *6.A.2.a.2.c.3. does not apply to compound semiconductor photocathodes designed to achieve a maximum "radiant sensitivity" of any of the following:*

a. 10 mA/W or less at the peak response in the wavelength range exceeding 400 nm but not exceeding 1,050 nm; or

b. 15 mA/W or less at the peak response in the wavelength range exceeding 1,050 nm but not exceeding 1,800 nm.

6. A. 2. a. 3. Non-"space-qualified" "focal plane arrays" as follows:

N.B. 'Microbolometer' non-"space-qualified" "focal plane arrays" are only specified by 6.A.2.a.3.f.

Technical Note

Linear or two-dimensional multi-element detector arrays are referred to as "focal plane arrays";

Note 1 *6.A.2.a.3. includes photoconductive arrays and photovoltaic arrays.*

Note 2 *6.A.2.a.3. does not apply to:*

a. Multi-element (not to exceed 16 elements) encapsulated photoconductive cells using either lead sulphide or lead selenide;

b. Pyroelectric detectors using any of the following:

1. Triglycine sulphate and variants;
2. Lead-lanthanum-zirconium titanate and variants;
3. Lithium tantalate;
4. Polyvinylidene fluoride and variants; or
5. Strontium barium niobate and variants.

Note 2 to 6.A.2.a.3. cont.

c. "Focal plane arrays" specially designed or modified to achieve 'charge multiplication' and limited by design to have a maximum "radiant sensitivity" of 10 mA/W or less for wavelengths exceeding 760 nm, having all of the following:

1. Incorporating a response limiting mechanism designed not to be removed or modified; and

2. Any of the following:

a. The response limiting mechanism is integral to or combined with the detector element; or

b. The "focal plane array" is only operable with the response limiting mechanism in place.

Technical Note

A response limiting mechanism integral to the detector element is designed not to be removed or modified without rendering the detector inoperable.

d. Thermopile arrays having less than 5,130 elements;

6. A. 2. a. 3. a. Non-"space-qualified" "focal plane arrays" having all of the following:

1. Individual elements with a peak response within the wavelength range exceeding 900 nm but not exceeding 1,050 nm; and
2. Any of the following:
   a. A response "time constant" of less than 0.5 ns; or
   b. Specially designed or modified to achieve 'charge multiplication' and having a maximum "radiant sensitivity" exceeding 10 mA/W;

6. A. 2. a. 3. b. Non-"space-qualified" "focal plane arrays" having all of the following:

1. Individual elements with a peak response in the wavelength range exceeding 1,050 nm but not exceeding 1,200 nm; and
2. Any of the following:
   a. A response "time constant" of 95 ns or less; or
   b. Specially designed or modified to achieve 'charge multiplication' and having a maximum "radiant sensitivity" exceeding 10 mA/W;

6. A. 2. a. 3. c. Non-"space-qualified" non-linear (2-dimensional) "focal plane arrays" having individual elements with a peak response in the wavelength range exceeding 1,200 nm but not exceeding 30,000 nm;

N.B. Silicon and other material based 'microbolometer' non-"space-qualified" "focal plane arrays" are only specified by 6.A.2.a.3.f.

6. A. 2. a. 3. d. Non-"space-qualified" linear (1-dimensional) "focal plane arrays" having all of the following :

1. Individual elements with a peak response in the wavelength range exceeding 1,200 nm but not exceeding 3,000 nm; and

6. A. 2. a. 3. d. 2. Any of the following:
   a. A ratio of 'scan direction' dimension of the detector element to the 'cross-scan direction' dimension of the detector element of less than 3.8; or
   b. Signal processing in the detector elements;

   Note *6.A.2.a.3.d. does not apply to "focal plane arrays" (not to exceed 32 elements) having detector elements limited solely to germanium material.*

   Technical Note
   For the purposes of 6.A.2.a.3.d., 'cross-scan direction' is defined as the axis parallel to the linear array of detector elements and the 'scan direction' is defined as the axis perpendicular to the linear array of detector elements.

6. A. 2. a. 3. e. Non-"space-qualified" linear (1-dimensional) "focal plane arrays" having individual elements with a peak response in the wavelength range exceeding 3,000 nm but not exceeding 30,000 nm;

6. A. 2. a. 3. f. Non-"space-qualified" non-linear (2-dimensional) infrared "focal plane arrays" based on 'microbolometer' material having individual elements with an unfiltered response in the wavelength range equal to or exceeding 8,000 nm but not exceeding 14,000 nm;

   Technical Note
   For the purposes of 6.A.2.a.3.f., 'microbolometer' is defined as a thermal imaging detector that, as a result of a temperature change in the detector caused by the absorption of infrared radiation, is used to generate any usable signal.

6. A. 2. a. 3. g. Non-"space-qualified" "focal plane arrays" having all of the following:
   1. Individual detector elements with a peak response in the wavelength range exceeding 400 nm but not exceeding 900 nm;
   2. Specially designed or modified to achieve 'charge multiplication' and having a maximum "radiant sensitivity" exceeding 10 mA/W for wavelengths exceeding 760 nm; and
   3. Greater than 32 elements;

6. A. 2. b. "Monospectral imaging sensors" and "multispectral imaging sensors", designed for remote sensing applications and having any of the following:
   1. An Instantaneous-Field-Of-View (IFOV) of less than 200 µrad (microradians); or
   2. Specified for operation in the wavelength range exceeding 400 nm but not exceeding 30,000 nm and having all the following;
      a. Providing output imaging data in digital format; and
      b. Having any of the following characteristics:
         1. "Space-qualified"; or
         2. Designed for airborne operation, using other than silicon detectors, and having an IFOV of less than 2.5 mrad (milliradians);

Note *6.A.2.b.1. does not apply to "monospectral imaging sensors" with a peak response in the wavelength range exceeding 300 nm but not exceeding 900 nm and only incorporating any of the following non-"space-qualified" detectors or non-"space-qualified" "focal plane arrays":*

a. Charge Coupled Devices (CCD) not designed or modified to achieve 'charge multiplication'; or

b. Complementary Metal Oxide Semiconductor (CMOS) devices not designed or modified to achieve 'charge multiplication'.

6. A. 2. c. 'Direct view' imaging equipment incorporating any of the following:

1. Image intensifier tubes having the characteristics listed in 6.A.2.a.2.a. or 6.A.2.a.2.b.;
2. "Focal plane arrays" having the characteristics listed in 6.A.2.a.3.; or
3. Solid state detectors specified by 6.A.2.a.1.;

Technical Note

'Direct view' refers to imaging equipment that presents a visual image to a human observer without converting the image into an electronic signal for television display, and that cannot record or store the image photographically, electronically or by any other means.

Note *6.A.2.c. does not apply to equipment as follows, when incorporating other than GaAs or GaInAs photocathodes:*

a. Industrial or civilian intrusion alarm, traffic or industrial movement control or counting systems;

b. Medical equipment;

c. Industrial equipment used for inspection, sorting or analysis of the properties of materials;

d. Flame detectors for industrial furnaces;

e. Equipment specially designed for laboratory use.

6. A. 2. d. Special support components for optical sensors, as follows:

1. "Space-qualified" cryocoolers;
2. Non-"space-qualified" cryocoolers having a cooling source temperature below 218 K (-55°C), as follows:
   a. Closed cycle type with a specified Mean-Time-To-Failure (MTTF) or Mean-Time-Between-Failures (MTBF), exceeding 2,500 hours;
   b. Joule-Thomson (JT) self-regulating minicoolers having bore (outside) diameters of less than 8 mm;
3. Optical sensing fibres specially fabricated either compositionally or structurally, or modified by coating, to be acoustically, thermally, inertially, electromagnetically or nuclear radiation sensitive.

   Note *6.A.2.d.3. does not apply to encapsulated optical sensing fibres specially designed for bore hole sensing applications.*

6. A. 2. e. Not used since 2008

CAMERAS

6. A. 3. Cameras, systems or equipment, and components therefor, as follows:

a. Instrumentation cameras and specially designed components therefor, as follows:

Note *Instrumentation cameras, specified by 6.A.3.a.3. to 6.A.3.a.5., with modular structures should be evaluated by their maximum capability, using plug-ins available according to the camera manufacturer's specifications.*

6. A. 3. a. 1. High-speed cinema recording cameras using any film format from 8 mm to 16 mm inclusive, in which the film is continuously advanced throughout the recording period, and that are capable of recording at framing rates exceeding 13,150 frames/s;

Note *6.A.3.a.1. does not apply to cinema recording cameras designed for civil purposes.*

2. Mechanical high speed cameras, in which the film does not move, capable of recording at rates exceeding 1,000,000 frames/s for the full framing height of 35 mm film, or at proportionately higher rates for lesser frame heights, or at proportionately lower rates for greater frame heights;

3. Mechanical or electronic streak cameras as follows:
   a. Mechanical streak cameras having writing speeds exceeding 10 mm/µs;
   b. Electronic streak cameras having temporal resolution better than 50 ns;

4. Electronic framing cameras having a speed exceeding 1,000,000 frames/s;

5. Electronic cameras having all of the following:
   a. An electronic shutter speed (gating capability) of less than 1 µs per full frame; and
   b. A read out time allowing a framing rate of more than 125 full frames per second;

6. Plug-ins having all of the following characteristics:
   a. Specially designed for instrumentation cameras which have modular structures and which are specified by 6.A.3.a.; and
   b. Enabling these cameras to meet the characteristics specified by 6.A.3.a.3., 6.A.3.a.4. or 6.A.3.a.5., according to the manufacturer's specifications;

6. A. 3. b. Imaging cameras as follows:

Note *6.A.3.b. does not apply to television or video cameras, specially designed for television broadcasting.*

1. Video cameras incorporating solid state sensors, having a peak response in the wavelength range exceeding 10 nm, but not exceeding 30,000 nm and having all of the following:

6. A. 3. b. 1. a. Having any of the following:
   1. More than 4 x 10^6 "active pixels" per solid state array for monochrome (black and white) cameras;
   2. More than 4 x 10^6 "active pixels" per solid state array for colour cameras incorporating three solid state arrays; or
   3. More than 12 x 10^6 "active pixels" for solid state array colour cameras incorporating one solid state array; and

   b. Having any of the following:
   1. Optical mirrors specified by 6.A.4.a.;
   2. Optical control equipment specified by 6.A.4.d.; or
   3. The capability for annotating internally generated 'camera tracking data';

   Technical Notes

   1. For the purpose of this entry, digital video cameras should be evaluated by the maximum number of "active pixels" used for capturing moving images.

   2. For the purpose of this entry, 'camera tracking data' is the information necessary to define camera line of sight orientation with respect to the earth. This includes: 1) the horizontal angle the camera line of sight makes with respect to the earth's magnetic field direction and; 2) the vertical angle between the camera line of sight and the earth's horizon.

6. A. 3. b. 2. Scanning cameras and scanning camera systems, having all of the following:
   a. A peak response in the wavelength range exceeding 10 nm, but not exceeding 30,000 nm;
   b. Linear detector arrays with more than 8,192 elements per array; and
   c. Mechanical scanning in one direction;

   Note 6.A.3.b.2. does not apply to scanning cameras and scanning camera systems, specially designed for any of the following:
   a. Industrial or civilian photocopiers;
   b. Image scanners specially designed for civil, stationary, close proximity scanning applications (e.g., reproduction of images or print contained in documents, artwork or photographs); or
   c. Medical equipment.

6. A. 3. b. 3. Imaging cameras incorporating image intensifier tubes having the characteristics listed in 6.A.2.a.2.a. or 6.A.2.a.2.b.;

6. A. 3. b. 4. Imaging cameras incorporating "focal plane arrays" having any of the following:
   a. Incorporating "focal plane arrays" specified by 6.A.2.a.3.a. to 6.A.2.a.3.e.;
   b. Incorporating "focal plane arrays" specified by 6.A.2.a.3.f.; or
   c. Incorporating "focal plane arrays" specified by 6.A.2.a.3.g.;

   Note 1 Imaging cameras specified by 6.A.3.b.4. include "focal plane arrays" combined with sufficient "signal processing" electronics, beyond the read out integrated circuit, to enable as a minimum the output of an analogue or digital signal once power is supplied.

Note 2 *6.A.3.b.4.a. does not apply to imaging cameras incorporating linear "focal plane arrays" with 12 elements or fewer, not employing time-delay-and-integration within the element and designed for any of the following:*

a. Industrial or civilian intrusion alarm, traffic or industrial movement control or counting systems;
b. Industrial equipment used for inspection or monitoring of heat flows in buildings, equipment or industrial processes;
c. Industrial equipment used for inspection, sorting or analysis of the properties of materials;
d. Equipment specially designed for laboratory use; or
e. Medical equipment.

Note 3 *6.A.3.b.4.b. does not apply to imaging cameras having any of the following:*

a. A maximum frame rate equal to or less than 9 Hz;
b. Having all of the following:
1. Having a minimum horizontal or vertical 'Instantaneous-Field-of-View (IFOV)' of at least 10 mrad (milliradians);
2. Incorporating a fixed focal-length lens that is not designed to be removed;
3. Not incorporating a 'direct view' display; and

Technical Note
'Direct view' refers to an imaging camera operating in the infrared spectrum that presents a visual image to a human observer using a near-to-eye micro display incorporating any light-security mechanism.

4. Having any of the following:
a. No facility to obtain a viewable image of the detected field-of-view; or
b. The camera is designed for a single kind of application and designed not to be user modified; or

Technical Note
'Instantaneous Field of View (IFOV)' specified in Note 3.b. is the lesser figure of the 'Horizontal IFOV' or the 'Vertical IFOV'.
'Horizontal IFOV' = horizontal Field of View (FOV)/number of horizontal detector elements
'Vertical IFOV'= vertical Field of View (FOV)/number of vertical detector elements.

c. The camera is specially designed for installation into a civilian passenger land vehicle and having all of the following:
1. The placement and configuration of the camera within the vehicle are solely to assist the driver in the safe operation of the vehicle;

Note 3 to 6.A.3.b.4.b. cont.

2. *Is only operable when installed in any of the following:*
   a. *The civilian passenger land vehicle for which it was intended and the vehicle weighs less than 4,500 kg (gross vehicle weight); or*
   b. *A specially designed, authorized maintenance test facility; and*
3. *Incorporates an active mechanism that forces the camera not to function when it is removed from the vehicle for which it was intended.*

Note *When necessary, details of the item will be provided, upon request, to the appropriate authority in the exporter's country in order to ascertain compliance with the conditions described in Note 3.b.4. and Note 3.c. above.*

Note 4 *6.A.3.b.4.c. does not apply to imaging cameras having any of the following characteristics:*

a. *Having all of the following:*
   1. *Where the camera is specially designed for installation as an integrated component into indoor and wall-plug-operated systems or equipment, limited by design for a single kind of application, as follows:*
      a. *Industrial process monitoring, quality control, or analysis of the properties of materials;*
      b. *Laboratory equipment specially designed for scientific research;*
      c. *Medical equipment;*
      d. *Financial fraud detection equipment; and*
   2. *Is only operable when installed in any of the following:*
      a. *The system(s) or equipment for which it was intended; or*
      b. *A specially designed, authorised maintenance facility; and*
   3. *Incorporates an active mechanism that forces the camera not to function when it is removed from the system(s) or equipment for which it was intended;*

b. *Where the camera is specially designed for installation into a civilian passenger land vehicle or passenger and vehicle ferries, and having all of the following:*
   1. *The placement and configuration of the camera within the vehicle or ferry is solely to assist the driver or operator in the safe operation of the vehicle or ferry;*

Note 4 to 6.A.3.b.4.c. cont.

2. *Is only operable when installed in any of the following:*
   a. *The civilian passenger land vehicle for which it was intended and the vehicle weighs less than 4,500 kg (gross vehicle weight);*
   b. *The passenger and vehicle ferry for which it was intended and having a length overall (LOA) 65 m or greater; or*
   c. *A specially designed, authorised maintenance test facility; and*
3. *Incorporates an active mechanism that forces the camera not to function when it is removed from the vehicle for which it was intended;*

c. *Limited by design to have a maximum "radiant sensitivity" of 10 mA/W or less for wavelengths exceeding 760 nm, having all of the following:*
   1. *Incorporating a response limiting mechanism designed not to be removed or modified;*
   2. *Incorporates an active mechanism that forces the camera not to function when the response limiting mechanism is removed; and*
   3. *Not specially designed or modified for underwater use; or*

d. *Having all of the following:*
   1. *Not incorporating a 'direct view' or electronic image display;*
   2. *Has no facility to output a viewable image of the detected field of view;*
   3. *The "focal plane array" is only operable when installed in the camera for which it was intended; and*
   4. *The "focal plane array" incorporates an active mechanism that forces it to be permanently inoperable when removed from the camera for which it was intended.*

Note *When necessary, details of the item will be provided, upon request, to the appropriate authority in the exporter's country in order to ascertain compliance with the conditions described in Note 4 above.*

6. A. 3. b. 5. Imaging cameras incorporating solid-state detectors specified by 6.A.2.a.1.

OPTICS

6. A. 4. Optical equipment and components, as follows:

a. Optical mirrors (reflectors) as follows:

Technical Note
For the purpose of 6.A.4.a., Laser Induced Damage Threshold (LIDT) is measured according to ISO 21254-1:2011.

6. A. 4. a. 1. "Deformable mirrors" having an active optical aperture greater than 10 mm and having any of the following, and specially designed components therefor:
   a. Having all the following:
      1. A mechanical resonant frequency of 750 Hz or more; and
      2. More than 200 actuators; or
   b. A Laser Induced Damage Threshold (LIDT) being any of the following:
      1. Greater than 1 kW/cm^2 using a "CW laser"; or
      2. Greater than 2 J/cm^2 using 20 ns "laser" pulses at 20 Hz repetition rate;

6. A. 4. a. 2. Lightweight monolithic mirrors having an average "equivalent density" of less than 30 kg/m² and a total mass exceeding 10 kg;

6. A. 4. a. 3. Lightweight "composite" or foam mirror structures having an average "equivalent density" of less than 30 kg/m² and a total mass exceeding 2 kg;

Note *6.A.4.a.2. and 6.A.4.a.3. do not apply to mirrors specially designed to direct solar radiation for terrestrial heliostat installations.*

6. A. 4. a. 4. Mirrors specially designed for beam steering mirror stages specified in 6.A.4.d.2.a. with a flatness of λ/10 or better (λ is equal to 633 nm) and having any of the following:
   a. Diameter or major axis length greater than or equal to 100 mm; or
   b. Having all of the following:
      1. Diameter or major axis length greater than 50 mm but less than 100 mm; and
      2. A Laser Induced Damage Threshold (LIDT) being any of the following:
         a. Greater than 10 kW/cm^2 using a "CW laser"; or
         b. Greater than 20 J/cm^2 using 20 ns "laser" pulses at 20 Hz repetition rate;

N.B. *For optical mirrors specially designed for lithography equipment, see 3.B.1.*

6. A. 4. b. Optical components made from zinc selenide (ZnSe) or zinc sulphide (ZnS) with transmission in the wavelength range exceeding 3,000 nm but not exceeding 25,000 nm and having any of the following:
   1. Exceeding 100 cm^3 in volume; or
   2. Exceeding 80 mm in diameter or length of major axis and 20 mm in thickness (depth);

6. A. 4. c. "Space-qualified" components for optical systems, as follows:
   1. Components lightweighted to less than 20% "equivalent density" compared with a solid blank of the same aperture and thickness;
   2. Raw substrates, processed substrates having surface coatings (single-layer or multi-layer, metallic or dielectric, conducting, semiconducting or insulating) or having protective films;
   3. Segments or assemblies of mirrors designed to be assembled in space into an optical system with a collecting aperture equivalent to or larger than a single optic 1 m in diameter;
   4. Components manufactured from "composite" materials having a coefficient of linear thermal expansion equal to or less than 5 x 10^{-6} in any coordinate direction;

6. A. 4. d. Optical control equipment as follows:

1. Equipment specially designed to maintain the surface figure or orientation of the "space-qualified" components specified by 6.A.4.c.1. or 6.A.4.c.3.;
2. Steering, tracking, stabilisation and resonator alignment equipment as follows:
   a. Beam steering mirror stages designed to carry mirrors having diameter or major axis length greater than 50 mm and having all of the following, and specially designed electronic control equipment therefor:
      1. A maximum angular travel of ±26 mrad or more;
      2. A mechanical resonant frequency of 500 Hz or more; and
      3. An angular "accuracy" of 10 µrad (microradians) or less (better);
   b. Resonator alignment equipment having bandwidths equal to or more than 100 Hz and an "accuracy" of 10 µrad or less (better);

6. A. 4. d. 3. Gimbals having all of the following:
   a. A maximum slew exceeding 5°;
   b. A bandwidth of 100 Hz or more;
   c. Angular pointing errors of 200 µrad (microradians) or less; and
   d. Having any of the following:
      1. Exceeding 0.15 m but not exceeding 1 m in diameter or major axis length and capable of angular accelerations exceeding 2 rad (radians)/s²; or
      2. Exceeding 1 m in diameter or major axis length and capable of angular accelerations exceeding 0.5 rad (radians)/s²;

6. A. 4. d. 4. Not used since 2014

6. A. 4. e. 'Aspheric optical elements' having all of the following:

1. Largest dimension of the optical-aperture greater than 400 mm;
2. Surface roughness less than 1 nm (rms) for sampling lengths equal to or greater than 1 mm; and
3. Coefficient of linear thermal expansion's absolute magnitude less than $3x10^{-6}$/K at 25°C.

Technical Notes

1. *An 'aspheric optical element' is any element used in an optical system whose imaging surface or surfaces are designed to depart from the shape of an ideal sphere.*
2. *Manufacturers are not required to measure the surface roughness listed in 6.A.4.e.2. unless the optical element was designed or manufactured with the intent to meet, or exceed, the specified parameter.*

Note *6.A.4.e. does not apply to 'aspheric optical elements' having any of the following:*

a. Largest optical-aperture dimension less than 1 m and focal length to aperture ratio equal to or greater than 4.5:1;

b. Largest optical-aperture dimension equal to or greater than 1 m and focal length to aperture ratio equal to or greater than 7:1;

Note to 6.A.4.e. cont.

c. Designed as Fresnel, flyeye, stripe, prism or diffractive optical elements;
d. Fabricated from borosilicate glass having a coefficient of linear thermal expansion greater than $2.5x10^{-6}$ /K at 25 °C; or
e. An x-ray optical element having inner mirror capabilities (e.g., tube-type mirrors).

N.B. For 'aspheric optical elements' specially designed for lithography equipment, see 3.B.1.

LASERS

6. A. 5. "Lasers", components and optical equipment, as follows:

Note 1 Pulsed "lasers" include those that run in a continuous wave (CW) mode with pulses superimposed.

Note 2 Excimer, semiconductor, chemical, CO, CO_2, and 'non-repetitive pulsed' Nd:glass "lasers" are only specified by 6.A.5.d.

Technical Note
'Non-repetitive pulsed' refers to "lasers" that produce either a single output pulse or that have a time interval between pulses exceeding one minute.

Note 3 6.A.5. includes fibre "lasers".

Note 4 The status of "lasers" incorporating frequency conversion (i.e., wavelength change) by means other than one "laser" pumping another "laser" is determined by applying the specified parameters for both the output of the source "laser" and the frequency-converted optical output.

Note 5 6.A.5. does not apply to "lasers" as follows:
a. Ruby with output energy below 20 J;
b. Nitrogen;
c. Krypton.

6. A. 5. a. Non-"tunable" continuous wave "(CW) lasers" having any of the following:
1. Output wavelength less than 150 nm and output power exceeding 1 W;
2. Output wavelength of 150 nm or more but not exceeding 510 nm and output power exceeding 30 W;

Note 6.A.5.a.2. does not apply to Argon "lasers" having an output power equal to or less than 50 W.

3. Output wavelength exceeding 510 nm but not exceeding 540 nm and any of the following:
   a. Single transverse mode output and output power exceeding 50 W; or
   b. Multiple transverse mode output and output power exceeding 150 W;
4. Output wavelength exceeding 540 nm but not exceeding 800 nm and output power exceeding 30 W;

6. A. 5. a. 5. Output wavelength exceeding 800 nm but not exceeding 975 nm and any of the following:
   a. Single transverse mode output and output power exceeding 50 W; or
   b. Multiple transverse mode output and output power exceeding 80 W;

6. A. 5. a. 6. Output wavelength exceeding 975 nm but not exceeding 1,150 nm and any of the following:
   a. Single transverse mode and output power exceeding 500 W; or
   b. Multiple transverse mode output and any of the following:
      1. 'Wall-plug efficiency' exceeding 18% and output power exceeding 500 W; or
      2. Output power exceeding 2 kW;

   Note 1 *6.A.5.a.6.b. does not apply to multiple transverse mode, industrial "lasers" with output power exceeding 2 kW and not exceeding 6 kW with a total mass greater than 1,200 kg. For the purpose of this note, total mass includes all components required to operate the "laser", e.g., "laser", power supply, heat exchanger, but excludes external optics for beam conditioning and/or delivery.*

   Note 2 *6.A.5.a.6.b. does not apply to multiple transverse mode, industrial "lasers" having any of the following:*
   a. Output power exceeding 500 W but not exceeding 1 kW and having all of the following:
      1. Beam Parameter Product (BPP) exceeding 0.7 mm•mrad; and
      2. 'Brightness' not exceeding 1024 W/(mm•mrad)^2;
   b. Output power exceeding 1 kW but not exceeding 1.6 kW and having a BPP exceeding 1.25 mm•mrad;
   c. Output power exceeding 1.6 kW but not exceeding 2.5 kW and having a BPP exceeding 1.7 mm•mrad;
   d. Output power exceeding 2.5 kW but not exceeding 3.3 kW and having a BPP exceeding 2.5 mm•mrad;
   e. Output power exceeding 3.3 kW but not exceeding 4 kW and having a BPP exceeding 3.5 mm•mrad;
   f. Output power exceeding 4 kW but not exceeding 5 kW and having a BPP exceeding 5 mm•mrad;
   g. Output power exceeding 5 kW but not exceeding 6 kW and having a BPP exceeding 7.2 mm•mrad;
   h. Output power exceeding 6 kW but not exceeding 8 kW and having a BPP exceeding 12 mm•mrad; or
   i. Output power exceeding 8 kW but not exceeding 10 kW and having a BPP exceeding 24 mm•mrad;

   Technical Note
   For the purpose of 6.A.5.a.6.b., Note 2.a., 'brightness' is defined as the output power of the "laser" divided by the squared Beam Parameter Product (BPP), i.e., (output power)/BPP^2.

Technical Note
'Wall-plug efficiency' is defined as the ratio of "laser" output power (or "average output power") to total electrical input power required to operate the "laser", including the power supply/conditioning and thermal conditioning/heat exchanger.

6. A. 5. a. 7. Output wavelength exceeding 1,150 nm but not exceeding 1,555 nm and any of the following:
   a. Single transverse mode and output power exceeding 50 W; or
   b. Multiple transverse mode and output power exceeding 80 W;

6. A. 5. a. 8. Output wavelength exceeding 1,555 nm but not exceeding 1,850 nm, and output power exceeding 1 W;

6. A. 5. a. 9. Output wavelength exceeding 1,850 nm but not exceeding 2,100 nm, and any of the following:
   a. Single transverse mode and output power exceeding 1 W; or
   b. Multiple transverse mode output and output power exceeding 120 W; or

6. A. 5. a. 10. Output wavelength exceeding 2,100 nm and output power exceeding 1 W;

6. A. 5. b. Non-"tunable" "pulsed lasers" having any of the following:
   1. Output wavelength less than 150 nm and any of the following:
      a. Output energy exceeding 50 mJ per pulse and "peak power" exceeding 1 W; or
      b. "Average output power" exceeding 1 W;
   2. Output wavelength of 150 nm or more but not exceeding 510 nm and any of the following:
      a. Output energy exceeding 1.5 J per pulse and "peak power" exceeding 30W; or
      b. "Average output power" exceeding 30 W;

      Note *6.A.5.b.2.b. does not apply to Argon "lasers" having an "average output power" equal to or less than 50 W.*

6. A. 5. b. 3. Output wavelength exceeding 510 nm but not exceeding 540 nm and any of the following:
   a. Single transverse mode output and any of the following:
      1. Output energy exceeding 1.5 J per pulse and "peak power" exceeding 50 W; or
      2. "Average output power" exceeding 50 W; or
   b. Multiple transverse mode output and any of the following:
      1. Output energy exceeding 1.5 J per pulse and "peak power" exceeding 150 W; or
      2. "Average output power" exceeding 150 W;

6. A. 5. b. 4. Output wavelength exceeding 540 nm but not exceeding 800 nm and any of the following:
   a. "Pulse duration" less than 1 ps and any of the following:
      1. Output energy exceeding 0.005 J per pulse and "peak power" exceeding 5 GW; or
      2. "Average output power" exceeding 20 W; or

6. A. 5. b. 4. b. "Pulse duration" equal to or exceeding 1 ps and any of the following:
   1. Output energy exceeding 1.5 J per pulse and "peak power" exceeding 30 W; or
   2. "Average output power" exceeding 30 W;

6. A. 5. b. 5. Output wavelength exceeding 800 nm but not exceeding 975 nm and any of the following:
   a. "Pulse duration" less than 1 ps and any of the following:
      1. Output energy exceeding 0.005 J per pulse and "peak power" exceeding 5 GW; or
      2. Single transverse mode output and "average output power" exceeding 20 W;
   b. "Pulse duration" equal to or exceeding 1 ps and not exceeding 1 μs and any of the following:
      1. Output energy exceeding 0.5 J per pulse and "peak power" exceeding 50 W;
      2. Single transverse mode output and "average output power" exceeding 20 W; or
      3. Multiple transverse mode output and "average output power" exceeding 50 W; or
   c. "Pulse duration" exceeding 1 μs and any of the following:
      1. Output energy exceeding 2 J per pulse and "peak power" exceeding 50 W;
      2. Single transverse mode output and "average output power" exceeding 50 W; or
      3. Multiple transverse mode output and "average output power" exceeding 80 W;

6. A. 5. b. 6. Output wavelength exceeding 975 nm but not exceeding 1,150 nm and any of the following:
   a. "Pulse duration" of less than 1 ps, and any of the following:
      1. Output "peak power" exceeding 2 GW per pulse;
      2. "Average output power" exceeding 30 W; or
      3. Output energy exceeding 0.002 J per pulse;
   b. "Pulse duration" equal to or exceeding 1 ps and less than 1 ns, and any of the following:
      1. Output "peak power" exceeding 5 GW per pulse;
      2. "Average output power" exceeding 50 W; or
      3. Output energy exceeding 0.1 J per pulse;
   c. "Pulse duration" equal to or exceeding 1 ns but not exceeding 1 μs and any of the following:

6. A. 5. b. 6. c. 1. Single transverse mode output and any of the following:
   a. "Peak power" exceeding 100 MW;
   b. "Average output power" exceeding 20 W limited by design to a maximum pulse repetition frequency less than or equal to 1 kHz;
   c. 'Wall-plug efficiency' exceeding 12%, "average output power" exceeding 100 W and capable of operating at a pulse repetition frequency greater than 1 kHz;
   d. "Average output power" exceeding 150 W and capable of operating at a pulse repetition frequency greater than 1 kHz; or
   e. Output energy exceeding 2 J per pulse; or

6. A. 5. b. 6. c. 2. Multiple transverse mode output and any of the following:
   a. "Peak power" exceeding 400 MW;
   b. 'Wall-plug efficiency' exceeding 18% and "average output power" exceeding 500 W;
   c. "Average output power" exceeding 2 kW; or
   d. Output energy exceeding 4 J per pulse; or

6. A. 5. b. 6. d. "Pulse duration" exceeding 1 μs and any of the following:
   1. Single transverse mode output and any of the following:
      a. "Peak power" exceeding 500 kW;
      b. 'Wall-plug efficiency' exceeding 12% and "average output power" exceeding 100 W; or
      c. "Average output power" exceeding 150 W; or
   2. Multiple transverse mode output and any of the following:
      a. "Peak power" exceeding 1 MW;
      b. 'Wall-plug efficiency' exceeding 18% and "average output power" exceeding 500 W; or
      c. "Average output power" exceeding 2 kW;

6. A. 5. b. 7. Output wavelength exceeding 1,150 nm but not exceeding 1,555 nm, and any of the following:
   a. "Pulse duration" not exceeding 1 μs and any of the following:
      1. Output energy exceeding 0.5 J per pulse and "peak power" exceeding 50 W;
      2. Single transverse mode output and "average output power" exceeding 20 W; or
      3. Multiple transverse mode output and "average output power" exceeding 50 W; or
   b. "Pulse duration" exceeding 1 μs and any of the following:
      1. Output energy exceeding 2 J per pulse and "peak power" exceeding 50 W;
      2. Single transverse mode output and "average output power" exceeding 50 W; or
      3. Multiple transverse mode output and "average output power" exceeding 80 W;

6. A. 5. b. 8. Output wavelength exceeding 1,555 nm but not exceeding 1,850 nm, and any of the following:
   a. Output energy exceeding 100 mJ per pulse and "peak power" exceeding 1 W; or
   b. "Average output power" exceeding 1 W;

6. A. 5. b. 9. Output wavelength exceeding 1,850 nm but not exceeding 2,100 nm, and any of the following:
   a. Single transverse mode and any of the following:
      1. Output energy exceeding 100 mJ per pulse and "peak power" exceeding 1 W; <u>or</u>
      2. "Average output power" exceeding 1 W; <u>or</u>
   b. Multiple transverse mode and any of the following:
      1. Output energy exceeding 100 mJ per pulse and "peak power" exceeding 10 kW; <u>or</u>
      2. "Average output power" exceeding 120 W; <u>or</u>

6. A. 5. b. 10. Output wavelength exceeding 2,100 nm and any of the following:
   a. Output energy exceeding 100 mJ per pulse and "peak power" exceeding 1 W; <u>or</u>
   b. "Average output power" exceeding 1 W;

6. A. 5. c. "Tunable" "lasers" having any of the following:
   1. Output wavelength less than 600 nm and any of the following:
      a. Output energy exceeding 50 mJ per pulse and "peak power" exceeding 1 W; <u>or</u>
      b. Average or CW output power exceeding 1 W;

      <u>Note</u> *6.A.5.c.1. does not apply to dye "lasers" or other liquid "lasers", having a multimode output and a wavelength of 150 nm or more but not exceeding 600 nm and all of the following:*
      1. Output energy less than 1.5 J per pulse or a "peak power" less than 20 W; <u>and</u>
      2. Average or CW output power less than 20 W.

