

## **MISSILE TECHNOLOGY CONTROL REGIME**

The United States Government has, after careful consideration and subject to its international treaty obligations, decided that, when considering the transfer of equipment and technology related to missiles, it will act in accordance with the attached Guidelines beginning on January 7, 1993. These Guidelines replace those adopted on April 16, 1987.

### **GUIDELINES FOR SENSITIVE MISSILE-RELEVANT TRANSFERS**

1. The purpose of these Guidelines is to limit the risks of proliferation of weapons of mass destruction (i.e. nuclear, chemical and biological weapons), by controlling transfers that could make a contribution to delivery systems (other than manned aircraft) for such weapons. The Guidelines are not designed to impede national space programs or international cooperation in such programs as long as such programs could not contribute to delivery systems for weapons of mass destruction. These Guidelines, including the attached Annex, form the basis for controlling transfers to any destination beyond the Government's jurisdiction or control of all delivery systems (other than manned aircraft) capable of delivering weapons of mass destruction, and of equipment and technology relevant to missiles whose performance in terms of payload and range exceeds stated parameters. Restraint will be exercised in the consideration of all transfers of items contained within the Annex and all such transfers will be considered on a case-by-case basis. The Government will implement the Guidelines in accordance with national legislation.

2. The Annex consists of two categories of items, which term includes equipment and technology. Category I items, all of which are in Annex Items 1 and 2, are those items of greatest sensitivity. If a Category I item is included in a system, that system will also be considered as Category I, except when the incorporated item cannot be separated, removed or duplicated. Particular restraint will be exercised in the consideration of Category I transfers regardless of their purpose, and there will be a strong presumption to deny such transfers. Particular restraint will also be exercised in the consideration of transfers of any items in the Annex, or of any missiles (whether or not in the Annex), if the Government judges, on the basis of all available, persuasive information, evaluated according to factors including those in paragraph 3, that they are intended to be used for the delivery of weapons of mass destruction, and there will be a strong presumption to deny such transfers. Until further notice, the transfer of Category I production facilities will not be authorized. The transfer of other Category I items will be authorized only on rare occasions and where the Government (A) obtains binding government-to-government undertakings embodying the assurances from the recipient government called for in paragraph 5 of these Guidelines and (B) assumes responsibility for taking all steps necessary to ensure

that the item is put only to its stated end-use. It is understood that the decision to transfer remains the sole and sovereign judgment of the United States Government.

3. In the evaluation of transfer applications for Annex items, the following factors will be taken into account:

- A. Concerns about the proliferation of weapons of mass destruction;
- B. The capabilities and objectives of the missile and space programs of the recipient state;
- C. The significance of the transfer in terms of the potential development of delivery systems (other than manned aircraft) for weapons of mass destruction;
- D. The assessment of the end-use of the transfers, including the relevant assurances of the recipient states referred to in sub-paragraphs 5.A and 5.B below;
- E. The applicability of relevant multilateral agreements.

4. The transfer of design and production technology directly associated with any items in the Annex will be subject to as great a degree of scrutiny and control as will the equipment itself, to the extent permitted by national legislation.

5. Where the transfer could contribute to a delivery system for weapons of mass destruction, the Government will authorize transfers of items in the Annex only on receipt of appropriate assurances from the government of the recipient state that:

- A. The items will be used only for the purpose stated and that such use will not be modified nor the items modified or replicated without the prior consent of the United States Government;
- B. Neither the items nor replicas nor derivatives thereof will be retransferred without the consent of the United States Government.

6. In furtherance of the effective operation of the Guidelines, the United States Government will, as necessary and appropriate, exchange relevant information with other governments applying the same Guidelines.

7. The adherence of all States to these Guidelines in the interest of international peace and security would be welcome.

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# MISSILE TECHNOLOGY CONTROL REGIME (MTCR)

## EQUIPMENT AND TECHNOLOGY ANNEX

11 JUN 1996

### **1. INTRODUCTION**

(a) This Annex consists of two categories of items, which term includes equipment and "technology". Category I items, all of which are in Annex items 1 and 2, are those items of greatest sensitivity. If a Category I item is included in a system, that system will also be considered as Category I, except when the incorporated item cannot be separated, removed or duplicated. Category II items are those items in the Annex not designated Category I.

(b) The transfer of "technology" directly associated any items in the Annex will be subject to as great a degree of scrutiny and control as will the equipment itself, to the extent permitted by national legislation. The approval of any Annex item for export also authorizes the export to the same end user of the minimum technology required for the installation, operation, maintenance, and repair of the item.

