



Center for Nonproliferation Studies
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Preliminary Analysis of Chinese Missile Technology Export Control List

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PRELIMINARY CONCLUSIONS

This paper identifies differences and omissions between the MTCR Annex and the Chinese Missile and Missile Technology Export Control List and makes a preliminary assessment of their potential significance. It is based on a comparison of the Chinese Missile and Missile Technology Regulations and Export Control List released on August 25, 2002 with the Missile Technology Control Regime (MTCR) Annex text contained in the [Missile Technology Control Regime \(MTCR\) Annex Handbook](#). The analysis freely draws upon descriptions of specific technologies and their ballistic missile applications from the MTCR Annex Handbook.

Liu Jieyi, director general of the Chinese Foreign Ministry's Department of Arms Control and Disarmament, commented on the new regulations and control list in a press conference on August 27, 2002. Liu stated: "If you compare the list with MTCR, you will find that the categorization is a bit different for the sake of easy administration. There are items not contained in MTCR in the list. So in this respect, this list covers a wider area than MTCR. Of course there is also a very limited number of MTCR items that are not in the list because they are not really that relevant, either because we don't have them, or they have never come into the picture, or because our experts do not know exactly what they are."

The Chinese Missile and Missile Technology Export Control List incorporates almost all of the key elements of the MTCR Annex. The Chinese list is divided into Part I (covered by the [Regulations of the People's Republic of China on Administration of Arms Exports](#)) and Part II (covered by the newly issued [missile technology export control regulations](#)). All MTCR category I (complete systems and subsystems) items are fully covered (with one partial exception). The Chinese export control list also covers production facilities and equipment for MTCR Category I systems and subsystems. Part I of the Chinese list also includes some items covered by the MTCR as Category II items.

The Chinese Missile and Missile Technology Control List is reasonably comprehensive, and generally follows the MTCR Annex closely. The Chinese control list follows the MTCR's "presumption of denial" approach by requiring explicit approval and an export license for the export of covered systems and technologies to authorized end-users. The effectiveness of the regulations and control list in preventing proliferation of ballistic missiles and missile technology will ultimately depend on enforcement as well as on the coverage of the regulations.

A preliminary analysis of the new Chinese regulations has identified a few potentially significant omissions and differences with the MTCR Annex text:

1. The Chinese list control might not cover the main engine for the SA-2/CSA-1 surface to air missile. This engine is used in shorter range missile systems such as the M-7 (8610/CSS-8) that have a range of about 160 km. China previously exported the 8610 missile to Iran.
2. The Chinese control list covers the most important missile propellants and component chemicals, but omits some chemical constituents with missile/rocket propellant applications. The Chinese list would permit license-free export of some chemicals that could aid in indigenous efforts to develop missile propellants.
3. The Chinese export control list does not specifically include "maraging steel," high-strength steel that can be used to make solid rocket motor cases, propellant tanks, and missile interstages. The list does cover two specific missile-related applications of maraging steel: "interstage mechanisms" and "rocket motor cases and production equipment." The list does not specifically address the possible export of maraging steel for use in propellant tanks.
4. The Chinese control list includes many of the specific guidance and control technologies listed under MTCR Annex Item 9. The Chinese control list adopts a somewhat different philosophy by including broader specifications on guidance sets and flight control systems that could be used on missiles rather than specifying all individual components. The Chinese control list covers gyros and accelerometers with the degree of accuracy specified in the MTCR Annex.
5. The Chinese control list omits high-acceleration gyros and accelerometers (over 100 g) that could potentially be used as fuses in re-entry vehicles (RVs), and in guidance sets that steer maneuvering RVs as they evade defenses or terminally guide themselves to a target. Both China and Russia produce this type of equipment. It is possible that these items were omitted to facilitate potential Chinese cooperation with Russia in developing maneuvering RVs that could evade future U.S. missile defenses.
6. The Chinese control list does not specifically include GPS receivers, which can potentially be used to improve missile accuracy. GPS receivers have a host of other civilian and military applications, including in precision-guided munitions.
7. The Chinese control list does not specifically address range instrumentation radars, which are useful in testing missile performance.
8. The Chinese control list allows the export of more powerful vibration test systems without a license. The practical difference in coverage is unclear, but could allow export of equipment that could be used to test missiles with slightly less thrust than a Scud missile. These test systems would be most useful for countries with reasonably advanced ballistic missile programs. The specific limit suggests the control list might be worded to allow fulfillment of an existing contract.

9. The Chinese control list permits export of higher-performance wind tunnels without a license, and includes clauses permitting the export of wind tunnels specially designed for teaching and those with small dimensions. This could allow license-free export of technology that could be used for short-range ballistic missiles or cruise missiles that travel at relatively low speeds. The specific limit suggests the control list might be worded to allow fulfillment of an existing contract.
10. The Chinese control list permits export of X-ray devices that can potentially be used to analyze missiles and missile components. X-ray testing devices allow for non-destructive testing of solid rocket motors in order to discover flaws that might cause missiles to explode. The omission may be intended to allow fulfillment of an existing contract, possibly to export this type of X-ray system to Pakistan.
11. The Chinese control list incorporates the MTCR's standard of 300 km range with a 500 kg payload. It does not include language in MTCR Annex Items 19 and 20 that extends the MTCR's reach to cover any rocket systems with a range equal or superior to 300 km, regardless of payload. [MTCR Annex Item 20 covers subsystems, production facilities, and production equipment for this class of missiles]. The Chinese control list potentially allows the export of shorter-range missiles and missile components that do not exceed the MTCR standard of 300 km range with a 500 kg payload. This omission could potentially allow the export of missiles such as the M-7 (8610/CSS-8) that might be covered under MTCR Annex Item 19.