6. A. 5. c. 2. Output wavelength of 600 nm or more but not exceeding 1,400 nm, and any of the following:
   a. Output energy exceeding 1 J per pulse and "peak power" exceeding 20 W; <u>or</u>
   b. Average or CW output power exceeding 20 W; <u>or</u>

   3. Output wavelength exceeding 1,400 nm and any of the following:
      a. Output energy exceeding 50 mJ per pulse and "peak power" exceeding 1 W; <u>or</u>
      b. Average or CW output power exceeding 1 W;

6. A. 5. d. Other "lasers", not specified by 6.A.5.a., 6A.5.b. or 6.A.5.c. as follows:
   1. Semiconductor "lasers" as follows:

      <u>Note 1</u> *6.A.5.d.1. includes semiconductor "lasers" having optical output connectors (e.g. fibre optic pigtails).*

      <u>Note 2</u> *The status of semiconductor "lasers" specially designed for other equipment is determined by the status of the other equipment.*

6. A. 5. d. 1. a. Individual single-transverse mode semiconductor "lasers" having any of the following:
   1. Wavelength equal to or less than 1,510 nm and average or CW output power, exceeding 1.5 W; or
   2. Wavelength greater than 1,510 nm and average or CW output power, exceeding 500 mW;

6. A. 5. d. 1. b. Individual, multiple-transverse mode semiconductor "lasers" having any of the following:
   1. Wavelength of less than 1,400 nm and average or CW output power, exceeding 15 W;
   2. Wavelength equal to or greater than 1,400 nm and less than 1,900 nm and average or CW output power, exceeding 2.5 W; or
   3. Wavelength equal to or greater than 1,900 nm and average or CW output power, exceeding 1 W;

6. A. 5. d. 1. c. Individual semiconductor "laser" 'bars' having any of the following:
   1. Wavelength of less than 1,400 nm and average or CW output power, exceeding 100 W;
   2. Wavelength equal to or greater than 1,400 nm and less than 1,900 nm and average or CW output power, exceeding 25 W; or
   3. Wavelength equal to or greater than 1,900 nm and average or CW output power, exceeding 10 W;

6. A. 5. d. 1. d. Semiconductor "laser" 'stacked arrays' (two-dimensional arrays) having any of the following:
   1. Wavelength less than 1,400 nm and having any of the following:
      a. Average or CW total output power less than 3 kW and having average or CW output 'power density' greater than 500 W/cm^2;
      b. Average or CW total output power equal to or exceeding 3 kW but less than or equal to 5 kW, and having average or CW output 'power density' greater than 350W/cm^2;
      c. Average or CW total output power exceeding 5 kW;
      d. Peak pulsed 'power density' exceeding 2,500 W/cm^2; or

         Note *6.A.5.d.1.d.1.d. does not apply to epitaxially-fabricated monolithic devices.*

      e. Spatially coherent average or CW total output power, greater than 150 W;

6. A. 5. d. 1. d. 2. Wavelength greater than or equal to 1,400 nm but less than 1,900 nm, and having any of the following:
   a. Average or CW total output power less than 250 W and average or CW output 'power density' greater than 150 W/cm^2;
   b. Average or CW total output power equal to or exceeding 250 W but less than or equal to 500 W, and having average or CW output 'power density' greater than 50W/cm^2;
   c. Average or CW total output power exceeding 500 W;
   d. Peak pulsed 'power density' exceeding 500 W/cm^2; or

   Note *6.A.5.d.1.d.2.d. does not apply to epitaxially-fabricated monolithic devices.*

   e. Spatially coherent average or CW total output power, exceeding 15 W;

6. A. 5. d. 1. d. 3. Wavelength greater than or equal to 1,900 nm and having any of the following:
   a. Average or CW output 'power density' greater than 50 W/cm^2;
   b. Average or CW output power greater than 10 W; or
   c. Spatially coherent average or CW total output power, exceeding 1.5 W; or

6. A. 5. d. 1. d. 4. At least one "laser" 'bar' specified by 6.A.5.d.1.c.;

Technical Note
For the purposes of 6.A.5.d.1.d., 'power density' means the total "laser" output power divided by the emitter surface area of the 'stacked array'.

6. A. 5. d. 1. e. Semiconductor "laser" 'stacked arrays', other than those specified by 6.A.5.d.1.d., having all of the following:
   1. Specially designed or modified to be combined with other 'stacked arrays' to form a larger 'stacked array'; and
   2. Integrated connections, common for both electronics and cooling;

   Note 1 *'Stacked arrays', formed by combining semiconductor "laser" 'stacked arrays' specified by 6.A.5.d.1.e., that are not designed to be further combined or modified are specified by 6.A.5.d.1.d.*

   Note 2 *'Stacked arrays', formed by combining semiconductor "laser" 'stacked arrays' specified by 6.A.5.d.1.e., that are designed to be further combined or modified are specified by 6.A.5.d.1.e.*

   Note 3 *6.A.5.d.1.e. does not apply to modular assemblies of single 'bars' designed to be fabricated into end-to-end stacked linear arrays.*

Technical Notes

1. *Semiconductor "lasers" are commonly called "laser" diodes.*
2. *A 'bar' (also called a semiconductor "laser" 'bar', a "laser" diode 'bar' or diode 'bar') consists of multiple semiconductor "lasers" in a one-dimensional array.*
3. *A 'stacked array' consists of multiple 'bars' forming a two-dimensional array of semiconductor "lasers".*

6. A. 5. d. 2. Carbon monoxide (CO) "lasers" having any of the following:
   a. Output energy exceeding 2 J per pulse and "peak power" exceeding 5 kW; or
   b. Average or CW output power exceeding 5 kW;

6. A. 5. d. 3. Carbon dioxide (CO_2) "lasers" having any of the following:
   a. CW output power exceeding 15 kW;
   b. Pulsed output with a "pulse duration" exceeding 10 µs and any of the following:
      1. "Average output power" exceeding 10 kW; or
      2. "Peak power" exceeding 100 kW; or
   c. Pulsed output with a "pulse duration" equal to or less than 10 µs and any of the following:
      1. Pulse energy exceeding 5 J per pulse; or
      2. "Average output power" exceeding 2.5 kW;

6. A. 5. d. 4. Excimer "lasers" having any of the following:
   a. Output wavelength not exceeding 150 nm and any of the following:
      1. Output energy exceeding 50 mJ per pulse; or
      2. "Average output power" exceeding 1 W;
   b. Output wavelength exceeding 150 nm but not exceeding 190 nm and any of the following:
      1. Output energy exceeding 1.5 J per pulse; or
      2. "Average output power" exceeding 120 W;
   c. Output wavelength exceeding 190 nm but not exceeding 360 nm and any of the following:
      1. Output energy exceeding 10 J per pulse; or
      2. "Average output power" exceeding 500 W; or
   d. Output wavelength exceeding 360 nm and any of the following:
      1. Output energy exceeding 1.5 J per pulse; or
      2. "Average output power" exceeding 30 W;

   N.B. *For excimer "lasers" specially designed for lithography equipment, see 3.B.1.*

6. A. 5. d. 5. "Chemical lasers" as follows:
   a. Hydrogen Fluoride (HF) "lasers";
   b. Deuterium Fluoride (DF) "lasers";
   c. "Transfer lasers" as follows:
      1. Oxygen Iodine (O_2-I) "lasers";
      2. Deuterium Fluoride-Carbon dioxide (DF-CO_2) "lasers";

6. A. 5. d. 6. 'Non-repetitive pulsed' Nd: glass "lasers" having any of the following:
   a. "Pulse duration" not exceeding 1 μs and output energy exceeding 50 J per pulse; or
   b. "Pulse duration" exceeding 1 μs and output energy exceeding 100 J per pulse;

6. A. 5. e. Components as follows:
   1. Mirrors cooled either by 'active cooling' or by heat pipe cooling;

      Technical Notes
      'Active cooling' is a cooling technique for optical components using flowing fluids within the subsurface (nominally less than 1 mm below the optical surface) of the optical component to remove heat from the optic.

   2. Optical mirrors or transmissive or partially transmissive optical or electro-optical components, other than fused tapered fibre combiners and Multi-Layer Dielectric gratings (MLDs), specially designed for use with specified "lasers";

      Note *Fibre combiners and MLDs are specified by 6.A.5.e.3.*

6. A. 5. e. 3. Fibre "laser" components as follows:
   a. Multimode to multimode fused tapered fibre combiners having all of the following:
      1. An insertion loss better (less) than or equal to 0.3 dB maintained at a rated total average or CW output power (excluding output power transmitted through the single mode core if present) exceeding 1,000 W; and
      2. Number of input fibres equal to or greater than 3;

6. A. 5. e. 3. b. Single mode to multimode fused tapered fibre combiners having all of the following:
      1. An insertion loss better (less) than 0.5 dB maintained at a rated total average or CW output power exceeding 4,600 W;
      2. Number of input fibres equal to or greater than 3; and
      3. Having any of the following:
         a. A Beam Parameter Product (BPP) measured at the output not exceeding 1.5 mm mrad for a number of input fibres less than or equal to 5; or
         b. A BPP measured at the output not exceeding 2.5 mm mrad for a number of input fibres greater than 5;

6. A. 5. e. 3. c. MLDs having all of the following:
      1. Designed for spectral or coherent beam combination of 5 or more fibre "lasers"; and
      2. CW "Laser" Induced Damage Threshold (LIDT) greater than or equal to 10 kW/cm^2.

6. A. 5. f. Optical equipment as follows:

*N.B. For shared aperture optical elements, capable of operating in "Super-High Power Laser" ("SHPL") applications, see ML19. Note 2.d.**

1. Dynamic wavefront (phase) measuring equipment capable of mapping at least 50 positions on a beam wavefront and any of the following:
   a. Frame rates equal to or more than 100 Hz and phase discrimination of at least 5% of the beam's wavelength; or
   b. Frame rates equal to or more than 1,000 Hz and phase discrimination of at least 20% of the beam's wavelength;
2. "Laser" diagnostic equipment capable of measuring "SHPL" system angular beam steering errors of equal to or less than 10 µrad;
3. Optical equipment and components, specially designed for a phased-array "SHPL" system for coherent beam combination to an "accuracy" of $\lambda/10$ at the designed wavelength, or 0.1 µm, whichever is the smaller;
4. Projection telescopes specially designed for use with "SHPL" systems;

6. A. 5. g. 'Laser acoustic detection equipment' having all of the following:
1. CW "laser" output power equal to or exceeding 20 mW;
2. "Laser" frequency stability equal to or better (less) than 10 MHz;
3. "Laser" wavelengths equal to or exceeding 1,000 nm but not exceeding 2,000 nm;
4. Optical system resolution better (less) than 1 nm; and
5. Optical Signal to Noise ratio equal to or exceeding 10^3.

Technical Note
'Laser acoustic detection equipment' is sometimes referred to as a "Laser" Microphone or Particle Flow Detection Microphone.

MAGNETIC AND ELECTRIC FIELD SENSORS

6. A. 6. "Magnetometers", "magnetic gradiometers", "intrinsic magnetic gradiometers", underwater electric field sensors, "compensation systems", and specially designed components therefor, as follows:

Note 6.A.6. does not apply to instruments specially designed for fishery applications or biomagnetic measurements for medical diagnostics.

6. A. 6. a. "Magnetometers" and subsystems, as follows:
1. "Magnetometers" using "superconductive" (SQUID) "technology" and having any of the following:
   a. SQUID systems designed for stationary operation, without specially designed subsystems designed to reduce in-motion noise, and having a 'sensitivity' equal to or lower (better) than 50 fT (rms) per square root Hz at a frequency of 1 Hz; or
   b. SQUID systems having an in-motion-magnetometer 'sensitivity' lower (better) than 20 pT (rms) per square root Hz at a frequency of 1 Hz and specially designed to reduce in-motion noise;

* The Russian Federation and Ukraine view this list as a reference list drawn up to help in the selection of dual-use goods which could contribute to the indigenous development, production or enhancement of conventional munitions capabilities.

6. A. 6. a. 2. "Magnetometers" using optically pumped or nuclear precession (proton/Overhauser) "technology" having a 'sensitivity' lower (better) than 20 pT (rms) per square root Hz at a frequency of 1 Hz;

3. "Magnetometers" using fluxgate "technology" having a 'sensitivity' equal to or lower (better) than 10 pT (rms) per square root Hz at a frequency of 1 Hz;

4. Induction coil "magnetometers" having a 'sensitivity' lower (better) than any of the following:
   a. 0.05 nT (rms)/square root Hz at frequencies of less than 1 Hz;
   b. 1×10^{-3} nT (rms)/square root Hz at frequencies of 1 Hz or more but not exceeding 10 Hz; <u>or</u>
   c. 1×10^{-4} nT (rms)/square root Hz at frequencies exceeding 10 Hz;

5. Fibre optic "magnetometers" having a 'sensitivity' lower (better) than 1 nT (rms) per square root Hz;

6. A. 6. b. Underwater Electric Field Sensors having a 'sensitivity' lower (better) than 8 nanovolt per meter per square root Hz when measured at 1 Hz;

6. A. 6. c. "Magnetic gradiometers" as follows:

1. "Magnetic gradiometers" using multiple "magnetometers" specified by 6.A.6.a.;

2. Fibre optic "intrinsic magnetic gradiometers" having a magnetic gradient field 'sensitivity' lower (better) than 0.3 nT/m (rms) per square root Hz;

3. "Intrinsic magnetic gradiometers", using "technology" other than fibre-optic "technology", having a magnetic gradient field 'sensitivity' lower (better) than 0.015 nT/m (rms) per square root Hz;

6. A. 6. d. "Compensation systems" for magnetic or underwater electric field sensors resulting in a performance equal to or better than the specified parameters of 6.A.6.a., 6.A.6.b., or 6.A.6.c.;

6. A. 6. e. Underwater electromagnetic receivers incorporating magnetic field sensors specified by 6.A.6.a. or underwater electric field sensors specified by 6.A.6.b.

<u>Technical Note</u>
For the purposes of 6.A.6., 'sensitivity' (noise level) is the root mean square of the device-limited noise floor which is the lowest signal that can be measured.

<u>GRAVIMETERS</u>

6. A. 7. Gravity meters (gravimeters) and gravity gradiometers, as follows:

a. Gravity meters designed or modified for ground use and having a static "accuracy" of less (better) than 10 µGal;

<u>Note</u> 6.A.7.a. does not apply to ground gravity meters of the quartz element (Worden) type.

6. A. 7. b. Gravity meters designed for mobile platforms and having all of the following:
1. A static "accuracy" of less (better) than 0.7 mGal; and
2. An in-service (operational) "accuracy" of less (better) than 0.7 mGal having a 'time-to-steady-state registration' of less than 2 minutes under any combination of attendant corrective compensations and motional influences;

Technical Note
For the purposes of 6.A.7.b., 'time-to-steady-state registration' (also referred to as the gravimeter's response time) is the time over which the disturbing effects of platform induced accelerations (high frequency noise) are reduced.

6. A. 7. c. Gravity gradiometers.

RADAR

6. A. 8. Radar systems, equipment and assemblies, having any of the following, and specially designed components therefor:

Note *6.A.8. does not apply to:*
- *Secondary Surveillance Radar (SSR);*
- *Civil Automotive Radar;*
- *Displays or monitors used for Air Traffic Control (ATC);*
- *Meteorological (weather) Radar;*
- *Precision Approach Radar (PAR) equipment conforming to ICAO standards and employing electronically steerable linear (1-dimensional) arrays or mechanically positioned passive antennae.*

6. A. 8. a. Operating at frequencies from 40 GHz to 230 GHz and having any of the following:
1. An average output power exceeding 100 mW; or
2. Locating "accuracy" of 1 m or less (better) in range and 0.2 degree or less (better) in azimuth;

b. A tunable bandwidth exceeding ± 6.25% of the 'centre operating frequency';

Technical Note
The 'centre operating frequency' equals one half of the sum of the highest plus the lowest specified operating frequencies.

c. Capable of operating simultaneously on more than two carrier frequencies;
d. Capable of operating in synthetic aperture (SAR), inverse synthetic aperture (ISAR) radar mode, or sidelooking airborne (SLAR) radar mode;
e. Incorporating electronically steerable array antennae;
f. Capable of heightfinding non-cooperative targets;
g. Specially designed for airborne (balloon or airframe mounted) operation and having Doppler "signal processing" for the detection of moving targets;

6. A. 8. h. Employing processing of radar signals and using any of the following:
1. "Radar spread spectrum" techniques; or
2. "Radar frequency agility" techniques;

6. A. 8. i. Providing ground-based operation with a maximum "instrumented range" exceeding 185 km;

Note *6.A.8.i. does not apply to:*

a. Fishing ground surveillance radar;

b. Ground radar equipment specially designed for enroute air traffic control and having all of the following:

1. A maximum "instrumented range" of 500 km or less;

2. Configured so that radar target data can be transmitted only one way from the radar site to one or more civil ATC centres;

3. Contains no provisions for remote control of the radar scan rate from the enroute ATC centre; and

4. Permanently installed.

c. Weather balloon tracking radars.

6. A. 8. j. Being "laser" radar or Light Detection and Ranging (LIDAR) equipment and having any of the following:

1. "Space-qualified";
2. Employing coherent heterodyne or homodyne detection techniques and having an angular resolution of less (better) than 20 µrad (microradians); or
3. Designed for carrying out airborne bathymetric littoral surveys to International Hydrographic Organization (IHO) Order 1a Standard (5th Edition February 2008) for Hydrographic Surveys or better, and using one or more "lasers" with a wavelength exceeding 400 nm but not exceeding 600 nm;

Note 1 *LIDAR equipment specially designed for surveying is only specified by 6.A.8.j.3.*

Note 2 *6.A.8.j. does not apply to LIDAR equipment specially designed for meteorological observation.*

Note 3 *Parameters in the IHO Order 1a Standard 5th Edition February 2008 are summarized as follows:*

Horizontal Accuracy (95% Confidence Level) = 5 m + 5% of depth.

Depth Accuracy for Reduced Depths (95% confidence level)
$= \pm\sqrt{(a^2+(b*d)^2)}$ *where:*

a = 0.5 m = constant depth error, i.e. the sum of all constant depth errors
b = 0.013 = factor of depth dependent error
*b*d = depth dependent error, i.e. the sum of all depth dependent errors*
d = depth

Feature Detection
= Cubic features > 2 m in depths up to 40 m;
10% of depth beyond 40 m.

6. A. 8. k. Having "signal processing" sub-systems using "pulse compression" and having any of the following:
   1. A "pulse compression" ratio exceeding 150; or
   2. A compressed pulse width of less than 200 ns; or

      Note *6.A.8.k.2. does not apply to two dimensional 'marine radar' or 'vessel traffic service' radar , having all of the following:*

      a. "Pulse compression" ratio not exceeding 150;
      b. Compressed pulse width of greater than 30 ns;
      c. Single and rotating mechanically scanned antenna;
      d. Peak output power not exceeding 250 W; and
      e. Not capable of "frequency hopping".

6. A. 8. l. Having data processing sub-systems and having any of the following:
   1. "Automatic target tracking" providing, at any antenna rotation, the predicted target position beyond the time of the next antenna beam passage; or

      Note *6.A.8.l.1. does not apply to conflict alert capability in ATC systems, or 'marine radar'.*

   2. Not used since 2010
   3. Not used since 2010
   4. Configured to provide superposition and correlation, or fusion, of target data within six seconds from two or more "geographically dispersed" radar sensors to improve the aggregate performance beyond that of any single sensor specified by 6.A.8.f. or 6.A.8.i.

      N.B. *See also ML5.b.*

   Note *6.A.8.l. does not apply to systems, equipment and assemblies used for 'vessel traffic services'.*

Technical Notes

1. *For the purposes of 6.A.8., 'marine radar' is a radar that is used to navigate safely at sea, inland waterways or near-shore environments.*
2. *For the purposes of 6.A.8., 'vessel traffic service' is a vessel traffic monitoring and control service similar to air traffic control for "aircraft".*

6. B. TEST, INSPECTION AND PRODUCTION EQUIPMENT

1. ACOUSTICS - None

2. OPTICAL SENSORS - None

3. CAMERAS - None

OPTICS

6. B. 4. Optical equipment as follows:
   a. Equipment for measuring absolute reflectance to an "accuracy" of equal to or better than 0.1% of the reflectance value;
   b. Equipment other than optical surface scattering measurement equipment, having an unobscured aperture of more than 10 cm, specially designed for the non-contact optical measurement of a non-planar optical surface figure (profile) to an "accuracy" of 2 nm or less (better) against the required profile.

Note *6.B.4. does not apply to microscopes.*

6. B. 5. LASERS - None

6. B. 6. MAGNETIC AND ELECTRIC FIELD SENSORS - None

GRAVIMETERS

6. B. 7. Equipment to produce, align and calibrate land-based gravity meters with a static "accuracy" of better than 0.1 mGal.

RADAR

6. B. 8. Pulse radar cross-section measurement systems having transmit pulse widths of 100 ns or less, and specially designed components therefor.

6. C. MATERIALS

6. C. 1. ACOUSTICS - None

OPTICAL SENSORS

6. C. 2. Optical sensor materials as follows:
   a. Elemental tellurium (Te) of purity levels of 99.9995% or more;
   b. Single crystals (including epitaxial wafers) of any of the following:
      1. Cadmium zinc telluride (CdZnTe) with zinc content of less than 6% by 'mole fraction';
      2. Cadmium telluride (CdTe) of any purity level; or
      3. Mercury cadmium telluride (HgCdTe) of any purity level.

   Technical Note
   'Mole fraction' is defined as the ratio of moles of ZnTe to the sum of the moles of CdTe and ZnTe present in the crystal.

6. C. 3. CAMERAS - None

OPTICS

6. C. 4. Optical materials as follows:
   a. Zinc selenide (ZnSe) and zinc sulphide (ZnS) "substrate blanks", produced by the chemical vapour deposition process and having any of the following:
      1. A volume greater than 100 cm^3; or
      2. A diameter greater than 80 mm and a thickness of 20 mm or more;

   b. Electro-optic materials and non-linear optical materials, as follows:
      1. Potassium titanyl arsenate (KTA) (CAS 59400-80-5);
      2. Silver gallium selenide ($AgGaSe_2$, also known as AGSE) (CAS 12002-67-4);
      3. Thallium arsenic selenide (Tl_3AsSe_3, also known as TAS) (CAS 16142-89-5);
      4. Zinc germanium phosphide ($ZnGeP_2$, also known as ZGP, zinc germanium biphosphide or zinc germanium diphosphide); or
      5. Gallium selenide (GaSe) (CAS 12024-11-2);

6. C. 4. c. Non-linear optical materials, other than those specified by 6.C.4.b., having any of the following:
   1. Having all of the following:
      a. Dynamic (also known as non-stationary) third order non-linear susceptibility ($\chi^{(3)}$, chi 3) of $10^{-6}m^2/V^2$ or more; and
      b. Response time of less than 1 ms; or

   2. Second order non-linear susceptibility ($\chi^{(2)}$, chi 2) of 3.3×10^{-11} m/V or more;

6. C. 4. d. "Substrate blanks" of silicon carbide or beryllium beryllium (Be/Be) deposited materials, exceeding 300 mm in diameter or major axis length;

6. C. 4. e. Glass, including fused silica, phosphate glass, fluorophosphate glass, zirconium fluoride (ZrF_4) (CAS 7783-64-4) and hafnium fluoride (HfF_4) (CAS 13709-52-9) and having all of the following:
   1. A hydroxyl ion (OH-) concentration of less than 5 ppm;
   2. Integrated metallic purity levels of less than 1 ppm; and
   3. High homogeneity (index of refraction variance) less than 5×10^{-6};

6. C. 4. f. Synthetically produced diamond material with an absorption of less than 10^{-5} cm^{-1} for wavelengths exceeding 200 nm but not exceeding 14,000 nm.

LASERS

6. C. 5. "Laser" materials as follows:

a. Synthetic crystalline "laser" host material in unfinished form as follows:
   1. Titanium doped sapphire.
   2. Not used since 2012

b. Rare-earth-metal doped double-clad fibres having any of the following:
   1. Nominal "laser" wavelength of 975 nm to 1,150 nm and having all of the following:
      a. Average core diameter equal to or greater than 25 µm; and
      b. Core 'Numerical Aperture' ('NA') less than 0.065; or

      Note *6.C.5.b.1. does not apply to double-clad fibres having an inner glass cladding diameter exceeding 150 µm and not exceeding 300 µm.*
   2. Nominal "laser" wavelength exceeding 1,530 nm and having all of the following:
      a. Average core diameter equal to or greater than 20 µm; and
      b. Core 'NA' less than 0.1.

Technical Notes
1. *For the purposes of 6.C.5., the core 'Numerical Aperture' ('NA') is measured at the emission wavelengths of the fibre.*
2. *6.C.5.b. includes fibres assembled with end caps.*

6. C. 6. MAGNETIC AND ELECTRIC FIELD SENSORS - None

6. C. 7. GRAVIMETERS - None

6. C. 8. RADAR - None

6. D. SOFTWARE

1. "Software" specially designed for the "development" or "production" of equipment specified by 6.A.4., 6.A.5., 6.A.8. or 6.B.8.
2. "Software" specially designed for the "use" of equipment specified by 6.A.2.b., 6.A.8. or 6.B.8.

6. D. 3. Other "software" as follows:

ACOUSTICS

6. D. 3. a. "Software" as follows:
1. "Software" specially designed for acoustic beam forming for the "real-time processing" of acoustic data for passive reception using towed hydrophone arrays;
2. "Source code" for the "real-time processing" of acoustic data for passive reception using towed hydrophone arrays;
3. "Software" specially designed for acoustic beam forming for the "real-time processing" of acoustic data for passive reception using bottom or bay cable systems;
4. "Source code" for the "real-time processing" of acoustic data for passive reception using bottom or bay cable systems;
5. "Software" or "source code", specially designed for all of the following:
a. "Real-time processing" of acoustic data from sonar systems specified by 6.A.1.a.1.e.; and
b. Automatically detecting, classifying and determining the location of divers or swimmers;
N.B. For diver detection "software" or "source code", specially designed or modified for military use, see the Munitions List.

6. D. 3. b. OPTICAL SENSORS – None

CAMERAS

6. D. 3. c. "Software" designed or modified for cameras incorporating "focal plane arrays" specified by 6.A.2.a.3.f. and designed or modified to remove a frame rate restriction and allow the camera to exceed the frame rate specified in 6.A.3.b.4. Note 3.a.

OPTICS

6. D. 3. d. "Software" specially designed to maintain the alignment and phasing of segmented mirror systems consisting of mirror segments having a diameter or major axis length equal to or larger than 1 m;

6. D. 3. e. LASERS – None

MAGNETIC AND ELECTRIC FIELD SENSORS

6. D. 3. f. "Software" as follows:
1. "Software" specially designed for magnetic and electric field "compensation systems" for magnetic sensors designed to operate on mobile platforms;
2. "Software" specially designed for magnetic and electric field anomaly detection on mobile platforms;
3. "Software" specially designed for "real-time processing" of electromagnetic data using underwater electromagnetic receivers specified by 6.A.6.e.;
4. "Source code" for "real-time processing" of electromagnetic data using underwater electromagnetic receivers specified by 6.A.6.e;

GRAVIMETERS

6. D. 3. g. "Software" specially designed to correct motional influences of gravity meters or gravity gradiometers;

RADAR

6. D. 3. h. "Software" as follows:
1. Air Traffic Control (ATC) "software" application "programs" designed to be hosted on general purpose computers located at Air Traffic Control centres and capable of accepting radar target data from more than four primary radars;
2. "Software" for the design or "production" of radomes and having all of the following:
a. Specially designed to protect the "electronically steerable phased array antennae" specified by 6.A.8.e.; and
b. Resulting in an antenna pattern having an 'average side lobe level' more than 40 dB below the peak of the main beam level.
Technical Note
'Average side lobe level' in 6.D.3.h.2.b. is measured over the entire array excluding the angular extent of the main beam and the first two side lobes on either side of the main beam.

6. E. TECHNOLOGY

6. E. 1. "Technology" according to the General Technology Note for the "development" of equipment, materials or "software" specified by 6.A., 6.B., 6.C. or 6.D.

6. E. 2. "Technology" according to the General Technology Note for the "production" of equipment or materials specified by 6.A., 6.B. or 6.C.

6. E. 3. Other "technology" as follows:

a. ACOUSTICS – None

b. OPTICAL SENSORS – None

c. CAMERAS – None

OPTICS

6. E. 3. d. "Technology" as follows:

1. "Technology" "required" for the coating and treatment of optical surfaces to achieve an 'optical thickness' uniformity of 99.5% or better for optical coatings 500 mm or more in diameter or major axis length and with a total loss (absorption and scatter) of less than 5×10^{-3};

   N.B. See also 2.E.3.f.

   Technical Note
   'Optical thickness' is the mathematical product of the index of refraction and the physical thickness of the coating.

2. "Technology" for the fabrication of optics using single point diamond turning techniques to produce surface finish "accuracies" of better than 10 nm rms on non-planar surfaces exceeding 0.5 m^2;

LASERS

6. E. 3. e. "Technology" "required" for the "development", "production" or "use" of specially designed diagnostic instruments or targets in test facilities for "SHPL" testing or testing or evaluation of materials irradiated by "SHPL" beams;

6. E. 3. f. MAGNETIC AND ELECTRIC FIELD SENSORS - Not used since 2004;

6. E. 3. g. GRAVIMETERS – None

6. E. 3. h. RADAR – None

7. A. SYSTEMS, EQUIPMENT AND COMPONENTS

N.B. For automatic pilots for underwater vehicles, see Category 8.
For radar, see Category 6.

7. A. 1. Accelerometers as follows and specially designed components therefor:

N.B. For angular or rotational accelerometers, see 7.A.1.b.

a. Linear accelerometers having any of the following:

1. Specified to function at linear acceleration levels less than or equal to 15 g and having any of the following:
   a. A "bias" "stability" of less (better) than 130 micro g with respect to a fixed calibration value over a period of one year; or
   b. A "scale factor" "stability" of less (better) than 130 ppm with respect to a fixed calibration value over a period of one year;
2. Specified to function at linear acceleration levels exceeding 15 g but less than or equal to 100 g and having all of the following:
   a. A "bias" "repeatability" of less (better) than 1,250 micro g over a period of one year; and
   b. A "scale factor" "repeatability" of less (better) than 1,250 ppm over a period of one year; or
3. Designed for use in inertial navigation or guidance systems and specified to function at linear acceleration levels exceeding 100 g;

Note 7.A.1.a.1. and 7.A.1.a.2. do not apply to accelerometers limited to measurement of only vibration or shock.

7. A. 1. b. Angular or rotational accelerometers, specified to function at linear acceleration levels exceeding 100 g.

7. A. 2. Gyros or angular rate sensors, having any of the following and specially designed components therefor:

N.B. For angular or rotational accelerometers, see 7.A.1.b.

a. Specified to function at linear acceleration levels less than or equal to 100 g and having any of the following:

1. A rate range of less than 500 degrees per second and having any of the following:
   a. A "bias" "stability" of less (better) than 0.5 degree per hour, when measured in a 1 g environment over a period of one month, and with respect to a fixed calibration value; or
   b. An "angle random walk" of less (better) than or equal to 0.0035 degree per square root hour; or

   Note 7.A.2.a.1.b. does not apply to "spinning mass gyros".

7. A. 2. a. 2. A rate range greater than or equal to 500 degrees per second and having any of the following:
   a. A "bias" "stability" of less (better) than 4 degrees per hour, when measured in a 1 g environment over a period of three minutes, and with respect to a fixed calibration value; or

7. A. 2. a. 2. b. An "angle random walk" of less (better) than or equal to 0.1 degree per square root hour; or

Note 7.A.2.a.2.b. does not apply to "spinning mass gyros".