(c) In reviewing the proposed applications for transfers of complete rocket and unmanned air vehicle systems described in Items 1 and 19, and of equipment or technology which is listed in the Technical Annex, for potential use in such systems, the Government will take account of the ability to trade off range and payload.

### **2. DEFINITIONS**

For the purpose of this Annex, the following definitions apply:

(a) "Development" is related to all phases prior to "production" such as:

- design
- design research
- design analysis
- 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

(b) A "microcircuit" is defined as a device in which a number of passive and/or active elements are considered as indivisibly associated on or within a continuous structure to perform the function of a circuit.

(c) "Production" means all production phases such as:

- production engineering
- manufacture
- integration
- assembly (mounting)
- inspection
- testing
- quality assurance

(d) "Production equipment" means tooling, templates, jigs, mandrels, moulds, dies, fixtures, alignment mechanisms, test equipment, other machinery and components therefor, limited to those specially designed or modified for "development" or for one or more phases of "production".

(e) "Production facilities" means equipment and specially designed software therefor integrated into installations for "development" or for one or more phases of "production".

(f) "Radiation Hardened" means that the component or equipment is designed or rated to withstand radiation levels which meet or exceed a total irradiation dose of  $5 \times 10^5$  rads (Si).

(g) "Technology" means specific information which is required for the "development", "production" or "use" of a product. The information may take the form of "technical data" or "technical assistance".

(1) "Technical assistance" may take forms such as:

- instruction
- skills
- training
- working knowledge
- consulting services

(2) "Technical data" may take forms such as:

- blueprints
- plans
- diagrams
- models
- formulae
- engineering designs and specifications
- manuals and instructions written or recorded on other media or devices such as:
  - disk
  - tape
  - read-only memories

NOTE:

This definition of technology does not include technology "in the public domain" nor "basic scientific research".

(i) "In the public domain" as it applies to this Annex means technology which has been made available without restrictions upon its further dissemination. (Copyright restrictions do not remove technology from being "in the public domain".)

(ii) "Basic scientific research" means experimental or theoretical work undertaken principally to acquire new knowledge of the fundamental principles of phenomena and observable facts, not primarily directed towards a specific practical aim or objective.

(h) "Use" means:

- operation
- installation (including on-site installation)
- maintenance
- repair
- overhaul
- refurbishing

### **3. TERMINOLOGY**

Where the following terms appear in the text, they are to be understood according to the explanations below:

(a) "Specially Designed" describes equipment, parts, components or software which, as a result of "development", have unique properties that distinguish them for certain predetermined purposes. For example, a piece of equipment that is "specially designed" for use in a missile will only be considered so if it has no other function or use. Similarly, a piece of manufacturing equipment that is "specially designed" to produce a certain type of component will only be considered such if it is not capable of producing other types of components.

(b) "Designed or Modified" describes equipment, parts, components or software which, as a result of "development," or modification, have specified properties that make them fit for a particular application. "Designed or Modified" equipment, parts, components or software can be used for other applications. For example, a titanium coated pump designed for a missile may be used with corrosive fluids other than propellants.

(c) "Usable In" or "Capable Of" describes equipment, parts, components or software which are suitable for a particular purpose. There is no need for the equipment, parts, components or software to have been configured, modified or specified for the particular purpose. For example, any military specification memory circuit would be "capable of" operation in a guidance system.

### **ITEM 1- CATEGORY I**

Complete rocket systems (including ballistic missile systems, space launch vehicles and sounding rockets) and unmanned air vehicle systems (including cruise missile systems, target drones and reconnaissance drones) capable of delivering at least a 500 kg payload to a range of at least 300 km as well as the specially designed "production facilities" for these systems.

### **ITEM 2 - CATEGORY I**

Complete subsystems usable in the systems in Item 1, as follows, as well as the specially designed "production facilities" and "production equipment" therefor:

(a) Individual rocket stages;

(b) Reentry vehicles, and equipment designed or modified therefor, as follows, except as provided in Note (1) below for those designed for non-weapon payloads:

- (1) Heat shields and components thereof fabricated of ceramic or ablative materials;
- (2) Heat sinks and components thereof fabricated of light-weight, high heat capacity materials;
- (3) Electronic equipment specially designed for reentry vehicles;
- (c) Solid or liquid propellant rocket engines, having a total impulse capacity of  $1.1 \times 10^6$  N-sec ( $2.5 \times 10^5$  lb-sec) or greater;
- (d) "Guidance sets" capable of achieving system accuracy of 3.33 percent or less of the range (e.g. a CEP of 10 km or less at a range of 300 km), except as provided in Note (1) below for those designed for missiles with a range under 300 km or manned aircraft;
- (e) Thrust vector control sub-systems, except as provided in Note (1) below for those designed for rocket systems that do not exceed the range/payload capability of Item 1;
- (f) Weapon or warhead safing, arming, fuzing, and firing mechanisms, except as provided in Note (1) below for those designed for systems other than those in Item 1.

