DUAL-USE LIST - CATEGORY 5 - PART 1 - TELECOMMUNICATIONS

5. E. 1. c. 2. Equipment employing a "laser" and having any of the following:
   a. A transmission wavelength exceeding 1750 nm;
   b. Performing "optical amplification" using praseodymium-doped fluoride fibre amplifiers (PDFFA);
   c. Employing coherent optical transmission or coherent optical detection techniques (also called optical heterodyne or homodyne techniques);
   d. Employing wavelength division multiplexing techniques exceeding 8 optical carriers in a single optical window; or
   e. Employing analogue techniques and having a bandwidth exceeding 2.5 GHz;
      Note *5.E.1.c.2.e. does not control "technology" for the "development" or "production" of commercial TV systems.*

3. Equipment employing "optical switching";

4. Radio equipment having any of the following:
   a. Quadrature-amplitude-modulation (QAM) techniques above level 256; or
   b. Operating at input or output frequencies exceeding 31.8 GHz; or
      Note *5.E.1.c.4.b. does not control "technology" for the "development" or "production" of 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.*

5. Equipment employing "common channel signalling" operating in non-associated mode of operation.

DUAL-USE LIST - CATEGORY 5 - PART 2 - "INFORMATION SECURITY"

Part 2 - "INFORMATION SECURITY"

Note 1 *The control status of "information security" equipment, "software", systems, application specific "electronic assemblies", modules, integrated circuits, components or functions is determined in Category 5, Part 2 even if they are components or "electronic assemblies" of other equipment.*

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

Note 3 *Cryptography Note*

5.A.2. and 5.D.2. do not control items that meet all of the following:

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

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

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

d. Deleted;

e. 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 a. to c. above.

Technical Note
In Category 5 - Part 2, parity bits are not included in the key length.

5. A. 2. SYSTEMS, EQUIPMENT AND COMPONENTS

a. Systems, equipment, application specific "electronic assemblies", modules and integrated circuits for "information security", as follows, and other specially designed components therefor:

N.B. *For the control of global navigation satellite systems receiving equipment containing or employing decryption (i.e. GPS or GLONASS), see 7.A.5.*

5. A. 2. a. 1. Designed or modified to use "cryptography" employing digital techniques performing any cryptographic function other than authentication or digital signature having any of the following:

DUAL-USE LIST - CATEGORY 5 - PART 2 - "INFORMATION SECURITY"

Technical Notes

1. *Authentication and digital signature functions include their associated key management function.*
2. *Authentication includes 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 unauthorised access.*
3. *"Cryptography" does not include "fixed" data compression or coding techniques.*

Note *5.A.2.a.1. includes equipment designed or modified to use "cryptography" employing analogue principles when implemented with digital techniques.*

5. A. 2. a. 1. a. A "symmetric algorithm" employing a key length in excess of 56 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 5.A.2.a.1.b.2. in excess of 112 bits (e.g., Diffie-Hellman over an elliptic curve);

2. Designed or modified to perform cryptanalytic functions;

3. Deleted;

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

5. Designed or modified to use cryptographic techniques to generate the spreading code for "spread spectrum" systems, including the hopping code for "frequency hopping" systems;

6. Designed or modified to use cryptographic techniques to generate channelizing or scrambling codes for "time-modulated ultra-wideband" systems;

7. Deleted

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

DUAL-USE LIST - CATEGORY 5 - PART 2 - "INFORMATION SECURITY"

Note *5.A.2. does not control:*

a. "Personalised smart cards":
1. Where the cryptographic capability is restricted for use in equipment or systems excluded from control under entries b. to f. of this Note; or
2. For general public-use applications where the cryptographic capability is not user-accessible and it is specially designed and limited to allow protection of personal data stored within.
N.B. If a "personalised smart card" has multiple functions, the control status of each function is assessed individually.

b. Receiving equipment for radio broadcast, pay television or similar restricted audience broadcast of the consumer type, without digital encryption except that exclusively used for sending the billing or programme-related information back to the broadcast providers.

c. Equipment where the cryptographic capability is not user-accessible and which is specially designed and limited to allow any of the following:
1. Execution of copy-protected software;
2. Access to any of the following:
a. Copy-protected contents stored on read-only media; or
b. Information stored in encrypted form on media (e.g. in connection with the protection of intellectual property rights) when the media is offered for sale in identical sets to the public; or
3. Copying control of copyright protected audio/video data.

d. Cryptographic equipment specially designed and limited for banking use or money transactions.
Technical Note
'Money transactions' in 5.A.2. Note d. includes the collection and settlement of fares or credit functions.

e. Portable or mobile radiotelephones for civil use (e.g., for use with commercial civil cellular radiocommunications systems) that are not capable of end-to-end encryption.

f. 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 basestation) is less than 400 metres according to the manufacturer's specifications.

DUAL-USE LIST - CATEGORY 5 - PART 2 - "INFORMATION SECURITY"

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

a. Equipment specially designed for:

1. The "development" of equipment or functions controlled by Category 5 - Part 2, including measuring or test equipment;
2. The "production" of equipment or functions controlled by Category 5 - Part 2, including measuring, test, repair or production equipment.

b. Measuring equipment specially designed to evaluate and validate the "information security" functions controlled by 5.A.2. or 5.D.2.

5. C. 2. MATERIALS - None

5. D. 2. SOFTWARE

a. "Software" specially designed or modified for the "development", "production" or "use" of equipment or "software" controlled by Category 5 - Part 2;
b. "Software" specially designed or modified to support "technology" controlled by 5.E.2.;
c. Specific "software", as follows:
   1. "Software" having the characteristics, or performing or simulating the functions of the equipment controlled by 5.A.2. or 5.B.2.;
   2. "Software" to certify "software" controlled by 5.D.2.c.1.

Note *5.D.2. does not control:*
a. "Software" required for the "use" of equipment excluded from control under the Note to 5.A.2.;
b. "Software" providing any of the functions of equipment excluded from control under the Note to 5.A.2.

5. E. 2. TECHNOLOGY

a. "Technology" according to the General Technology Note for the "development", "production" or "use" of equipment or "software" controlled by Category 5 - Part 2.