7. A. 2. b. Specified to function at linear acceleration levels exceeding 100 g.

7. A. 3. 'Inertial measurement equipment or systems', having any of the following:

Note 1 'Inertial measurement equipment or systems' incorporate accelerometers or gyroscopes to measure changes in velocity and orientation in order to determine or maintain heading or position without requiring an external reference once aligned. 'Inertial measurement equipment or systems' include:

- *Attitude and Heading Reference Systems (AHRSs);*
- *Gyrocompasses;*
- *Inertial Measurement Units (IMUs);*
- *Inertial Navigation Systems (INSs);*
- *Inertial Reference Systems (IRSs);*
- *Inertial Reference Units (IRUs).*

Note 2 7.A.3. does not apply to 'inertial measurement equipment or systems' which are certified for use on "civil aircraft" by civil aviation authorities of one or more Wassenaar Arrangement Participating States.

Technical Note
'Positional aiding references' independently provide position, and include:
a. Global Navigation Satellite Systems (GNSS);
b. "Data-Based Referenced Navigation" ("DBRN").

7. A. 3. a. Designed for "aircraft", land vehicles or vessels, providing position without the use of 'positional aiding references', and having any of the following "accuracies" subsequent to normal alignment:

1. 0.8 nautical miles per hour (nm/hr) "Circular Error Probable" ("CEP") rate or less (better);
2. 0.5% distanced travelled "CEP" or less (better); or
3. Total drift of 1 nautical mile "CEP" or less (better) in a 24 hr period;

Technical Note
The performance parameters in 7.A.3.a.1., 7.A.3.a.2. and 7.A.3.a.3. typically apply to 'inertial measurement equipment or systems' designed for "aircraft", vehicles and vessels, respectively. These parameters result from the utilisation of specialised non-positional aiding references (e.g., altimeter, odometer, velocity log). As a consequence, the specified performance values cannot be readily converted between these parameters. Equipment designed for multiple platforms are evaluated against each applicable entry 7.A.3.a.1., 7.A.3.a.2., or 7.A.3.a.3.

7. A. 3. b. Designed for "aircraft", land vehicles or vessels, with an embedded 'positional aiding reference' and providing position after loss of all 'positional aiding references' for a period of up to 4 minutes, having an "accuracy" of less (better) than 10 meters "CEP";

Technical Note
7.A.3.b. refers to systems in which 'inertial measurement equipment or systems' and other independent 'positional aiding references' are built into a single unit (i.e., embedded) in order to achieve improved performance.

7. A. 3. c. Designed for "aircraft", land vehicles or vessels, providing heading or True North determination and having any of the following:
1. A maximum operating angular rate less (lower) than 500 deg/s and a heading "accuracy" without the use of 'positional aiding references' equal to or less (better) than 0.07 deg sec(Lat) (equivalent to 6 arc minutes rms at 45 degrees latitude); or
2. A maximum operating angular rate equal to or greater (higher) than 500 deg/s and a heading "accuracy" without the use of 'positional aiding references' equal to or less (better) than 0.2 deg sec(Lat) (equivalent to 17 arc minutes rms at 45 degrees latitude);

7. A. 3. d. Providing acceleration measurements or angular rate measurements, in more than one dimension, and having any of the following:
1. Performance specified by 7.A.1. or 7.A.2. along any axis, without the use of any aiding references; or
2. Being "space-qualified" and providing angular rate measurements having an "angle random walk" along any axis of less (better) than or equal to 0.1 degree per square root hour.

Note *7.A.3.d.2. does not apply to 'inertial measurement equipment or systems' that contain "spinning mass gyros" as the only type of gyro.*

7. A. 4. 'Star trackers' and components therefor, as follows:
a. 'Star trackers' with a specified azimuth "accuracy" of equal to or less (better) than 20 seconds of arc throughout the specified lifetime of the equipment;
b. Components specially designed for equipment specified in 7.A.4.a. as follows:
1. Optical heads or baffles;
2. Data processing units.

Technical Note
'Star trackers' are also referred to as stellar attitude sensors or gyro-astro compasses.

7. A. 5. Global Navigation Satellite Systems (GNSS) receiving equipment having any of the following and specially designed components therefor:

N.B. *For equipment specially designed for military use, see ML11.*

a. Employing a decryption algorithm specially designed or modified for government use to access the ranging code for position and time; or
b. Employing 'adaptive antenna systems'.

Note *7.A.5.b. does not apply to GNSS receiving equipment that only uses components designed to filter, switch, or combine signals from multiple omni-directional antennae that do not implement adaptive antenna techniques.*

Technical Note
For the purposes of 7.A.5.b 'adaptive antenna systems' dynamically generate one or more spatial nulls in an antenna array pattern by signal processing in the time domain or frequency domain.

7. A. 6. Airborne altimeters operating at frequencies other than 4.2 to 4.4 GHz inclusive and having any of the following:
   a. "Power management"; or
   b. Using phase shift key modulation.

7. A. 7. Not used since 2004

7. A. 8. Underwater sonar navigation systems using doppler velocity or correlation velocity logs integrated with a heading source and having a positioning "accuracy" of equal to or less (better) than 3% of distance travelled "Circular Error Probable" ("CEP") and specially designed components therefor.

Note *7.A.8. does not apply to systems specially designed for installation on surface vessels or systems requiring acoustic beacons or buoys to provide positioning data.*

N.B. *See Category 6.A.1.a. for acoustic systems, and 6.A.1.b. for correlation-velocity and Doppler-velocity sonar log equipment.*
See Category 8.A.2. for other marine systems.

7. B. TEST, INSPECTION AND PRODUCTION EQUIPMENT

7. B. 1. Test, calibration or alignment equipment, specially designed for equipment specified by 7.A.

Note *7.B.1. does not apply to test, calibration or alignment equipment for 'Maintenance Level I' or 'Maintenance Level II'.*

Technical Notes

1. *'Maintenance Level I'*
   The failure of an inertial navigation unit is detected on the "aircraft" by indications from the Control and Display Unit (CDU) or by the status message from the corresponding sub-system. By following the manufacturer's manual, the cause of the failure may be localised at the level of the malfunctioning Line Replaceable Unit (LRU). The operator then removes the LRU and replaces it with a spare.
2. *'Maintenance Level II'*
   The defective LRU is sent to the maintenance workshop (the manufacturer's or that of the operator responsible for level II maintenance). At the maintenance workshop, the malfunctioning LRU is tested by various appropriate means to verify and localise the defective Shop Replaceable Assembly (SRA) module responsible for the failure. This SRA is removed and replaced by an operative spare. The defective SRA (or possibly the complete LRU) is then shipped to the manufacturer. 'Maintenance Level II' does not include the disassembly or repair of specified accelerometers or gyro sensors.

7. B. 2. Equipment specially designed to characterize mirrors for ring "laser" gyros, as follows:
   a. Scatterometers having a measurement "accuracy" of 10 ppm or less (better);
   b. Profilometers having a measurement "accuracy" of 0.5 nm (5 angstrom) or less (better).

7. B. 3. Equipment specially designed for the "production" of equipment specified by 7.A.

Note *7.B.3. includes:*
- *Gyro tuning test stations;*
- *Gyro dynamic balance stations;*
- *Gyro run-in/motor test stations;*
- *Gyro evacuation and fill stations;*
- *Centrifuge fixtures for gyro bearings;*
- *Accelerometer axis align stations;*
- *Fibre optic gyro coil winding machines.*

7. C. MATERIALS - None

7. D. SOFTWARE

7. D. 1. "Software" specially designed or modified for the "development" or "production" of equipment specified by 7.A. or 7.B.

7. D. 2. "Source code" for the operation or maintenance of any inertial navigation equipment, including inertial equipment not specified by 7.A.3. or 7.A.4., or Attitude and Heading Reference Systems ('AHRS').

Note *7.D.2. does not apply to "source code" for the operation or maintenance of gimballed 'AHRS'.*

Technical Note
'AHRS' generally differ from Inertial Navigation Systems (INS) in that an 'AHRS' provides attitude and heading information and normally does not provide the acceleration, velocity and position information associated with an INS.

7. D. 3. Other "software" as follows:
   a. "Software" specially designed or modified to improve the operational performance or reduce the navigational error of systems to the levels specified by 7.A.3., 7.A.4. or 7.A.8.;
   b. "Source code" for hybrid integrated systems which improves the operational performance or reduces the navigational error of systems to the level specified by 7.A.3. or 7.A.8. by continuously combining heading data with any of the following:
      1. Doppler radar or sonar velocity data;
      2. Global Navigation Satellite Systems (GNSS) reference data; or
      3. Data from "Data-Based Referenced Navigation" ("DBRN") systems;
   c. Not used since 2013
   d. Not used since 2012

N.B. *For flight control "source code", see 7.D.4.*

7. D. 3. e. Computer-Aided-Design (CAD) "software" specially designed for the "development" of "active flight control systems", helicopter multi-axis fly-by-wire or fly-by-light controllers or helicopter "circulation controlled anti-torque or circulation-controlled direction control systems", whose "technology" is specified by 7.E.4.b.1., 7.E.4.b.3. to 7.E.4.b.5., 7.E.4.b.7., 7.E.4.b.8., 7.E.4.c.1. or 7.E.4.c.2.

7. D. 4. "Source code" incorporating "development" "technology" specified by 7.E.4.a.2., 7.E.4.a.3., 7.E.4.a.5., 7.E.4.a.6. or 7.E.4.b., for any of the following:

a. Digital flight management systems for "total control of flight";
b. Integrated propulsion and flight control systems;
c. "Fly-by-wire systems" or "fly-by-light systems";
d. Fault-tolerant or self-reconfiguring "active flight control systems";
e. Not used since 2012
f. Air data systems based on surface static data; <u>or</u>
g. Three dimensional displays.

<u>Note</u> *7.D.4. does not apply to "source code" associated with common computer elements and utilities (e.g., input signal acquisition, output signal transmission, computer program and data loading, built-in test, task scheduling mechanisms) not providing a specific flight control system function.*

7. D. 5. "Software" specially designed to decrypt Global Navigation Satellite Systems (GNSS) ranging code designed for government use.

7. E. <u>TECHNOLOGY</u>

7. E. 1. "Technology" according to the General Technology Note for the "development" of equipment or "software", specified by 7.A., 7.B., 7.D.1., 7.D.2., 7.D.3. or 7.D.5.

<u>Note</u> *7.E.1. includes key management "technology" exclusively for equipment specified in 7.A.5.a.*

7. E. 2. "Technology" according to the General Technology Note for the "production" of equipment specified by 7.A. or 7.B.

7. E. 3. "Technology" according to the General Technology Note for the repair, refurbishing or overhaul of equipment specified by 7.A.1. to 7.A.4.

<u>Note</u> *7.E.3. does not apply to "technology" for maintenance, directly associated with calibration, removal or replacement of damaged or unserviceable LRUs and SRAs of a "civil aircraft" as described in 'Maintenance Level I' or 'Maintenance Level II'.*

<u>N.B.</u> *See Technical Notes to 7.B.1.*

7. E. 4. Other "technology" as follows:

a. "Technology" for the "development" or "production" of any of the following:
   1. Not used since 2011
   2. Air data systems based on surface static data only, i.e., which dispense with conventional air data probes;
   3. Three dimensional displays for "aircraft";
   4. Not used since 2010

7. E. 4. a. 5. Electric actuators (i.e., electromechanical, electrohydrostatic and integrated actuator package) specially designed for "primary flight control";

6. "Flight control optical sensor array" specially designed for implementing "active flight control systems"; or

7. "DBRN" systems designed to navigate underwater, using sonar or gravity databases, that provide a positioning "accuracy" equal to or less (better) than 0.4 nautical miles;

7. E. 4. b. "Development" "technology", as follows, for "active flight control systems" (including "fly-by-wire systems" or "fly-by-light systems"):

1. Photonic-based "technology" for sensing "aircraft" or flight control component state, transferring flight control data, or commanding actuator movement, "required" for "fly-by-light systems" "active flight control systems";

2. Not used since 2012

3. Real-time algorithms to analyze component sensor information to predict and preemptively mitigate impending degradation and failures of components within an "active flight control system";

Note *7.E.4.b.3. does not include algorithms for the purpose of off-line maintenance.*

4. Real-time algorithms to identify component failures and reconfigure force and moment controls to mitigate "active flight control system" degradations and failures;

Note *7.E.4.b.4. does not include algorithms for the elimination of fault effects through comparison of redundant data sources, or off-line pre-planned responses to anticipated failures.*

5. Integration of digital flight control, navigation and propulsion control data, into a digital flight management system for "total control of flight";

Note *7.E.4.b.5. does not apply to:*

1. "Technology" for integration of digital flight control, navigation and propulsion control data, into a digital flight management system for "flight path optimisation";

2. "Technology" for "aircraft" flight instrument systems integrated solely for VOR, DME, ILS or MLS navigation or approaches.

7. E. 4. b. 6. Not used since 2013

7. E. 4. b. 7. "Technology" "required" for deriving the functional requirements for "fly-by-wire systems" having all of the following:

a. 'Inner-loop' airframe stability controls requiring loop closure rates of 40 Hz or greater; and

Technical Note

'Inner-loop' refers to functions of "active flight control systems" that automate airframe stability controls.

7. E. 4. b. 7. b. Having any of the following:

1. Corrects an aerodynamically unstable airframe, measured at any point in the design flight envelope, that would lose recoverable control if not corrected within 0.5 seconds;
2. Couples controls in two or more axes while compensating for 'abnormal changes in aircraft state';

   Technical Note
   'Abnormal changes in aircraft state' include in-flight structural damage, loss of engine thrust, disabled control surface, or destabilizing shifts in cargo load.

3. Performs the functions specified in 7.E.4.b.5.; or

   Note 7.E.4.b.7.b.3. does not apply to autopilots.

4. Enables "aircraft" to have stable controlled flight, other than during take-off or landing, at greater than 18 degrees angle of attack, 15 degrees side slip, 15 degrees/second pitch or yaw rate, or 90 degrees/second roll rate;

7. E. 4. b. 8. "Technology" "required" for deriving the functional requirements for "fly-by-wire systems" to achieve all of the following:

a. No loss of control of the "aircraft" in the event of a consecutive sequence of any two individual faults within the "fly-by-wire system"; and
b. Probability of loss of control of the "aircraft" being less (better) than $1x10^{-9}$ failures per flight hour;

Note 7.E.4.b. does not apply to "technology" associated with common computer elements and utilities (e.g., input signal acquisition, output signal transmission, computer program and data loading, built-in test, task scheduling mechanisms) not providing a specific flight control system function.

7. E. 4. c. "Technology" for the "development" of helicopter systems, as follows:

1. Multi-axis fly-by-wire or fly-by-light controllers, which combine the functions of at least two of the following into one controlling element:
   a. Collective controls;
   b. Cyclic controls;
   c. Yaw controls;
2. "Circulation-controlled anti-torque or circulation-controlled direction control systems";
3. Rotor blades incorporating "variable geometry airfoils", for use in systems using individual blade control.

8. A. SYSTEMS, EQUIPMENT AND COMPONENTS

8. A. 1. Submersible vehicles and surface vessels, as follows:

N.B. For the status of equipment for submersible vehicles, see:
- *Category 6 for sensors;*
- *Categories 7 and 8 for navigation equipment;*
- *Category 8.A. for underwater equipment.*

8. A. 1. a. Manned, tethered submersible vehicles designed to operate at depths exceeding 1,000 m;

8. A. 1. b. Manned, untethered submersible vehicles having any of the following:
1. Designed to 'operate autonomously' and having a lifting capacity of all the following:
   a. 10% or more of their weight in air; and
   b. 15 kN or more;
2. Designed to operate at depths exceeding 1,000 m; or
3. Having all of the following:
   a. Designed to continuously 'operate autonomously' for 10 hours or more; and
   b. 'Range' of 25 nautical miles or more;

Technical Notes
1. *For the purposes of 8.A.1.b., 'operate autonomously' means fully submerged, without snorkel, all systems working and cruising at minimum speed at which the submersible can safely control its depth dynamically by using its depth planes only, with no need for a support vessel or support base on the surface, sea-bed or shore, and containing a propulsion system for submerged or surface use.*
2. *For the purposes of 8.A.1.b., 'range' means half the maximum distance a submersible vehicle can 'operate autonomously'.*

8. A. 1. c. Unmanned, tethered submersible vehicles designed to operate at depths exceeding 1,000 m and having any of the following:
1. Designed for self-propelled manoeuvre using propulsion motors or thrusters specified by 8.A.2.a.2.; or
2. Fibre optic data link;

8. A. 1. d. Unmanned, untethered submersible vehicles having any of the following:
1. Designed for deciding a course relative to any geographical reference without real-time human assistance;
2. Acoustic data or command link; or
3. Optical data or command link exceeding 1,000 m;

8. A. 1. e. Ocean salvage systems with a lifting capacity exceeding 5 MN for salvaging objects from depths exceeding 250 m and having any of the following:
   1. Dynamic positioning systems capable of position keeping within 20 m of a given point provided by the navigation system; or
   2. Seafloor navigation and navigation integration systems, for depths exceeding 1,000 m and with positioning "accuracies" to within 10 m of a predetermined point.

8. A. 1. f. Not used since 2014

8. A. 1. g. Not used since 2014

8. A. 1. h. Not used since 2014

8. A. 1. i. Not used since 2014

8. A. 2. Marine systems, equipment and components, as follows:

N.B. *For underwater communications systems, see Category 5 – Part 1 - Telecommunications.*

a. Systems, equipment and components, specially designed or modified for submersible vehicles and designed to operate at depths exceeding 1,000 m, as follows:
   1. Pressure housings or pressure hulls with a maximum inside chamber diameter exceeding 1.5 m;
   2. Direct current propulsion motors or thrusters;
   3. Umbilical cables, and connectors therefor, using optical fibre and having synthetic strength members;
   4. Components manufactured from material specified by 8.C.1.;

      Technical Note
      The objective of 8.A.2.a.4. should not be defeated by the export of 'syntactic foam' specified by 8.C.1. when an intermediate stage of manufacture has been performed and it is not yet in its final component form.

8. A. 2. b. Systems specially designed or modified for the automated control of the motion of submersible vehicles specified by 8.A.1., using navigation data, having closed loop servo-controls and having any of the following:
   1. Enabling a vehicle to move within 10 m of a predetermined point in the water column;
   2. Maintaining the position of the vehicle within 10 m of a predetermined point in the water column; or
   3. Maintaining the position of the vehicle within 10 m while following a cable on or under the seabed;

8. A. 2. c. Fibre optic pressure hull penetrators;

8. A. 2. d. Underwater vision systems specially designed or modified for remote operation with an underwater vehicle, employing techniques to minimise the effects of back scatter and including range-gated illuminators or "laser" systems;

8. A. 2. e. Not used since 2015

8. A. 2. f. Not used since 2009

1. Not used since 2009

N.B. *For electronic imaging systems specially designed or modified for underwater use incorporating image intensifier tubes specified by 6.A.2.a.2.a. or 6.A.2.a.2.b., see 6.A.3.b.3.*

2. Not used since 2009

N.B. *For electronic imaging systems specially designed or modified for underwater use incorporating "focal plane arrays" specified by 6.A.2.a.3.g., see 6.A.3.b.4.c.*

8. A. 2. g. Light systems specially designed or modified for underwater use, as follows:

1. Stroboscopic light systems capable of a light output energy of more than 300 J per flash and a flash rate of more than 5 flashes per second;
2. Argon arc light systems specially designed for use below 1,000 m;

8. A. 2. h. "Robots" specially designed for underwater use, controlled by using a dedicated computer and having any of the following:

1. Systems that control the "robot" using information from sensors which measure force or torque applied to an external object, distance to an external object, or tactile sense between the "robot" and an external object; or
2. The ability to exert a force of 250 N or more or a torque of 250 Nm or more and using titanium based alloys or "composite" "fibrous or filamentary materials" in their structural members;

8. A. 2. i. Remotely controlled articulated manipulators specially designed or modified for use with submersible vehicles and having any of the following:

1. Systems which control the manipulator using information from sensors which measure any of the following:
   a. Torque or force applied to an external object; or
   b. Tactile sense between the manipulator and an external object; or
2. Controlled by proportional master-slave techniques and having 5 degrees of 'freedom of movement' or more;

Technical Note

Only functions having proportionally related motion control using positional feedback are counted when determining the number of degrees of 'freedom of movement'.

8. A. 2. j. Air independent power systems specially designed for underwater use, as follows:
   1. Brayton or Rankine cycle engine air independent power systems having any of the following:
      a. Chemical scrubber or absorber systems, specially designed to remove carbon dioxide, carbon monoxide and particulates from recirculated engine exhaust;
      b. Systems specially designed to use a monoatomic gas;
      c. Devices or enclosures, specially designed for underwater noise reduction in frequencies below 10 kHz, or special mounting devices for shock mitigation; or
      d. Systems having all of the following:
         1. Specially designed to pressurise the products of reaction or for fuel reformation;
         2. Specially designed to store the products of the reaction; and
         3. Specially designed to discharge the products of the reaction against a pressure of 100 kPa or more;

8. A. 2. j. 2. Diesel cycle engine air independent systems having all of the following:
   a. Chemical scrubber or absorber systems, specially designed to remove carbon dioxide, carbon monoxide and particulates from recirculated engine exhaust;
   b. Systems specially designed to use a monoatomic gas;
   c. Devices or enclosures, specially designed for underwater noise reduction in frequencies below 10 kHz, or special mounting devices for shock mitigation; and
   d. Specially designed exhaust systems that do not exhaust continuously the products of combustion;

8. A. 2. j. 3. "Fuel cell" air independent power systems with an output exceeding 2 kW and having any of the following:
   a. Devices or enclosures, specially designed for underwater noise reduction in frequencies below 10 kHz, or special mounting devices for shock mitigation; or
   b. Systems having all of the following:
      1. Specially designed to pressurise the products of reaction or for fuel reformation;
      2. Specially designed to store the products of the reaction; and
      3. Specially designed to discharge the products of the reaction against a pressure of 100 kPa or more;

8. A. 2. j. 4. Stirling cycle engine air independent power systems having all of the following:
   a. Devices or enclosures, specially designed for underwater noise reduction in frequencies below 10 kHz, or special mounting devices for shock mitigation; and
   b. Specially designed exhaust systems which discharge the products of combustion against a pressure of 100 kPa or more;

8. A. 2. k. Not used since 2014

8. A. 2. l. Not used since 2014

8. A. 2. m. Not used since 2014

8. A. 2. n. Not used since 2014

8. A. 2. o. Propellers, power transmission systems, power generation systems and noise reduction systems, as follows:

1. Not used since 2014

2. Water-screw propeller, power generation systems or transmission systems, designed for use on vessels, as follows:

a. Controllable-pitch propellers and hub assemblies, rated at more than 30 MW;

b. Internally liquid-cooled electric propulsion engines with a power output exceeding 2.5 MW;

c. "Superconductive" propulsion engines or permanent magnet electric propulsion engines, with a power output exceeding 0.1 MW;

d. Power transmission shaft systems incorporating "composite" material components and capable of transmitting more than 2 MW;

e. Ventilated or base-ventilated propeller systems, rated at more than 2.5 MW;

8. A. 2. o. 3. Noise reduction systems designed for use on vessels of 1,000 tonnes displacement or more, as follows:

a. Systems that attenuate underwater noise at frequencies below 500 Hz and consist of compound acoustic mounts for the acoustic isolation of diesel engines, diesel generator sets, gas turbines, gas turbine generator sets, propulsion motors or propulsion reduction gears, specially designed for sound or vibration isolation and having an intermediate mass exceeding 30% of the equipment to be mounted;

b. 'Active noise reduction or cancellation systems' or magnetic bearings, specially designed for power transmission systems;

Technical Note

'Active noise reduction or cancellation systems' incorporate electronic control systems capable of actively reducing equipment vibration by the generation of anti-noise or anti-vibration signals directly to the source.

8. A. 2. p. Pumpjet propulsion systems having all of the following:

1. Power output exceeding 2.5 MW; and

2. Using divergent nozzle and flow conditioning vane techniques to improve propulsive efficiency or reduce propulsion-generated underwater-radiated noise;

8. A. 2. q. Underwater swimming and diving equipment as follows:

1. Closed circuit rebreathers;

2. Semi-closed circuit rebreathers;

Note *8.A.2.q. does not apply to individual rebreathers for personal use when accompanying their users.*

N.B. *For equipment and devices specially designed for military use, see ML17.a. on the Munitions List.*

8. A. 2. r. Diver deterrent acoustic systems specially designed or modified to disrupt divers and having a sound pressure level equal to or exceeding 190 dB (reference 1 µPa at 1 m) at frequencies of 200 Hz and below.

Note 1 *8.A.2.r. does not apply to diver deterrent systems based on underwater explosive devices, air guns or combustible sources.*

Note 2 *8.A.2.r. includes diver deterrent acoustic systems that use spark gap sources, also known as plasma sound sources.*

8. B. TEST, INSPECTION AND PRODUCTION EQUIPMENT

8. B. 1. Water tunnels having a background noise of less than 100 dB (reference 1 µPa, 1 Hz) in the frequency range from 0 to 500 Hz and designed for measuring acoustic fields generated by a hydro-flow around propulsion system models.

8. C. MATERIALS

8. C. 1. 'Syntactic foam' designed for underwater use and having all of the following:
a. Designed for marine depths exceeding 1,000 m; and
b. A density less than 561 kg/m^3.

Technical Note
'Syntactic foam' consists of hollow spheres of plastic or glass embedded in a resin "matrix".

N.B. *See also 8.A.2.a.4.*

8. D. SOFTWARE

8. D. 1. "Software" specially designed or modified for the "development", "production" or "use" of equipment or materials, specified by 8.A., 8.B. or 8.C.

8. D. 2. Specific "software" specially designed or modified for the "development", "production", repair, overhaul or refurbishing (re-machining) of propellers specially designed for underwater noise reduction.

8. E. TECHNOLOGY

8. E. 1. "Technology" according to the General Technology Note for the "development" or "production" of equipment or materials, specified by 8.A., 8.B. or 8.C.

8. E. 2. Other "technology" as follows:

a. "Technology" for the "development", "production", repair, overhaul or refurbishing (re-machining) of propellers specially designed for underwater noise reduction;
b. "Technology" for the overhaul or refurbishing of equipment specified by 8.A.1., 8.A.2.b., 8.A.2.j., 8.A.2.o. or 8.A.2.p.

8. E. 2. c. "Technology" according to the General Technology Note for the "development" or "production" of any of the following:

1. Surface-effect vehicles (fully skirted variety) having all of the following:
   a. Maximum design speed, fully loaded, exceeding 30 knots in a significant wave height of 1.25 m or more;
   b. Cushion pressure exceeding 3,830 Pa; and
   c. Light-ship-to-full-load displacement ratio of less than 0.70;
2. Surface-effect vehicles (rigid sidewalls) with a maximum design speed, fully loaded, exceeding 40 knots in a significant wave height of 3.25 m or more;
3. Hydrofoil vessels with active systems for automatically controlling foil systems, with a maximum design speed, fully loaded, of 40 knots or more in a significant wave height of 3.25 m or more; or
4. 'Small waterplane area vessels' having any of the following:
   a. Full load displacement exceeding 500 tonnes with a maximum design speed, fully loaded, exceeding 35 knots in a significant wave height of 3.25 m or more; or
   b. Full load displacement exceeding 1,500 tonnes with a maximum design speed, fully loaded, exceeding 25 knots in a significant wave height of 4 m or more.

Technical Note

A 'small waterplane area vessel' is defined by the following formula: waterplane area at an operational design draft less than 2x (displaced volume at the operational design draft)$^{2/3}$.

9. A. SYSTEMS, EQUIPMENT AND COMPONENTS

*N.B. For propulsion systems designed or rated against neutron or transient ionizing radiation, see the Munitions List.**

9. A. 1. Aero gas turbine engines having any of the following:

a. Incorporating any of the "technologies" specified by 9.E.3.a., 9.E.3.h. or 9.E.3.i.; or

Note 1 9.A.1.a. does not apply to aero gas turbine engines which meet all of the following:

a. Certified by civil aviation authorities of one or more Wassenaar Arrangement Participating States; and

b. Intended to power non-military manned "aircraft" for which any of the following has been issued by civil aviation authorities of one or more Wassenaar Arrangement Participating States for the "aircraft" with this specific engine type:

1. A civil type certificate; or

2. An equivalent document recognised by the International Civil Aviation Organisation (ICAO).

Note 2 9.A.1.a. does not apply to aero gas turbine engines designed for Auxiliary Power Units (APUs) approved by the civil aviation authority in a Wassenaar Arrangement Participating State.

9. A. 1. b. Designed to power an "aircraft" designed to cruise at Mach 1 or higher, for more than 30 minutes.

9. A. 2. 'Marine gas turbine engines' with an ISO standard continuous power rating of 24,245 kW or more and a specific fuel consumption not exceeding 0.219 kg/kWh in the power range from 35 to 100%, and specially designed assemblies and components therefor.

Note The term 'marine gas turbine engines' includes those industrial, or aero-derivative, gas turbine engines adapted for a ship's electric power generation or propulsion.

9. A. 3. Specially designed assemblies or components, incorporating any of the "technologies" specified by 9.E.3.a., 9.E.3.h. or 9.E.3.i., for any of the following aero gas turbine engines:

a. Specified by 9.A.1. or;

b. Whose design or production origins are either not from a Wassenaar Arrangement Participating State or unknown to the manufacturer.

* The Russian Federation and Ukraine view this list as a reference list drawn up to help in the selection of dual-use goods which could contribute to the indigenous development, production or enhancement of conventional munitions capabilities.

9. A. 4. Space launch vehicles, "spacecraft", "spacecraft buses", "spacecraft payloads", "spacecraft" on-board systems or equipment, and terrestrial equipment, as follows:
   a. Space launch vehicles;
   b. "Spacecraft";
   c. "Spacecraft buses";
   d. "Spacecraft payloads" incorporating items specified by 3.A.1.b.1.a.4., 3.A.2.g., 5.A.1.a.1., 5.A.1.b.3., 5.A.2.c., 5.A.2.e., 6.A.2.a.1., 6.A.2.a.2., 6.A.2.b., 6.A.2.d., 6.A.3.b., 6.A.4.c., 6.A.4.e., 6.A.8.d., 6.A.8.e., 6.A.8.k., 6.A.8.l. or 9.A.10.c.;

9. A. 4. e. On-board systems or equipment, specially designed for "spacecraft" and having any of the following functions:
   1. 'Command and telemetry data handling';

      Note *For the purpose of 9.A.4.e.1., 'command and telemetry data handling' includes bus data management, storage, and processing.*

   2. 'Payload data handling'; or

      Note *For the purpose of 9.A.4.e.2., 'payload data handling' includes payload data management, storage, and processing.*

   3. 'Attitude and orbit control';

      Note *For the purpose of 9.A.4.e.3., 'attitude and orbit control' includes sensing and actuation to determine and control the position and orientation of a "spacecraft".*

N.B. *For equipment specially designed for military use, see ML 11.c.*

9. A. 4. f. Terrestrial equipment specially designed for "spacecraft", as follows:
   1. Telemetry and telecommand equipment;
   2. Simulators.

9. A. 5. Liquid rocket propulsion systems containing any of the systems or components, specified by 9.A.6.

9. A. 6. Systems and components, specially designed for liquid rocket propulsion systems, as follows:
   a. Cryogenic refrigerators, flightweight dewars, cryogenic heat pipes or cryogenic systems, specially designed for use in space vehicles and capable of restricting cryogenic fluid losses to less than 30% per year;
   b. Cryogenic containers or closed-cycle refrigeration systems, capable of providing temperatures of 100 K (-173°C) or less for "aircraft" capable of sustained flight at speeds exceeding Mach 3, launch vehicles or "spacecraft";
   c. Slush hydrogen storage or transfer systems;
   d. High pressure (exceeding 17.5 MPa) turbo pumps, pump components or their associated gas generator or expander cycle turbine drive systems;
   e. High-pressure (exceeding 10.6 MPa) thrust chambers and nozzles therefor;

9. A. 6. f. Propellant storage systems using the principle of capillary containment or positive expulsion (i.e., with flexible bladders);

g. Liquid propellant injectors with individual orifices of 0.381 mm or smaller in diameter (an area of 1.14 x 10^{-3} cm² or smaller for non-circular orifices) and specially designed for liquid rocket engines;

h. One-piece carbon-carbon thrust chambers or one-piece carbon-carbon exit cones, with densities exceeding 1.4 g/cm³ and tensile strengths exceeding 48 MPa.

9. A. 7. Solid rocket propulsion systems having any of the following:

a. Total impulse capacity exceeding 1.1 MNs;

b. Specific impulse of 2.4 kNs/kg or more, when the nozzle flow is expanded to ambient sea level conditions for an adjusted chamber pressure of 7 MPa;

c. Stage mass fractions exceeding 88% and propellant solid loadings exceeding 86%;

d. Components specified by 9.A.8.; or

e. Insulation and propellant bonding systems, using direct-bonded motor designs to provide a 'strong mechanical bond' or a barrier to chemical migration between the solid propellant and case insulation material.

Technical Note
A 'strong mechanical bond' means bond strength equal to or more than propellant strength.