**Notes to Item 2:**

- (1) The exceptions in (b), (d), (e) and (f) above may be treated as Category II if the subsystem is exported subject to end use statements and quantity limits appropriate for the excepted end use stated above.
- (2) CEP (circle of equal probability) is a measure of accuracy; and defined as the radius of the circle centered at the target, at a specific range, in which 50 percent of the payloads impact.
- (3) A "guidance set" integrates the process of measuring and computing a vehicle's position and velocity (i.e. navigation) with that of computing and sending commands to the vehicle's flight control systems to correct the trajectory.
- (4) Examples of methods of achieving thrust vector control which are covered by (e) include:
  - a. Flexible nozzle;

- b. Fluid or secondary gas injection;
- c. Movable engine or nozzle;
- d. Deflection of exhaust gas stream (jet vanes or probes); or
- e. Use of thrust tabs.

### **ITEM 3 - CATEGORY II**

Propulsion components and equipment usable in the systems in Item 1, as follows, as well as the specially designed "production facilities" and "production equipment" therefor, and flow-forming machines specified in Note (1):

- (a) Lightweight turbojet and turbofan engines (including turbocompound engines) that are small and fuel efficient;
- (b) Ramjet/scramjet/pulse jet/combined cycle engines, including devices to regulate combustion, and specially designed components therefor;
- (c) Rocket motor cases, "interior lining", "insulation" and nozzles therefor;
- (d) Staging mechanisms, separation mechanisms, and interstages therefor;
- (e) Liquid and slurry propellant (including oxidizers) control systems, and specially designed components therefor, designed or modified to operate in vibration environments of more than 10 g RMS between 20 Hz and 2,000 Hz.
- (f) Hybrid rocket motors and specially designed component therefor.

### **Notes to Item 3:**

(1) Flow-forming machines, and specially designed components and specially designed software therefor, which:

- (a) according to the manufacturer's technical specification, can be equipped with numerical control units or a computer control, even when not equipped with such units at delivery, and
- (b) with more than two axes which can be coordinated simultaneously for contouring control.

Technical Note:

Machines combining the function of spin-forming and flow-forming are for the purpose of this item regarded as flow-forming machines.

This item does not include machines that are not usable in the production of propulsion components and equipments (e.g. motor cases) for systems in Item 1.

(2) (a) The only engines covered in subitem (a) above, are the following:

(1) Engines having both of the following characteristics:

(a) Maximum thrust value greater than 1000N (achieved un-installed) excluding civil certified engines with a maximum thrust value greater than 8,890N (achieved un-installed), and

(b) Specific fuel consumption of 0.13kg/N/hr or less (at sea level static and standard conditions); or

(2) Engines designed or modified for systems in Item 1, regardless of thrust or specific fuel consumption.

(b) Item 3(a) engines may be exported as part of a manned aircraft or in quantities appropriate for replacement parts for manned aircraft.

(3) In Item 3(c), "interior lining" suited for the bond interface between the solid propellant and the case or insulating liner is usually a liquid polymer based dispersion of refractory or insulating materials. e.g., carbon filled HTPB or other polymer with added curing agents to be sprayed or screeded over a case interior.

(4) In Item 3(c), "insulation" intended to be applied to the components of a rocket motor, i.e., the case, nozzle inlets, case closures, includes cured or semi-cured compounded rubber sheet stock containing an insulating or refractory material. It may also be incorporated as stress relief boots or flaps.

(5) The only servo valves and pumps covered in (e) above, are the following:

a. Servo valves designed for flow rates of 24 litres per minute or greater, at an absolute pressure of 7,000 kPa (1,000 psi) or greater, that have an actuator response time of less than 100 msec;

b. Pumps, for liquid propellants, with shaft speeds equal to or greater than 8,000 RPM or with discharge pressures equal to or greater than 7,000 kPa (1,000 psi).

(6) Item 3(e) systems and components may be exported as part of a satellite.