DUAL-USE LIST - CATEGORY 6 - SENSORS AND "LASERS"

6. A. SYSTEMS, EQUIPMENT AND COMPONENTS

6. A. 1. ACOUSTICS

6. A. 1. a. Marine acoustic systems, equipment and specially designed components therefor, as follows:

6. A. 1. a. 1. Active (transmitting or transmitting-and-receiving) systems, equipment and specially designed components therefor, as follows:

Note *6.A.1.a.1. does not control:*

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. Wide-swath bathymetric survey systems designed for sea bed topographic mapping, having all of the following:

1. Being designed to take measurements at an angle exceeding 20° from the vertical;
2. Being designed to measure depths exceeding 600 m below the water surface; and
3. Being designed to provide any of the following:
   a. Incorporation of multiple beams any of which is less than 1.9°; or
   b. Data accuracies of better than 0.3% of water depth across the swath averaged over the individual measurements within the swath;

6. A. 1. a. 1. b. Object detection or location systems 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;

DUAL-USE LIST - CATEGORY 6 - SENSORS AND "LASERS"

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, having any of the following:

Note 1 *The control status of acoustic projectors, including transducers, specially designed for other equipment is determined by the control status of the other equipment.*

Note 2 *6.A.1.a.1.c. does not control electronic sources which direct the sound vertically only, or mechanical (e.g., air gun or vapour-shock gun) or chemical (e.g., explosive) sources.*

6. A. 1. a. 1. c. 1. An instantaneous radiated acoustic power density exceeding 0.01 $mW/mm^2/Hz$ for devices operating at frequencies below 10 kHz;

2. A continuously radiated acoustic power density exceeding 0.001 $mW/mm^2/Hz$ for devices operating at frequencies below 10 kHz; or

Technical Note
Acoustic power density is obtained by dividing the output acoustic power by the product of the area of the radiating surface and the frequency of operation.

3. Side-lobe suppression exceeding 22 dB;

6. A. 1. a. 1. d. Acoustic systems, equipment and specially designed components for determining the position of surface vessels or underwater vehicles designed to operate at a range exceeding 1,000 m with a positioning accuracy 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.

DUAL-USE LIST - CATEGORY 6 - SENSORS AND "LASERS"

6. A. 1. a. 2. Passive (receiving, whether or not related in normal application to separate active equipment) systems, equipment and specially designed components therefor, as follows:

a. Hydrophones having any of the following characteristics:

Note *The control status of hydrophones specially designed for other equipment is determined by the control status of the other equipment.*

1. Incorporating continuous flexible sensors or assemblies of discrete sensor elements with either a diameter or length less than 20 mm and with a separation between elements of less than 20 mm;
2. Having any of the following sensing elements:
   a. Optical fibres; or
   b. Flexible piezoelectric ceramic materials;
3. A hydrophone sensitivity better than -180 dB at any depth with no acceleration compensation;
4. When designed to operate at depths exceeding 35 m with acceleration compensation; or
5. Designed for operation at depths exceeding 1,000 m;

Technical Note

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:

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.

DUAL-USE LIST - CATEGORY 6 - SENSORS AND "LASERS"

6. A. 1. a. 2. b. 3. Heading sensors controlled by 6.A.1.a.2.d.;
4. Longitudinally reinforced array hoses;
5. An assembled array of less than 40 mm in diameter;
6. Multiplexed hydrophone group signals 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; or
7. Hydrophone characteristics specified in 6.A.1.a.2.a.;

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;

6. A. 1. a. 2. e. Bottom or bay cable systems having any of the following:
1. Incorporating hydrophones specified in 6.A.1.a.2.a.; or
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;

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. b. Correlation-velocity sonar log equipment designed to measure the horizontal speed of the equipment carrier relative to the sea bed at distances between the carrier and the sea bed exceeding 500 m.

DUAL-USE LIST - CATEGORY 6 - SENSORS AND "LASERS"

6. A. 2. OPTICAL SENSORS

a. Optical detectors, as follows:
Note *6.A.2.a. does not control germanium or silicon photodevices.*

1. "Space-qualified" solid-state detectors, as follows:
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;

6. A. 2. a. 2. Image intensifier tubes and specially designed components therefor, as follows:
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. A microchannel plate for electron image amplification with a hole pitch (centre-to-centre spacing) of 12 µm or less; and

3. Any of the following photocathodes:
a. S-20, S-25 or multialkali photocathodes with a luminous sensitivity exceeding 350 µA/lm;
b. GaAs or GaInAs photocathodes; or
c. Other III-V compound semiconductor photocathodes;
Note *6.A.2.a.2.a.3.c. does not apply to compound semiconductor photocathodes with a maximum radiant sensitivity of 10 mA/W or less.*

b. Specially designed components, as follows:
1. Microchannel plates having a hole pitch (centre-to-centre spacing) of 12 µm or less;
2. GaAs or GaInAs photocathodes;
3. Other III-V compound semiconductor photocathodes;
Note *6.A.2.a.2.b.3. does not control compound semiconductor photocathodes with a maximum radiant sensitivity of 10 mA/W or less.*

DUAL-USE LIST - CATEGORY 6 - SENSORS AND "LASERS"

6. A. 2. a. 3. Non-"space-qualified" "focal plane arrays", as follows:

Technical Notes

1. Linear or two-dimensional multi-element detector arrays are referred to as "focal plane arrays";

2. For the purposes of 6.A.2.a.3. '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.

Note 1 6.A.2.a.3. includes photoconductive arrays and photovoltaic arrays.

Note 2 6.A.2.a.3. does not control:

a. Silicon "focal plane arrays";

b. Multi-element (not to exceed 16 elements) encapsulated photoconductive cells using either lead sulphide or lead selenide;

c. 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.

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. A response "time constant" of less than 0.5 ns;

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. A response "time constant" of 95 ns or less;

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;

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 2,500 nm; and

DUAL-USE LIST - CATEGORY 6 - SENSORS AND "LASERS"

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 element (SPRITE);

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 2,500 nm but not exceeding 30,000 nm.

6. A. 2 b. "Monospectral imaging sensors" and "multispectral imaging sensors" designed for remote sensing applications, having any of the following:
   1. An Instantaneous-Field-Of-View (IFOV) of less than 200 µrad (microradians); or
   2. Being 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. Being any of the following:
         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).

6. A. 2 c. Direct view imaging equipment operating in the visible or infrared spectrum, incorporating any of the following:
   1. Image intensifier tubes having the characteristics listed in 6.A.2.a.2.a.; or
   2. "Focal plane arrays" having the characteristics listed in 6.A.2.a.3.