9. A. 8. Components specially designed for solid rocket propulsion systems, as follows:

a. Insulation and propellant bonding systems, using liners to provide a 'strong mechanical bond' or a barrier to chemical migration between the solid propellant and case insulation material;

b. Filament-wound "composite" motor cases exceeding 0.61 m in diameter or having 'structural efficiency ratios (PV/W)' exceeding 25 km;

Technical Note
'Structural efficiency ratio (PV/W)' is the burst pressure (P) multiplied by the vessel volume (V) divided by the total pressure vessel weight (W).

c. Nozzles with thrust levels exceeding 45 kN or nozzle throat erosion rates of less than 0.075 mm/s;

d. Movable nozzle or secondary fluid injection thrust vector control systems, capable of any of the following:

1. Omni-axial movement exceeding ± 5°;
2. Angular vector rotations of 20°/s or more; or
3. Angular vector accelerations of 40°/s^2 or more.

9. A. 9. Hybrid rocket propulsion systems having any of the following:

a. Total impulse capacity exceeding 1.1 MNs; or

b. Thrust levels exceeding 220 kN in vacuum exit conditions.

9. A. 10. Specially designed components, systems and structures, for launch vehicles, launch vehicle propulsion systems or "spacecraft", as follows:

a. Components and structures, each exceeding 10 kg and specially designed for launch vehicles manufactured using any of the following:

1. "Composite" materials consisting of "fibrous or filamentary materials" specified by 1.C.10.e. and resins specified by 1.C.8. or 1.C.9.b.;

2. Metal "matrix" "composites" reinforced by any of the following:

a. Materials specified by 1.C.7.;

b. "Fibrous or filamentary materials" specified by 1.C.10.; or

c. Aluminides specified by 1.C.2.a.; or

3. Ceramic "matrix" "composite" materials specified by 1.C.7.;

Note *The weight cut-off is not relevant for nose cones.*

9. A. 10. b. Components and structures, specially designed for launch vehicle propulsion systems specified by 9.A.5. to 9.A.9. manufactured using any of the following:

1. "Fibrous or filamentary materials" specified by 1.C.10.e. and resins specified by 1.C.8. or 1.C.9.b.;

2. Metal "matrix" "composite" materials reinforced by any of the following:

a. Materials specified by 1.C.7.;

b. "Fibrous or filamentary materials" specified by 1.C.10.; or

c. Aluminides specified by 1.C.2.a.; or

3. Ceramic "matrix" "composite" materials specified by 1.C.7.;

c. Structural components and isolation systems, specially designed to control actively the dynamic response or distortion of "spacecraft" structures;

d. Pulsed liquid rocket engines with thrust-to-weight ratios equal to or more than 1 kN/kg and a response time (the time required to achieve 90% of total rated thrust from start-up) of less than 30 ms.

9. A. 11. Ramjet, scramjet or combined cycle engines, and specially designed components therefor.

9. A. 12. "Unmanned Aerial Vehicles" ("UAVs"), unmanned "airships", related equipment and components, as follows:

a. "UAVs" or unmanned "airships", designed to have controlled flight out of the direct 'natural vision' of the 'operator' and having any of the following:

1. Having all of the following:

a. A maximum 'endurance' greater than or equal to 30 minutes but less than 1 hour; and

b. Designed to take-off and have stable controlled flight in wind gusts equal to or exceeding 46.3 km/h (25 knots); or

2. A maximum 'endurance' of 1 hour or greater;

Technical Notes

1. For the purposes of 9.A.12.a., 'operator' is a person who initiates or commands the "UAV" or unmanned "airship" flight.

2. For the purposes of 9.A.12.a., 'endurance' is to be calculated for ISA conditions (ISO 2533:1975) at sea level in zero wind.

3. For the purposes of 9.A.12.a., 'natural vision' means unaided human sight, with or without corrective lenses.

9. A. 12. b. Related equipment and components, as follows:
   1. Not used since 2014
   2. Not used since 2014
   3. Equipment or components, specially designed to convert a manned "aircraft" or a manned "airship" to a "UAV" or unmanned "airship", specified by 9.A.12.a.;
   4. Air breathing reciprocating or rotary internal combustion type engines, specially designed or modified to propel "UAVs" or unmanned "airships", at altitudes above 15,240 meters (50,000 feet).

9. B. TEST, INSPECTION AND PRODUCTION EQUIPMENT

9. B. 1. Equipment, tooling or fixtures, specially designed for manufacturing gas turbine engine blades, vanes or "tip shrouds", as follows:
   a. Directional solidification or single crystal casting equipment;
   b. Casting tooling, manufactured from refractory metals or ceramics, as follows:
      1. Cores;
      2. Shells (moulds);
      3. Combined core and shell (mould) units;
   c. Directional-solidification or single-crystal additive-manufacturing equipment.

9. B. 2. On-line (real time) control systems, instrumentation (including sensors) or automated data acquisition and processing equipment, having all of the following:
   a. Specially designed for the "development" of gas turbine engines, assemblies or components; and
   b. Incorporating any of the "technologies" specified by 9.E.3.h. or 9.E.3.i.

9. B. 3. Equipment specially designed for the "production" or test of gas turbine brush seals designed to operate at tip speeds exceeding 335 m/s and temperatures in excess of 773 K (500°C), and specially designed components or accessories therefor.

9. B. 4. Tools, dies or fixtures, for the solid state joining of "superalloy", titanium or intermetallic airfoil-to-disk combinations described in 9.E.3.a.3. or 9.E.3.a.6. for gas turbines.

9. B. 5. On-line (real time) control systems, instrumentation (including sensors) or automated data acquisition and processing equipment, specially designed for use with any of the following:
   a. Wind tunnels designed for speeds of Mach 1.2 or more;

      Note *9.B.5.a. does not apply to wind tunnels specially designed for educational purposes and having a 'test section size' (measured laterally) of less than 250 mm.*

      Technical Note
      'Test section size' means the diameter of the circle, or the side of the square, or the longest side of the rectangle, at the largest test section location.

9. B. 5. b. Devices for simulating flow-environments at speeds exceeding Mach 5, including hot-shot tunnels, plasma arc tunnels, shock tubes, shock tunnels, gas tunnels and light gas guns; or
c. Wind tunnels or devices, other than two-dimensional sections, capable of simulating Reynolds number flows exceeding 25 x 10^6.

9. B. 6. Acoustic vibration test equipment capable of producing sound pressure levels of 160 dB or more (referenced to 20 μPa) with a rated output of 4 kW or more at a test cell temperature exceeding 1,273 K (1,000°C), and specially designed quartz heaters therefor.

9. B. 7. Equipment specially designed for inspecting the integrity of rocket motors and using Non-Destructive Test (NDT) techniques other than planar x-ray or basic physical or chemical analysis.

9. B. 8. Direct measurement wall skin friction transducers specially designed to operate at a test flow total (stagnation) temperature exceeding 833 K (560°C).

9. B. 9. Tooling specially designed for producing gas turbine engine powder metallurgy rotor components having all of the following:
a. Designed to operate at stress levels of 60% of Ultimate Tensile Strength (UTS) or more measured at a temperature of 873 K (600°C); and
b. Designed to operate at 873 K (600°C) or more.

Note 9.B.9. does not specify tooling for the production of powder.

9. B. 10. Equipment specially designed for the production of items specified by 9.A.12.

9. C. MATERIALS - None

9. D. SOFTWARE

9. D. 1. "Software" specially designed or modified for the "development" of equipment or "technology", specified by 9.A., 9.B. or 9.E.3.

9. D. 2. "Software" specially designed or modified for the "production" of equipment specified by 9.A. or 9.B.

9. D. 3. "Software" incorporating "technology" specified by 9.E.3.h. and used in "FADEC Systems" for systems specified by 9.A. or equipment specified by 9.B.

9. D. 4. Other "software" as follows:
a. 2D or 3D viscous "software", validated with wind tunnel or flight test data required for detailed engine flow modelling;
b. "Software" for testing aero gas turbine engines, assemblies or components, specially designed to collect, reduce and analyse data in real time and capable of feedback control, including the dynamic adjustment of test articles or test conditions, as the test is in progress;
c. "Software" specially designed to control directional-solidification or single-crystal material growth in equipment specified by 9.B.1.a. or 9.B.1.c.;
d. Not used since 2011

9. D. 4. e. "Software" specially designed or modified for the operation of items specified by 9.A.12;

f. "Software" specially designed to design the internal cooling passages of aero gas turbine engine blades, vanes and "tip shrouds";

g. "Software" having all of the following:

1. Specially designed to predict aero thermal, aeromechanical and combustion conditions in aero gas turbine engines; and

2. Theoretical modelling predictions of the aero thermal, aeromechanical and combustion conditions, which have been validated with actual aero gas turbine engine (experimental or production) performance data.

9. D. 5. "Software" specially designed or modified for the operation of items specified by 9.A.4.e. or 9.A.4.f.

9. E. TECHNOLOGY

Note *"Development" or "production" "technology" specified by 9.E. for gas turbine engines remains specified by 9.E. when used for repair or overhaul. Excluded from 9.E. are: technical data, drawings or documentation for maintenance activities directly associated with calibration, removal or replacement of damaged or unserviceable line replaceable units, including replacement of whole engines or engine modules.*

9. E. 1. "Technology" according to the General Technology Note for the "development" of equipment or "software", specified by 9.A.1.b., 9.A.4. to 9.A.12., 9.B. or 9.D.

9. E. 2. "Technology" according to the General Technology Note for the "production" of equipment specified by 9.A.1.b., 9.A.4. to 9.A.11. or 9.B.

N.B. *For "technology" for the repair of specified structures, laminates or materials, see 1.E.2.f.*

9. E. 3. Other "technology" as follows:

a. "Technology" "required" for the "development" or "production" of any of the following gas turbine engine components or systems:

1. Gas turbine blades, vanes or "tip shrouds", made from directionally solidified (DS) or single crystal (SC) alloys and having (in the 001 Miller Index Direction) a stress-rupture life exceeding 400 hours at 1,273 K (1,000°C) at a stress of 200 MPa, based on the average property values;

Technical Note
For the purposes of 9.E.3.a.1., stress-rupture life testing is typically conducted on a test specimen.

2. Combustors having any of the following:

a. 'Thermally decoupled liners' designed to operate at 'combustor exit temperature' exceeding 1,883K (1,610°C);

b. Non-metallic liners;

c. Non-metallic shells; or

d. Liners designed to operate at 'combustor exit temperature' exceeding 1,883K (1,610°C) and having holes that meet the parameters specified by 9.E.3.c.;

Note *The "required" "technology" for holes in 9.E.3.a.2. is limited to the derivation of the geometry and location of the holes.*

Technical Notes

1. *'Thermally decoupled liners' are liners that feature at least a support structure designed to carry mechanical loads and a combustion facing structure designed to protect the support structure from the heat of combustion. The combustion facing structure and support structure have independent thermal displacement (mechanical displacement due to thermal load) with respect to one another, i.e. they are thermally decoupled.*
2. *'Combustor exit temperature' is the bulk average gas path total (stagnation) temperature between the combustor exit plane and the leading edge of the turbine inlet guide vane (i.e., measured at engine station T40 as defined in SAE ARP 755A) when the engine is running in a 'steady state mode' of operation at the certificated maximum continuous operating temperature.*

N.B. *See 9.E.3.c. for "technology" "required" for manufacturing cooling holes.*

9. E. 3. a. 3. Components that are any of the following:

a. Manufactured from organic "composite" materials designed to operate above 588 K (315°C);

b. Manufactured from any of the following:

1. Metal "matrix" "composites" reinforced by any of the following:
   a. Materials specified by 1.C.7.;
   b. "Fibrous or filamentary materials" specified by 1.C.10.; or
   c. Aluminides specified by 1.C.2.a.; or
2. Ceramic "matrix" "composites" specified by 1.C.7.; or

c. Stators, vanes, blades, tip seals (shrouds), rotating blings, rotating blisks, or 'splitter ducts', that are all of the following:

1. Not specified in 9.E.3.a.3.a.;
2. Designed for compressors or fans; and
3. Manufactured from material specified by 1.C.10.e. with resins specified by 1.C.8.;

Technical Note

A 'splitter duct' performs the initial separation of the air-mass flow between the bypass and core sections of the engine.

9. E. 3. a. 4. Uncooled turbine blades, vanes or "tip-shrouds", designed to operate at a 'gas path temperature' of 1,373 K (1,100°C) or more;

9. E. 3. a. 5. Cooled turbine blades, vanes, "tip-shrouds" other than those described in 9.E.3.a.1., designed to operate at a 'gas path temperature' of 1,693 K (1,420°C) or more;

Technical Notes

1. *'Gas path temperature' is the bulk average gas path total (stagnation) temperature at the leading edge plane of the turbine component when the engine is running in a 'steady state mode' of operation at the certificated or specified maximum continuous operating temperature.*

Technical Notes (cont.)

2. *The term 'steady state mode' defines engine operation conditions, where the engine parameters, such as thrust/power, rpm and others, have no appreciable fluctuations, when the ambient air temperature and pressure at the engine inlet are constant.*

9. E. 3. a. 6. Airfoil-to-disk blade combinations using solid state joining;

7. Gas turbine engine components using "diffusion bonding" "technology" specified by 2.E.3.b.;

8. 'Damage tolerant' gas turbine engine rotor components using powder metallurgy materials specified by 1.C.2.b.; or

Technical Note
'Damage tolerant' components are designed using methodology and substantiation to predict and limit crack growth.

9. Not used since 2009

N.B. For "FADEC systems", see 9.E.3.h.

10. Not used since 2010

N.B. For adjustable flow path geometry, see 9.E.3.i.

11. Hollow fan blades;

9. E. 3. b. "Technology" "required" for the "development" or "production" of any of the following:

1. Wind tunnel aero-models equipped with non-intrusive sensors capable of transmitting data from the sensors to the data acquisition system; or
2. "Composite" propeller blades or prop fans, capable of absorbing more than 2,000 kW at flight speeds exceeding Mach 0.55;

9. E. 3. c. "Technology" "required" for manufacturing cooling holes, in gas turbine engine components incorporating any of the "technologies" specified by 9.E.3.a.1., 9.E.3.a.2. or 9.E.3.a.5., and having any of the following:

1. Having all of the following:
   a. Minimum 'cross-sectional area' less than 0.45 mm^2;
   b. 'Hole shape ratio' greater than 4.52; and
   c. 'Incidence angle' equal to or less than 25°; or
2. Having all of the following:
   a. Minimum 'cross-sectional area' less than 0.12 mm^2;
   b. 'Hole shape ratio' greater than 5.65; and
   c. 'Incidence angle' more than 25°;

Note 9.E.3.c. does not apply to "technology" for manufacturing constant radius cylindrical holes that are straight through and enter and exit on the external surfaces of the component.

Technical Notes

1. *For the purposes of 9.E.3.c., the 'cross-sectional area' is the area of the hole in the plane perpendicular to the hole axis.*
2. *For the purposes of 9.E.3.c., 'hole shape ratio' is the nominal length of the axis of the hole divided by the square root of its minimum 'cross-sectional area'.*
3. *For the purposes of 9.E.3.c., 'incidence angle' is the acute angle measured between the plane tangential to the aerofoil surface and the hole axis at the point where the hole axis enters the aerofoil surface.*
4. *Techniques for manufacturing holes in 9.E.3.c include "laser", water jet, Electro-Chemical Machining (ECM) or Electrical Discharge Machining (EDM) methods.*

9. E. 3. d. "Technology" "required" for the "development" or "production" of helicopter power transfer systems or tilt rotor or tilt wing "aircraft" power transfer systems;

9. E. 3. e. "Technology" for the "development" or "production" of reciprocating diesel engine ground vehicle propulsion systems having all of the following:

1. 'Box volume' of 1.2 m^3 or less;
2. An overall power output of more than 750 kW based on 80/1269/EEC, ISO 2534 or national equivalents; and
3. Power density of more than 700 kW/m^3 of 'box volume';

Technical Note

'Box volume' is the product of three perpendicular dimensions measured in the following way:

Length: The length of the crankshaft from front flange to flywheel face;

Width: The widest of any of the following:

a. The outside dimension from valve cover to valve cover;
b. The dimensions of the outside edges of the cylinder heads; or
c. The diameter of the flywheel housing;

Height: The largest of any of the following:

a. The dimension of the crankshaft centre-line to the top plane of the valve cover (or cylinder head) plus twice the stroke; or
b. The diameter of the flywheel housing.

9. E. 3. f. "Technology" "required" for the "production" of specially designed components for high output diesel engines, as follows:

1. "Technology" "required" for the "production" of engine systems having all of the following components employing ceramics materials specified by 1.C.7.:
   a. Cylinder liners;
   b. Pistons;
   c. Cylinder heads; and
   d. One or more other components (including exhaust ports, turbochargers, valve guides, valve assemblies or insulated fuel injectors);

9. E. 3. f. 2. "Technology" "required" for the "production" of turbocharger systems with single-stage compressors and having all of the following:

a. Operating at pressure ratios of 4:1 or higher;
b. Mass flow in the range from 30 to 130 kg per minute; and
c. Variable flow area capability within the compressor or turbine sections;

9. E. 3. f. 3. "Technology" "required" for the "production" of fuel injection systems with a specially designed multifuel (e.g., diesel or jet fuel) capability covering a viscosity range from diesel fuel (2.5 cSt at 310.8 K (37.8°C)) down to gasoline fuel (0.5 cSt at 310.8 K (37.8°C)) and having all of the following:

a. Injection amount in excess of 230 mm^3 per injection per cylinder; and

b. Electronic control features specially designed for switching governor characteristics automatically depending on fuel property to provide the same torque characteristics by using the appropriate sensors;

9. E. 3. g. "Technology" "required" for the "development" or "production" of 'high output diesel engines' for solid, gas phase or liquid film (or combinations thereof) cylinder wall lubrication and permitting operation to temperatures exceeding 723 K (450°C), measured on the cylinder wall at the top limit of travel of the top ring of the piston;

Technical Note

'High output diesel engines' are diesel engines with a specified brake mean effective pressure of 1.8 MPa or more at a speed of 2,300 r.p.m., provided the rated speed is 2,300 r.p.m. or more.

9. E. 3. h. "Technology" for gas turbine engine "FADEC systems" as follows:

1. "Development" "technology" for deriving the functional requirements for the components necessary for the "FADEC system" to regulate engine thrust or shaft power (e.g., feedback sensor time constants and accuracies, fuel valve slew rate);
2. "Development" or "production" "technology" for control and diagnostic components unique to the "FADEC system" and used to regulate engine thrust or shaft power;
3. "Development" "technology" for the control law algorithms, including "source code", unique to the "FADEC system" and used to regulate engine thrust or shaft power;

Note *9.E.3.h. does not apply to technical data related to engine-"aircraft" integration required by civil aviation authorities of one or more Wassenaar Arrangement Participating States to be published for general airline use (e.g., installation manuals, operating instructions, instructions for continued airworthiness) or interface functions (e.g., input/output processing, airframe thrust or shaft power demand).*

9. E. 3. i. "Technology" for adjustable flow path systems designed to maintain engine stability for gas generator turbines, fan or power turbines, or propelling nozzles, as follows:

1. "Development" "technology" for deriving the functional requirements for the components that maintain engine stability;
2. "Development" or "production" "technology" for components unique to the adjustable flow path system and that maintain engine stability;
3. "Development" "technology" for the control law algorithms, including "source code", unique to the adjustable flow path system and that maintain engine stability.

Note *9.E.3.i. does not apply to "technology" for any of the following:*
a. Inlet guide vanes;
b. Variable pitch fans or prop-fans;
c. Variable compressor vanes;
d. Compressor bleed valves; or
e. Adjustable flow path geometry for reverse thrust.

9. E. 3. j. "Technology" "required" for the "development" of wing-folding systems designed for fixed-wing "aircraft" powered by gas turbine engines.

N.B. For "technology" "required" for the "development" of wing-folding systems designed for fixed-wing "aircraft" specified in ML10., see ML22.

THE SENSITIVE LIST OF DUAL-USE GOODS AND TECHNOLOGIES

N.B. *Where abbreviated entries are used, see the List of Dual-Use Goods and Technologies for full details. Text that differs from that in the List of Dual-Use Goods and Technologies is shaded.*

Category 1

1.A.2.	"Composite" structures or laminates...
1.C.1.	Materials specially designed for use as absorbers of electromagnetic waves...
1.C.7.c.	Ceramic-"matrix" "composite" materials...
1.C.7.d.	Not used since 2016
1.C.10.c. & 1.C.10.d.	"Fibrous or filamentary materials"...
1.C.12.	Materials as follows...
1.D. 2	"Software" for the "development" of organic "matrix", metal "matrix" or carbon "matrix" laminates or "composites" specified by this List.
1.E.1.	"Technology" according to the General Technology Note for the "development" or "production" of equipment and materials specified by 1.A.2. or 1.C. of this List.
1.E. 2.e. & 1.E.2.f.	Other "technology"...

Category 2

2.B.1.a.	Not used since 2002
2.B.1.b.	Not used since 2002
2.B.1.d.	Not used since 2002
2.B.1.f.	Not used since 2002
2.B.3.	Not used since 2002

2.D.1. "Software", other than that specified by 2.D.2., specially designed for the "development" or "production" of equipment as follows:

a. Machine tools for turning having two or more axes which can be coordinated simultaneously for "contouring control" having any of the following:
   1. "Unidirectional positioning repeatability" equal to or less (better) than 0.9 µm along one or more linear axis with a travel length less than 1.0 m; or
   2. "Unidirectional positioning repeatability" equal to or less (better) than 1.1 µm along one or more linear axis with a travel length equal to or greater than 1.0 m;

2.D.1. b. Machine tools for milling having any of the following:
   1. Three linear axes plus one rotary axis which can be coordinated simultaneously for "contouring control" having any of the following:
      a. "Unidirectional positioning repeatability" equal to or less (better) than 0.9 µm along one or more linear axis with a travel length less than 1.0 m; or
      b. "Unidirectional positioning repeatability" equal to or less (better) than 1.1 µm along one or more linear axis with a travel length equal to or greater than 1.0 m;
   2. Specified by 2.B.1.b.2.a., 2.B.1.b.2.b. or 2.B.1.b.2.c., and having a "unidirectional positioning repeatability" equal to or less (better) than 0.9 µm along one or more linear axis; or

Category 2 cont.

2.D.1.

b. 3. A "unidirectional positioning repeatability" for jig boring machines equal to or less (better) than 1.1 µm along one or more linear axis;

c. Electrical discharge machines (EDM) as specified in 2.B.1.d.;

d. Deep-hole-drilling machines as specified in 2.B.1.f.;

e. "Numerically controlled" or manual machine tools as specified in 2.B.3.

2.E.1.

"Technology" according to the General Technology Note for the "development" of "software" specified by 2.D. of this List or for the "development" of equipment as follows:

a. Machine tools for turning having two or more axes which can be coordinated simultaneously for "contouring control" having any of the following:

1. "Unidirectional positioning repeatability" equal to or less (better) than 0.9 µm along one or more linear axis with a travel length less than 1.0 m; or

2. "Unidirectional positioning repeatability" equal to or less (better) than 1.1 µm along one or more linear axis with a travel length equal to or greater than 1.0 m;

2.E.1.

b. Machine tools for milling having any of the following:

1. Three linear axes plus one rotary axis which can be coordinated simultaneously for "contouring control" having any of the following:

a. "Unidirectional positioning repeatability" equal to or less (better) than 0.9 µm along one or more linear axis with a travel length less than 1.0 m; or

b. "Unidirectional positioning repeatability" equal to or less (better) than 1.1 µm along one or more linear axis with a travel length equal to or greater than 1.0 m;

2. Specified by 2.B.1.b.2.a., 2.B.1.b.2.b. or 2.B.1.b.2.c., and having a "unidirectional positioning repeatability" equal to or less (better) than 0.9 µm along one or more linear axis; or

3. A "unidirectional positioning repeatability" for jig boring machines equal to or less (better) than 1.1 µm along one or more linear axis;

2.E.1.

c. Electrical discharge machines (EDM) as specified in 2.B.1.d.;

d. Deep-hole-drilling machines as specified in 2.B.1.f.;

e. "Numerically controlled" or manual machine tools as specified in 2.B.3.

2.E.2.

"Technology" according to the General Technology Note for the "production" of equipment as follows:

a. Machine tools for turning having two or more axes which can be coordinated simultaneously for "contouring control" having any of the following:

Category 2 cont.

2.E.2. a. 1. "Unidirectional positioning repeatability" equal to or less (better) than 0.9 µm along one or more linear axis with a travel length less than 1.0 m; or
2. "Unidirectional positioning repeatability" equal to or less (better) than 1.1 µm along one or more linear axis with a travel length equal to or greater than 1.0 m;

2.E.2. b. Machine tools for milling having any of the following:
1. Three linear axes plus one rotary axis which can be coordinated simultaneously for "contouring control" having any of the following:
a. "Unidirectional positioning repeatability" equal to or less (better) than 0.9 µm along one or more linear axis with a travel length less than 1.0 m; or
b. "Unidirectional positioning repeatability" equal to or less (better) than 1.1 µm along one or more linear axis with a travel length equal to or greater than 1.0 m;

2.E.2. b. 2. Specified by 2.B.1.b.2.a., 2.B.1.b.2.b. or 2.B.1.b.2.c., and having a "unidirectional positioning repeatability" equal to or less (better) than 0.9 µm along one or more linear axis; or
3. A "unidirectional positioning repeatability" for jig boring machines equal to or less (better) than 1.1 µm along one or more linear axis;

2.E.2. c. Electrical discharge machines (EDM) as specified in 2.B.1.d.;
d. Deep-hole-drilling machines as specified in 2.B.1.f.;
e. "Numerically controlled" or manual machine tools as specified in 2.B.3.

Category 3

3.A.2.g.1. Atomic frequency standards... "Space-qualified"
3.B.1.a.2. Not used since 2011
3.D.1. "Software" specially designed for the "development" or "production" of equipment specified by 3.A.2.g. of this List.
3.E.1. "Technology" according to the General Technology Note for the "development" or "production" of equipment specified by 3.A. of this List.

Category 4

4.A.1.a.2. Electronic computers...radiation hardened…
4.A.3.b. Not used since 2002
4.A.3.c. Not used since 2001

4.D.1. "Software" specially designed for the "development" or "production" of equipment specified by 4.A. of this List or for the "development" or "production" of "digital computers" having an 'Adjusted Peak Performance' ('APP') exceeding 16 Weighted TeraFLOPS (WT).

Category 4 cont.

4.E.1.	"Technology" according to the General Technology Note for the "development" or "production" of any of the following equipment or "software": - Equipment specified by 4.A. of this List; - "Digital computers" having an 'Adjusted Peak Performance' ('APP') exceeding 16 Weighted TeraFLOPS (WT); or - "Software" specified by 4.D. of this List.

Category 5 - Part 1

5.A.1.b.3.	Being radio equipment...
5.A.1.b.5.	Being digitally controlled radio receivers...
5.A.1.h.	Counter Improvised Explosive Device (IED) equipment and related equipment...
5.B.1.a.	Equipment and specially designed components or accessories therefor, specially designed for the "development" or "production" of equipment, functions or features specified by 5.A.1. of this List.
5.D.1.a.	"Software" specially designed for the "development" or "production" of equipment, functions or features, specified by 5.A.1. of this List.
5.D.1.b.	Not used since 2014
5.E.1.a.	"Technology" according to the General Technology Note for the "development" or "production" of equipment, functions or features specified by 5.A.1. or "software" specified by 5.D.1.a. of this List.

Category 5 - Part 2 - None

Category 6

6.A.1.a.1.b.	Systems or transmitting and receiving arrays, designed for object detection or location, having any of the following: 1. A transmitting frequency below 5 kHz or a sound pressure level exceeding 224 dB (reference 1 µPa at 1 m) for equipment with an operating frequency in the band from 5 kHz to 10 kHz inclusive; 2. Sound pressure level exceeding 224 dB… 3. Sound pressure level exceeding 235 dB… 4. Forming beams of… 5. Designed to operate… 6. Designed to withstand…
6.A.1.a.1.e.	Active individual sonars...
6.A.1.a.2.a.1.	Hydrophones...Incorporating…
6.A.1.a.2.a.2.	Hydrophones...Incorporating flexible assemblies…
6.A.1.a.2.a.3.	Hydrophones...Having any...
6.A.1.a.2.a.5.	Hydrophones...Designed to operate...
6.A.1.a.2.a.6.	Hydrophones...Designed for...

Category 6 cont.

6.A.1.a.2.b. Towed acoustic hydrophone arrays...

6.A.1.a.2.c. Processing equipment, specially designed for real time application with towed acoustic hydrophone arrays, having "user-accessible programmability" and time or frequency domain processing and correlation, including spectral analysis, digital filtering and beamforming using Fast Fourier or other transforms or processes;

6.A.1.a.2.d. Heading sensors...

6.A.1.a.2.e. Bottom or bay-cable hydrophone arrays having any of the following:
1. Incorporating hydrophones... or
2. Incorporating multiplexed hydrophone group signal modules…

6.A.1.a.2.f. Processing equipment, specially designed for real time application with bottom or bay cable systems, having "user-accessible programmability" and time or frequency domain processing and correlation, including spectral analysis, digital filtering and beamforming using Fast Fourier or other transforms or processes.

6.A.2.a.1.a., b. and c. "Space-qualified" solid-state detectors...

6.A.2.a.1.d. "Space-qualified" "focal plane arrays"....

6.A.2.a.2.a. Image intensifier tubes ...
1. A peak response…
2. Electron image amplification…
3. Photocathodes, as follows:
   a. Multialkali photocathodes (e.g., S-20 and S-25) having a luminous sensitivity exceeding 700 µA/lm;
   b. GaAs or GaInAs photocathodes;
   c. Other "III/V compound" semiconductor photocathodes.

6.A.2.a.2.b. Image intensifier tubes…

6.A.2.a.3. Non-"space-qualified" "focal plane arrays"…;

Note 3

6.A.2.a.3. does not apply to the following "focal plane arrays" in this List:

a. Platinum Silicide (PtSi) "focal plane arrays" having less than 10,000 elements;

b. Iridium Silicide (IrSi) "focal plane arrays".

Note 4

6.A.2.a.3. does not apply to the following "focal plane arrays" in this List:

a. Indium Antimonide (InSb) or Lead Selenide (PbSe) "focal plane arrays" having less than 256 elements;

b. Indium Arsenide (InAs) "focal plane arrays";

c. Lead Sulphide (PbS) "focal plane arrays";

d. Indium Gallium Arsenide (InGaAs) "focal plane arrays".

Category 6 cont.

Note 5
6.A.2.a.3. does not apply to Mercury Cadmium Telluride (HgCdTe) "focal plane arrays" as follows in this List:
a. 'Scanning Arrays' having any of the following:
1. 30 elements or less; or
2. Incorporating time delay-and-integration within the element and having 2 elements or less;
b. 'Staring Arrays' having less than 256 elements.

Technical Notes
1. 'Scanning Arrays' are defined as "focal plane arrays" designed for use with a scanning optical system that images a scene in a sequential manner to produce an image;
2. 'Staring Arrays' are defined as "focal plane arrays" designed for use with a non-scanning optical system that images a scene.

Note 6
6.A.2.a.3. does not apply to the following "focal plane arrays" in this List:
a. Gallium Arsenide (GaAs) or Gallium Aluminium Arsenide (GaAlAs) quantum well "focal plane arrays" having less than 256 elements;
b. Microbolometer "focal plane arrays" having less than 8,000 elements.

Note 7
6.A.2.a.3.g. does not apply to the linear (1-dimensional) "focal plane arrays" specially designed or modified to achieve 'charge multiplication' having 4,096 elements or less.

Note 8
6.A.2.a.3.g. does not apply to the non-linear (2-dimensional) "focal plane arrays" specially designed or modified to achieve 'charge multiplication' having a maximum linear dimension of 4,096 elements and a total of 250,000 elements or less.

6.A.2.b. "Monospectral imaging sensors" and "multispectral imaging sensors"...

6.A.2.c. 'Direct view' imaging equipment incorporating any of the following:
1. Image intensifier tubes having the characteristics listed in 6.A.2.a.2.a. or 6.A.2.a.2.b. of this List;
2. "Focal plane arrays" having the characteristics listed in 6.A.2.a.3. of this List; or
3. Solid-state detectors having the characteristics listed in 6.A.2.a.1.;

6.A.2.e. Not used since 2008
N.B. Entry moved to 6.A.2.a.1.d. in 2008.

6.A.3.b.3. Imaging cameras incorporating image intensifier tubes having the characteristics listed in 6.A.2.a.2.a. or 6.A.2.a.2.b. of this List;

Note 6.A.3.b.3. does not apply to imaging cameras specially designed or modified for underwater use.

Category 6 cont.

6.A.3.b.4. Imaging cameras incorporating "focal plane arrays" having any of the following:

a. Incorporating "focal plane arrays" specified by 6.A.2.a.3.a. to 6.A.2.a.3.e. of this List;
b. Incorporating "focal plane arrays" specified by 6.A.2.a.3.f. of this List; or
c. Incorporating "focal plane arrays" listed in 6.A.2.a.3.g. of this List.

Note 1 ...
Note 2 ...
Note 3 ...
Note 4 ...

Note 5 *6.A.3.b.4.c. does not apply to imaging cameras specially designed or modified for underwater use.*

6.A.3.b.5. Imaging cameras incorporating solid-state detectors specified by 6.A.2.a.1.;

6.A.4.c. "Space-qualified" components for optical systems...

6.A.4.d. Optical control equipment...