#### **ITEM 4 - CATEGORY II**

Propellants and constituent chemicals for propellants as follows:

(a) Composite Propellants

(1) Composite and composite modified double base propellants;

(b) Fuel Substances

(1) Hydrazine with concentration of more than 70 percent and its derivatives including monomethylhydrazine (MMH);

(2) Unsymmetric dimethylhydrazine (UDMH);

(3) Spherical aluminum powder with particles of uniform diameter of less than  $500 \times 10^{-6}$  m (500 micrometer) and an aluminum content of 97 percent by weight or greater;

(4) Metal with particle sizes less than  $500 \times 10^{-6}$  m (500 micrometer), whether spherical, atomized, spheroidal, flaked or ground, consisting of 97 percent by weight or more of the following: beryllium, boron, magnesium, zirconium, and alloys of these;

(5) High energy density materials such as boron slurry, having an energy density of  $40 \times 10^6$  J/kg or greater.

(c) Oxidizers/Fuels

(1) Perchlorates, chlorates, or chromates mixed with powdered metals or other high energy fuel components.

(d) Oxidizer Substances

(1) Liquid

(a) Dinitrogen tetroxide;

- (b) Nitrogen dioxide/dinitrogen tetroxide;
- (c) Dinitrogen pentoxide;
- (d) Inhibited Red Fuming Nitric Acid (IRFNA);
- (e) Compounds composed of fluorine and one or more of other halogens, oxygen or nitrogen.

(2) Solid

- (a) Ammonium perchlorate;
- (b) Ammonium Dinitramide (ADN);
- (c) Nitro-amines (cyclotetramethylene-tetranitramine (HMX), cyclotrimethylene-trinitramine (RDX));

(e) Polymeric Substances

- (1) Carboxyl-terminated polybutadiene (CTPB)
- (2) Hydroxy-terminated polybutadiene (HTPB)
- (3) Glycidyl azide polymer (GAP)
- (4) Polybutadiene-acrylic acid (PBAA)
- (5) Polybutadiene-acrylic acid-acrylonitrile (PBAN).

(f) Other Propellant Additives and Agents

(1) Bonding Agents

- (a) Tris (1-(2-methyl)aziridinyl phosphine oxide (MAPO);
- (b) Trimesoyl-1(2-ethyl)aziridine (HX-868,BITA);
- (c) "Tepanol" (HX-878), reaction product of tetraethylenepentamine, acrylonitrile and glycidol;
- (d) "Tepan" (HX-879), reaction product of tetraethylenepentamine and acrylonitrile;

(e) Polyfunctional aziridine amides with isophthalic, trimesic, isocyanuric, or trimethyladipic backbone and also having a 2-methyl or 2-ethyl aziridine group (HX-752, HX-874 and HX-77)

(2) Curing Agents and Catalysts

(a) Triphenyl Bismuth (TPB);

(3) Burning Rate Modifiers

(a) Catocene;

(b) N-butyl-ferrocene;

(c) Butacene;

(d) Other ferrocene derivatives;

(e) Carboranes, decaboranes; pentaboranes and derivatives thereof;

(4) Nitrate Esters and Nitrated Plasticizers

(a) Triethylene glycol dinitrate (TEGDN);

(b) Trimethylolethane trinitrate (TMETN);

(c) 1,2,4-Butanetriol trinitrate (BTTN);

(d) Diethylene glycol dinitrate (DEGDN);

(5) Stabilizers, as follows

(a) 2-Nitrodiphenylamine;

(b) N-methyl-p-nitroaniline

**ITEM 5 - CATEGORY II**

Production technology, or "production equipment" (including its specially designed components) for:

(a) Production, handling or acceptance testing of liquid propellants or propellant constituents described in Item 4.

(b) Production, handling, mixing, curing, casting, pressing, machining, extruding or acceptance testing of solid propellants or propellant constituents described in Item 4.

**Notes to Item 5:**

(1) Batch mixers or continuous mixers covered by (b) above, both with provision for mixing under vacuum in the range of zero to 13.326 kPa and with temperature control capability of the mixing chamber, are the following:

Batch mixers having:

- a. A total volumetric capacity of 110 litres (30 gallons) or more; and
- b. At least one mixing/kneading shaft mounted off centre.

Continuous mixers having:

- a. Two or more mixing/kneading shafts; and
- b. Capability to open the mixing chamber.

(2) The following equipment is included in (b) above:

- a. Equipment for the production of atomized or spherical metallic powder in a controlled environment;
- b. Fluid energy mills for grinding or milling ammonium perchlorate, RDX or HMX.