   Technical Note
   'Direct view' refers to imaging equipment, operating in the visible or infrared spectrum, 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 control the following equipment 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.

WA-LIST (03) 1
12-12-03

DUAL-USE LIST - CATEGORY 6 - SENSORS AND "LASERS"

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.

   e. "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. 3. CAMERAS

N.B. *For cameras specially designed or modified for underwater use, see 8.A.2.d. and 8.A.2.e.*

6. A. 3. a. Instrumentation cameras and specially designed components therefor, as follows:

Note *Instrumentation cameras, controlled 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.*

   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 control 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 having writing speeds exceeding 10 mm/µs;
   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.

WA-LIST (03) 1
12-12-03

DUAL-USE LIST - CATEGORY 6 - SENSORS AND "LASERS"

6. A. 3. a. 6. Plug-ins, having all of the following characteristics:
   a. Specially designed for instrumentation cameras which have modular structures and which are controlled by 6.A.3.a.; and
   b. Enabling these cameras to meet the characteristics specified in 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 control 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:
      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 controlled by 6.A.4.a.;
         2. Optical control equipment controlled 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;

6. A. 3. b. 3. Imaging cameras incorporating image intensifier tubes having the characteristics listed in 6.A.2.a.2.a.;

DUAL-USE LIST - CATEGORY 6 - SENSORS AND "LASERS"

6. A. 3. b. 4. Imaging cameras incorporating "focal plane arrays" having the characteristics listed in 6.A.2.a.3.

Note *6.A.3.b.4 does not control imaging cameras incorporating linear "focal plane arrays" with twelve elements or fewer, not employing time-delay-and-integration within the element, 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.

6. A. 4. OPTICS

a. Optical mirrors (reflectors), as follows:

1. "Deformable mirrors" having either continuous or multi-element surfaces, and specially designed components therefor, capable of dynamically repositioning portions of the surface of the mirror at rates exceeding 100 Hz;
2. Lightweight monolithic mirrors having an average "equivalent density" of less than 30 kg/m² and a total mass exceeding 10 kg;
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;
4. Beam steering mirrors more than 100 mm in diameter or length of major axis, which maintain a flatness of lambda/2 or better (lambda is equal to 633 nm) having a control bandwidth exceeding 100 Hz.

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. 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. Manufactured from "composite" materials having a coefficient of linear thermal expansion equal to or less than 5×10^{-6} in any coordinate direction.

DUAL-USE LIST - CATEGORY 6 - SENSORS AND "LASERS"

6. A. 4. d. Optical control equipment, as follows:

1. Specially designed to maintain the surface figure or orientation of the "space-qualified" components controlled by 6.A.4.c.1. or 6.A.4.c.3.;

2. Having steering, tracking, stabilisation or resonator alignment bandwidths equal to or more than 100 Hz and an accuracy of 10 µrad (microradians) or less;

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)/s^2; or
      2. Exceeding 1 m in diameter or major axis length and capable of angular accelerations exceeding 0.5 rad (radians)/s^2;

4. Specially designed to maintain the alignment of phased array or phased segment mirror systems consisting of mirrors with a segment diameter or major axis length of 1 m or more.

6. A. 4. e. Aspheric optical elements having all of the following characteristics:

1. The largest dimension of the optical-aperture is greater than 400 mm;
2. The surface roughness is less than 1 nm (rms) for sampling lengths equal to or greater than 1 mm; and
3. The coefficient of linear thermal expansion's absolute magnitude is 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 control parameter.

Note *6.A.4.e. does not control aspheric optical elements having any of the following:*

a. A largest optical-aperture dimension less than 1 m and a focal length to aperture ratio equal to or greater than 4.5:1;

b. A largest optical-aperture dimension equal to or greater than 1 m and a focal length to aperture ratio equal to or greater than 7:1;

c. Being designed as Fresnel, flyeye, stripe, prism or diffractive optical elements;

DUAL-USE LIST - CATEGORY 6 - SENSORS AND "LASERS"

d. Being fabricated from borosilicate glass having a coefficient of linear thermal expansion greater than 2.5x10^{-6} /K at 25 °C; or

e. Being 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 Item 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 Pulse-excited "lasers" include those that run in a continuously excited mode with pulse excitation superimposed.

Note 3 The control status of Raman "lasers" is determined by the parameters of the pumping source "lasers". The pumping source "lasers" can be any of the "lasers" described below.

6. A. 5. a. Gas "lasers", as follows:

1. Excimer "lasers", having any of the following:
   a. An output wavelength not exceeding 150 nm and having any of the following:
      1. An output energy exceeding 50 mJ per pulse; or
      2. An average output power exceeding 1 W;
   b. An output wavelength exceeding 150 nm but not exceeding 190 nm and having any of the following:
      1. An output energy exceeding 1.5 J per pulse; or
      2. An average output power exceeding 120 W;
   c. An output wavelength exceeding 190 nm but not exceeding 360 nm and having any of the following:
      1. An output energy exceeding 10 J per pulse; or
      2. An average output power exceeding 500 W; or
   d. An output wavelength exceeding 360 nm and having any of the following:
      1. An output energy exceeding 1.5 J per pulse; or
      2. An average output power exceeding 30 W;

N.B. For excimer "lasers" specially designed for lithography equipment, see 3.B.1.

6. A. 5. a. 2. Metal vapour "lasers", as follows:

   a. Copper (Cu) "lasers" having an average output power exceeding 20 W;
   b. Gold (Au) "lasers" having an average output power exceeding 5 W;
   c. Sodium (Na) "lasers" having an output power exceeding 5 W;
   d. Barium (Ba) "lasers" having an average output power exceeding 2 W;

6. A. 5. a. 3. Carbon monoxide (CO) "lasers" having any of the following:

DUAL-USE LIST - CATEGORY 6 - SENSORS AND "LASERS"

a. An output energy exceeding 2 J per pulse and a pulsed "peak power" exceeding 5 kW; or
b. An average or CW output power exceeding 5 kW;

DUAL-USE LIST - CATEGORY 6 - SENSORS AND "LASERS"