6.A.6.a. Not used since 2006

6.A.6.a.1. "Magnetometers"... Using "superconductive" (SQUID) "technology"...

6.A.6.a.2. "Magnetometers" … Using optically pumped or nuclear precession (proton/Overhauser) "technology" having a 'sensitivity' lower (better) than 2pT rms per square root Hz;

6.A.6.c.1. "Magnetic gradiometers" using multiple "magnetometers" specified by 6.A.6.a.1. or 6.A.6.a.2. of this List;

6.A.6.d. "Compensation systems" for the following:

1. Magnetic sensors specified by 6.A.6.a.2. and using optically pumped or nuclear precession (proton/Overhauser) "technology" that will permit these sensors to realize a 'sensitivity' lower (better) than 2 pT rms per square root Hz.
2. Underwater electric field sensors specified by 6.A.6.b.
3. "Magnetic gradiometers" specified by 6.A.6.c. that will permit these sensors to realize a 'sensitivity' lower (better) than 3 pT/m rms per square root Hz.

6.A.6.e. Underwater electromagnetic receivers incorporating "magnetometers" specified by 6.A.6.a.1. or 6.A.6.a.2. of this List.

Category 6 cont.

6.A.6.g.	Not used since 2006
6.A.6.h.	Not used since 2006
6.A.8.d.	Radar systems...Capable of…
6.A.8.h.	Radar systems…Employing processing…
6.A.8.k.	Radar systems…Having "signal processing"…
6.A.8.l.3.	Not used since 2010
6.B.8.	Pulse radar cross-section…
6.D.1.	"Software" specially designed for the "development" or "production" of equipment specified by 6.A.4., 6.A.8. or 6.B.8. of this List.
6.D.3.a.	"Software", as follows:…
6.E.1.	"Technology" according to…
6.E.2.	"Technology" according to the General Technology Note for the "production" of equipment specified by 6.A. or 6.B. of this List.

Category 7

7.D.2.	"Source code" for the operation or maintenance…
7.D.3.a.	"Software" specially designed or modified to…
7.D.3.b.	"Source code" for…
7.D.3.c.	Not used since 2013
7.D.3.d.1. to 4. & 7.	Not used since 2012
7.D.4.a. to d. & g.	"Source code" incorporating "development" "technology" specified by…
7.E.1. & 7.E.2.	"Technology" according to the General Technology Note...

Category 8

8.A.1.b.	Manned, untethered submersible vehicles…
8.A.1.c.	Unmanned, tethered submersible vehicles...
8.A.1.d.	Unmanned, untethered submersible vehicles...
8.A.2.b.	Systems specially designed or modified for the automated control of the motion of submersible vehicles specified by 8.A.1. of this List using navigation data having closed loop servo-controls and having any of the following: 1. Enabling… 2. Maintaining… 3. Maintaining…
8.A.2.h.	"Robots" specially designed for underwater use...
8.A.2.j.	Air independent power systems...
8.A.2.o.3.	Noise reduction systems for use on vessels...
8.A.2.p.	Pumpjet propulsion systems...

Category 8 cont.

8.D.1.	"Software" specially designed for the "development" or "production" of equipment in 8.A. of this List.
8.D.2	Specific "software"…
8.E.1.	"Technology" according to the General Technology Note for the "development" or "production" of equipment specified by 8.A. of this List.
8.E.2.a.	Other "technology"...

Category 9

9.A.11.	Ramjet, scramjet or combined cycle engines...
9.B.1.	Equipment, tooling or fixtures, specially designed for manufacturing gas turbine engine blades, vanes or "tip shrouds", as follows: a. Directional-solidification or single-crystal casting equipment; b. Casting tooling, manufactured from refractory metals or ceramics, as follows: 1. Cores; 2. Shells (moulds); 3. Combined core and shell (mould) units; c. Directional-solidification...
9.D.1.	"Software" specially designed or modified for the "development" of equipment or "technology", specified by 9.A., 9.B. or 9.E.3. of this List.
9.D.2.	"Software" specially designed or modified for the "production" of equipment specified by 9.A. or 9.B. of this List.
9.D.4.a.	Other "software"… 2D or 3D…
9.D.4.c.	Other "software"…"Software" specially…
9.E.1.	"Technology" according to the General Technology Note…
9.E.2.	"Technology" according to the General Technology Note…
9.E.3.a.1. to 5. & 9.E.3.a.8.	"Technology" "required" for…
9.E.3.h.	"Technology" "required" for gas turbine "FADEC systems"…

VERY SENSITIVE LIST OF DUAL-USE GOODS AND TECHNOLOGIES

N.B. *Where abbreviated entries are used, see List of Dual-Use Goods and Technologies for full details. Text that differs from that in the List of Dual-Use Goods and Technologies is shaded.*

Category 1

1.A.2.a.	"Composite" structures or laminates consisting of an organic "matrix" and materials specified by 1.C.10.c. or 1.C.10.d.
1.C.1.	Materials specially designed for use as absorbers of electromagnetic waves...
1.C.12.	Materials as follows...
1.E.1.	"Technology" according to the General Technology Note for the "development" or "production" of equipment and materials specified by 1.A.2 or 1.C. of this List.

Category 2 None

Category 3 None

Category 4 None

Category 5 - Part 1

5.A.1.b.5.	Digitally controlled radio receivers...
5.A.1.h.	Counter Improvised Explosive Device (IED) equipment and related equipment...
5.D.1.a.	"Software" specially designed for the "development" or "production" of equipment, functions or features specified by Category 5 – Part 1 of this List.
5.E.1.a.	"Technology" according to the General Technology Note for the "development" or "production" of equipment, functions, features or "software" specified by Category 5 – Part 1 of this List.

Category 5 - Part 2 None

Category 6

6.A.1.a.1.b.1.	Systems or transmitting and receiving arrays, designed for object detection or location, having a sound pressure level exceeding 210 dB (reference 1 µPa at 1 m) and an operating frequency in the band from 30 Hz to 2 kHz.
6.A.1.a.2.a.1.	Hydrophones...Incorporating…
6.A.1.a.2.a.2.	Hydrophones...Incorporating flexible assemblies...
6.A.1.a.2.a.3.	Hydrophones...Having any...
6.A.1.a.2.a.5.	Hydrophones...Designed to operate …
6.A.1.a.2.a.6.	Hydrophones...Designed for...
6.A.1.a.2.b.	Towed acoustic hydrophone arrays...
6.A.1.a.2.c.	Processing equipment, specially designed for real time application with towed acoustic hydrophone arrays, having "user accessible programmability" and time or frequency domain processing and correlation, including spectral analysis, digital filtering and beamforming using Fast Fourier or other transforms or processes;
6.A.1.a.2.e.	Bottom or bay-cable hydrophone arrays having any of the following: 1. Incorporating hydrophones... or 2. Incorporating multiplexed hydrophone group signal modules …
6.A.1.a.2.f.	Processing equipment, specially designed for real time application with bottom or bay cable systems, having "user accessible programmability" and time or frequency domain processing and correlation, including spectral analysis, digital filtering and beamforming using Fast Fourier or other transforms or processes;
6.A.2.a.1.c.	"Space-qualified" solid-state detectors...
6.A.8.l.3.	Not used since 2010
6.B.8.	Pulse radar cross-section…
6.D.1.	"Software" specially designed for the "development" or "production" of equipment specified by 6.B.8. of this List.
6.D.3.a.	"Software", as follows: …
6.E.1.	"Technology" according to the General Technology Note for the "development" of equipment or "software" specified by 6.A., 6.B., or 6.D. of this List.
6.E.2.	"Technology" according to the General Technology Note for the "production" of equipment specified by 6.A. or 6.B. of this List.

Category 7

7.D.3.a.	"Software" specially designed or modified to…
7.D.3.b.	"Source code" for…

Category 8

8.A.1.b.	Manned, untethered submersible vehicles...
8.A.1.d.	Unmanned, untethered submersible vehicles...
8.A.2.o.3.b.	Active noise reduction or cancellation systems...
8.D.1.	"Software" specially designed for the "development" or "production" of equipment specified by 8.A. of this List.
8.E.1.	"Technology" according to the General Technology Note for the "development" or "production" of equipment specified by 8.A. of this List.

Category 9

9.A.11.	Ramjet, scramjet or combined cycle engines...
9.D.1.	"Software" specially designed or modified for the "development" of equipment or "technology" specified by 9.A. or 9.E.3. of this List.
9.D.2.	"Software" specially designed or modified for the "production" of equipment specified by 9.A. of this List.
9.E.1.	"Technology" according to the General Technology Note for the "development" of equipment or "software" specified by 9.A.11. or 9.D. of this List.
9.E.2.	"Technology" according to the General Technology Note for the "production" of equipment specified by 9.A.11. of this List.
9.E.3.a.1.	"Technology" "required" for… Gas turbine blades…
9.E.3.a.3.a.	"Technology" "required" for… Components... Manufactured from organic "composite" materials designed to operate above 588 K (315°C).

Note 1 *Terms in "quotations" are defined terms. Refer to 'Definitions of Terms used in these Lists' annexed to this List.*

Note 2 *In some instances chemicals are listed by name and CAS number. The list applies to chemicals of the same structural formula (including hydrates) regardless of name or CAS number. CAS numbers are shown to assist in identifying a particular chemical or mixture, irrespective of nomenclature. CAS numbers cannot be used as unique identifiers because some forms of the listed chemical have different CAS numbers, and mixtures containing a listed chemical may also have different CAS numbers.*

ML1. Smooth-bore weapons with a calibre of less than 20 mm, other arms and automatic weapons with a calibre of 12.7 mm (calibre 0.50 inches) or less and accessories, as follows, and specially designed components therefor:

Note *ML1. does not apply to:*

a. Firearms specially designed for dummy ammunition and which are incapable of discharging a projectile;
b. Firearms specially designed to launch tethered projectiles having no high explosive charge or communications link, to a range of less than or equal to 500 m.;
c. Weapons using non-centre fire cased ammunition and which are not of the fully automatic firing type;
d. "Deactivated firearms".

ML1. a. Rifles and combination guns, handguns, machine, sub-machine and volley guns;

Note *ML1.a. does not apply to the following:*

a. Rifles and combination guns, manufactured earlier than 1938;
b. Reproductions of rifles and combination guns, the originals of which were manufactured earlier than 1890;
c. Handguns, volley guns and machine guns, manufactured earlier than 1890, and their reproductions;
d. Rifles or handguns, specially designed to discharge an inert projectile by compressed air or CO_2.

ML1. b. Smooth-bore weapons as follows:

1. Smooth-bore weapons specially designed for military use;
2. Other smooth-bore weapons as follows:
   a. Fully automatic type weapons;
   b. Semi-automatic or pump-action type weapons;

Note *ML1.b.2. does not apply to weapons specially designed to discharge an inert projectile by compressed air or CO_2.*

* The Russian Federation and Ukraine view this list as a reference list drawn up to help in the selection of dual-use goods which could contribute to the indigenous development, production or enhancement of conventional munitions capabilities.

Note *ML1.b. does not apply to the following:*

a. Smooth-bore weapons manufactured earlier than 1938;

b. Reproductions of smooth-bore weapons, the originals of which were manufactured earlier than 1890.

c. Smooth-bore weapons used for hunting or sporting purposes. These weapons must not be specially designed for military use or of the fully automatic firing type;

d. Smooth-bore weapons specially designed for any of the following:

1. Slaughtering of domestic animals;

2. Tranquilizing of animals;

3. Seismic testing;

4. Firing of industrial projectiles; or

5. Disrupting Improvised Explosive Devices (IEDs).

N.B. For disruptors, see ML4. and 1.A.6. on the Dual-Use List.

ML1. c. Weapons using caseless ammunition;

ML1. d. Detachable cartridge magazines, sound suppressors or moderators, special gun-mountings, optical weapon-sights and flash suppressors, for arms specified by ML1.a., ML1.b. or ML1.c.

Note *ML1.d. does not apply to optical weapon-sights without electronic image processing, with a magnification of 9 times or less, provided they are not specially designed or modified for military use, or incorporate any reticles specially designed for military use.*

ML2. Smooth-bore weapons with a calibre of 20 mm or more, other weapons or armament with a calibre greater than 12.7 mm (calibre 0.50 inches), projectors and accessories, as follows, and specially designed components therefor:

a. Guns, howitzers, cannon, mortars, anti-tank weapons, projectile launchers, military flame throwers, rifles, recoilless rifles, smooth-bore weapons and signature reduction devices therefor;

Note 1 *ML2.a. includes injectors, metering devices, storage tanks and other specially designed components for use with liquid propelling charges for any of the equipment specified by ML2.a.*

Note 2 *ML2.a. does not apply to weapons as follows:*

a. Rifles, smooth-bore weapons and combination guns, manufactured earlier than 1938;

b. Reproductions of rifles, smooth-bore weapons and combination guns, the originals of which were manufactured earlier than 1890;

c. Guns, howitzers, cannons, mortars, manufactured earlier than 1890;

d. Smooth-bore weapons used for hunting or sporting purposes. These weapons must not be specially designed for military use or of the fully automatic firing type;

e. Smooth-bore weapons specially designed for any of the following:

1. Slaughtering of domestic animals;

2. Tranquilizing of animals;

3. Seismic testing;

4. Firing of industrial projectiles; or

5. Disrupting Improvised Explosive Devices (IEDs);

N.B. For disruptors, see ML4. and 1.A.6. on the Dual-Use List.

f. Hand-held projectile launchers specially designed to launch tethered projectiles having no high explosive charge or communications link, to a range of less than or equal to 500 m.

ML2. b. Smoke, gas and pyrotechnic projectors or generators, specially designed or modified for military use;

Note *ML2.b. does not apply to signal pistols.*

ML2. c. Weapons sights and weapon sight mounts, having all of the following:

1. Specially designed for military use; and
2. Specially designed for weapons specified in ML2.a.;

ML2. d. Mountings and detachable cartridge magazines, specially designed for the weapons specified in ML2.a.

ML3. Ammunition and fuze setting devices, as follows, and specially designed components therefor:

a. Ammunition for weapons specified by ML1., ML2. or ML12.;

b. Fuze setting devices specially designed for ammunition specified by ML3.a.

Note 1 *Specially designed components specified by ML3. include:*

a. Metal or plastic fabrications such as primer anvils, bullet cups, cartridge links, rotating bands and munitions metal parts;

b. Safing and arming devices, fuzes, sensors and initiation devices ;

c. Power supplies with high one-time operational output;

d. Combustible cases for charges;

e. Submunitions including bomblets, minelets and terminally guided projectiles.

Note 2 *ML3.a. does not apply to any of the following:*

a. Ammunition crimped without a projectile (blank star);

b. Dummy ammunition with a pierced powder chamber;

c. Other blank and dummy ammunition, not incorporating components designed for live ammunition; or

d. Components specially designed for blank or dummy ammunition, specified in this Note 2.a., b. or c.

Note 3 *ML3.a. does not apply to cartridges specially designed for any of the following purposes:*

a. Signalling;

b. Bird scaring; or

c. Lighting of gas flares at oil wells.

ML4. Bombs, torpedoes, rockets, missiles, other explosive devices and charges and related equipment and accessories, as follows, and specially designed components therefor:

N.B.1. For guidance and navigation equipment, see ML11.

N.B.2. For Aircraft Missile Protection Systems (AMPS), see ML4.c.

ML4. a. Bombs, torpedoes, grenades, smoke canisters, rockets, mines, missiles, depth charges, demolition-charges, demolition-devices, demolition-kits, "pyrotechnic" devices, cartridges and simulators (i.e., equipment simulating the characteristics of any of these items), specially designed for military use;

Note ML4.a. includes:

a. Smoke grenades, fire bombs, incendiary bombs and explosive devices;

b. Missile rocket nozzles and re-entry vehicle nosetips.

ML4. b. Equipment having all of the following:

1. Specially designed for military use; and
2. Specially designed for 'activities' relating to any of the following:
   a. Items specified by ML4.a.; or
   b. Improvised Explosive Devices (IEDs).

Technical Note

For the purpose of ML4.b.2. 'activities' applies to handling, launching, laying, controlling, discharging, detonating, activating, powering with one-time operational output, decoying, jamming, sweeping, detecting, disrupting or disposing.

Note 1 ML4.b. includes:

a. Mobile gas liquefying equipment capable of producing 1,000 kg or more per day of gas in liquid form;

b. Buoyant electric conducting cable suitable for sweeping magnetic mines.

Note 2 ML4.b. does not apply to hand-held devices limited by design solely to the detection of metal objects and incapable of distinguishing between mines and other metal objects.

ML4. c. Aircraft Missile Protection Systems (AMPS).

Note ML4.c. does not apply to AMPS having all of the following:

a. Any of the following missile warning sensors:

1. Passive sensors having peak response between 100-400 nm; or

2. Active pulsed Doppler missile warning sensors;

b. Countermeasures dispensing systems;

c. Flares, which exhibit both a visible signature and an infrared signature, for decoying surface-to-air missiles; and

d. Installed on "civil aircraft" and having all of the following:

1. The AMPS is only operable in a specific "civil aircraft" in which the specific AMPS is installed and for which any of the following has been issued:

a. A civil Type Certificate issued by civil aviation authorities of one or more Wassenaar Arrangement Participating States; or

b. An equivalent document recognised by the International Civil Aviation Organisation (ICAO);

2. The AMPS employs protection to prevent unauthorised access to "software"; and

3. The AMPS incorporates an active mechanism that forces the system not to function when it is removed from the "civil aircraft" in which it was installed.

ML5. Fire control, and related alerting and warning equipment, and related systems, test and alignment and countermeasure equipment, as follows, specially designed for military use, and specially designed components and accessories therefor:

a. Weapon sights, bombing computers, gun laying equipment and weapon control systems;

b. Target acquisition, designation, range-finding, surveillance or tracking systems; detection, data fusion, recognition or identification equipment; and sensor integration equipment;

c. Countermeasure equipment for items specified by ML5.a. or ML5.b.;

Note *For the purposes of ML5.c., countermeasure equipment includes detection equipment.*

d. Field test or alignment equipment, specially designed for items specified by ML5.a., ML5.b. or ML5.c.

ML6. Ground vehicles and components, as follows:
N.B. *For guidance and navigation equipment, see ML11.*

a. Ground vehicles and components therefor, specially designed or modified for military use;

Technical Note
For the purposes of ML6.a. the term ground vehicles includes trailers.

ML6. b. Other ground vehicles and components, as follows:

1. Vehicles having all of the following:
   a. Manufactured or fitted with materials or components to provide ballistic protection to level III (NIJ 0108.01, September 1985, or comparable national standard) or better;
   b. A transmission to provide drive to both front and rear wheels simultaneously, including those vehicles having additional wheels for load bearing purposes whether driven or not;
   c. Gross Vehicle Weight Rating (GVWR) greater than 4,500 kg; and
   d. Designed or modified for off-road use;

2. Components having all of the following:
   a. Specially designed for vehicles specified in ML6.b.1.; and
   b. Providing ballistic protection to level III (NIJ 0108.01, September 1985, or comparable national standard) or better.

N.B. *See also ML13.a.*

Note 1 *ML6.a. includes:*
a. Tanks and other military armed vehicles and military vehicles fitted with mountings for arms or equipment for mine laying or the launching of munitions specified by ML4;
b. Armoured vehicles;
c. Amphibious and deep water fording vehicles;
d. Recovery vehicles and vehicles for towing or transporting ammunition or weapon systems and associated load handling equipment.

Note 2 *Modification of a ground vehicle for military use specified by ML6.a. entails a structural, electrical or mechanical change involving one or more components that are specially designed for military use. Such components include:*
a. Pneumatic tyre casings of a kind specially designed to be bullet-proof;
b. Armoured protection of vital parts (e.g., fuel tanks or vehicle cabs);
c. Special reinforcements or mountings for weapons;
d. Black-out lighting.

Note 3 *ML6. does not apply to civil vehicles designed or modified for transporting money or valuables.*

Note 4 *ML6. does not apply to vehicles that meet all of the following;*
a. Were manufactured before 1946;
b. Do not have items specified by the Munitions List and manufactured after 1945, except for reproductions of original components or accessories for the vehicle; and
c. Do not incorporate weapons specified in ML1., ML2. or ML4. unless they are inoperable and incapable of discharging a projectile.

ML7. Chemical agents, "biological agents", "riot control agents", radioactive materials, related equipment, components and materials, as follows:

a. "Biological agents" or radioactive materials selected or modified to increase their effectiveness in producing casualties in humans or animals, degrading equipment or damaging crops or the environment;

b. Chemical warfare (CW) agents, including:

1. CW nerve agents:

a. O-Alkyl (equal to or less than C_{10}, including cycloalkyl) alkyl (Methyl, Ethyl, n-Propyl or Isopropyl) - phosphonofluoridates, such as:
Sarin (GB):O-Isopropyl methylphosphonofluoridate (CAS 107-44-8); and
Soman (GD):O-Pinacolyl methylphosphonofluoridate (CAS 96-64-0);

b. O-Alkyl (equal to or less than C10, including cycloalkyl) N,N-dialkyl (Methyl, Ethyl, n-Propyl or Isopropyl) phosphoramidocyanidates, such as: Tabun (GA):O-Ethyl N,N-dimethylphosphoramidocyanidate (CAS 77-81-6);

c. O-Alkyl (H or equal to or less than C10, including cycloalkyl) S-2-dialkyl (Methyl, Ethyl, n-Propyl or Isopropyl)-aminoethyl alkyl (Methyl, Ethyl, n-Propyl or Isopropyl) phosphonothiolates and corresponding alkylated and protonated salts, such as:
VX: O-Ethyl S-2-diisopropylaminoethyl methyl phosphonothiolate (CAS 50782-69-9);

ML7. b. 2. CW vesicant agents:

a. Sulphur mustards, such as:
1. 2-Chloroethylchloromethylsulphide (CAS 2625-76-5);
2. Bis(2-chloroethyl) sulphide (CAS 505-60-2);
3. Bis(2-chloroethylthio) methane (CAS 63869-13-6);
4. 1,2-bis (2-chloroethylthio) ethane (CAS 3563-36-8);
5. 1,3-bis (2-chloroethylthio) -n-propane (CAS 63905-10-2);
6. 1,4-bis (2-chloroethylthio) -n-butane (CAS 142868-93-7) ;
7. 1,5-bis (2-chloroethylthio) -n-pentane (CAS 142868-94-8);
8. Bis (2-chloroethylthiomethyl) ether (CAS 63918-90-1);
9. Bis (2-chloroethylthioethyl) ether (CAS 63918-89-8);

b. Lewisites, such as:
1. 2-chlorovinyldichloroarsine (CAS 541-25-3);
2. Tris (2-chlorovinyl) arsine (CAS 40334-70-1);
3. Bis (2-chlorovinyl) chloroarsine (CAS 40334-69-8);

c. Nitrogen mustards, such as:
1. HN1: bis (2-chloroethyl) ethylamine (CAS 538-07-8);
2. HN2: bis (2-chloroethyl) methylamine (CAS 51-75-2);
3. HN3: tris (2-chloroethyl) amine (CAS 555-77-1);

ML7. b. 3. CW incapacitating agents, such as:

a. 3-Quinuclidinyl benzilate (BZ) (CAS 6581-06-2);

ML7. b. 4. CW defoliants, such as:

a. Butyl 2-chloro-4-fluorophenoxyacetate (LNF);

b. 2,4,5-trichlorophenoxyacetic acid (CAS 93-76-5) mixed with 2,4-dichlorophenoxyacetic acid (CAS 94-75-7) (Agent Orange (CAS 39277-47-9));

ML7. c. CW binary precursors and key precursors, as follows:

1. Alkyl (Methyl, Ethyl, n-Propyl or Isopropyl) Phosphonyl Difluorides, such as: DF: Methyl Phosphonyldifluoride (CAS 676-99-3);
2. O-Alkyl (H or equal to or less than C_{10}, including cycloalkyl) O-2-dialkyl (Methyl, Ethyl, n-Propyl or Isopropyl)-aminoethyl alkyl (Methyl, Ethyl, n-Propyl or Isopropyl) phosphonites and corresponding alkylated and protonated salts, such as:
   QL: O-Ethyl O-2-di-isopropylaminoethyl methylphosphonite (CAS 57856-11-8);
3. Chlorosarin: O-Isopropyl methylphosphonochloridate (CAS 1445-76-7);
4. Chlorosoman: O-Pinacolyl methylphosphonochloridate (CAS 7040-57-5);

ML7. d. "Riot control agents", active constituent chemicals and combinations thereof, including:

1. α-Bromobenzeneacetonitrile, (Bromobenzyl cyanide) (CA) (CAS 5798-79-8);
2. [(2-chlorophenyl) methylene] propanedinitrile, (o-Chlorobenzylidenemalononitrile) (CS) (CAS 2698-41-1);
3. 2-Chloro-1-phenylethanone, Phenylacyl chloride (ω-chloroacetophenone) (CN) (CAS 532-27-4);
4. Dibenz-(b,f)-1,4-oxazephine, (CR) (CAS 257-07-8);
5. 10-Chloro-5,10-dihydrophenarsazine, (Phenarsazine chloride), (Adamsite), (DM) (CAS 578-94-9);
6. N-Nonanoylmorpholine, (MPA) (CAS 5299-64-9);

<u>Note 1</u> *ML7.d. does not apply to "riot control agents" individually packaged for personal self-defence purposes.*

<u>Note 2</u> *ML7.d. does not apply to active constituent chemicals, and combinations thereof, identified and packaged for food production or medical purposes.*

ML7. e. Equipment, specially designed or modified for military use, designed or modified for the dissemination of any of the following, and specially designed components therefor:

1. Materials or agents specified by ML7.a., ML7.b. or ML7.d.; <u>or</u>
2. CW agents made up of precursors specified by ML7.c.;

ML7. f. Protective and decontamination equipment, specially designed or modified for military use, components and chemical mixtures, as follows:

1. Equipment designed or modified for defence against materials specified by ML7.a., ML7.b. or ML7.d., and specially designed components therefor;
2. Equipment designed or modified for decontamination of objects contaminated with materials specified by ML7.a. or ML7.b., and specially designed components therefor;
3. Chemical mixtures specially developed or formulated for the decontamination of objects contaminated with materials specified by ML7.a. or ML7.b.;

<u>Note</u> *ML7.f.1. includes:*

a. Air conditioning units specially designed or modified for nuclear, biological or chemical filtration;

b. Protective clothing.

<u>N.B.</u> *For civil gas masks, protective and decontamination equipment, see also 1.A.4. on the Dual-Use List.*

ML7. g. Equipment, specially designed or modified for military use designed or modified for the detection or identification of materials specified by ML7.a., ML7.b. or ML7.d., and specially designed components therefor;
Note *ML7.g. does not apply to personal radiation monitoring dosimeters.*

N.B. *See also 1.A.4. on the Dual-Use List.*

ML7. h. "Biopolymers" specially designed or processed for the detection or identification of CW agents specified by ML7.b., and the cultures of specific cells used to produce them;

ML7. i. "Biocatalysts" for the decontamination or degradation of CW agents, and biological systems therefor, as follows:
1. "Biocatalysts" specially designed for the decontamination or degradation of CW agents specified by ML7.b., and resulting from directed laboratory selection or genetic manipulation of biological systems;
2. Biological systems containing the genetic information specific to the production of "biocatalysts" specified by ML7.i.1., as follows:
   a. "Expression vectors";
   b. Viruses;
   c. Cultures of cells.

Note 1 *ML7.b. and ML7.d. do not apply to the following:*
a. Cyanogen chloride (CAS 506-77-4);
b. Hydrocyanic acid (CAS 74-90-8);
c. Chlorine (CAS 7782-50-5);
d. Carbonyl chloride (phosgene) (CAS 75-44-5);
e. Diphosgene (trichloromethyl-chloroformate) (CAS 503-38-8);
f. Not used since 2004
g. Xylyl bromide, ortho: (CAS 89-92-9), meta: (CAS 620-13-3), para: (CAS 104-81-4);
h. Benzyl bromide (CAS 100-39-0);
i. Benzyl iodide (CAS 620-05-3);
j. Bromo acetone (CAS 598-31-2);
k. Cyanogen bromide (CAS 506-68-3);
l. Bromo methylethylketone (CAS 816-40-0);
m. Chloro acetone (CAS 78-95-5);
n. Ethyl iodoacetate (CAS 623-48-3);
o. Iodo acetone (CAS 3019-04-3);
p. Chloropicrin (CAS 76-06-2).

Note 2 *The cultures of cells and biological systems specified by ML7.h. and ML7.i.2. are exclusive and these sub-items do not apply to cells or biological systems for civil purposes, such as agricultural, pharmaceutical, medical, veterinary, environmental, waste management, or in the food industry.*

ML8. "Energetic materials" and related substances, as follows:

N.B.1. See also 1.C.11. on the Dual-Use List.

N.B.2. For charges and devices, see ML4 and 1.A.8. on the Dual-Use List.

Technical Notes

1. *For the purposes of ML8., excluding ML8.c.11. or ML8.c.12., 'mixture' refers to a composition of two or more substances with at least one substance being listed in the ML8 sub-items.*
2. *Any substance listed in the ML8 sub-items is subject to this list, even when utilised in an application other than that indicated. (e.g., TAGN is predominantly used as an explosive but can also be used either as a fuel or an oxidizer.)*
3. *For the purposes of ML8., particle size is the mean particle diameter on a weight or volume basis. International or equivalent national standards will be used in sampling and determining particle size.*

ML8. a. "Explosives" as follows, and 'mixtures' thereof:

1. ADNBF (aminodinitrobenzofuroxan or 7-amino-4,6-dinitrobenzofurazane-1-oxide) (CAS 97096-78-1);
2. BNCP (cis-bis (5-nitrotetrazolato) tetra amine-cobalt (III) perchlorate) (CAS 117412-28-9);
3. CL-14 (diamino dinitrobenzofuroxan or 5,7-diamino-4,6-dinitrobenzofurazane-1-oxide) (CAS 117907-74-1);
4. CL-20 (HNIW or Hexanitrohexaazaisowurtzitane) (CAS 135285-90-4); chlathrates of CL-20 (see also ML8.g.3. and g.4. for its "precursors");
5. CP (2-(5-cyanotetrazolato) penta amine-cobalt (III) perchlorate) (CAS 70247-32-4);
6. DADE (1,1-diamino-2,2-dinitroethylene, FOX7) (CAS 145250-81-3);
7. DATB (diaminotrinitrobenzene) (CAS 1630-08-6);
8. DDFP (1,4-dinitrodifurazanopiperazine);
9. DDPO (2,6-diamino-3,5-dinitropyrazine-1-oxide, PZO) (CAS 194486-77-6);
10. DIPAM (3,3′-diamino-2,2′,4,4′,6,6′-hexanitrobiphenyl or dipicramide) (CAS 17215-44-0);
11. DNGU (DINGU or dinitroglycoluril) (CAS 55510-04-8);
12. Furazans as follows:
    a. DAAOF (DAAF, DAAFox, or diaminoazoxyfurazan);
    b. DAAzF (diaminoazofurazan) (CAS 78644-90-3);
13. HMX and derivatives (see also ML8.g.5. for its "precursors"), as follows:
    a. HMX (Cyclotetramethylenetetranitramine, octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazine, 1,3,5,7-tetranitro-1,3,5,7-tetraza-cyclooctane, octogen or octogene) (CAS 2691-41-0);
    b. difluoroaminated analogs of HMX;
    c. K-55 (2,4,6,8-tetranitro-2,4,6,8-tetraazabicyclo [3,3,0]-octanone-3, tetranitrosemiglycouril or keto-bicyclic HMX) (CAS 130256-72-3);
14. HNAD (hexanitroadamantane) (CAS 143850-71-9);
15. HNS (hexanitrostilbene) (CAS 20062-22-0);
16. Imidazoles as follows:
    a. BNNII (Octahydro-2,5-bis(nitroimino)imidazo [4,5-d]imidazole);
    b. DNI (2,4-dinitroimidazole) (CAS 5213-49-0);
    c. FDIA (1-fluoro-2,4-dinitroimidazole);
    d. NTDNIA (N-(2-nitrotriazolo)-2,4-dinitroimidazole);
    e. PTIA (1-picryl-2,4,5-trinitroimidazole);

ML8. a. 17. NTNMH (1-(2-nitrotriazolo)-2-dinitromethylene hydrazine);
18. NTO (ONTA or 3-nitro-1,2,4-triazol-5-one) (CAS 932-64-9);
19. Polynitrocubanes with more than four nitro groups;
20. PYX (2,6-Bis(picrylamino)-3,5-dinitropyridine) (CAS 38082-89-2);
21. RDX and derivatives, as follows:
    a. RDX (cyclotrimethylenetrinitramine, cyclonite, T4, hexahydro-1,3,5-trinitro-1,3,5-triazine, 1,3,5-trinitro-1,3,5-triaza-cyclohexane, hexogen or hexogene) (CAS 121-82-4);
    b. Keto-RDX (K-6 or 2,4,6-trinitro-2,4,6-triazacyclohexanone) (CAS 115029-35-1);
22. TAGN (triaminoguanidinenitrate) (CAS 4000-16-2);
23. TATB (triaminotrinitrobenzene) (CAS 3058-38-6) (see also ML8.g.7 for its "precursors");
24. TEDDZ (3,3,7,7-tetrabis(difluoroamine) octahydro-1,5-dinitro-1,5-diazocine);
25. Tetrazoles as follows:
    a. NTAT (nitrotriazol aminotetrazole);
    b. NTNT (1-N-(2-nitrotriazolo)-4-nitrotetrazole);
26. Tetryl (trinitrophenylmethylnitramine) (CAS 479-45-8);
27. TNAD (1,4,5,8-tetranitro-1,4,5,8-tetraazadecalin) (CAS 135877-16-6) (see also ML8.g.6. for its "precursors");
28. TNAZ (1,3,3-trinitroazetidine) (CAS 97645-24-4) (see also ML8.g.2. for its "precursors");
29. TNGU (SORGUYL or tetranitroglycoluril) (CAS 55510-03-7);
30. TNP (1,4,5,8-tetranitro-pyridazino[4,5-d]pyridazine) (CAS 229176-04-9);
31. Triazines as follows:
    a. DNAM (2-oxy-4,6-dinitroamino-s-triazine) (CAS 19899-80-0);
    b. NNHT (2-nitroimino-5-nitro-hexahydro-1,3,5-triazine) (CAS 130400-13-4);
32. Triazoles as follows:
    a. 5-azido-2-nitrotriazole;
    b. ADHTDN (4-amino-3,5-dihydrazino-1,2,4-triazole dinitramide) (CAS 1614-08-0);
    c. ADNT (1-amino-3,5-dinitro-1,2,4-triazole);
    d. BDNTA ((bis-dinitrotriazole)amine);
    e. DBT (3,3′-dinitro-5,5-bi-1,2,4-triazole) (CAS 30003-46-4);
    f. DNBT (dinitrobistriazole) (CAS 70890-46-9);
    g. Not used since 2010
    h. NTDNT (1-N-(2-nitrotriazolo) 3,5-dinitrotriazole);
    i. PDNT (1-picryl-3,5-dinitrotriazole);
    j. TACOT (tetranitrobenzotriazolobenzotriazole) (CAS 25243-36-1);
33. Explosives not listed elsewhere in ML8.a. and having any of the following:
    a. Detonation velocity exceeding 8,700 m/s, at maximum density, <u>or</u>
    b. Detonation pressure exceeding 34 GPa (340 kbar);
34. Not used since 2013
35. DNAN (2,4-dinitroanisole) (CAS 119-27-7);
36. TEX (4,10-Dinitro-2,6,8,12-tetraoxa-4,10-diazaisowurtzitane)
37. GUDN (Guanylurea dinitramide) FOX-12 (CAS 217464-38-5)
38. Tetrazines as follows:
    a. BTAT (Bis(2,2,2-trinitroethyl)-3,6-diaminotetrazine);
    b. LAX-112 (3,6-diamino-1,2,4,5-tetrazine-1,4-dioxide);
39. Energetic ionic materials melting between 343 K (70°C) and 373 K (100°C) and with detonation velocity exceeding 6,800 m/s or detonation pressure exceeding 18 GPa (180 kbar);

ML8. a. 40. BTNEN (Bis(2,2,2-trinitroethyl)-nitramine) (CAS 19836-28-3);
41. FTDO (5,6-(3',4'-furazano)- 1,2,3,4-tetrazine-1,3-dioxide);

Note *ML8.a. includes 'explosive co-crystals'.*

Technical Note
An 'explosive co-crystal' is a solid material consisting of an ordered three dimensional arrangement of two or more explosive molecules, where at least one is specified in ML8.a.