**ITEM 6 - CATEGORY II**

Equipment, "technical-data" and procedures for the production of structural composites usable in the systems in Item 1 as follows and specially designed components, and accessories and specially designed software therefor:

- (a) Filament winding machines of which the motions for positioning, wrapping and winding fibers can be coordinated and programmed in three or more axes, designed to fabricate composite structures or laminates from fibrous or filamentary materials, and coordinating and programming controls;

(b) Tape-laying machines of which the motions for positioning and laying tape and sheets can be coordinated and programmed in two or more axes, designed for the manufacture of composite airframes and missile structures;

(c) Multi-directional, multi-dimensional weaving machines or interlacing machines, including adapters and modification kits for weaving, interlacing or braiding fibres to manufacture composite structures except textile machinery not modified for the above end uses;

(d) Equipment designed or modified for the production of fibrous or filamentary materials as follows:

(1) Equipment for converting polymeric fibres (such as polyacrylonitrile, rayon or polycarbosilane) including special provision to strain the fibre during heating;

(2) Equipment for the vapor deposition of elements or compounds on heated filament substrates; and

(3) Equipment for the wet-spinning of refractory ceramics (such as aluminium oxide);

(e) Equipment designed or modified for special fibre surface treatment or for producing prepregs and preforms.

(f) "Technical data" (including processing conditions) and procedures for the regulation of temperature, pressures or atmosphere in autoclaves or hydroclaves when used for the production of composites or partially processed composites.

**Note to Item 6:**

(1) Examples of components and accessories for the machines covered by this entry are: moulds, mandrels, dies, fixtures and tooling for the preform pressing, curing, casting, sintering or bonding of composite structures, laminates and manufactures thereof.

(2) Equipment covered by sub item (e) includes but is not limited to rollers, tension stretchers, coating equipment cutting equipment and clicker dies.

**ITEM 7 - CATEGORY II**

Pyrolytic deposition and densification equipment and "technology" as follows:

(a) "Technology" for producing pyrolytically derived materials formed on a mould, mandrel or other substrate from precursor gases which decompose in the 1,300 degrees C to 2,900 degrees C temperature range at pressures of 130 Pa (1 mm Hg) to 20 kPa (150 mm Hg) including technology for the composition of precursor gases, flow-rates and process control schedules and parameters;

(b) Specially designed nozzles for the above processes;

(c) Equipment and process controls, and specially designed software therefor, designed or modified for densification and pyrolysis of structural composite rocket nozzles and reentry vehicle nose tips.

### **Notes to Item 7:**

(1) Equipment included under (c) above are isostatic presses having all of the following characteristics:

a. Maximum working pressure of 69 MPa (10,000 psi) or greater;

b. Designed to achieve and maintain a controlled thermal environment of 600 degrees C or greater; and

c. Possessing a chamber cavity with an inside diameter of 254 mm (10 inches) or greater.

(2) Equipment included under (c) above are chemical vapour deposition furnances designed or modified for the densification of carbon-carbon composites.

### **ITEM 8 - CATEGORY II**

Structural materials usable in the system in Item 1, as follows:

(a) Composite structures, laminates, and manufactures thereof, specially designed for use in the systems in Item 1 and the subsystems in Item 2, and resin impregnated fibre prepregs and metal coated fibre preforms therefor, made either with organic matrix or metal matrix utilizing fibrous or filamentary reinforcements having a specific tensile strength greater than  $7.62 \times 10^4$  m (3 x  $10^6$  inches) and a specific modulus greater than  $3.18 \times 10^6$  m (1.25 x  $10^8$  inches);

- (b) Resaturated pyrolyzed (i.e. carbon-carbon) materials designed for rocket systems;
- (c) Fine grain recrystallized bulk graphites (with a bulk density of at least 1.72 g/cc measured at 15 degrees C and having a particle size of  $100 \times 10^{-6}$  m (100 microns) or less), pyrolytic, or fibrous reinforced graphites usable for rocket nozzles and reentry vehicle nose tips;
- (d) Ceramic composite materials (dielectric constant less than 6 at frequencies from 100 Hz to 10,000 MHz) for use in missile radomes, and bulk machinable silicon-carbide reinforced unfired ceramic usable for nose tips;
- (e) Tungsten, molybdenum and alloys of these metals in the form of uniform spherical or atomized particles of 500 micrometer diameter or less with a purity of 97 percent or higher for fabrication of rocket motor components; i.e. heat shields, nozzle substrates, nozzle throats and thrust vector control surfaces;
- (f) Maraging steels (steels generally characterized by high Nickel, very low carbon content and the use of substitutional elements or precipitates to produce age-hardening) having an Ultimate Tensile Strength of  $1.5 \times 10^9$  Pa or greater, measured at 20 C.