6. A. 5. a. 4. Carbon dioxide (CO_2) "lasers" having any of the following:
   a. A CW output power exceeding 15 kW;
   b. A pulsed output having a "pulse duration" exceeding 10 µs and having any of the following:
      1. An average output power exceeding 10 kW; or
      2. A pulsed "peak power" exceeding 100 kW; or
   c. A pulsed output having a "pulse duration" equal to or less than 10 µs; and having any of the following:
      1. A pulse energy exceeding 5 J per pulse; or
      2. An average output power exceeding 2.5 kW;

6. A. 5. a. 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. a. 6. Krypton ion or argon ion "lasers" having any of the following:
   a. An output energy exceeding 1.5 J per pulse and a pulsed "peak power" exceeding 50 W; or
   b. An average or CW output power exceeding 50 W;

6. A. 5. a. 7. Other gas "lasers", having any of the following:
   Note *6.A.5.a.7. does not control nitrogen "lasers".*

   a. An output wavelength not exceeding 150 nm and having any of the following:
      1. An output energy exceeding 50 mJ per pulse and a pulsed "peak power" exceeding 1 W; or
      2. An average or CW output power exceeding 1 W;

   b. An output wavelength exceeding 150 nm but not exceeding 800 nm and having any of the following:
      1. An output energy exceeding 1.5 J per pulse and a pulsed "peak power" exceeding 30 W; or
      2. An average or CW output power exceeding 30 W;

   c. An output wavelength exceeding 800 nm but not exceeding 1,400 nm and having any of the following:
      1. An output energy exceeding 0.25 J per pulse and a pulsed "peak power" exceeding 10 W; or
      2. An average or CW output power exceeding 10 W; or

   d. An output wavelength exceeding 1,400 nm and an average or CW output power exceeding 1 W.

DUAL-USE LIST - CATEGORY 6 - SENSORS AND "LASERS"

6. A. 5. b. Semiconductor "lasers", as follows:

Note 1 *6.A.5.b. includes semiconductor "lasers" having optical output connectors (e.g. fibre optic pigtails).*

Note 2 *The control status of semiconductor "lasers" specially designed for other equipment is determined by the control status of the other equipment.*

1. Individual single-transverse mode semiconductor "lasers", having any of the following:
   a. A wavelength equal to or less than 1510 nm, and having an average or CW output power exceeding 1.5 W; or
   b. A wavelength greater than 1510 nm, and having an average or CW output power exceeding 500 mW;

2. Individual, multiple-transverse mode semiconductor "lasers", having any of the following:
   a. A wavelength of less than 1400 nm, and having an average or CW output power exceeding 10W;
   b. A wavelength equal to or greater than 1400 nm and less than 1900 nm, and having an average or CW output power exceeding 2.5 W; or
   c. A wavelength equal to or greater than 1900 nm and having an average or CW output power exceeding 1 W.

6. A. 5. b. 3. Individual semiconductor "laser" arrays, having any of the following:
   a. A wavelength of less than 1400 nm, and having an average or CW output power exceeding 80 W;
   b. A wavelength equal to or greater than 1400 nm and less than 1900 nm, and having an average or CW output power exceeding 25 W; or
   c. A wavelength equal to or greater than 1900 nm, and having an average or CW output power exceeding 10 W.

6. A. 5. b. 4. Array stacks of semiconductor "lasers" containing at least one array that is controlled under 6.A.5.b.3.

Technical Notes

1. *Semiconductor "lasers" are commonly called "laser" diodes.*
2. *An 'array' consists of multiple semiconductor "laser" emitters fabricated as a single chip so that the centres of the emitted light beams are on parallel paths.*
3. *An 'array stack' is fabricated by stacking, or otherwise assembling, 'arrays' so that the centres of the emitted light beams are on parallel paths.*

DUAL-USE LIST - CATEGORY 6 - SENSORS AND "LASERS"

6. A. 5. c. Solid state "lasers", as follows:

1. "Tunable" "lasers" having any of the following:
Note *6.A.5.c.1. includes titanium - sapphire($Ti: Al_2O_3$), thulium - YAG (Tm: YAG), thulium - YSGG (Tm: YSGG), alexandrite ($Cr: BeAl_2O_4$) and colour centre "lasers".*

a. An output wavelength less than 600 nm and having any of the following:
1. An output energy exceeding 50 mJ per pulse and a pulsed "peak power" exceeding 1 W; or
2. An average or CW output power exceeding 1 W;

b. An output wavelength of 600 nm or more but not exceeding 1,400 nm and having any of the following:
1. An output energy exceeding 1 J per pulse and a pulsed "peak power" exceeding 20 W; or
2. An average or CW output power exceeding 20 W; or

c. An output wavelength exceeding 1,400 nm and having any of the following:
1. An output energy exceeding 50 mJ per pulse and a pulsed "peak power" exceeding 1 W; or
2. An average or CW output power exceeding 1 W;

6. A. 5. c. 2. Non-"tunable" "lasers", as follows:
Note *6.A.5.c.2. includes atomic transition solid state "lasers".*

a. Neodymium glass "lasers", as follows:
1. "Q-switched lasers" having any of the following:
a. An output energy exceeding 20 J but not exceeding 50 J per pulse and an average output power exceeding 10 W; or
b. An output energy exceeding 50 J per pulse;

2. Non-"Q-switched lasers" having any of the following:
a. An output energy exceeding 50 J but not exceeding 100 J per pulse and an average output power exceeding 20 W; or
b. An output energy exceeding 100 J per pulse;

6. A. 5. c. 2. b. Neodymium-doped (other than glass) "lasers", having an output wavelength exceeding 1,000 nm but not exceeding 1,100 nm, as follows:
N.B. *For neodymium-doped (other than glass) "lasers" having an output wavelength not exceeding 1,000 nm or exceeding 1,100 nm, see 6.A.5.c.2.c.*

DUAL-USE LIST - CATEGORY 6 - SENSORS AND "LASERS"

6. A. 5. c. 2. b. 1. Pulse-excited, mode-locked, "Q-switched lasers" having a "pulse duration" of less than 1 ns and having any of the following:
   a. A "peak power" exceeding 5 GW;
   b. An average output power exceeding 10 W; or
   c. A pulsed energy exceeding 0.1 J;