ML8. b. "Propellants" as follows:
1. Any solid "propellant" with a theoretical specific impulse (under standard conditions) of more than:
   a. 240 seconds for non-metallized, non-halogenized "propellant";
   b. 250 seconds for non-metallized, halogenized "propellant"; or
   c. 260 seconds for metallized "propellant";
2. Not used since 2013
3. "Propellants" having a force constant of more than 1,200 kJ/kg;
4. "Propellants" that can sustain a steady-state linear burning rate of more than 38 mm/s under standard conditions (as measured in the form of an inhibited single strand) of 6.89 MPa (68.9 bar) pressure and 294K (21°C);
5. Elastomer Modified Cast Double Base (EMCDB) "propellants" with extensibility at maximum stress of more than 5% at 233K (-40°C);
6. Any "propellant" containing substances specified by ML8.a.;
7. "Propellants", not specified elsewhere in the Munitions List, specially designed for military use;

ML8. c. "Pyrotechnics", fuels and related substances, as follows, and 'mixtures' thereof:
1. "Aircraft" fuels specially formulated for military purposes;
   Note *"Aircraft" fuels specified by ML8.c.1. are finished products, not their constituents.*
2. Alane (aluminium hydride) (CAS 7784-21-6);
3. Boranes, as follows, and their derivatives:
   a. Carboranes;
   b. Borane homologues, as follows:
      1. Decaborane (14) (CAS 17702-41-9);
      2. Pentaborane (9) (CAS 19624-22-7);
      3. Pentaborane (11) (CAS 18433-84-6);
4. Hydrazine and derivatives, as follows (see also ML8.d.8. and d.9. for oxidising hydrazine derivatives):
   a. Hydrazine (CAS 302-01-2) in concentrations of 70% or more;
   b. Monomethyl hydrazine (CAS 60-34-4);
   c. Symmetrical dimethyl hydrazine (CAS 540-73-8);
   d. Unsymmetrical dimethyl hydrazine (CAS 57-14-7);
   Note *ML8.c.4.a. does not apply to hydrazine 'mixtures' specially formulated for corrosion control.*

ML8. c. 5. Metal fuels, fuel 'mixtures' or "pyrotechnic" 'mixtures', in particle form whether spherical, atomized, spheroidal, flaked or ground, manufactured from material consisting of 99 % or more of any of the following:
   a. Metals as follows and 'mixtures' thereof:
      1. Beryllium (CAS 7440-41-7) in particle sizes of less than 60 µm;
      2. Iron powder (CAS 7439-89-6) with particle size of 3 µm or less produced by reduction of iron oxide with hydrogen;

ML8. c. 5. b. 'Mixtures' containing any of the following:
1. Zirconium (CAS 7440-67-7), magnesium (CAS 7439-95-4) or alloys of these in particle sizes of less than 60 µm; or
2. Boron (CAS 7440-42-8) or boron carbide (CAS 12069-32-8) fuels of 85% purity or higher and particle sizes of less than 60 µm;

Note 1 *ML8.c.5 applies to "explosives" and fuels, whether or not the metals or alloys are encapsulated in aluminium, magnesium, zirconium, or beryllium.*

Note 2 *ML8.c.5.b. only applies to metal fuels in particle form when they are mixed with other substances to form a 'mixture' formulated for military purposes such as liquid "propellant" slurries, solid "propellants", or "pyrotechnic" 'mixtures'.*

Note 3 *ML8.c.5.b.2. does not apply to boron and boron carbide enriched with boron-10 (20% or more of total boron-10 content.)*

ML8. c. 6. Military materials, containing thickeners for hydrocarbon fuels, specially formulated for use in flame throwers or incendiary munitions, such as metal stearates (e.g., octal (CAS 637-12-7)) or palmitates;

7. Perchlorates, chlorates and chromates, composited with powdered metal or other high energy fuel components;

8. Spherical or spheroidal aluminium powder (CAS 7429-90-5) with a particle size of 60 µm or less and manufactured from material with an aluminium content of 99% or more;

9. Titanium subhydride (TiH_n) of stoichiometry equivalent to n= 0.65-1.68;

10. Liquid high energy density fuels not specified in ML8.c.1., as follows:
a. Mixed fuels, that incorporate both solid and liquid fuels (e.g., boron slurry), having a mass-based energy density of 40 MJ/kg or greater;
b. Other high energy density fuels and fuel additives (e.g., cubane, ionic solutions, JP-7, JP-10), having a volume-based energy density of 37.5 GJ per cubic meter or greater, measured at 293 K (20^0C) and one atmosphere (101.325 kPa) pressure;

Note *ML8.c.10.b. does not apply to JP-4, JP-8, fossil refined fuels or biofuels, or fuels for engines certified for use in civil aviation.*

ML8. c. 11. "Pyrotechnic" and pyrophoric materials as follows:
a. "Pyrotechnic" or pyrophoric materials specifically formulated to enhance or control the production of radiated energy in any part of the IR spectrum;
b. Mixtures of magnesium, polytetrafluoroethylene (PTFE) and a vinylidene difluoride-hexafluoropropylene copolymer (e.g., MTV);

12. Fuel mixtures, "pyrotechnic" mixtures or "energetic materials", not specified elsewhere in ML8, having all of the following:
a. Containing greater than 0.5% of particles of any of the following:
1. Aluminium;
2. Beryllium;
3. Boron;
4. Zirconium;
5. Magnesium; or
6. Titanium;
b. Particles specified by ML8.c.12.a. with a size less than 200 nm in any direction; and
c. Particles specified by ML8.c.12.a. with a metal content of 60% or greater;

ML8. d. Oxidizers as follows, and 'mixtures' thereof:

1. ADN (ammonium dinitramide or SR 12) (CAS 140456-78-6);
2. AP (ammonium perchlorate) (CAS 7790-98-9);
3. Compounds composed of fluorine and any of the following:
   a. Other halogens;
   b. Oxygen; or
   c. Nitrogen;

   Note 1 *ML8.d.3. does not apply to chlorine trifluoride (CAS 7790-91-2).*

   Note 2 *ML8.d.3. does not apply to nitrogen trifluoride (CAS 7783-54-2) in its gaseous state.*
4. DNAD (1,3-dinitro-1,3-diazetidine) (CAS 78246-06-7);
5. HAN (hydroxylammonium nitrate) (CAS 13465-08-2);
6. HAP (hydroxylammonium perchlorate) (CAS 15588-62-2);
7. HNF (hydrazinium nitroformate) (CAS 20773-28-8);
8. Hydrazine nitrate (CAS 37836-27-4);
9. Hydrazine perchlorate (CAS 27978-54-7);
10. Liquid oxidisers comprised of or containing inhibited red fuming nitric acid (IRFNA) (CAS 8007-58-7);

    Note *ML8.d.10. does not apply to non-inhibited fuming nitric acid.*

ML8. e. Binders, plasticizers, monomers and polymers, as follows:

1. AMMO (azidomethylmethyloxetane and its polymers) (CAS 90683-29-7) (see also ML8.g.1. for its "precursors");
2. BAMO (3,3-bis(azidomethyl)oxetane and its polymers) (CAS 17607-20-4) (see also ML8.g.1. for its "precursors");
3. BDNPA (bis (2,2-dinitropropyl)acetal) (CAS 5108-69-0);
4. BDNPF (bis (2,2-dinitropropyl)formal) (CAS 5917-61-3);
5. BTTN (butanetrioltrinitrate) (CAS 6659-60-5) (see also ML8.g.8. for its "precursors");
6. Energetic monomers, plasticizers or polymers, specially formulated for military use and containing any of the following:
   a. Nitro groups;
   b. Azido groups;
   c. Nitrate groups;
   d. Nitraza groups; or
   e. Difluoroamino groups;

ML8. e.

7. FAMAO (3-difluoroaminomethyl-3-azidomethyl oxetane) and its polymers;
8. FEFO (bis-(2-fluoro-2,2-dinitroethyl) formal) (CAS 17003-79-1);
9. FPF-1 (poly-2,2,3,3,4,4-hexafluoropentane-1,5-diol formal) (CAS 376-90-9);
10. FPF-3 (poly-2,4,4,5,5,6,6-heptafluoro-2-tri-fluoromethyl-3-oxaheptane-1,7-diol formal);
11. GAP (glycidylazide polymer) (CAS 143178-24-9) and its derivatives;
12. HTPB (hydroxyl terminated polybutadiene) with a hydroxyl functionality equal to or greater than 2.2 and less than or equal to 2.4, a hydroxyl value of less than 0.77 meq/g, and a viscosity at 30°C of less than 47 poise (CAS 69102-90-5);
13. Alcohol functionalised poly(epichlorohydrin) with a molecular weight less than 10,000, as follows:
    a. Poly(epichlorohydrindiol);
    b. Poly(epichlorohydrintriol).

ML8. e. 14. NENAs (nitratoethylnitramine compounds) (CAS 17096-47-8, 85068-73-1, 82486-83-7, 82486-82-6 and 85954-06-9);
15. PGN (poly-GLYN, polyglycidylnitrate or poly(nitratomethyl oxirane)) (CAS 27814-48-8);
16. Poly-NIMMO (poly nitratomethylmethyloxetane), poly-NMMO or poly(3-Nitratomethyl-3-methyloxetane)) (CAS 84051-81-0);
17. Polynitroorthocarbonates;
18. TVOPA (1,2,3-tris[1,2-bis(difluoroamino)ethoxy] propane or tris vinoxy propane adduct) (CAS 53159-39-0);
19. 4,5 diazidomethyl-2-methyl-1,2,3-triazole (iso- DAMTR);
20. PNO (Poly(3-nitrato oxetane));

ML8. f. "Additives" as follows:
1. Basic copper salicylate (CAS 62320-94-9);
2. BHEGA (bis-(2-hydroxyethyl) glycolamide) (CAS 17409-41-5);
3. BNO (butadienenitrileoxide);
4. Ferrocene derivatives as follows:
   a. Butacene (CAS 125856-62-4);
   b. Catocene (2,2-bis-ethylferrocenyl propane) (CAS 37206-42-1);
   c. Ferrocene carboxylic acids and ferrocene carboxylic acid esters;
   d. n-butyl-ferrocene (CAS 31904-29-7);
   e. Other adducted polymer ferrocene derivatives not specified elsewhere in ML8.f.4.;
   f. Ethyl ferrocene (CAS 1273-89-8);
   g. Propyl ferrocene;
   h. Pentyl ferrocene (CAS 1274-00-6);
   i. Dicyclopentyl ferrocene;
   j. Dicyclohexyl ferrocene;
   k. Diethyl ferrocene (CAS 1273-97-8);
   l. Dipropyl ferrocene;
   m. Dibutyl ferrocene (CAS 1274-08-4);
   n. Dihexyl ferrocene (CAS 93894-59-8);
   o. Acetyl ferrocene (CAS 1271-55-2)/1,1'-diacetyl ferrocene (CAS 1273-94-5);

ML8. f. 5. Lead beta-resorcylate (CAS 20936-32-7);
6. Lead citrate (CAS 14450-60-3);
7. Lead-copper chelates of beta-resorcylate or salicylates (CAS 68411-07-4);
8. Lead maleate (CAS 19136-34-6);
9. Lead salicylate (CAS 15748-73-9);
10. Lead stannate (CAS 12036-31-6);
11. MAPO (tris-1-(2-methyl)aziridinyl phosphine oxide) (CAS 57-39-6); BOBBA 8 (bis(2-methyl aziridinyl) 2-(2-hydroxypropanoxy) propylamino phosphine oxide); and other MAPO derivatives;
12. Methyl BAPO (bis(2-methyl aziridinyl) methylamino phosphine oxide) (CAS 85068-72-0);
13. N-methyl-p-nitroaniline (CAS 100-15-2);
14. 3-Nitraza-1,5-pentane diisocyanate (CAS 7406-61-9);

ML8. f. 15. Organo-metallic coupling agents as follows:

a. Neopentyl[diallyl]oxy, tri[dioctyl]phosphato-titanate (CAS 103850-22-2); also known as titanium IV, 2,2[bis 2-propenolato-methyl, butanolato, tris (dioctyl) phosphato] (CAS 110438-25-0); or LICA 12 (CAS 103850-22-2);

b. Titanium IV, [(2-propenolato-1) methyl, n-propanolatomethyl] butanolato-1, tris[dioctyl] pyrophosphate or KR3538;

c. Titanium IV, [(2-propenolato-1)methyl, n-propanolatomethyl] butanolato-1, tris(dioctyl)phosphate;

16. Polycyanodifluoroaminoethyleneoxide*;*

ML8. f. 17. Bonding agents as follows:

a. 1,1R,1S-trimesoyl-tris(2-ethylaziridine) (HX-868, BITA) (CAS 7722-73-8);

b. Polyfunctional aziridine amides with isophthalic, trimesic, isocyanuric or trimethyladipic backbone also having a 2-methyl or 2-ethyl aziridine group;

<u>Note</u> *Item ML.8.f.17.b. includes:*

a. 1,1H-Isophthaloyl-bis(2-methylaziridine)(HX-752) (CAS 7652-64-4);

b. 2,4,6-tris(2-ethyl-1-aziridinyl)-1,3,5-triazine (HX-874) (CAS 18924-91-9);

c. 1,1'-trimethyladipoyl-bis(2-ethylaziridine) (HX-877) (CAS 71463-62-2).

18. Propyleneimine (2-methylaziridine) (CAS 75-55-8);
19. Superfine iron oxide (Fe_2O_3) (CAS 1317-60-8) with a specific surface area more than 250 m^2/g and an average particle size of 3.0 nm or less;
20. TEPAN (tetraethylenepentaamineacrylonitrile) (CAS 68412-45-3); cyanoethylated polyamines and their salts;
21. TEPANOL (tetraethylenepentaamineacrylonitrileglycidol) (CAS 68412-46-4); cyanoethylated polyamines adducted with glycidol and their salts;
22. TPB (triphenyl bismuth) (CAS 603-33-8);
23. TEPB (Tris (ethoxyphenyl) bismuth) (CAS 90591-48-3);

ML8. g. "Precursors" as follows:

<u>N.B.</u> *In ML8.g. the references are to specified "Energetic Materials" manufactured from these substances.*

1. BCMO (3,3-bis(chloromethyl)oxetane) (CAS 78-71-7) (see also ML8.e.1. and e.2.);
2. Dinitroazetidine-t-butyl salt (CAS 125735-38-8) (see also ML8.a.28.);
3. Hexaazaisowurtzitane derivates including HBIW (hexabenzylhexaazaisowurtzitane) (CAS 124782-15-6) (see also ML8.a.4.) and TAIW (tetraacetyldibenzylhexaazaisowurtzitane) (CAS 182763-60-6) (see also ML8.a.4.);
4. Not used since 2013
5. TAT (1,3,5,7 tetraacetyl-1,3,5,7,-tetraaza cyclo-octane) (CAS 41378-98-7) (see also ML8.a.13.);
6. 1,4,5,8-tetraazadecalin (CAS 5409-42-7) (see also ML8.a.27.);
7. 1,3,5-trichlorobenzene (CAS 108-70-3) (see also ML8.a.23.);
8. 1,2,4-trihydroxybutane (1,2,4-butanetriol) (CAS 3068-00-6) (see also ML8.e.5.);
9. DADN (1,5-diacetyl-3,7-dinitro-1, 3, 5, 7-tetraaza-cyclooctane) (see also ML8.a.13).

ML8. h. 'Reactive material' powders and shapes, as follows:

1. Powders of any of the following materials, with a particle size less than 250 µm in any direction and not specified elsewhere by ML8:
   a. Aluminium;
   b. Niobium;
   c. Boron;
   d. Zirconium;
   e. Magnesium;
   f. Titanium;
   g. Tantalum;
   h. Tungsten;
   i. Molybdenum; or
   j. Hafnium;
2. Shapes, not specified by ML3, ML4, ML12 or ML16, fabricated from powders specified by ML8.h.1.

Technical Notes

1. *'Reactive materials' are designed to produce an exothermic reaction only at high shear rates and for use as liners or casings in warheads.*
2. *'Reactive material' powders are produced by, for example, a high energy ball milling process.*
3. *'Reactive material' shapes are produced by, for example, selective laser sintering.*

*Note 1** *ML8. does not apply to the following substances unless they are compounded or mixed with the "energetic material" specified by ML8.a. or powdered metals specified by ML8.c.:*

a. Ammonium picrate (CAS 131-74-8);
b. Black powder;
c. Hexanitrodiphenylamine (CAS 131-73-7);
d. Difluoroamine (CAS 10405-27-3);
e. Nitrostarch (CAS 9056-38-6);
f. Potassium nitrate (CAS 7757-79-1);
g. Tetranitronaphthalene;
h. Trinitroanisol;
i. Trinitronaphthalene;
j. Trinitroxylene;
k. N-pyrrolidinone; 1-methyl-2-pyrrolidinone (CAS 872-50-4);
l. Dioctylmaleate (CAS 142-16-5);
m. Ethylhexylacrylate (CAS 103-11-7);
n. Triethylaluminium (TEA) (CAS 97-93-8), trimethylaluminium (TMA) (CAS 75-24-1), and other pyrophoric metal alkyls and aryls of lithium, sodium, magnesium, zinc or boron;
o. Nitrocellulose (CAS 9004-70-0);
p. Nitroglycerin (or glyceroltrinitrate, trinitroglycerine) (NG) (CAS 55-63-0);
q. 2,4,6-trinitrotoluene (TNT) (CAS 118-96-7);
r. Ethylenediaminedinitrate (EDDN) (CAS 20829-66-7);
s. Pentaerythritoltetranitrate (PETN) (CAS 78-11-5);

* Former Note 5 was deleted in 2009. Remaining Notes 6 and 7 were renumbered Notes 1 and 2 in 2012.

Note 1 cont.

t. *Lead azide (CAS 13424-46-9), normal lead styphnate (CAS 15245-44-0) and basic lead styphnate (CAS 12403-82-6), and primary explosives or priming compositions containing azides or azide complexes;*

u. *Triethyleneglycoldinitrate (TEGDN) (CAS 111-22-8);*

v. *2,4,6-trinitroresorcinol (styphnic acid) (CAS 82-71-3);*

w. *Diethyldiphenylurea; (CAS 85-98-3); dimethyldiphenylurea; (CAS 611-92-7), methylethyldiphenylurea; [Centralites]*

x. *N,N-diphenylurea (unsymmetrical diphenylurea) (CAS 603-54-3);*

y. *Methyl-N,N-diphenylurea (methyl unsymmetrical diphenylurea) (CAS 13114-72-2);*

z. *Ethyl-N,N-diphenylurea (ethyl unsymmetrical diphenylurea) (CAS 64544-71-4);*

aa. *2-Nitrodiphenylamine (2-NDPA) (CAS 119-75-5);*

bb. *4-Nitrodiphenylamine (4-NDPA) (CAS 836-30-6);*

cc. *2,2-dinitropropanol (CAS 918-52-5);*

dd. *Nitroguanidine (CAS 556-88-7) (see 1.C.11.d. on the Dual-Use List).*

Note 2 *ML8. does not apply to ammonium perchlorate (ML8.d.2.), NTO (ML8.a.18.) or catocene (ML8.f.4.b.), and meeting all of the following:*

a. Specially shaped and formulated for civil-use gas generation devices;

b. Compounded or mixed, with non-active thermoset binders or plasticizers, and having a mass of less than 250 g;

c. Having a maximum of 80% ammonium perchlorate (ML8.d.2.) in mass of active material;

d. Having less than or equal to 4 g of NTO (ML8.a.18.); and

e. Having less than or equal to 1 g of catocene (ML8.f.4.b.).

ML9. Vessels of war (surface or underwater), special naval equipment, accessories, components and other surface vessels, as follows:

N.B. For guidance and navigation equipment, see ML11.

ML9. a. Vessels and components, as follows:

1. Vessels (surface or underwater) specially designed or modified for military use, regardless of current state of repair or operating condition, and whether or not they contain weapon delivery systems or armour, and hulls or parts of hulls for such vessels, and components therefor specially designed for military use;

2. Surface vessels, other than those specified in ML9.a.1., having any of the following, fixed or integrated into the vessel:
   a. Automatic weapons specified in ML1., or weapons specified in ML2., ML4., ML12. or ML19., or 'mountings' or hard points for weapons having a calibre of 12.7 mm or greater;

      Technical Note
      'Mountings' refers to weapon mounts or structural strengthening for the purpose of installing weapons.

   b. Fire control systems specified in ML5.;

   c. Having all of the following:
      1. 'Chemical, Biological, Radiological and Nuclear (CBRN) protection'; and
      2. 'Pre-wet or wash down system' designed for decontamination purposes; or

      Technical Notes
      1. 'CBRN protection' is a self-contained interior space containing features such as over-pressurization, isolation of ventilation systems, limited ventilation openings with CBRN filters and limited personnel access points incorporating air-locks.
      2. 'Pre-wet or wash down system' is a seawater spray system capable of simultaneously wetting the exterior superstructure and decks of a vessel.

ML9. a. 2. d. Active weapon countermeasure systems specified in ML4.b., ML5.c. or ML11.a. and having any of the following:
   1. 'CBRN protection';
   2. Hull and superstructure, specially designed to reduce the radar cross section;
   3. Thermal signature reduction devices, (e.g., an exhaust gas cooling system), excluding those specially designed to increase overall power plant efficiency or to reduce the environmental impact; or
   4. A degaussing system designed to reduce the magnetic signature of the whole vessel;

ML9. b. Engines and propulsion systems, as follows, specially designed for military use and components therefor specially designed for military use:

1. Diesel engines specially designed for submarines and having all of the following:
   a. Power output of 1.12 MW (1,500 hp) or more; and
   b. Rotary speed of 700 rpm or more;

ML9. b. 2. Electric motors specially designed for submarines and having all of the following:
a. Power output of more than 0.75 MW (1,000 hp);
b. Quick reversing;
c. Liquid cooled; and
d. Totally enclosed;

3. Non-magnetic diesel engines having all of the following:
a. Power output of 37.3 kW (50 hp) or more; and
b. Non-magnetic content in excess of 75% of total mass;

4. 'Air Independent Propulsion' (AIP) systems specially designed for submarines;

Technical Note
'Air Independent Propulsion' (AIP) allows a submerged submarine to operate its propulsion system, without access to atmospheric oxygen, for a longer time than the batteries would have otherwise allowed. For the purposes of ML9.b.4., AIP does not include nuclear power.

ML9. c. Underwater detection devices, specially designed for military use, controls therefor and components therefor specially designed for military use;

d. Anti-submarine nets and anti-torpedo nets, specially designed for military use;

e. Not used since 2003;

f. Hull penetrators and connectors, specially designed for military use, that enable interaction with equipment external to a vessel, and components therefor specially designed for military use;

Note *ML9.f. includes connectors for vessels which are of the single-conductor, multi-conductor, coaxial or waveguide type, and hull penetrators for vessels, both of which are capable of remaining impervious to leakage from without and of retaining required characteristics at marine depths exceeding 100 m; and fibre-optic connectors and optical hull penetrators, specially designed for "laser" beam transmission, regardless of depth. ML9.f. does not apply to ordinary propulsive shaft and hydrodynamic control-rod hull penetrators.*

ML9. g. Silent bearings having any of the following, components therefor and equipment containing those bearings, specially designed for military use:
1. Gas or magnetic suspension;
2. Active signature controls; or
3. Vibration suppression controls.

ML10. "Aircraft", "lighter-than-air vehicles", "Unmanned Aerial Vehicles" ("UAVs"), aero-engines and "aircraft" equipment, related equipment, and components, as follows, specially designed or modified for military use:

N.B. For guidance and navigation equipment, see ML11.

a. Manned "aircraft" and "lighter-than-air vehicles", and specially designed components therefor;

b. Not used since 2011

c. Unmanned "aircraft" and "lighter-than-air vehicles", and related equipment, as follows, and specially designed components therefor:
   1. "UAVs", Remotely Piloted Air Vehicles (RPVs), autonomous programmable vehicles and unmanned "lighter-than-air vehicles";
   2. Launchers, recovery equipment and ground support equipment;
   3. Equipment designed for command or control;

d. Propulsion aero-engines and specially designed components therefor;

e. Airborne refuelling equipment specially designed or modified for any of the following, and specially designed components therefor:
   1. "Aircraft" specified by ML10.a.; or
   2. Unmanned "aircraft" specified by ML10.c.;

f. 'Ground equipment' specially designed for "aircraft" specified by ML10.a. or aero-engines specified by ML10.d.;

   Technical Note
   'Ground equipment' includes pressure refuelling equipment and equipment designed to facilitate operations in confined areas.

g. Aircrew life support equipment, aircrew safety equipment and other devices for emergency escape, not specified in ML10.a., designed for "aircraft" specified by ML10.a.;

   Note ML10.g. does not control aircrew helmets that do not incorporate, or have mountings or fittings for, equipment specified in the Munitions List.

   N.B. For helmets see also ML13.c.

h. Parachutes, paragliders and related equipment, as follows, and specially designed components therefor:
   1. Parachutes not specified elsewhere in the Munitions List;
   2. Paragliders;
   3. Equipment specially designed for high altitude parachutists (e.g., suits, special helmets, breathing systems, navigation equipment);

i. Controlled opening equipment or automatic piloting systems, designed for parachuted loads.

Note 1 *ML10.a. does not apply to "aircraft" and "lighter-than-air vehicles" or variants of those "aircraft", specially designed for military use and which are all of the following:*

a. Not a combat "aircraft";

b. Not configured for military use and not fitted with equipment or attachments specially designed or modified for military use; and

c. Certified for civil use by civil aviation authorities of one or more Wassenaar Arrangement Participating States.

Note 2 *ML10.d. does not apply to:*

a. Aero-engines designed or modified for military use which have been certified by civil aviation authorities of one or more Wassenaar Arrangement Participating States for use in "civil aircraft", or specially designed components therefor;

b. Reciprocating engines or specially designed components therefor, except those specially designed for "UAVs".

Note 3 *For the purposes of ML10.a. and ML10.d., specially designed components and related equipment for non-military "aircraft" or aero-engines modified for military use applies only to those military components and to military related equipment required for the modification to military use.*

Note 4 *For the purposes of ML10.a., military use includes: combat, military reconnaissance, assault, military training, logistics support, and transporting and airdropping troops or military equipment.*

Note 5 *ML10.a. does not apply to "aircraft" that meet all of the following:*

a. Were first manufactured before 1946;

b. Do not incorporate items specified by the Munitions List, unless the items are required to meet safety or airworthiness standards of civil aviation authorities of one or more Wassenaar Arrangement Participating States; and

c. Do not incorporate weapons specified by the Munitions List, unless inoperable and incapable of being returned to operation.

ML11. Electronic equipment, "spacecraft" and components, not specified elsewhere on the Munitions List, as follows:

a. Electronic equipment specially designed for military use and specially designed components therefor;

<u>Note</u> *ML11.a. includes:*

a. Electronic countermeasure and electronic counter-countermeasure equipment (i.e., equipment designed to introduce extraneous or erroneous signals into radar or radio communication receivers or otherwise hinder the reception, operation or effectiveness of adversary electronic receivers including their countermeasure equipment), including jamming and counter-jamming equipment;

b. Frequency agile tubes;

c. Electronic systems or equipment, designed either for surveillance and monitoring of the electro-magnetic spectrum for military intelligence or security purposes or for counteracting such surveillance and monitoring;

d. Underwater countermeasures, including acoustic and magnetic jamming and decoy, equipment designed to introduce extraneous or erroneous signals into sonar receivers;

e. Data processing security equipment, data security equipment and transmission and signalling line security equipment, using ciphering processes;

f. Identification, authentification and keyloader equipment and key management, manufacturing and distribution equipment;

g. Guidance and navigation equipment;

h. Digital troposcatter-radio communications transmission equipment;

i. Digital demodulators specially designed for signals intelligence;

j. "Automated Command and Control Systems".

<u>N.B.</u> *For "software" associated with military "Software" Defined Radio (SDR), see ML21.*

ML11. b. Global Navigation Satellite Systems (GNSS) jamming equipment and specially designed components therefor;

c. "Spacecraft" specially designed or modified for military use, and "spacecraft" components specially designed for military use.

ML12. High velocity kinetic energy weapon systems and related equipment, as follows, and specially designed components therefor:

a. Kinetic energy weapon systems specially designed for destruction or effecting mission-abort of a target;

b. Specially designed test and evaluation facilities and test models, including diagnostic instrumentation and targets, for dynamic testing of kinetic energy projectiles and systems.

N.B. *For weapon systems using sub-calibre ammunition or employing solely chemical propulsion, and ammunition therefor, see ML1. to ML4.*

Note 1 *ML12. includes the following when specially designed for kinetic energy weapon systems:*

a. Launch propulsion systems capable of accelerating masses larger than 0.1 g to velocities in excess of 1.6 km/s, in single or rapid fire modes;

b. Prime power generation, electric armour, energy storage (e.g., high energy storage capacitors), thermal management, conditioning, switching or fuel-handling equipment; and electrical interfaces between power supply, gun and other turret electric drive functions;

N.B. *See also 3.A.1.e.2. on the Dual-Use List for high energy storage capacitors.*

c. Target acquisition, tracking, fire control or damage assessment systems;

d. Homing seeker, guidance or divert propulsion (lateral acceleration) systems for projectiles.

Note 2 *ML12. applies to weapon systems using any of the following methods of propulsion:*

a. Electromagnetic;

b. Electrothermal;

c. Plasma;

d. Light gas; or

e. Chemical (when used in combination with any of the above).

ML13. Armoured or protective equipment, constructions and components, as follows:

a. Metallic or non-metallic armoured plate, having any of the following:
   1. Manufactured to comply with a military standard or specification; or
   2. Suitable for military use;

   N.B. *For body armour plate, see ML13.d.2.*

b. Constructions of metallic or non-metallic materials, or combinations thereof, specially designed to provide ballistic protection for military systems, and specially designed components therefor;

c. Helmets manufactured according to military standards or specifications, or comparable national standards, and specially designed helmet shells, liners, or comfort pads, therefor;

   N.B. *For other military helmet components or accessories, see the relevant ML entry.*

d. Body armour or protective garments, and components therefor, as follows:
   1. Soft body armour or protective garments, manufactured to military standards or specifications, or to their equivalents, and specially designed components therefor;

      Note *For the purposes of ML13.d.1., military standards or specifications include, at a minimum, specifications for fragmentation protection.*

   2. Hard body armour plates providing ballistic protection equal to or greater than level III (NIJ 0101.06, July 2008) or national equivalents.