### **Notes to Item 8:**

- (1) Maraging steels are only covered by 8(f) above for the purpose of this Annex in the form of sheet, plate or tubing with a wall or plate thickness equal to or less than 5.0 mm (0.2 inch).
- (2) The only resin impregnated fibre prepreps specified in (a) above are those using resins with a glass transition temperature ( $T_g$ ), after cure, exceeding 145°C as determined by ASTM D4065 or national equivalents.

### **ITEM 9 - CATEGORY II**

Instrumentation, navigation and direction finding equipment and systems, and associated production and test equipment as follows; and specially designed components and software therefor:

- (a) Integrated flight instrument systems, which include gyrostabilizers or automatic pilots and integration software therefor, designed or modified for use in the systems in Item 1;

- (b) Gyro-astro compasses and other devices which derive position or orientation by means of automatically tracking celestial bodies or satellites;
- (c) Accelerometers with a threshold of 0.05 g or less, or a linearity error within 0.25 percent of full scale output, or both, which are designed for use in inertial navigation systems or in guidance systems of all types;
- (d) All types of gyros usable in the systems in Item 1, with a rated drift rate stability of less than 0.5 degree (1 sigma or rms) per hour in a 1 g environment;
- (e) Continuous output accelerometers or gyros of any type, specified to function at acceleration levels greater than 100 g;
- (f) Inertial or other equipment using accelerometers described by subitems (c) or (e) above or gyros described by subitems (d) or (e) above, and systems incorporating such equipment, and specially designed integration software therefor;
- (g) Specially designed test, calibration, and alignment equipment, and "production equipment" for the above, including the following:
  - (1) For laser gyro equipment, the following equipment used to characterize mirrors, having the threshold accuracy shown or better:
    - (i) Scatterometer (10 ppm);
    - (ii) Reflectometer (50 ppm);
    - (iii) Profilometer (5 Angstroms).
  - (2) For other inertial equipment:
    - (i) Inertial Measurement Unit (IMU Module) Tester;
    - (ii) IMU Platform Tester;
    - (iii) IMU Stable Element Handling Fixture;
    - (iv) IMU Platform Balance fixture;
    - (v) Gyro Tuning Test Station;
    - (vi) Gyro Dynamic Balance Station;

- (vii) Gyro Run-In/Motor Test Station;
- (viii) Gyro Evacuation and Filling Station;
- (ix) Centrifuge Fixture for Gyro Bearings;
- (x) Accelerometer Axis Align Station;
- (xi) Accelerometer Test Station.

**Notes to Item 9:**

(1) Items (a) through (f) may be exported as part of a manned aircraft, satellite, land vehicle or marine vessel or in quantities appropriate for replacement parts for such applications.

(2) In sub-item (d):

a. Drift rate is defined as the time rate of output deviation from the desired output. It consists of random and systematic components and is expressed as an equivalent angular displacement per unit time with respect to inertial space.

b. Stability is defined as 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.

(3) Accelerometers which are specially designed and developed as MWD (Measurement While Drilling) Sensors for use in downhole well service operations are not specified in Item 9(c).

**ITEM 10 - CATEGORY II**

Flight control systems and "technology" as follows; designed or modified for the systems in Item 1 as well as the specially designed test, calibration, and alignment equipment therefor:

- (a) Hydraulic, mechanical, electro-optical, or electro-mechanical flight control systems (including fly-by-wire systems);
- (b) Attitude control equipment;

(c) Design technology for integration of air vehicle fuselage, propulsion system and lifting control surfaces to optimize aerodynamic performance throughout the flight regime of an unmanned air vehicle;

(d) Design technology for integration of the flight control, guidance, and propulsion data into a flight management system for optimization of rocket system trajectory.

**Note of Item 10:**

Items (a) and (b) may be exported as part of a manned aircraft or satellite or in quantities appropriate for replacement parts for manned aircraft.

**ITEM 11 - CATEGORY II**

Avionics equipment, "technology" and components as follows; designed or modified for use in the systems in Item 1, and specially designed software therefor:

(a) Radar and laser radar systems, including altimeters;

(b) Passive sensors for determining bearings to specific electromagnetic sources (direction finding equipment) or terrain characteristics;

(c) Global Positioning System (GPS) or similar satellite receivers;

(1) Capable of providing navigation information under the following operational conditions;

(i) At speeds in excess of 515 m/sec (1,000 nautical miles/hour);  
and

(ii) At altitudes in excess of 18 km (60,000 feet); or

(2) Designed or modified for use with unmanned air vehicles covered by Item 1.