2. Pulse-excited, "Q-switched lasers" having a pulse duration equal to or more than 1 ns, and having any of the following:
   a. A single-transverse mode output having:
      1. A "peak power" exceeding 100 MW;
      2. An average output power exceeding 20 W; or
      3. A pulsed energy exceeding 2 J; or
   b. A multiple-transverse mode output having:
      1. A "peak power" exceeding 400 MW;
      2. An average output power exceeding 2 kW; or
      3. A pulsed energy exceeding 2 J;

3. Pulse-excited, non-"Q-switched lasers", having:
   a. A single-transverse mode output having:
      1. A "peak power" exceeding 500 kW; or
      2. An average output power exceeding 150 W; or
   b. A multiple-transverse mode output having:
      1. A "peak power" exceeding 1 MW; or
      2. An average power exceeding 2 kW;

4. Continuously excited "lasers" having:
   a. A single-transverse mode output having:
      1. A "peak power" exceeding 500 kW; or
      2. An average or CW output power exceeding 150 W; or
   b. A multiple-transverse mode output having:
      1. A "peak power" exceeding 1 MW; or
      2. An average or CW output power exceeding 2 kW;

6. A. 5. c. 2. c. Other non-"tunable" "lasers", having any of the following:
1. A wavelength less than 150 nm and having any of the following:
   a. An output energy exceeding 50 mJ per pulse and a pulsed "peak power" exceeding 1 W; or
   b. An average or CW output power exceeding 1 W;

2. A wavelength of 150 nm or more but not exceeding 800 nm and having any of the following:
   a. An output energy exceeding 1.5 J per pulse and a pulsed "peak power" exceeding 30 W; or
   b. An average or CW output power exceeding 30 W;

DUAL-USE LIST - CATEGORY 6 - SENSORS AND "LASERS"

6. A. 5. c. 2. c. 3. A wavelength exceeding 800 nm but not exceeding 1,400 nm, as follows:
   a. "Q-switched lasers" having:
      1. An output energy exceeding 0.5 J per pulse and a pulsed "peak power" exceeding 50 W; or
      2. An average output power exceeding:
         a. 10 W for single-transverse mode "lasers";
         b. 30 W for multiple-transverse mode "lasers";
   b. Non-"Q-switched lasers" having:
      1. An output energy exceeding 2 J per pulse and a pulsed "peak power" exceeding 50 W; or
      2. An average or CW output power exceeding 50 W; or

   4. A wavelength exceeding 1,400 nm and having any of the following:
      a. An output energy exceeding 100 mJ per pulse and a pulsed "peak power" exceeding 1 W; or
      b. An average or CW output power exceeding 1 W;

6. A. 5. d. Dye and other liquid "lasers", having any of the following:
   1. A wavelength less than 150 nm and:
      a. An output energy exceeding 50 mJ per pulse and a pulsed "peak power" exceeding 1 W; or
      b. An average or CW output power exceeding 1 W;

   2. A wavelength of 150 nm or more but not exceeding 800 nm and having any of the following:
      a. An output energy exceeding 1.5 J per pulse and a pulsed "peak power" exceeding 20 W;
      b. An average or CW output power exceeding 20 W; or
      c. A pulsed single longitudinal mode oscillator having an average output power exceeding 1 W and a repetition rate exceeding 1 kHz if the "pulse duration" is less than 100 ns;

6. A. 5. d. 3. A wavelength exceeding 800 nm but not exceeding 1,400 nm and having any of the following:
   a. An output energy exceeding 0.5 J per pulse and a pulsed "peak power" exceeding 10 W; or
   b. An average or CW output power exceeding 10 W; or

   4. A wavelength exceeding 1,400 nm and having any of the following:
      a. An output energy exceeding 100 mJ per pulse and a pulsed "peak power" exceeding 1 W; or
      b. An average or CW output power exceeding 1 W;

DUAL-USE LIST - CATEGORY 6 - SENSORS AND "LASERS"

6. A. 5. e. Components, as follows:

1. Mirrors cooled either by active cooling or by heat pipe cooling;
   Technical Note
   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 specially designed for use with controlled "lasers";

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 Item 19. Note 2. d. on the Munitions List.*[*]

1. Dynamic wavefront (phase) measuring equipment capable of mapping at least 50 positions on a beam wavefront having 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.

MAGNETOMETERS

6. A. 6. "Magnetometers", "magnetic gradiometers", "intrinsic magnetic gradiometers" and compensation systems, and specially designed components therefor, as follows:

Note *6.A.6. does not control instruments specially designed for biomagnetic measurements for medical diagnostics.*

a. "Magnetometers" using "superconductive", optically pumped, nuclear precession (proton/Overhauser) or triaxial fluxgate "technology" having a "noise level" (sensitivity) lower (better) than 0.05 nT rms per square root Hz;

[*] France, 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.

DUAL-USE LIST - CATEGORY 6 - SENSORS AND "LASERS"

6. A. 6. b. Induction coil "magnetometers" having a "noise level" (sensitivity) lower (better) than any of the following:
   1. 0.05 nT rms/square root Hz at frequencies of less than 1 Hz;
   2. 1×10^{-3} nT rms/square root Hz at frequencies of 1 Hz or more but not exceeding 10 Hz; or
   3. 1×10^{-4} nT rms/square root Hz at frequencies exceeding 10 Hz;

   c. Fibre optic "magnetometers" having a "noise level" (sensitivity) lower (better) than 1 nT rms per square root Hz;

   d. "Magnetic gradiometers" using multiple "magnetometers" controlled by 6.A.6.a., 6.A.6.b. or 6.A.6.c.;

   e. Fibre optic "intrinsic magnetic gradiometers" having a magnetic gradient field "noise level" (sensitivity) lower (better) than 0.3 nT/m rms per square root Hz;

   f. "Intrinsic magnetic gradiometers", using "technology" other than fibre-optic "technology", having a magnetic gradient field "noise level" (sensitivity) lower (better) than 0.015 nT/m rms per square root Hz;

   g. Magnetic compensation systems for magnetic sensors designed for operation on mobile platforms;

6. A. 6. h. "Superconductive" electromagnetic sensors, containing components manufactured from "superconductive" materials and having all of the following:
   1. Being designed for operation at temperatures below the "critical temperature" of at least one of their "superconductive" constituents (including Josephson effect devices or "superconductive" quantum interference devices (SQUIDS));
   2. Being designed for sensing electromagnetic field variations at frequencies of 1 kHz or less; and

   3. Having any of the following characteristics:
      a. Incorporating thin-film SQUIDS with a minimum feature size of less than 2 µm and with associated input and output coupling circuits;
      b. Designed to operate with a magnetic field slew rate exceeding 1×10^{6} magnetic flux quanta per second;
      c. Designed to function without magnetic shielding in the earth's ambient magnetic field; or
      d. Having a temperature coefficient less (smaller) than 0.1 magnetic flux quantum/K.