Note 1 *ML13.b. includes materials specially designed to form explosive reactive armour or to construct military shelters.*

Note 2 *ML13.c. does not apply to conventional steel helmets, neither modified or designed to accept, nor equipped with any type of accessory device.*

Note 3 *ML13.c. and d. do not apply to helmets, body armour or protective garments, when accompanying their user for the user's own personal protection.*

Note 4 *The only helmets specially designed for bomb disposal personnel that are specified by ML13. are those specially designed for military use.*

N.B. 1 *See also entry 1.A.5. on the Dual-Use List.*

N.B. 2 *For "fibrous or filamentary materials" used in the manufacture of body armour and helmets, see entry 1.C.10. on the Dual-Use List.*

ML14. 'Specialised equipment for military training' or for simulating military scenarios, simulators specially designed for training in the use of any firearm or weapon specified by ML1. or ML2., and specially designed components and accessories therefor.

Technical Note
The term 'specialised equipment for military training' includes military types of attack trainers, operational flight trainers, radar target trainers, radar target generators, gunnery training devices, anti-submarine warfare trainers, flight simulators (including human-rated centrifuges for pilot/astronaut training), radar trainers, instrument flight trainers, navigation trainers, missile launch trainers, target equipment, drone "aircraft", armament trainers, pilotless "aircraft" trainers, mobile training units and training equipment for ground military operations.

Note 1 *ML14. includes image generating and interactive environment systems for simulators, when specially designed or modified for military use.*

Note 2 *ML14. does not apply to equipment specially designed for training in the use of hunting or sporting weapons.*

ML15. Imaging or countermeasure equipment, as follows, specially designed for military use, and specially designed components and accessories therefor:

a. Recorders and image processing equipment;
b. Cameras, photographic equipment and film processing equipment;
c. Image intensifier equipment;
d. Infrared or thermal imaging equipment;
e. Imaging radar sensor equipment;
f. Countermeasure or counter-countermeasure equipment, for the equipment specified by ML15.a. to ML15.e.

Note *ML15.f. includes equipment designed to degrade the operation or effectiveness of military imaging systems or to minimize such degrading effects.*

Note 1 *In ML15., the term specially designed components includes the following, when specially designed for military use:*

a. Infrared image converter tubes;
b. Image intensifier tubes (other than first generation);
c. Microchannel plates;
d. Low-light-level television camera tubes;
e. Detector arrays (including electronic interconnection or read out systems);
f. Pyroelectric television camera tubes;
g. Cooling systems for imaging systems;
h. Electrically triggered shutters of the photochromic or electro-optical type having a shutter speed of less than 100 µs, except in the case of shutters which are an essential part of a high speed camera;
i. Fibre optic image inverters;
j. Compound semiconductor photocathodes.

Note 2 *ML15. does not apply to "first generation image intensifier tubes" or equipment specially designed to incorporate "first generation image intensifier tubes".*

N.B. *For the classification of weapons sights incorporating "first generation image intensifier tubes" see ML1., ML2. and ML5.a.*

N.B. *See also 6.A.2.a.2. and 6.A.2.b. on the Dual-Use List.*

ML16. Forgings, castings and other unfinished products, specially designed for items specified by ML1.to ML4., ML6., ML9., ML10., ML12. or ML19.

Note *ML16. applies to unfinished products when they are identifiable by material composition, geometry or function.*

ML17. Miscellaneous equipment, materials and "libraries", as follows, and specially designed components therefor:

a. Diving and underwater swimming apparatus, specially designed or modified for military use, as follows:
   1. Self-contained diving rebreathers, closed or semi-closed circuit;
   2. Underwater swimming apparatus specially designed for use with the diving apparatus specified in ML17.a.1;

   N.B. See also 8.A.2.q. on the Dual-Use List.

b. Construction equipment specially designed for military use;
c. Fittings, coatings and treatments, for signature suppression, specially designed for military use;
d. Field engineer equipment specially designed for use in a combat zone;
e. "Robots", "robot" controllers and "robot" "end-effectors", having any of the following characteristics:
   1. Specially designed for military use;
   2. Incorporating means of protecting hydraulic lines against externally induced punctures caused by ballistic fragments (e.g., incorporating self-sealing lines) and designed to use hydraulic fluids with flash points higher than 839 K (566°C); or
   3. Specially designed or rated for operating in an electro-magnetic pulse (EMP) environment;

   Technical Note
   Electro-magnetic pulse does not refer to unintentional interference caused by electromagnetic radiation from nearby equipment (e.g., machinery, appliances or electronics) or lightning.

f. "Libraries" specially designed or modified for military use with systems, equipment or components, specified by the Munitions List;
g. Nuclear power generating equipment or propulsion equipment, including "nuclear reactors", specially designed for military use and components therefor specially designed or 'modified' for military use;
h. Equipment and material, coated or treated for signature suppression, specially designed for military use, other than those specified elsewhere in the Munitions List;
i. Simulators specially designed for military "nuclear reactors";
j. Mobile repair shops specially designed or 'modified' to service military equipment;
k. Field generators specially designed or 'modified' for military use;
l. Containers specially designed or 'modified' for military use;
m. Ferries, other than those specified elsewhere in the Munitions List, bridges and pontoons, specially designed for military use;
n. Test models specially designed for the "development" of items specified by ML4., ML6., ML9. or ML10.;
o. "Laser" protection equipment (e.g., eye and sensor protection) specially designed for military use;
p. "Fuel cells", other than those specified elsewhere in the Munitions List, specially designed or 'modified' for military use.

Technical Note

1. *Not used since 2014*
2. *For the purpose of ML17, 'modified' means any structural, electrical, mechanical, or other change that provides a non-military item with military capabilities equivalent to an item which is specially designed for military use.*

ML18. 'Production' equipment and components, as follows:

a. Specially designed or modified 'production' equipment for the 'production' of products specified by the Munitions List, and specially designed components therefor;

b. Specially designed environmental test facilities and specially designed equipment therefor, for the certification, qualification or testing of products specified by the Munitions List.

Technical Note

For the purposes of ML18., the term 'production' includes design, examination, manufacture, testing and checking.

Note *ML18.a. and ML18.b. include the following equipment:*

a. Continuous nitrators;

b. Centrifugal testing apparatus or equipment, having any of the following:

1. Driven by a motor or motors having a total rated horsepower of more than 298 kW (400 hp);

2. Capable of carrying a payload of 113 kg or more; or

3. Capable of exerting a centrifugal acceleration of 8 g or more on a payload of 91 kg or more;

c. Dehydration presses;

d. Screw extruders specially designed or modified for military "explosive" extrusion;

e. Cutting machines for the sizing of extruded "propellants";

f. Sweetie barrels (tumblers) 1.85 m or more in diameter and having over 227 kg product capacity;

g. Continuous mixers for solid "propellants";

h. Fluid energy mills for grinding or milling the ingredients of military "explosives";

i. Equipment to achieve both sphericity and uniform particle size in metal powder listed in ML8.c.8.;

j. Convection current converters for the conversion of materials listed in ML8.c.3.

ML19. Directed Energy Weapon (DEW) systems, related or countermeasure equipment and test models, as follows, and specially designed components therefor:

a. "Laser" systems specially designed for destruction or effecting mission-abort of a target;
b. Particle beam systems capable of destruction or effecting mission-abort of a target;
c. High power Radio-Frequency (RF) systems capable of destruction or effecting mission-abort of a target;
d. Equipment specially designed for the detection or identification of, or defence against, systems specified by ML19.a. to ML19.c.;
e. Physical test models for the systems, equipment and components, specified by ML19.
f. "Laser" systems specially designed to cause permanent blindness to unenhanced vision, i.e., to the naked eye or to the eye with corrective eyesight devices.

<u>Note 1</u> *DEW systems specified by ML19. include systems whose capability is derived from the controlled application of:*

a. "Lasers" of sufficient power to effect destruction similar to the manner of conventional ammunition;
b. Particle accelerators which project a charged or neutral particle beam with destructive power;
c. High pulsed power or high average power radio frequency beam transmitters, which produce fields sufficiently intense to disable electronic circuitry at a distant target.

<u>Note 2</u> *ML19. includes the following when specially designed for DEW systems:*

a. Prime power generation, energy storage, switching, power conditioning or fuel-handling equipment;
b. Target acquisition or tracking systems;
c. Systems capable of assessing target damage, destruction or mission-abort;
d. Beam-handling, propagation or pointing equipment;
e. Equipment with rapid beam slew capability for rapid multiple target operations;
f. Adaptive optics and phase conjugators;
g. Current injectors for negative hydrogen ion beams;
h. "Space-qualified" accelerator components;
i. Negative ion beam funnelling equipment;
j. Equipment for controlling and slewing a high energy ion beam;
k. "Space-qualified" foils for neutralising negative hydrogen isotope beams.

ML20. Cryogenic and "superconductive" equipment, as follows, and specially designed components and accessories therefor:

a. Equipment specially designed or configured to be installed in a vehicle for military ground, marine, airborne or space applications, capable of operating while in motion and of producing or maintaining temperatures below 103 K (- 170°C);

Note *ML20.a. includes mobile systems incorporating or employing accessories or components manufactured from non-metallic or non-electrical conductive materials, such as plastics or epoxy-impregnated materials.*

b. "Superconductive" electrical equipment (rotating machinery and transformers) specially designed or configured to be installed in a vehicle for military ground, marine, airborne or space applications and capable of operating while in motion.

Note *ML20.b. does not apply to direct-current hybrid homopolar generators that have single-pole normal metal armatures which rotate in a magnetic field produced by superconducting windings, provided those windings are the only superconducting components in the generator.*

ML21. "Software" as follows:

a. "Software" specially designed or modified for any of the following:
   1. "Development", "production", operation or maintenance of equipment specified by the Munitions List;
   2. "Development" or "production" of materials specified by the Munitions List; or
   3. "Development", "production", operation or maintenance of "software" specified by the Munitions List.

b. Specific "software", other than that specified by ML21.a., as follows:
   1. "Software" specially designed for military use and specially designed for modelling, simulating or evaluating military weapon systems;
   2. "Software" specially designed for military use and specially designed for modelling or simulating military operational scenarios;
   3. "Software" for determining the effects of conventional, nuclear, chemical or biological weapons;
   4. "Software" specially designed for military use and specially designed for Command, Communications, Control and Intelligence (C^3I) or Command, Communications, Control, Computer and Intelligence (C^4I) applications;

c. "Software", not specified by ML21.a. or ML21b., specially designed or modified to enable equipment not specified by the Munitions List to perform the military functions of equipment specified by the Munitions List.

ML22. "Technology" as follows:

a. "Technology", other than specified in ML22.b, which is "required" for the "development", "production", operation, installation, maintenance (checking), repair, overhaul or refurbishing of items specified by the Munitions List;

b. "Technology" as follows:

1. "Technology" "required" for the design of, the assembly of components into, and the operation, maintenance and repair of, complete production installations for items specified by the Munitions List, even if the components of such production installations are not specified;
2. "Technology" "required" for the "development" and "production" of small arms, even if used to produce reproductions of antique small arms;
3. Not used since 2013

   N.B. *See ML22.a. for "technology" previously specified by ML22.b.3.*

4. Not used since 2013

   N.B. *See ML22.a. for "technology" previously specified by ML22.b.4.*

5. "Technology" "required" exclusively for the incorporation of "biocatalysts", specified by ML7.i.1., into military carrier substances or military material.

Note 1 *"Technology" "required" for the "development", "production", operation, installation, maintenance (checking), repair, overhaul or refurbishing of items specified by the Munitions List remains under control even when applicable to any item not specified by the Munitions List.*

Note 2 *ML22 does not apply to:*

a. "Technology" that is the minimum necessary for the installation, operation, maintenance (checking) or repair, of those items which are not controlled or whose export has been authorised;

b. "Technology" that is "in the public domain", "basic scientific research" or the minimum necessary information for patent applications;

c. "Technology" for magnetic induction for continuous propulsion of civil transport devices.

DEFINITIONS OF TERMS USED IN THESE LISTS

This document contains the definitions of the terms used in these Lists, in alphabetical order.

Note 1 *Definitions apply throughout the Lists and their Annexes. The references are purely advisory and have no effect on the universal application of defined terms throughout these Lists and their Annexes.*

Note 2 *Words and terms contained in the List of Definitions only take the defined meaning where this is indicated by their being enclosed in quotations marks (" "). Elsewhere, words and terms take their commonly accepted (dictionary) meanings, unless a local definition for a particular control is given. (See also 'Statements of Understanding and Validity Notes – Definition of Terms used in these Lists').*

Cat 2, 3, 6, 7, 8 "Accuracy"
(Usually measured in terms of inaccuracy) is the maximum deviation, positive or negative, of an indicated value from an accepted standard or true value.

Cat 7 "Active flight control systems"
Function to prevent undesirable "aircraft" and missile motions or structural loads by autonomously processing outputs from multiple sensors and then providing necessary preventive commands to effect automatic control.

Cat 6 "Active pixel"
A minimum (single) element of the solid state array which has a photoelectric transfer function when exposed to light (electromagnetic) radiation.

ML8 "Additives"
Substances used in explosive formulations to improve their properties.

Cat 1, 6, 7, 9 ML8, 10, 14 "Aircraft"
A fixed wing, swivel wing, rotary wing (helicopter), tilt rotor or tilt-wing airborne vehicle.

Cat 9 "Airship"
A power-driven airborne vehicle that is kept buoyant by a body of gas (usually helium, formerly hydrogen) which is lighter than air.

Cat 2 "All compensations available"
"All compensations available" means after all feasible measures available to the manufacturer to minimise all systematic positioning errors for the particular machine-tool model or measuring errors for the particular coordinate measuring machine are considered.

Cat 3 "Allocated by the ITU"

Cat 5P1 The allocation of frequency bands according to the current edition of the ITU Radio Regulations for primary, permitted and secondary services.

N.B. Additional and alternative allocations are not included.

Cat 7 "Angle random walk"

The angular error build up with time that is due to white noise in angular rate. (IEEE STD 528-2001)

Cat 5P2 "Asymmetric algorithm"

A cryptographic algorithm using different, mathematically-related keys for encryption and decryption.

Technical Note

A common use of "asymmetric algorithms" is key management.

Cat 5P2 "Authentication"

Verifying the identity of a user, process or device, often as a prerequisite to allowing access to resources in an information system. This includes verifying the origin or content of a message or other information, and all aspects of access control where there is no encryption of files or text except as directly related to the protection of passwords, Personal Identification Numbers (PINs) or similar data to prevent unauthorized access.

ML11 "Automated Command and Control Systems"

Electronic systems, through which information essential to the effective operation of the grouping, major formation, tactical formation, unit, ship, subunit or weapons under command is entered, processed and transmitted. This is achieved by the use of computer and other specialised hardware designed to support the functions of a military command and control organisation. The main functions of an automated command and control system are: the efficient automated collection, accumulation, storage and processing of information; the display of the situation and the circumstances affecting the preparation and conduct of combat operations; operational and tactical calculations for the allocation of resources among force groupings or elements of the operational order of battle or battle deployment according to the mission or stage of the operation; the preparation of data for appreciation of the situation and decision-making at any point during operation or battle; computer simulation of operations.

Cat 6 "Automatic target tracking"

A processing technique that automatically determines and provides as output an extrapolated value of the most probable position of the target in real time.

Cat 6 "Average output power"

The total "laser" output energy, in joules, divided by the period over which a series of consecutive pulses is emitted, in seconds. For a series of uniformly-spaced pulses it is equal to the total "laser" output energy in a single pulse, in joules, multiplied by the pulse frequency of the "laser", in Hertz.

Cat 3 "Basic gate propagation delay time"

The propagation delay time value corresponding to the basic gate used in a "monolithic integrated circuit". For a 'family' of "monolithic integrated circuits", this may be specified either as the propagation delay time per typical gate within the given 'family' or as the typical propagation delay time per gate within the given 'family'.

Technical Notes

1. *"Basic gate propagation delay time" is not to be confused with the input/output delay time of a complex "monolithic integrated circuit".*
2. *'Family' consists of all integrated circuits to which all of the following are applied as their manufacturing methodology and specifications except their respective functions:*
   a. *The common hardware and software architecture;*
   b. *The common design and process technology; and*
   c. *The common basic characteristics.*

GTN "Basic scientific research"
ML22

Experimental or theoretical work undertaken principally to acquire new knowledge of the fundamental principles of phenomena or observable facts, not primarily directed towards a specific practical aim or objective.

Cat 7 "Bias" (accelerometer)

The average over a specified time of accelerometer output, measured at specified operating conditions, that has no correlation with input acceleration or rotation. "Bias" is expressed in g or in metres per second^2 (g or m/s^2). (IEEE Std 528-2001) (Micro g equals 1x10^{-6} g).

Cat 7 "Bias" (gyro)

The average over a specified time of gyro output measured at specified operating conditions that has no correlation with input rotation or acceleration. "Bias" is typically expressed in degrees per hour (deg/hr). (IEEE Std 528-2001).

ML7, 22 "Biocatalysts"

'Enzymes' for specific chemical or biochemical reactions or other biological compounds which bind to and accelerate the degradation of CW agents.

Technical Note

'Enzymes' means "biocatalysts" for specific chemical or biochemical reactions.

Cat 1, ML7 "Biological agents"

Pathogens or toxins, selected or modified (such as altering purity, shelf life, virulence, dissemination characteristics, or resistance to UV radiation) to produce casualties in humans or animals, degrade equipment or damage crops or the environment.

ML7 "Biopolymers"

Biological macromolecules as follows:

a. Enzymes for specific chemical or biochemical reactions;
b. 'Anti-idiotypic', 'monoclonal' or 'polyclonal' 'antibodies';
c. Specially designed or specially processed 'receptors';

Technical Notes

1. *'Anti-idiotypic antibodies' means antibodies which bind to the specific antigen binding sites of other antibodies;*
2. *'Monoclonal antibodies' means proteins which bind to one antigenic site and are produced by a single clone of cells;*
3. *'Polyclonal antibodies' means a mixture of proteins which bind to the specific antigen and are produced by more than one clone of cells;*
4. *'Receptors' means biological macromolecular structures capable of binding ligands, the binding of which affects physiological functions.*

Cat 2 "Camming" (axial displacement)

Axial displacement in one revolution of the main spindle measured in a plane perpendicular to the spindle faceplate, at a point next to the circumference of the spindle faceplate (Reference: ISO 230/1 1986, paragraph 5.63).

Cat 1 "Carbon fibre preforms"

An ordered arrangement of uncoated or coated fibres intended to constitute a framework of a part before the "matrix" is introduced to form a "composite".

Cat 6 "Chemical Laser"

A "laser" in which the excited species is produced by the output energy from a chemical reaction.

"Circuit element"

A single active or passive functional part of an electronic circuit, such as one diode, one transistor, one resistor, one capacitor, etc.

Cat 7 "Circular Error Probable" ("CEP")

In a circular normal distribution, the radius of the circle containing 50% of the individual measurements being made, or the radius of the circle within which there is a 50% probability of being located.

Cat 7 "Circulation-controlled anti-torque or circulation-controlled direction control systems"

Control systems using air blown over aerodynamic surfaces to increase or control the forces generated by the surfaces.

Cat 1, 3, 4, 7 ML4, 10 "Civil aircraft"

Those "aircraft" listed by designation in published airworthiness certification lists by civil aviation authorities of one or more Wassenaar Arrangement Participating States to fly commercial civil internal and external routes or for legitimate civil, private or business use.

Cat 1 "Commingled"

Filament to filament blending of thermoplastic fibres and reinforcement fibres in order to produce a fibre reinforcement "matrix" mix in total fibre form.

Cat 1 "Comminution"

A process to reduce a material to particles by crushing or grinding.

Cat 4 "Communications channel controller"

The physical interface which controls the flow of synchronous or asynchronous digital information. It is an assembly that can be integrated into computer or telecommunications equipment to provide communications access.

Cat 6 "Compensation systems"

Consist of the primary scalar sensor, one or more reference sensors (e.g. vector magnetometers) together with software that permit reduction of rigid body rotation noise of the platform.

Cat 1 Cat 2 Cat 6 Cat 8 & 9 "Composite"

A "matrix" and an additional phase or additional phases consisting of particles, whiskers, fibres or any combination thereof, present for a specific purpose or purposes.

Cat 2 "Compound rotary table"

A table allowing the workpiece to rotate and tilt about two non-parallel axes, which can be coordinated simultaneously for "contouring control".

Cat 3 Cat 6 "III/V compounds"

Polycrystalline or binary or complex monocrystalline products consisting of elements of groups IIIA and VA of Mendeleyev's periodic classification table (e.g., gallium arsenide, gallium-aluminium arsenide, indium phosphide).

Cat 2 "Contouring control"

Two or more "numerically controlled" motions operating in accordance with instructions that specify the next required position and the required feed rates to that position. These feed rates are varied in relation to each other so that a desired contour is generated (Ref. ISO/DIS 2806 - 1980).

Cat 1, 3 "Critical temperature"
Cat 5P1

(sometimes referred to as the transition temperature) of a specific "superconductive" material is the temperature at which the material loses all resistance to the flow of direct electrical current.

Cat 5P2 "Cryptographic activation"

Any technique that activates or enables cryptographic capability of an item, by means of a secure mechanism implemented by the manufacturer of the item, where this mechanism is uniquely bound to any of the following:

1. A single instance of the item; or
2. One customer, for multiple instances of the item.

Technical Notes

1. *"Cryptographic activation" techniques and mechanisms may be implemented as hardware, "software" or "technology".*
2. *Mechanisms for "cryptographic activation" can, for example, be serial number-based licence keys or authentication instruments such as digitally signed certificates.*

Cat 5P2 "Cryptography"

The discipline which embodies principles, means and methods for the transformation of data in order to hide its information content, prevent its undetected modification or prevent its unauthorized use. "Cryptography" is limited to the transformation of information using one or more 'secret parameters' (e.g., crypto variables) or associated key management.

Note *"Cryptography" does not include 'fixed' data compression or coding techniques.*

Technical Notes

1. *'Secret parameter': a constant or key kept from the knowledge of others or shared only within a group.*
2. *'Fixed': the coding or compression algorithm cannot accept externally supplied parameters (e.g., cryptographic or key variables) and cannot be modified by the user.*

Cat 6 "CW Laser"

A "laser" that produces a nominally constant output energy for greater than 0.25 seconds.

Cat 7 "Data-Based Referenced Navigation" ("DBRN") Systems

Systems which use various sources of previously measured geo-mapping data integrated to provide accurate navigation information under dynamic conditions. Data sources include bathymetric maps, stellar maps, gravity maps, magnetic maps or 3-D digital terrain maps.

ML1 "Deactivated firearm"

A firearm that has been made incapable of firing any projectile by processes defined by the Wassenaar Arrangement Participating State's national authority. These processes permanently modify the essential elements of the firearm. According to national laws and regulations, deactivation of the firearm may be attested by a certificate delivered by a competent authority and may be marked on the firearm by a stamp on an essential part.

Cat 6 "Deformable Mirrors"

Mirrors:

a. Having a single continuous optical reflecting surface which is dynamically deformed by the application of individual torques or forces to compensate for distortions in the optical waveform incident upon the mirror; or
b. Having multiple optical reflecting elements that can be individually and dynamically repositioned by the application of torques or forces to compensate for distortions in the optical waveform incident upon the mirror.

"Deformable mirrors" are also known as adaptive optic mirrors.

GTN "Development"
Both Lists

Is related to all stages prior to serial production, such as: design, design research, design analyses, design concepts, assembly and testing of prototypes, pilot production schemes, design data, process of transforming design data into a product, configuration design, integration design, layouts.

Cat 1, 2, 9 "Diffusion bonding"

A solid state joining of at least two separate pieces of metals into a single piece with a joint strength equivalent to that of the weakest material, wherein the principal mechanism is interdiffusion of atoms across the interface.

Cat 4 "Digital computer"
Cat 5P1

Equipment which can, in the form of one or more discrete variables, perform all of the following:

a. Accept data;
b. Store data or instructions in fixed or alterable (writable) storage devices;
c. Process data by means of a stored sequence of instructions which is modifiable; and
d. Provide output of data.

Technical Note

Modifications of a stored sequence of instructions include replacement of fixed storage devices, but not a physical change in wiring or interconnections.

"Digital transfer rate"

The total bit rate of the information that is directly transferred on any type of medium. (See also "total digital transfer rate").

Cat 2 "Direct-acting hydraulic pressing"
A deformation process which uses a fluid-filled flexible bladder in direct contact with the workpiece.

"Discrete component"
A separately packaged "circuit element" with its own external connections.

Cat 1 "Effective gram"
"Effective gram" for plutonium isotope is defined as the isotope weight in grams.

Cat 5P1 "Electronically steerable phased array antenna"
Cat 6 An antenna which forms a beam by means of phase coupling, (i.e., the beam direction is controlled by the complex excitation coefficients of the radiating elements) and the direction of that beam can be varied (both in transmission and reception) in azimuth or in elevation, or both, by application of an electrical signal.

Cat 2, 3 "Electronic assembly"
Cat 4 A number of electronic components (i.e., "circuit elements", "discrete components", integrated circuits, etc.) connected together to perform (a) specific function(s), replaceable as an entity and normally capable of being disassembled.

Cat 2 "End-effectors"
ML17 Grippers, 'active tooling units' and any other tooling that is attached to the baseplate on the end of a "robot" manipulator arm.
Technical Note
'Active tooling units' are devices for applying motive power, process energy or sensing to a workpiece.

Cat 1 "Energetic materials"
ML8 Substances or mixtures that react chemically to release energy required for their intended application. "Explosives", "pyrotechnics" and "propellants" are subclasses of energetic materials.

Cat 6 "Equivalent Density"
The mass of an optic per unit optical area projected onto the optical surface.

ML8, 18 "Explosives"
Cat 1 Solid, liquid or gaseous substances or mixtures of substances which, in their application as primary, booster, or main charges in warheads, demolition and other applications, are required to detonate.

ML7 "Expression Vectors"

Carriers (e.g., plasmid or virus) used to introduce genetic material into host cells.

Cat 9 "FADEC Systems"

Full Authority Digital Engine Control Systems – A digital electronic control system for a gas turbine engine that is able to autonomously control the engine throughout its whole operating range from demanded engine start until demanded engine shut-down, in both normal and fault conditions.

Cat 1, 8, 9 "Fibrous or filamentary materials"
ML13

Include:

a. Continuous monofilaments;
b. Continuous yarns and rovings;
c. Tapes, fabrics, random mats and braids;
d. Chopped fibres, staple fibres and coherent fibre blankets;
e. Whiskers, either monocrystalline or polycrystalline, of any length;
f. Aromatic polyamide pulp.

Cat 3 "Film type integrated circuit"

An array of "circuit elements" and metallic interconnections formed by deposition of a thick or thin film on an insulating "substrate".

ML15 "First generation image intensifier tubes"

Electrostatically focused tubes, employing input and output fibre optic or glass face plates, multi-alkali photocathodes (S-20 or S-25), but not microchannel plate amplifiers.

Cat 7 "Flight control optical sensor array"

A network of distributed optical sensors, using "laser" beams, to provide real-time flight control data for on-board processing.

Cat 7 "Flight path optimization"

A procedure that minimizes deviations from a four-dimensional (space and time) desired trajectory based on maximizing performance or effectiveness for mission tasks.

Cat 7 "Fly-by-light system"

A primary digital flight control system employing feedback to control the "aircraft" during flight, where the commands to the effectors/actuators are optical signals.

Cat 7 "Fly-by-wire system"

A primary digital flight control system employing feedback to control the "aircraft" during flight, where the commands to the effectors/actuators are electrical signals.

Cat 6, 8 "Focal plane array"

A linear or two-dimensional planar layer, or combination of planar layers, of individual detector elements, with or without readout electronics, which work in the focal plane.

Note *This definition does not include a stack of single detector elements or any two, three or four element detectors provided time delay and integration is not performed within the element.*

Cat 3 "Fractional bandwidth"
Cat 5P1 The "instantaneous bandwidth" divided by the centre frequency, expressed
5P2 as a percentage.

Cat 5P1 "Frequency hopping"
5P2, 6 A form of "spread spectrum" in which the transmission frequency of a single communication channel is made to change by a random or pseudo-random sequence of discrete steps.

Cat 3 "Frequency mask trigger"

For "signal analysers" a mechanism where the trigger function is able to select a frequency range to be triggered on as a subset of the acquisition bandwidth while ignoring other signals that may also be present within the same acquisition bandwidth. A "frequency mask trigger" may contain more than one independent set of limits.

Cat 3 "Frequency switching time"

The time (i.e., delay) taken by a signal when switched from an initial specified output frequency, to arrive at or within any of the following:

a. ±100 Hz of a final specified output frequency of less than 1 GHz; or
b. ±0.1 part per million of a final specified output frequency equal to or greater than 1 GHz.

Cat 3 "Frequency synthesizer"

Any kind of frequency source, regardless of the actual technique used, providing a multiplicity of simultaneous or alternative output frequencies, from one or more outputs, controlled by, derived from or disciplined by a lesser number of standard (or master) frequencies.

Cat 8 "Fuel cell"
ML17 An electrochemical device that converts chemical energy directly into Direct Current (DC) electricity by consuming fuel from an external source.

Cat 1 "Fusible"

Capable of being cross-linked or polymerized further (cured) by the use of heat, radiation, catalysts, etc., or that can be melted without pyrolysis (charring).

DEFINITIONS

Cat 1 "Gas atomisation"

A process to reduce a molten stream of metal alloy to droplets of 500 µm diameter or less by a high pressure gas stream.

Cat 6 "Geographically dispersed"

Sensors are considered "geographically dispersed" when each location is distant from any other more than 1,500 m in any direction. Mobile sensors are always considered "geographically dispersed".

Cat 2 "Hot isostatic densification"

A process of pressurising a casting at temperatures exceeding 375 K (102°C) in a closed cavity through various media (gas, liquid, solid particles, etc.) to create equal force in all directions to reduce or eliminate internal voids in the casting.

Cat 3 "Hybrid integrated circuit"

Any combination of integrated circuit(s), or integrated circuit with "circuit elements" or "discrete components" connected together to perform (a) specific function(s), and having all of the following characteristics:

a. Containing at least one unencapsulated device;
b. Connected together using typical IC production methods;
c. Replaceable as an entity; and
d. Not normally capable of being disassembled.

Cat 4 "Image enhancement"

The processing of externally derived information-bearing images by algorithms such as time compression, filtering, extraction, selection, correlation, convolution or transformations between domains (e.g., fast Fourier transform or Walsh transform). This does not include algorithms using only linear or rotational transformation of a single image, such as translation, feature extraction, registration or false coloration.

GSN "Information security"
GISN
Cat 5P2

All the means and functions ensuring the accessibility, confidentiality or integrity of information or communications, excluding the means and functions intended to safeguard against malfunctions. This includes "cryptography", "cryptographic activation", 'cryptanalysis', protection against compromising emanations and computer security.

Technical Note

'Cryptanalysis': the analysis of a cryptographic system or its inputs and outputs to derive confidential variables or sensitive data, including clear text. (ISO 7498-2-1988 (E), paragraph 3.3.18).

Cat 3 "Instantaneous bandwidth"
Cat 5P1

The bandwidth over which output power remains constant within 3 dB without adjustment of other operating parameters.

Cat 6 "Instrumented range"

The specified unambiguous display range of a radar.

GTN "In the public domain"
GSN
ML22

This means "technology" or "software" which has been made available without restrictions upon its further dissemination.

Note *Copyright restrictions do not remove "technology" or "software" from being "in the public domain".*

Cat 6 "Intrinsic magnetic gradiometer"

A single magnetic field gradient sensing element and associated electronics the output of which is a measure of magnetic field gradient.

Cat 4 "Intrusion software"

"Software" specially designed or modified to avoid detection by 'monitoring tools', or to defeat 'protective countermeasures', of a computer or network-capable device, and performing any of the following:

a. The extraction of data or information, from a computer or network-capable device, or the modification of system or user data; or

b. The modification of the standard execution path of a program or process in order to allow the execution of externally provided instructions.

Notes

1. "Intrusion software" does not include any of the following:

a. Hypervisors, debuggers or Software Reverse Engineering (SRE) tools;

b. Digital Rights Management (DRM) "software"; or

c. "Software" designed to be installed by manufacturers, administrators or users, for the purposes of asset tracking or recovery.

2. Network-capable devices include mobile devices and smart meters.

Technical Notes

1. 'Monitoring tools': "software" or hardware devices, that monitor system behaviours or processes running on a device. This includes antivirus (AV) products, end point security products, Personal Security Products (PSP), Intrusion Detection Systems (IDS), Intrusion Prevention Systems (IPS) or firewalls.

2. 'Protective countermeasures': techniques designed to ensure the safe execution of code, such as Data Execution Prevention (DEP), Address Space Layout Randomisation (ASLR) or sandboxing.