(d) Electronic assemblies and components specially designed for military use and operation at temperatures in excess of 125 degrees C.

(e) Design technology for protection of avionics and electrical subsystems against electromagnetic pulse (EMP) and electromagnetic interference (EMI) hazards from external sources, as follows:

- (1) Design technology for shielding systems;
- (2) Design technology for the configuration of hardened electrical circuits and subsystems;
- (3) Determination of hardening criteria for the above.

**Notes to Item 11:**

(1) Item 11 equipment may be exported as part of a manned aircraft or satellite or in quantities appropriate for replacement parts for manned aircraft.

(2) Examples of equipment included in this Item:

- a. Terrain contour mapping equipment;
- b. Scene mapping and correlation (both digital and analogue) equipment;
- c. Doppler navigation radar equipment;
- d. Passive interferometer equipment;
- e. Imaging sensor equipment (both active and passive);

(3) In subitem (a), laser radar systems embody specialized transmission, scanning, receiving and signal processing techniques for utilization of lasers for echo ranging, direction finding and discrimination of targets by location, radial speed and body reflection characteristics.

**ITEM 12 - CATEGORY II**

Launch support equipment, facilities and software for the systems in Item 1, as follows:

- (a) Apparatus and devices designed or modified for the handling, control, activation and launching of the systems in Item 1;
- (b) Vehicles designed or modified for the transport, handling, control, activation and launching of the systems in Item 1;
- (c) Gravity meters (gravimeters), gravity gradiometers, and specially designed components therefor, designed or modified for airborne or marine use, and

having a static or operational accuracy of  $7 \times 10^{-6}$  m/sec<sup>2</sup> (0.7 milligal) or better, with a time to steady-state registration of two minutes or less;

(d) Telemetry and telecontrol equipment usable for unmanned air vehicles or rocket systems,

(e) Precision tracking systems:

(1) Tracking systems which use a code translator installed on the rocket or unmanned air vehicle in conjunction with either surface or airborne references or navigation satellite systems to provide real-time measurements of in-flight position and velocity;

(2) Range instrumentation radars including associated optical/infrared trackers and the specially designed software therefor with all of the following capabilities:

(i) an angular resolution better than 3 milli-radians (0.5 mils);

(ii) a range of 30 km or greater with a range resolution better than 10 metres RMS;

(iii) a velocity resolution better than 3 metres per second.

(3) Software which processes post-flight, recorded data, enabling determination of vehicle position throughout its flight path.

### **ITEM 13 - CATEGORY II**

Analogue computers, digital computers, or digital differential analyzers designed or modified for use in the systems in Item 1, having either of the following characteristics:

(a) Rated for continuous operation at temperatures from below minus 45 degrees C to above plus 55 degrees C; or

(b) Designed as ruggedized or "radiation hardened".

### **Note to Item 13:**

Item 13 equipment may be exported as part of a manned aircraft or satellite or in quantities appropriate for replacement parts for manned aircraft.

## **ITEM 14 - CATEGORY II**

Analogue-to-digital converters, usable in the systems in Item 1, having either of the following characteristics:

(a) Designed to meet military specifications for ruggedized equipment; or,

(b) Designed or modified for military use; and being one of the following types:

1) Analogue-to-digital converter "microcircuits", which are "radiation-hardened" or have all of the following characteristics:

i) Having a resolution of 8 bits or more;

ii) Rated for operation in the temperature range from below minus 54 degrees C to above plus 125 degrees C; and

iii) Hermetically sealed.

2) Electrical input type analogue-to-digital converter printed circuit boards or modules, with all of the following characteristics:

i) Having a resolution of 8 bits or more;

ii) Rated for operation in the temperature range from below minus 45 degrees C to above plus 55 degrees C; and

iii) Incorporating "microcircuits" listed in (1), above.