DUAL-USE LIST - CATEGORY 6 - SENSORS AND "LASERS"

GRAVIMETERS

6. A. 7. Gravity meters (gravimeters) and gravity gradiometers, as follows:

a. Gravity meters designed or modified for ground use having a static accuracy of less (better) than 10 μgal;
Note *6.A.7.a. does not control ground gravity meters of the quartz element (Worden) type.*

b. Gravity meters designed for mobile platforms, 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;

c. Gravity gradiometers.

RADAR

6. A. 8. Radar systems, equipment and assemblies having any of the following characteristics, and specially designed components therefor:

Note *6.A.8. does not control:*
a. Secondary surveillance radar (SSR);
b. Car radar designed for collision prevention;
c. Displays or monitors used for air traffic control (ATC) having no more than 12 resolvable elements per mm;
d. Meteorological (weather) radar.

6. A. 8. a. Operating at frequencies from 40 GHz to 230 GHz and having an average output power exceeding 100 mW;

b. Having 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 phased array antennae";

f. Capable of heightfinding non-cooperative targets;
Note *6.A.8.f. does not control precision approach radar (PAR) equipment conforming to ICAO standards.*

DUAL-USE LIST - CATEGORY 6 - SENSORS AND "LASERS"

6. A. 8. g. Specially designed for airborne (balloon or airframe mounted) operation and having Doppler "signal processing" for the detection of moving targets;

h. Employing processing of radar signals using any of the following:
1. "Radar spread spectrum" techniques; or
2. "Radar frequency agility" techniques;

i. Providing ground-based operation with a maximum "instrumented range" exceeding 185 km;
Note *6.A.8.i. does not control:*
a. Fishing ground surveillance radar;
b. Ground radar equipment specially designed for enroute air traffic control, provided that all the following conditions are met:
1. It has a maximum "instrumented range" of 500 km or less;
2. It is configured so that radar target data can be transmitted only one way from the radar site to one or more civil ATC centres;
3. It contains no provisions for remote control of the radar scan rate from the enroute ATC centre; and
4. It is to be permanently installed.
c. Weather balloon tracking radars.

6. A. 8. j. Being "laser" radar or Light Detection and Ranging (LIDAR) equipment, having any of the following:
1. "Space-qualified"; or
2. Employing coherent heterodyne or homodyne detection techniques and having an angular resolution of less (better) than 20 μrad (microradians);
Note *6.A.8.j. does not control LIDAR equipment specially designed for surveying or for meteorological observation.*

k. Having "signal processing" sub-systems using "pulse compression", with any of the following:
1. A "pulse compression" ratio exceeding 150; or
2. A pulse width of less than 200 ns; or

l. Having data processing sub-systems with 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;
Note *6.A.8.l.1. does not control conflict alert capability in ATC systems, or marine or harbour radar.*
2. Calculation of target velocity from primary radar having non-periodic (variable) scanning rates;

DUAL-USE LIST - CATEGORY 6 - SENSORS AND "LASERS"

3. Processing for automatic pattern recognition (feature extraction) and comparison with target characteristic data bases (waveforms or imagery) to identify or classify targets; or

6. A. 8. l. 4. Superposition and correlation, or fusion, of target data from two or more "geographically dispersed" and "interconnected radar sensors" to enhance and discriminate targets.

Note *6.A.8.l.4. does not control systems, equipment and assemblies used for marine traffic control.*

6. B. TEST, INSPECTION AND PRODUCTION EQUIPMENT

6. B. 1. ACOUSTICS - None

6. B. 2. OPTICAL SENSORS - None

6. B. 3. CAMERAS - None

OPTICS

6. B. 4. Optical equipment, as follows:

a. Equipment for measuring absolute reflectance to an accuracy of ± 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 control microscopes.*

6. B. 5. LASERS - None

6. B. 6. MAGNETOMETERS - 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.

DUAL-USE LIST - CATEGORY 6 - SENSORS AND "LASERS"

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 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, having any of the following:
1. A volume greater than 100 cm^3; or
2. A diameter greater than 80 mm having a thickness of 20 mm or more;

b. Boules of the following electro-optic materials:
1. Potassium titanyl arsenate (KTA);
2. Silver gallium selenide ($AgGaSe_2$);
3. Thallium arsenic selenide (Tl_3AsSe_3, also known as TAS);

c. Non-linear optical materials, having all of the following:
1. Third order susceptibility (chi 3) of 10^{-6} m^2/V^2 or more; and
2. A response time of less than 1 ms;

d. "Substrate blanks" of silicon carbide or beryllium beryllium (Be/Be) deposited materials exceeding 300 mm in diameter or major axis length;

DUAL-USE LIST - CATEGORY 6 - SENSORS AND "LASERS"

6. C. 4. e. Glass, including fused silica, phosphate glass, fluorophosphate glass, zirconium fluoride (ZrF_4) and hafnium fluoride (HfF_4), 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};

   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. Synthetic crystalline "laser" host material in unfinished form, as follows:
   a. Titanium doped sapphire;
   b. Alexandrite.

6. C. 6. MAGNETOMETERS - 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 controlled by 6.A.4, 6.A.5., 6.A.8 or 6.B.8.

2. "Software" specially designed for the "use" of equipment controlled by 6.A.2.b., 6.A.8 or 6.B.8.

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;

6. D. 3. b. OPTICAL SENSORS - None

DUAL-USE LIST - CATEGORY 6 - SENSORS AND "LASERS"

6. D. 3. c. CAMERAS - None

d. OPTICS - None

e. LASERS - None

MAGNETOMETERS

f. "Software", as follows:

1. "Software" specially designed for magnetic compensation systems for magnetic sensors designed to operate on mobile platforms;
2. "Software" specially designed for magnetic anomaly detection on mobile platforms;

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 "software" application "programmes" hosted on general purpose computers located at Air Traffic Control centres and capable of any of the following:
   a. Processing and displaying more than 150 simultaneous "system tracks"; or
   b. Accepting radar target data from more than four primary radars;

2. "Software" for the design or "production" of radomes which:
   a. Are specially designed to protect the "electronically steerable phased array antennae" controlled by 6.A.8.e.; and
   b. Result 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.