Cat 2 "Isostatic presses"

Equipment capable of pressurising a closed cavity through various media (gas, liquid, solid particles, etc.) to create equal pressure in all directions within the cavity upon a workpiece or material.

Cat 1, 2, 3, 5P1, 6, 7, 8, 9 ML9, 19 "Laser"
An item that produces spatially and temporally coherent light through amplification by stimulated emission of radiation.

Cat 1 ML17 "Library" (parametric technical database)
A collection of technical information, reference to which may enhance the performance of relevant systems, equipment or components.

ML10 "Lighter-than-air vehicles"
Balloons and "airships" that rely on hot air or on lighter-than-air gases such as helium or hydrogen for their lift.

Cat 2 "Linearity"
(Usually measured in terms of non-linearity) is the maximum deviation of the actual characteristic (average of upscale and downscale readings), positive or negative, from a straight line so positioned as to equalise and minimise the maximum deviations.

Cat 4 Cat 5P1 "Local area network"
A data communication system having all of the following characteristics:
a. Allows an arbitrary number of independent 'data devices' to communicate directly with each other; and
b. Is confined to a geographical area of moderate size (e.g., office building, plant, campus, warehouse).

Technical Note
'Data device' means equipment capable of transmitting or receiving sequences of digital information.

Cat 6 "Magnetic gradiometers"
Are designed to detect the spatial variation of magnetic fields from sources external to the instrument. They consist of multiple "magnetometers" and associated electronics the output of which is a measure of magnetic field gradient. (See also "Intrinsic Magnetic Gradiometer")

Cat 6 "Magnetometers"
Are designed to detect magnetic fields from sources external to the instrument. They consist of a single magnetic field sensing element and associated electronics the output of which is a measure of the magnetic field.

Cat 4 "Main storage"
The primary storage for data or instructions for rapid access by a central processing unit. It consists of the internal storage of a "digital computer" and any hierarchical extension thereto, such as cache storage or non-sequentially accessed extended storage.

Cat 1 Cat 2 Cat 8 & 9 "Matrix"
A substantially continuous phase that fills the space between particles, whiskers or fibres.

Cat 2 "Measurement uncertainty"

The characteristic parameter which specifies in what range around the output value the correct value of the measurable variable lies with a confidence level of 95%. It includes the uncorrected systematic deviations, the uncorrected backlash and the random deviations (Reference: ISO 10360-2).

Cat 1 "Mechanical alloying"

An alloying process resulting from the bonding, fracturing and rebonding of elemental and master alloy powders by mechanical impact. Non-metallic particles may be incorporated in the alloy by addition of the appropriate powders.

Cat 1 "Melt extraction"

A process to "solidify rapidly" and extract a ribbon-like alloy product by the insertion of a short segment of a rotating chilled block into a bath of a molten metal alloy.

Cat 1 "Melt spinning"

A process to "solidify rapidly" a molten metal stream impinging upon a rotating chilled block, forming a flake, ribbon or rod-like product.

Cat 3 "Microcomputer microcircuit"

A "monolithic integrated circuit" or "multichip integrated circuit" containing an arithmetic logic unit (ALU) capable of executing general purpose instructions from an internal storage, on data contained in the internal storage.

Technical Note

The internal storage may be augmented by an external storage.

Cat 3 "Microprocessor microcircuit"

A "monolithic integrated circuit" or "multichip integrated circuit" containing an arithmetic logic unit (ALU) capable of executing a series of general purpose instructions from an external storage.

Technical Note

The "microprocessor microcircuit" normally does not contain integral user-accessible storage, although storage present on-the-chip may be used in performing its logic function.

Note *This definition includes chip sets which are designed to operate together to provide the function of a "microprocessor microcircuit".*

"Microprogram"

A sequence of elementary instructions maintained in a special storage, the execution of which is initiated by the introduction of its reference instruction into an instruction register.

Cat 3 "Monolithic integrated circuit"

A combination of passive or active "circuit elements" or both which:

a. Are formed by means of diffusion processes, implantation processes or deposition processes in or on a single semiconducting piece of material, a so-called 'chip';
b. Can be considered as indivisibly associated; and
c. Perform the function(s) of a circuit.

Cat 3, 5P1 "Monolithic Microwave Integrated Circuit" ("MMIC")

A "monolithic integrated circuit" that operates at microwave or millimeter wave frequencies.

Cat 6 "Monospectral imaging sensors"

Are capable of acquisition of imaging data from one discrete spectral band.

Cat 3 "Multichip integrated circuit"

Two or more "monolithic integrated circuits" bonded to a common "substrate".

Cat 6 "Multispectral imaging sensors"

Are capable of simultaneous or serial acquisition of imaging data from two or more discrete spectral bands. Sensors having more than twenty discrete spectral bands are sometimes referred to as hyperspectral imaging sensors.

Cat 4 "Network access controller"

A physical interface to a distributed switching network. It uses a common medium which operates throughout at the same "digital transfer rate" using arbitration (e.g., token or carrier sense) for transmission. Independently from any other, it selects data packets or data groups (e.g., IEEE 802) addressed to it. It is an assembly that can be integrated into computer or telecommunications equipment to provide communications access.

Cat 4 "Neural computer"

A computational device designed or modified to mimic the behaviour of a neuron or a collection of neurons, i.e., a computational device which is distinguished by its hardware capability to modulate the weights and numbers of the interconnections of a multiplicity of computational components based on previous data.

ML17 "Nuclear reactor"

Includes the items within or attached directly to the reactor vessel, the equipment which controls the level of power in the core, and the components which normally contain or come into direct contact with or control the primary coolant of the reactor core.

Cat 2 "Numerical control"

The automatic control of a process performed by a device that makes use of numeric data usually introduced as the operation is in progress (Ref. ISO 2382).

GSN "Object code"

An equipment executable form of a convenient expression of one or more processes ("source code" (or source language)) which has been compiled by a programming system.

Cat 5P2 "Operations, Administration or Maintenance" ("OAM")

Means performing one or more of the following tasks:

a. Establishing or managing any of the following:
   1. Accounts or privileges of users or administrators;
   2. Settings of an item; or
   3. Authentication data in support of the tasks described in paragraphs a.1. or a.2.;
b. Monitoring or managing the operating condition or performance of an item; or
c. Managing logs or audit data in support of any of the tasks described in paragraphs a. or b.

Note *"OAM" does not include any of the following tasks or their associated key management functions:*

a. Provisioning or upgrading any cryptographic functionality that is not directly related to establishing or managing authentication data in support of the tasks described in paragraphs a.1. or a.2. above; or

b. Performing any cryptographic functionality on the forwarding or data plane of an item.

Cat 4 "Optical computer"

A computer designed or modified to use light to represent data and whose computational logic elements are based on directly coupled optical devices.

Cat 3 "Optical integrated circuit"

A "monolithic integrated circuit" or a "hybrid integrated circuit", containing one or more parts designed to function as a photosensor or photoemitter or to perform (an) optical or (an) electro-optical function(s).

Cat 5P1 "Optical switching"

The routing of or switching of signals in optical form without conversion to electrical signals.

Cat 3 "Overall current density"

The total number of ampere-turns in the coil (i.e., the sum of the number of turns multiplied by the maximum current carried by each turn) divided by the total cross-section of the coil (comprising the superconducting filaments, the metallic matrix in which the superconducting filaments are embedded, the encapsulating material, any cooling channels, etc.).

Cat 6 "Peak power"

The highest power attained in the "pulse duration".

Cat 5P2 "Personal area network"

A data communication system having all of the following characteristics:

a. Allows an arbitrary number of independent or interconnected 'data devices' to communicate directly with each other; and

b. Is confined to the communication between devices within the immediate vicinity of an individual person or device controller (e.g., single room, office, or automobile, and their nearby surrounding spaces).

Technical Note

'Data device' means equipment capable of transmitting or receiving sequences of digital information.

Cat 1 "Plasma atomisation"

A process to reduce a molten stream or solid metal to droplets of 500 µm diameter or less, using plasma torches in an inert gas environment.

Cat 7 "Power management"

Changing the transmitted power of the altimeter signal so that received power at the "aircraft" altitude is always at the minimum necessary to determine the altitude.

ML8 "Precursors"

Speciality chemicals used in the manufacture of explosives.

Cat 1 "Previously separated"

The application of any process intended to increase the concentration of the controlled isotope.

Cat 7 "Primary flight control"

"Aircraft" stability or manoeuvering control using force/moment generators, i.e. aerodynamic control surfaces or propulsive thrust vectoring.

Cat 4 "Principal element"

An element is a "principal element" when its replacement value is more than 35% of the total value of the system of which it is an element. Element value is the price paid for the element by the manufacturer of the system, or by the system integrator. Total value is the normal international selling price to unrelated parties at the point of manufacture or consolidation of shipment.

GTN "Production"

Both Lists Means all production stages, such as: product engineering, manufacture, integration, assembly (mounting), inspection, testing, quality assurance.

Cat 2, 6 "Program"

A sequence of instructions to carry out a process in, or convertible into, a form executable by an electronic computer.

ML8 "Propellants"

Substances or mixtures that react chemically to produce large volumes of hot gases at controlled rates to perform mechanical work.

Cat 6 "Pulse compression"

The coding and processing of a radar signal pulse of long time duration to one of short time duration, while maintaining the benefits of high pulse energy.

Cat 6 "Pulse duration"

Duration of a "laser" pulse is the time between the half-power points on the leading edge and trailing edge of an individual pulse.

Cat 6 "Pulsed laser"

A "laser" having a "pulse duration" that is less than or equal to 0.25 seconds.

ML4 "Pyrotechnic(s)"
ML8

Mixtures of solid or liquid fuels and oxidizers which, when ignited, undergo an energetic chemical reaction at a controlled rate intended to produce specific time delays, or quantities of heat, noise, smoke, visible light or infrared radiation. Pyrophorics are a subclass of pyrotechnics, which contain no oxidizers but ignite spontaneously on contact with air.

Cat 5P2 "Quantum cryptography"

A family of techniques for the establishment of a shared key for "cryptography" by measuring the quantum-mechanical properties of a physical system (including those physical properties explicitly governed by quantum optics, quantum field theory, or quantum electrodynamics).

Cat 6 "Radar frequency agility"

Any technique which changes, in a pseudo-random sequence, the carrier frequency of a pulsed radar transmitter between pulses or between groups of pulses by an amount equal to or larger than the pulse bandwidth.

Cat 6 "Radar spread spectrum"

Any modulation technique for spreading energy originating from a signal with a relatively narrow frequency band, over a much wider band of frequencies, by using random or pseudo-random coding.

Cat 6 "Radiant sensitivity"

Radiant sensitivity (mA/W) = 0.807 x (wavelength in nm) x Quantum Efficiency (QE)

Technical Note

QE is usually expressed as a percentage; however, for the purposes of this formula QE is expressed as a decimal number less than one, e.g., 78% is 0.78.

Cat 3 "Real-time bandwidth"

For "signal analysers", the widest frequency range for which the analyser can continuously transform time-domain data entirely into frequency-domain results using a Fourier or other discrete time transform that processes every incoming time point, without a reduction of measured amplitude of more than 3 dB below the actual signal amplitude caused by gaps or windowing effects, while outputting or displaying the transformed data.

Cat 6 "Real-time processing"

The processing of data by a computer system providing a required level of service, as a function of available resources, within a guaranteed response time, regardless of the load of the system, when stimulated by an external event.

Cat 7 "Repeatability"

The closeness of agreement among repeated measurements of the same variable under the same operating conditions when changes in conditions or non-operating periods occur between measurements. (Reference: IEEE STD 528-2001 (one sigma standard deviation))

Cat 5P1
Cat 6, 7, 9
GTN
ML22
"Required"

As applied to "technology", refers to only that portion of "technology" which is peculiarly responsible for achieving or exceeding the controlled performance levels, characteristics or functions. Such "required" "technology" may be shared by different products.

Cat 2 "Resolution"

The least increment of a measuring device; on digital instruments, the least significant bit. (Reference: ANSI B-89.1.12)

Cat 1
ML7
"Riot control agents"

Substances which, under the expected conditions of use for riot control purposes, produce rapidly in humans sensory irritation or disabling physical effects which disappear within a short time following termination of exposure. (Tear gases are a subset of "riot control agents".)

Cat 2 "Robot"
Cat 8 A manipulation mechanism, which may be of the continuous path or
ML17 of the point-to-point variety, may use sensors, and has all the following characteristics:

a. Is multifunctional;
b. Is capable of positioning or orienting material, parts, tools or special devices through variable movements in three dimensional space;
c. Incorporates three or more closed or open loop servo-devices which may include stepping motors; and
d. Has "user-accessible programmability" by means of the teach/playback method or by means of an electronic computer which may be a programmable logic controller, i.e., without mechanical intervention.

Note *The above definition does not include the following devices:*

1. *Manipulation mechanisms which are only manually/tele-operator controllable;*
2. *Fixed sequence manipulation mechanisms which are automated moving devices, operating according to mechanically fixed programmed motions. The programme is mechanically limited by fixed stops, such as pins or cams. The sequence of motions and the selection of paths or angles are not variable or changeable by mechanical, electronic or electrical means;*
3. *Mechanically controlled variable sequence manipulation mechanisms which are automated moving devices, operating according to mechanically fixed programmed motions. The programme is mechanically limited by fixed, but adjustable stops, such as pins or cams. The sequence of motions and the selection of paths or angles are variable within the fixed programme pattern. Variations or modifications of the programme pattern (e.g., changes of pins or exchanges of cams) in one or more motion axes are accomplished only through mechanical operations;*
4. *Non-servo-controlled variable sequence manipulation mechanisms which are automated moving devices, operating according to mechanically fixed programmed motions. The programme is variable but the sequence proceeds only by the binary signal from mechanically fixed electrical binary devices or adjustable stops;*
5. *Stacker cranes defined as Cartesian coordinate manipulator systems manufactured as an integral part of a vertical array of storage bins and designed to access the contents of those bins for storage or retrieval.*

Cat 1 "Rotary atomisation"

A process to reduce a stream or pool of molten metal to droplets to a diameter of 500 µm or less by centrifugal force.

Cat 2 "Run-out" (out-of-true running)

Radial displacement in one revolution of the main spindle measured in a plane perpendicular to the spindle axis at a point on the external or internal revolving surface to be tested (Reference: ISO 230/1-1986, paragraph 5.61).

Cat 7 "Scale factor" (gyro or accelerometer)
The ratio of change in output to a change in the input intended to be measured. Scale factor is generally evaluated as the slope of the straight line that can be fitted by the method of least squares to input-output data obtained by varying the input cyclically over the input range.

Cat 3 "Settling time"
The time required for the output to come within one-half bit of the final value when switching between any two levels of the converter.

Cat 3 "Signal analysers"
Apparatus capable of measuring and displaying basic properties of the single-frequency components of multi-frequency signals.

Cat 3, 4 "Signal processing"
Cat 5P1, 6 The processing of externally derived information-bearing signals by algorithms such as time compression, filtering, extraction, selection, correlation, convolution or transformations between domains (e.g., fast Fourier transform or Walsh transform).

Both Lists "Software"
A collection of one or more "programs" or "microprograms" fixed in any tangible medium of expression.

"Solidify rapidly"
A process involving the solidification of molten material at cooling rates exceeding 1 000 K/sec.

Cat 6, 7, 9 "Source code"
A convenient expression of one or more processes which may be turned by a programming system into equipment executable form ("object code" (or object language)).

Cat 9 "Spacecraft"
ML11 Active and passive satellites and space probes.

Cat 9 "Spacecraft bus"
Equipment that provides the support infrastructure of the "spacecraft" and location for the "spacecraft payload".

Cat 9 "Spacecraft payload"
Equipment, attached to the "spacecraft bus", designed to perform a mission in space (e.g., communications, observation, science).

Cat 3, 6, 7 "Space-qualified"
ML19 Designed, manufactured, or qualified through successful testing, for operation at altitudes greater than 100 km above the surface of the Earth.

Note *A determination that a specific item is "space- qualified" by virtue of testing does not mean that other items in the same production run or model series are "space-qualified" if not individually tested.*

Cat 1 "Specific modulus"
Young's modulus in pascals, equivalent to N/m^2, divided by specific weight in N/m^3, measured at a temperature of 296 ± 2 K (23 ± 2°C) and a relative humidity of (50 ± 5)%.

Cat 1 "Specific tensile strength"
Ultimate tensile strength in pascals, equivalent to N/m^2, divided by specific weight in N/m^3, measured at a temperature of 296 ± 2 K (23 ± 2°C) and a relative humidity of (50 ± 5)%.

Cat 7 "Spinning mass gyros"
"Spinning mass gyros" are gyros which use a continually rotating mass to sense angular motion.

Cat 1 "Splat quenching"
A process to "solidify rapidly" a molten metal stream impinging upon a chilled block, forming a flake-like product.

Cat 5P1 "Spread spectrum"
Cat 5P2 The technique whereby energy in a relatively narrow-band communication channel is spread over a much wider energy spectrum.

Cat 6 "Spread spectrum" radar - see "Radar spread spectrum"

Cat 7 "Stability"
Standard deviation (1 sigma) of the variation of a particular parameter from its calibrated value measured under stable temperature conditions. This can be expressed as a function of time.

Statement of Understanding
For gyroscopes, "stability" can be estimated by determining the Allan variance noise-analysis value at the integration period (i.e., sample time) consistent with the stated measurement period, which may include extrapolating the Allan variance noise analysis beyond the instability point into the rate random walk or rate ramp regions to an integration period consistent with the stated measurement period (Reference: IEEE Std 952-1997 [R2008]). Allan variance noise analysis is often used to characterize MicroElectroMechanical Systems (MEMS) gyroscopes, and is applicable to other gyroscopes, such as Ring Laser Gyroscopes (RLGs) and Fibre Optic Gyroscopes (FOGs).

Cat 3 "Substrate"
A sheet of base material with or without an interconnection pattern and on which or within which "discrete components" or integrated circuits or both can be located.

Cat 3, 6 "Substrate blanks"

Monolithic compounds with dimensions suitable for the production of optical elements such as mirrors or optical windows.

Cat 2 "Superalloy"
Cat 9

Nickel-, cobalt- or iron-base alloys having strengths superior to any alloys in the AISI 300 series at temperatures over 922 K (649°C) under severe environmental and operating conditions.

Cat 1, 3 "Superconductive"
Cat 5P1, 6
Cat 8
ML20

Refers to materials,(i.e., metals, alloys or compounds) which can lose all electrical resistance (i.e., which can attain infinite electrical conductivity and carry very large electrical currents without Joule heating).

Technical Note

The "superconductive" state of a material is individually characterised by a "critical temperature", a critical magnetic field, which is a function of temperature, and a critical current density which is, however, a function of both magnetic field and temperature.

Cat 6 "Super High Power Laser" ("SHPL")

A "laser" capable of delivering (the total or any portion of) the output energy exceeding 1 kJ within 50 ms or having an average or CW power exceeding 20 kW.

Cat 1 "Superplastic forming"
Cat 2

A deformation process using heat for metals that are normally characterised by low values of elongation (less than 20%) at the breaking point as determined at room temperature by conventional tensile strength testing, in order to achieve elongations during processing which are at least 2 times those values.

Cat 5P2 "Symmetric algorithm"

A cryptographic algorithm using an identical key for both encryption and decryption.

Technical Note

A common use of "symmetric algorithms" is confidentiality of data.

Cat 4 "Systolic array computer"

A computer where the flow and modification of the data is dynamically controllable at the logic gate level by the user.

GTN & Both Lists "Technology"

Specific information necessary for the "development", "production" or "use" of a product. The information takes the form of 'technical data' or 'technical assistance'. Specified "technology" for the Dual-Use List is defined in the General Technology Note and in the Dual-Use List. Specified "technology" for the Munitions List is defined in ML22.

Technical Notes

1. *'Technical data' may take forms such as blueprints, plans, diagrams, models, formulae, tables, engineering designs and specifications, manuals and instructions written or recorded on other media or devices such as disk, tape, read-only memories.*
2. *'Technical assistance' may take forms such as instruction, skills, training, working knowledge, consulting services. 'Technical assistance' may involve transfer of 'technical data'.*

Cat 3 "Three dimensional integrated circuit"

A collection of semiconductor dies or active device layers, integrated together, and having through semiconductor via connections passing completely through an interposer, substrate, die or layer to establish interconnections between the device layers. An interposer is an interface that enables electrical connections.

Cat 2 "Tilting spindle"

A tool-holding spindle which alters, during the machining process, the angular position of its centre line with respect to any other axis.

Cat 6 "Time constant"

The time taken from the application of a light stimulus for the current increment to reach a value of 1-1/e times the final value (i.e., 63% of the final value).

Cat 9 "Tip shroud"

A stationary ring component (solid or segmented) attached to the inner surface of the engine turbine casing or a feature at the outer tip of the turbine blade, which primarily provides a gas seal between the stationary and rotating components.

Cat 7 "Total control of flight"

Automated control of "aircraft" state variables and flight path to meet mission objectives responding to real time changes in data regarding objectives, hazards or other "aircraft".

Cat 5P1 "Total digital transfer rate"

The number of bits, including line coding, overhead and so forth per unit time passing between corresponding equipment in a digital transmission system. (See also "digital transfer rate")

Cat 6 "Transfer laser"

A "laser" in which the lasing species is excited through the transfer of energy by collision of a non-lasing atom or molecule with a lasing atom or molecule species.

Cat 6 "Tunable"

The ability of a "laser" to produce a continuous output at all wavelengths over a range of several "laser" transitions. A line selectable "laser" produces discrete wavelengths within one "laser" transition and is not considered "tunable".

Cat 2 "Unidirectional positioning repeatability"

The smaller of values R↑ and R↓ (forward and backward), as defined by 3.21 of ISO 230-2:2014 or national equivalents, of an individual machine tool axis.

Cat 9 "Unmanned aerial vehicle" ("UAV")
ML10

Any "aircraft" capable of initiating flight and sustaining controlled flight and navigation without any human presence on board.

GTN "Use"
Dual-Use List

Operation, installation (including on-site installation), maintenance (checking), repair, overhaul and refurbishing.

Cat 4 "User-accessible programmability"
Cat 5, 6

The facility allowing a user to insert, modify or replace "programs" by means other than:

a. A physical change in wiring or interconnections; or
b. The setting of function controls including entry of parameters.

Cat 1 "Vacuum atomisation"

A process to reduce a molten stream of metal to droplets of a diameter of 500 µm or less by the rapid evolution of a dissolved gas upon exposure to a vacuum.

Cat 7 "Variable geometry airfoils"

Use trailing edge flaps or tabs, or leading edge slats or pivoted nose droop, the position of which can be controlled in flight.

ACRONYMS AND ABBREVIATIONS USED IN THESE LISTS

An acronym or abbreviation, when used as a defined term, will be found in 'Definitions of Terms used in these Lists'.

ACRONYM OR ABBREVIATION	MEANING
ADC	Analogue-to-Digital Converter
AGMA	American Gear Manufacturers' Association
AHRS	Attitude and Heading Reference Systems
AISI	American Iron and Steel Institute
ALE	Atomic Layer Epitaxy
ALU	Arithmetic Logic Unit
ANSI	American National Standards Institute
APP	Adjusted Peak Performance
APU	Auxiliary Power Unit
ASTM	American Society for Testing and Materials
ATC	Air Traffic Control
BJT	Bipolar Junction Transistors
BPP	Beam Parameter Product
BSC	Base Station Controller
C3I	Command, Communications, Control & Intelligence
CAD	Computer-Aided-Design
CAS	Chemical Abstracts Service
CCD	Charge Coupled Device
CDU	Control and Display Unit
CEP	Circular Error Probable
CMM	Coordinate Measuring Machine
CMOS	Complementary Metal Oxide Semiconductor
CNTD	Controlled Nucleation Thermal Deposition
CPLD	Complex Programmable Logic Device
CPU	Central Processing Unit
CVD	Chemical Vapour Deposition
CW	Chemical Warfare
CW	(for lasers) Continuous Wave
DAC	Digital-to-Analogue Converter
DANL	Displayed Average Noise Level
DBRN	Data-Base Referenced Navigation
DDS	Direct Digital Synthesizer
DEW	Directed Energy Weapon
DMA	Dynamic Mechanical Analysis
DME	Distance Measuring Equipment
DMOSFET	Diffused Metal Oxide Semiconductor Field Effect Transistor
DS	Directionally Solidified
EB	Exploding Bridge
EB-PVD	Electron Beam-Physical Vapour Deposition
EBW	Exploding bridge wire
ECM	electro-chemical machining
EDM	Electrical Discharge Machine~~s~~

Acronyms and Abbreviations

ACRONYM OR ABBREVIATION	MEANING
EEPROM	Electrically Erasable Programmable Read Only Memory
EFI	Exploding Foil Initiators
EIRP	Effective Isotropic Radiated Power
EMCDB	Elastomer Modified Cast Double Based Propellants
ERF	Electrorheological Finishing
ERP	Effective Radiated Power
ETO	Emitter Turn-Off Thyristor
ETT	Electrical Triggering Thyristor
FADEC	Full Authority Digital Engine Control
FFT	Fast Fourier Transform
FPGA	Field Programmable Gate Array
FPIC	Field Programmable Interconnect
FPLA	Field Programmable Logic Array
FPO	Floating Point Operation
FWHM	Full-Width Half-Maximum
GSM	Global System for Mobile Communications
GNSS	Global Navigation Satellite System
GTO	Gate Turn-off Thyristor
HBT	Hetero-Bipolar Transistors
HEMT	High Electron Mobility Transistor~~s~~
ICAO	International Civil Aviation Organisation
IEC	International Electro-technical Commission
IED	Improvised Explosive Device
IEEE	Institute of Electrical and Electronic Engineers
IFOV	Instantaneous-Field-of-View
IGBT	Insulated Gate Bipolar Transistor
IGCT	Integrated Gate Commutated Thyristor
IHO	International Hydrographic Organization
ILS	Instrument Landing System
IMU	Inertial Measurement Unit
INS	Inertial Navigation System
IP	Internet Protocol
IRS	Inertial Reference System
IRU	Inertial Reference Unit
ISA	International Standard Atmosphere
ISAR	Inverse Synthetic Aperture Radar
ISO	International Organization for Standardization
ITU	International Telecommunication Union
JT	Joule-Thomson
LIDAR	Light Detection and Ranging
LIDT	Laser Induced Damage Threshold
LOA	Length Overall
LRU	Line Replaceable Unit
LTT	Light Triggering Thyristor
LVDT	Linear Variable Differential Transformer
MLS	Microwave Landing Systems
MMIC	Monolithic Microwave Integrated Circuit
MOCVD	Metal Organic Chemical Vapour Deposition

Acronyms and Abbreviations

ACRONYM OR ABBREVIATION	MEANING
MOSFET	Metal-Oxide-Semiconductor Field Effect Transistor
MPM	Microwave Power Module
MRAM	Magnetic Random Access Memory
MRF	Magnetorheological Finishing
MRF	Minimum Resolvable Feature size
MRI	Magnetic Resonance Imaging
MTBF	Mean-Time-Between-Failures
MTTF	Mean-Time-To-Failure
NA	Numerical Aperture
NDT	Non-Destructive Test
NEQ	Net Explosive Quantity
OAM	Operations, Administration or Maintenance
OSI	Open Systems Interconnection
PAI	Polyamide-imides
PAR	Precision Approach Radar
PCL	Passive Coherent Location
PIN	Personal Identification Number
PMR	Private Mobile Radio
PVD	Physical Vapour Deposition
QAM	Quadrature-Amplitude-Modulation
RAP	Reactive Atom Plasmas
RF	Radio Frequency
RNC	Radio Network Controller
RPV	Remotely Piloted Air Vehicles
S-FIL	Step and Flash Imprint Lithography
SAR	Synthetic Aperture Radar
SAS	Synthetic Aperture Sonar
SC	Single Crystal
SCR	Silicon Controlled Rectifier
SFDR	Spurious Free Dynamic Range
SHPL	Super High Powered Laser
SLAR	Sidelooking Airborne Radar
SOI	Silicon-on-Insulator
SPLD	Simple Programmable Logic Device
SQUID	Superconducting Quantum Interference Device
SRA	Shop Replaceable Assembly
SRAM	Static Random Access Memory
SSB	Single Sideband
SSR	Secondary Surveillance Radar
SSS	Side Scan Sonar
TE-PVD	Thermal Evaporation-Physical Vapour Deposition
TIR	Total Indicated Reading
TVR	Transmitting Voltage Response
UPR	Unidirectional Positioning Repeatability
UTS	Ultimate Tensile Strength
VJFET	Vertical Junction Field Effect Transistor
VOR	Very High Frequency Omni-directional Range
WLAN	Wireless Local Area Network

STATEMENTS OF UNDERSTANDING AND VALIDITY NOTES

Intangible Transfers* of Software and Technology (WA-GWG (01) DE 7 Version 2.0)

Participating States recognise that it is important to have comprehensive controls on listed "software" and "technology", including controls on intangible transfers. National export control legislation should therefore permit controls on transfers of listed "software" and "technology" irrespective of the way in which the transfer takes place.** Participating States also recognise that it is important to continue the mutual exchange within the Wassenaar Arrangement on the experiences gained concerning the implementation and enforcement of these national provisions on the control of intangible transfers. New developments should thus be taken into account in order to meet all risks connected with this issue.

* "Transfers" in this context is understood in the sense of the Initial Elements. The term covers exports from one country to another.

** "irrespective of the way in which the transfer takes place" means, at a minimum:
- tangible transfers
- intangible transfers via transmission of listed software and technology by electronic media, fax or telephone.

Statement of Understanding
Wassenaar Arrangement Participating States agree that lists headed by *including, includes, such as* or *e.g.* are illustrative and only intended to provide examples.

MUNITIONS LIST

ML 8
Statement of Understanding
It is understood that specially formulated pharmaceutical products containing ML8. materials are not controlled.

ML 10 (NF (95) WG2/2)
Absence of items from the Munitions List and absence of configuration for military use would mean that an aircraft would not be considered military.

DUAL-USE LIST OF GOODS AND TECHNOLOGIES

General Technology Note (NF (95) CA WP 1)

Governments agree that the transfer of "technology" according to the General Technology Note, for "production" or "development" of items on this list shall be treated with vigilance in accordance with national policies and the aims of this regime.

General Technology Note (WG2 GTN TWG/WP1 Revised 2)

It is understood that Member Governments are expected to exercise controls on intangible "technology" as far as the scope of their legislation will allow.

General Software Note (NF (95) CA WP 1)

Governments agree that the transfer of "software", for "production" or "development" of items on this list shall be treated with vigilance in accordance with national policies and the aims of this regime.

Statement of Understanding – Source Code

Taking into account national practices and legislation, Participating States agree that "source code" items are controlled either by "software" or by "software" and "technology" controls, except when such "source code" items are explicitly decontrolled.

Statement of Understanding - medical equipment (NF (96) DG PL/WP1)

Participating countries agree that equipment specially designed for medical end-use that incorporates an item controlled in the Dual-Use List is not controlled.

Statement of Understanding – Used goods

The specifications in the Dual-Use List apply equally to new or used goods. In the case of used goods, an evaluation by the national authority may be carried out in order to assess whether the goods are capable of meeting the relevant specifications.

Category 5 – Part 2

Note 3 – Cryptography Note

Statement of Understanding

Wassenaar Arrangement Participating States agree that the Note to the Cryptography Note, approved by the December 2012 Plenary, does not change the scope of the Cryptography Note and is not intended to change national practices.

Note 4

Statement of Understanding

Participating States understand that all items previously described by Notes b., c. and h. to 5.A.2. are now described by Note 4 to Category 5 – Part 2. Note h to 5.A.2 previously read:

h. Equipment specially designed for the servicing of portable or mobile radiotelephones and similar client wireless devices that meet all the provisions of the Cryptography Note (Note 3 in Category 5 – Part 2), where the servicing equipment meets all of the following:

1. *The cryptographic functionality of the servicing equipment cannot easily be changed by the user of the equipment;*
2. *The servicing equipment is designed for installation without further substantial support by the supplier; and*
3. *The servicing equipment cannot change the cryptographic functionality of the device being serviced;*

Category 9

9.A.12.
Statement of Understanding
Participating States understand a model aircraft as intended for recreational and competition purposes.

9.E.2.
Statement of Understanding
"Development" or "production" "technology" controlled by 9.E. for gas turbine engines remains controlled when used as "use" "technology" for repair, rebuild and overhaul. Excluded from control are: technical data, drawings or documentation for maintenance activities directly associated with calibration, removal or replacement of damaged or unserviceable line replaceable units, including replacement of whole engines or engine modules.

9.B.1.c.
Validity Note The control text contained in 9.B.1.c. is valid until 31 December 2017 and its renewal will require unanimous consent.

DEFINITION OF TERMS USED IN THESE LISTS

Statement of Understanding

Participating States note that, in these Lists, words and terms appearing under 'Definitions of Terms used in these Lists', if used in their undefined forms, take their common or dictionary meanings. Governments are expected to preserve these distinctions, as far as national languages and legislation allow, when the Lists are translated into national legislation.
(See also Note 2 to 'Definitions of Terms used in these Lists').

N.B. *The references in this section refer to the List of Dual-Use Goods and Technologies and the Munitions List approved by the Plenary meeting (6-8 December 2016).*