## **ITEM 15 - CATEGORY II**

Test facilities and test equipment usable for the systems in Item 1 and Item 2 as follows; and specially designed software therefor:

(a) Vibration test systems and components therefor, the following:

(1) Vibration test systems employing feedback or closed loop techniques and incorporating a digital controller, capable of vibrating a system at 10g RMS or more over the entire range 20 Hz to 2000 Hz and imparting forces of 50kN (11,250 lbs), measured 'bare table', or greater;

(2) Digital controllers, combined with specially designed vibration test software, with a real-time bandwidth greater than 5 kHz and designed for use with vibration test systems in (1) above;

(3) Vibration thrusters (shaker units), with or without associated amplifiers, capable of imparting a force of 50 kN (11,250 lbs), measured 'bare table', or greater, and usable in vibration test systems (1) above;

(4) Test piece support structures and electronic units designed to combine multiple shaker units into a complete shaker system capable of providing an effective combined force of 50 kN, measured 'bare table', or greater, and usable in vibration test systems in (1) above.

(b) Wind-tunnels for speeds of Mach 0.9 or more;

(c) Test benches/stands which have the capacity to handle solid or liquid propellant rockets or rocket motors of more than 90 kN (20,000 lbs) of thrust, or which are capable of simultaneously measuring the three axial thrust components;

(d) Environmental chambers and anechoic chambers capable of simulating the following flight conditions:

(1) Altitude of 15,000 meters or greater; or

(2) Temperature of at least minus 50 degrees C to plus 125 degrees C; and either

(3) Vibration environments of 10 g RMS or greater between 20 Hz and 2,000 Hz imparting forces of 5 kN or greater, for environmental chambers; or

(4) Acoustic environments at an overall sound pressure level of 140 dB or greater (referenced to  $2 \times 10^{-5}$  N per square metre) or with a rated power output of 4 kilowatts or greater, for anechoic chambers.

(e) Accelerators capable of delivering electromagnetic radiation produced by "bremsstrahlung" from accelerated electrons of 2 MeV or greater, and systems containing those accelerators.

Note: The above equipment does not include that specially designed for medical purposes.

**Note to Item 15(a):**

The term "digital control" refers to equipment, the functions of which are, partly or entirely, automatically controlled by stored and digitally coded electrical signals.

**ITEM 16 - CATEGORY II**

Specially designed software, or specially designed software with related specially designed hybrid (combined analogue/digital) computers, for modelling, simulation, or design integration of the systems in Item 1 and Item 2.

**Note to Item 16:**

The modelling includes in particular the aerodynamic and thermodynamic analysis of the systems.

**ITEM 17 - CATEGORY II**

Materials, devices, and specially designed software for reduced observables such as radar reflectivity, ultraviolet/infrared signatures and acoustic signatures (i.e. stealth technology), for applications usable for the systems in Item 1 or Item 2, for example:

- (a) Structural materials and coatings specially designed for reduced radar reflectivity;
- (b) Coatings, including paints, specially designed for reduced or tailored reflectivity or emissivity in the microwave, infrared or ultraviolet spectra, except when specially used for thermal control of satellites;
- (c) Specially designed software or databases for analysis of signature reduction;
- (d) Specially designed radar cross section measurement systems.

**ITEM 18 - CATEGORY II**

Devices for use in protecting rocket systems and unmanned air vehicles against nuclear effects (e.g. Electromagnetic Pulse (EMP), X-rays, combined blast and thermal effects), and usable for the systems in Item 1, as follows:

- (a) "Radiation Hardened" "microcircuits" and detectors.

(b) Radomes designed to withstand a combined thermal shock greater than 100 cal/sq cm accompanied by a peak over pressure of greater than 50 kPa (7 pounds per square inch).

**Note to Item 18 (a):**

A detector is defined as a mechanical, electrical, optical or chemical device that automatically identifies and records, or registers a stimulus such as an environmental change in pressure or temperature, an electrical or electromagnetic signal or radiation from a radioactive material.

**ITEM 19 - CATEGORY II**

Complete rocket systems (including ballistic missile systems, space launch vehicles and sounding rockets) and unmanned air vehicles (including cruise missile systems, target drones and reconnaissance drones), not covered in Item 1, capable of a maximum range equal or superior to 300 km.

**ITEM 20 - CATEGORY II**

Complete subsystems as follows, usable in systems in Item 19, but not in systems in Item 1, as well as specially designed "production facilities" and "production equipment" therefor:

(a) Individual rocket stages

(b) Solid or liquid propellant rocket engines, having a total impulse capacity of  $8.41 \times 10^5$ Ns ( $1.91 \times 10^5$  lb.s) or greater, but less than  $1.1 \times 10^6$  Ns ( $2.5 \times 10^5$ lb.s).

[http://www.state.gov/1997-2001-NOPDFS/global/arms/treaties/mtrc\\_anx.html](http://www.state.gov/1997-2001-NOPDFS/global/arms/treaties/mtrc_anx.html)