DUAL-USE LIST - CATEGORY 6 - SENSORS AND "LASERS"

6. E. TECHNOLOGY

6. E. 1. "Technology" according to the General Technology Note for the "development" of equipment, materials or "software" controlled 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 controlled 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. Optical surface coating and treatment "technology" "required" to achieve 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.*

2. Optical fabrication "technology" 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;

MAGNETOMETERS

6. E. 3. f. "Technology" "required" for the "development" or "production" of non-triaxial fluxgate "magnetometers" or non-triaxial fluxgate "magnetometer" systems, having any of the following:

1. A "noise level" of less than 0.05 nT rms per square root Hz at frequencies of less than 1 Hz; or

2. A "noise level" of less than 1×10^{-3} nT rms per square root Hz at frequencies of 1 Hz or more.

6. E. 3. g. GRAVIMETERS - None

6. E. 3. h. RADAR - None

WA-LIST (03) 1
12-12-03

DUAL-USE LIST - CATEGORY 7 - NAVIGATION AND AVIONICS

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. Linear accelerometers designed for use in inertial navigation or guidance systems and having any of the following characteristics, and specially designed components therefor:
   a. A "bias" "stability" of less (better) than 130 micro g with respect to a fixed calibration value over a period of one year;
   b. A "scale factor" "stability" of less (better) than 130 ppm with respect to a fixed calibration value over a period of one year; or
   c. Specified to function at linear acceleration levels exceeding 100 g.

   N.B. For angular or rotational accelerometers, see 7.A.2.

7. A. 2. Gyros, and angular or rotational accelerometers, having any of the following characteristics, and specially designed components therefor:
   a. A "drift rate" "stability", when measured in a 1 g environment over a period of three months and with respect to a fixed calibration value, of:
      1. Less (better) than 0.1° per hour when specified to function at linear acceleration levels below 10 g; or
      2. Less (better) than 0.5° per hour when specified to function at linear acceleration levels from 10 g to 100 g inclusive; or
   b. Specified to function at linear acceleration levels exceeding 100 g.

7. A. 3. Inertial Systems and specially designed components, as follows:
   a. Inertial Navigation Systems (INS) (gimballed or strapdown) and inertial equipment designed for "aircraft", land vehicles, vessels (surface or underwater) or "spacecraft", for attitude, guidance or control, having any of the following characteristics, and specially designed components therefor:
      1. Navigation error (free inertial) subsequent to normal alignment of 0.8 nautical mile per hour (nm/hr) Circular Error Probable (CEP) or less (better); or
      2. Specified to function at linear acceleration levels exceeding 10 g.

   b. Hybrid Inertial Navigation Systems embedded with Global Navigation Satellite System(s) (GNSS) or with "Data-Based Referenced Navigation" ("DBRN") System(s) for attitude, guidance or control, subsequent to normal alignment, having an INS navigation position accuracy, after loss of GNSS or "DBRN" for a period of up to 4 minutes, of less (better) than 10 meters CEP.

   c. Inertial Equipment for Azimuth, Heading, or North Pointing having any of the following characteristics, and specially designed components therefor:
      1. Designed to have an Azimuth, Heading, or North Pointing accuracy equal to, or less (better) than 6 arc minutes RMS at 45 degrees latitude; or
      2. Designed to have a non-operating shock level of 900 g or greater at a duration of 1-msec, or greater.

DUAL-USE LIST - CATEGORY 7 - NAVIGATION AND AVIONICS

Note 1 *The parameters of 7.A.3.a. and 7.A.3.b. are applicable with any of the following environmental conditions:*

1. *Input random vibration with an overall magnitude of 7.7 g rms in the first half hour and a total test duration of one and one half hour per axis in each of the three perpendicular axes, when the random vibration meets the following:*
   a. *A constant power spectral density (PSD) value of 0.04 g^2/Hz over a frequency interval of 15 to 1,000 Hz; and*
   b. *The PSD attenuates with frequency from 0.04 g^2/Hz to 0.01 g^2/Hz over a frequency interval from 1,000 to 2,000 Hz;*
2. *A roll and yaw rate of equal to or more than +2.62 rad (radians)/s (150 deg/s); or*
3. *According to national standards equivalent to 1. or 2. above.*

Note 2 *7.A.3. does not control inertial navigation systems which are certified for use on "civil aircraft" by civil authorities of a participating state.*

Note 3 *7.A.3.c.1 does not control theodolite systems incorporating inertial equipment specially designed for civil surveying purposes.*

Technical Notes

1. *7.A.3.b. refers to systems in which an INS and other independent navigation aids are built into a single unit (embedded) in order to achieve improved performance.*
2. *'Circular Error Probable' ('CEP') - In a circular normal distribution, the radius of the circle containing 50 percent of the individual measurements being made, or the radius of the circle within which there is a 50 percent probability of being located.*

7. A. 4. Gyro-astro compasses, and other devices which derive position or orientation by means of automatically tracking celestial bodies or satellites, with an azimuth accuracy of equal to or less (better) than 5 seconds of arc.

7. A. 5. Global navigation satellite systems (i.e., GPS or GLONASS) receiving equipment having any of the following characteristics, and specially designed components therefor:

a. Employing decryption; or
b. A null-steerable antenna.

7. A. 6. Airborne altimeters operating at frequencies other than 4.2 to 4.4 GHz inclusive, having any of the following characteristics:

a. "Power management"; or
b. Using phase shift key modulation.

7. A. 7. Direction finding equipment operating at frequencies above 30 MHz and having all of the following characteristics, and specially designed components therefor:

a. "Instantaneous bandwidth" of 1 MHz or more;
b. Parallel processing of more than 100 frequency channels; and

DUAL-USE LIST - CATEGORY 7 - NAVIGATION AND AVIONICS

c. Processing rate of more than 1,000 direction finding results per second and per frequency channel.

DUAL-USE LIST - CATEGORY 7 - NAVIGATION AND AVIONICS

7. B. TEST, INSPECTION AND PRODUCTION EQUIPMENT

7. B. 1. Test, calibration or alignment equipment specially designed for equipment controlled by 7.A.

Note *7.B.1. does not control 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 removal of controlled accelerometers or gyro sensors from the SRA.

7. B. 2. Equipment, as follows, specially designed to characterize mirrors for ring "laser" gyros:

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 controlled by 7.A.

Note *7.B.3 includes:*

a. Gyro tuning test stations;
b. Gyro dynamic balance stations;
c. Gyro run-in/motor test stations;
d. Gyro evacuation and fill stations;
e. Centrifuge fixtures for gyro bearings;
f. Accelerometer axis align stations.

7. C. MATERIALS - None

DUAL-USE LIST - CATEGORY 7 - NAVIGATION AND AVIONICS

7. D. SOFTWARE

7. D. 1. "Software" specially designed or modified for the "development" or "production" of equipment controlled by 7.A. or 7.B.

2. "Source code" for the "use" of any inertial navigation equipment, including inertial equipment not controlled by 7.A.3. or 7.A.4., or Attitude and Heading Reference Systems (AHRS).
Note *7.D.2. does not control "source code" for the "use" 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.

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 in 7.A.3. or 7.A.4.;

b. "Source code" for hybrid integrated systems which improves the operational performance or reduces the navigational error of systems to the level specified in 7.A.3. by continuously combining inertial data with any of the following:
1. Doppler radar velocity data;
2. Global navigation satellite systems (i.e., GPS or GLONASS) reference data; or
3. Data from "Data-Based Referenced Navigation" ("DBRN") systems;

c. "Source code" for integrated avionics or mission systems which combine sensor data and employ "expert systems";

d. "Source code" for the "development" of any of the following:
1. Digital flight management systems for "total control of flight";
2. Integrated propulsion and flight control systems;
3. Fly-by-wire or fly-by-light control systems;
4. Fault-tolerant or self-reconfiguring "active flight control systems";
5. Airborne automatic direction finding equipment;
6. Air data systems based on surface static data; or
7. Raster-type head-up displays or three dimensional displays;

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 controlled in 7.E.4.b., 7.E.4.c.1. or 7.E.4.c.2.

DUAL-USE LIST - CATEGORY 7 - NAVIGATION AND AVIONICS

7. E. TECHNOLOGY

1. "Technology" according to the General Technology Note for the "development" of equipment or "software" controlled by 7.A., 7.B. or 7.D.

2. "Technology" according to the General Technology Note for the "production" of equipment controlled by 7.A. or 7.B.

3. "Technology" according to the General Technology Note for the repair, refurbishing or overhaul of equipment controlled by 7.A.1. to 7.A.4.

Note *7.E.3. does not control maintenance "technology" 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.*

N.B. *See Technical Notes to 7.B.1.*

7. E. 4. Other "technology", as follows:

a. "Technology" for the "development" or "production" of:
   1. Airborne automatic direction finding equipment operating at frequencies exceeding 5 MHz;
   2. Air data systems based on surface static data only, i.e., which dispense with conventional air data probes;
   3. Raster-type head-up displays or three dimensional displays for "aircraft";
   4. Inertial navigation systems or gyro-astro compasses containing accelerometers or gyros controlled by 7.A.1. or 7.A.2.;
   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";

7. E. 4. b. "Development" "technology", as follows, for "active flight control systems" (including fly-by-wire or fly-by-light):
   1. Configuration design for interconnecting multiple microelectronic processing elements (on-board computers) to achieve "real time processing" for control law implementation;
   2. Control law compensation for sensor location or dynamic airframe loads, i.e., compensation for sensor vibration environment or for variation of sensor location from the centre of gravity;
   3. Electronic management of data redundancy or systems redundancy for fault detection, fault tolerance, fault isolation or reconfiguration;

   Note *7.E.4.b.3. does not control" technology" for the design of physical redundancy.*

DUAL-USE LIST - CATEGORY 7 - NAVIGATION AND AVIONICS

7. E. 4. b. 4. Flight controls which permit inflight reconfiguration of force and moment controls for real time autonomous air vehicle control;

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 control:*

1. "Development" "technology" for integration of digital flight control, navigation and propulsion control data into a digital flight management system for "flight path optimisation";

2. "Development" "technology" for "aircraft" flight instrument systems integrated solely for VOR, DME, ILS or MLS navigation or approaches.

6. Full authority digital flight control or multisensor mission management systems employing "expert systems";

N.B. *For "technology" for Full Authority Digital Engine Control ("FADEC"), see 9.E.3.a.9.*

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 directional control systems";
3. Rotor blades incorporating "variable geometry airfoils" for use in systems using individual blade control.

DUAL-USE LIST - CATEGORY 8 - MARINE

8. A. SYSTEMS, EQUIPMENT AND COMPONENTS

8. A. 1. Submersible vehicles and surface vessels, as follows:

N.B. For the control status of equipment for submersible vehicles, see:
Category 5, Part 2 "Information Security" for encrypted communication equipment;
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 carry a crew of 4 or more;
   b. Designed to operate autonomously for 10 hours or more;
   c. Having a range of 25 nautical miles or more; and
   d. Having a length of 21 m or less;

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 cover.*

8. A. 1. c. Unmanned, tethered submersible vehicles designed to operate at depths exceeding 1,000 m, having any of the following:

1. Designed for self-propelled manoeuvre using propulsion motors or thrusters controlled by 8.A.2.a.2.; or
2. Having a fibre optic data link;

DUAL-USE LIST - CATEGORY 8 - MARINE

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. Having an acoustic data or command link; or
3. Having a fibre optic 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 with positioning accuracies to within 10 m of a predetermined point;

8. A. 1. f. Surface-effect vehicles (fully skirted variety) having all of the following characteristics:

1. a maximum design speed, fully loaded, exceeding 30 knots in a significant wave height of 1.25 m (Sea State 3) or more;
2. a cushion pressure exceeding 3,830 Pa; and
3. a light-ship-to-full-load displacement ratio of less than 0.70;

8. A. 1. g. Surface-effect vehicles (rigid sidewalls) with a maximum design speed, fully loaded, exceeding 40 knots in a significant wave height of 3.25 m (Sea State 5) or more;

8. A. 1. h. 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 (Sea State 5) or more;

8. A. 1. i. Small waterplane area vessels having any of the following:

1. 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 (Sea State 5) or more; or
2. A 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 (Sea State 6) 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)$^{2/3}$.