The Chinese missile regulations include a catch-all clause (Article 16) that covers the export of any missile-related items and technologies for systems “that can be used to deliver weapons of mass destruction” even if these items or technologies are not included in the control list. There are also provisions in the regulations to amend the control list.

The export control list appears to cover most of the missiles, missile components, and missile technologies that the United States has sanctioned China for transferring in the past. However it has some gaps that could allow export license-free transfers of technologies and equipment that would be useful for countries with established indigenous ballistic missile programs.

“[Regulations of the People’s Republic of China on Export Control of Missiles and Missile-related Items and Technologies, 25 August 2002](#)” and “[China's Missiles and Missile-related Items and Technologies Export Control List, 25 August 2002](#)” are available at: <http://www.nti.org/db/china/prcdocs.htm#Law>. Information on Chinese export controls and missile proliferation behavior is available at: <http://www.nti.org/db/china/index.html>

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DETAILED ANALYSIS

Differences and Omissions between the MTCR Annex and the Chinese Missile Technology Export Control List:

MTCR Annex Item 2 (Category I)

c) Solid or liquid propellant rocket engines, having a total impulse capacity of 1.1×10^6 N-sec (2.5×10^5 lb-sec) or greater;

Chinese Missile Export Control List:

Part I, 2, (8), (9)

(8) Storable liquid propellant rocket engines, having a thrust force of 90 kN or greater;

(9) Solid propellant rocket engines, having a total impulse capacity of 1100 kN•s or greater;

ANALYSIS:

This is the one MTCR category I item not fully covered in the Chinese export control list.

The Chinese text separates the equivalent MTCR item into two parts dealing separately with solid and storable liquid propellant rocket engines. The solid propellant text is identical to the MTCR text, but the storable liquid propellant text uses “thrust force” rather than “total impulse capacity” as the unit of measurement. (Total impulse capacity measures thrust times engine burn time.) A Scud missile has thrust of roughly 130 kN. The difference suggests that the Chinese list would not cover some smaller liquid propellant rocket engines with limited thrust, but longer burn times.

The Chinese list control might not cover the main engine for the SA-2/CSA-1 surface to air missile. This engine is used in shorter range systems such as the M-7 (aka 8610 aka CSS-8) that have a range of about 160 km). China previously exported the 8610 missile to Iran.

The difference suggests the control list might be worded to allow fulfillment of an existing contract or the export of an existing system (possibly the 8610 missile, which does not exceed the MTCR range/payload limit of 300 km with a 500 kg payload). See analysis of MTCR Annex Item 19 below.

The Chinese list cites “storable liquid propellant engines” rather than “liquid propellant engines.” This distinction is potentially significant, but would apply only to older technology liquid propellant engines. The SA-2 engine uses storable liquid propellant.

MTCR Annex Item 3

(f) Hybrid rocket motors and specially designed components therefor.

Chinese Missile Export Control List:

Omitted.

ANALYSIS:

Hybrid rocket motors use both solid and liquid propellants, usually a solid fuel and a liquid oxidizer. Because flow of the liquid oxidizer can be controlled, hybrid motors can be throttled or shut down completely and then restarted. Hybrid rocket motors combine some of the simplicity of solid rocket motors with the controllability of liquid rocket engines.

Hybrid rocket motors have the potential to power MTCR Category I missiles, but to date there have been no serious attempts to build and deploy any such missiles.

This omission is probably not significant.

MTCR Annex Item 4 (Propellants and Constituent Chemicals)

(b) Fuel Substances

(4) beryllium... in particle size less than 500×10^{-6} m (500 micrometers)

(c) Oxidizers/Fuels

(d) Oxidizer Substances

(e) Polymeric Substances

(f) Other Propellant Additives and Agents

(1) Bonding Agents

(2) Curing Agents and Catalysts

(3) Burning Rate Modifiers

(4) Nitrate Esters and Nitrated Plasticizers

(5) Stabilizers

Chinese Missile Export Control List:

Part II, 3. Liquid Propellants

(1) Hydrazine with a concentration of more than 70 percent;

(2) Unsymmetric dimethylhydrazine (UDMH);

(3) Monomethylhydrazine (MMH);

(4) Mixed amine;

(5) Dinitrogen tetroxide;

(6) Red Fuming Nitric Acid.

Part II, 4. Solid Propellant and Propellant Constituents

(1) Metal fuels with particle sizes less than 500 μ m, whether spherical, atomized, spheroidal, flaked or ground, consisting of 97 percent by weight or greater of any of the following metal and alloys of these: (a) Zirconium; (b) Boron; (c) Magnesium; (d) Titanium; (e) Uranium; (f) Tungsten; (g) Zinc; (h) Cerium. [OMITS beryllium]

(2) Ammonium perchlorate with particle sizes less than 500 μ m;

(3) Spherical aluminum powder meeting the following requirements:

(a) With particle of uniform diameter; (b) With aluminum content of 97 percent or greater; (c) With diameter of less than 500 μ m.

(4) Boron Slurry, having an energy density of more than 40×10^6 J/kg;

(5) Nitro-amines:

(a) Cyclotetramethylene-tetranitramene (HMX);

(b) Cyclotrimethylene-trinitramine (RDX).

(6) Composite Propellants:

(a) Molded colloid propellants; (b) Propellant including nitrate bonding agents and with an aluminum (particle) content of 5 percent or greater.

(7) Polymeric substances:

(a) Carboxyl-terminated polybutadiene (CTPB);

(b) Hydroxy-terminated polybutadiene (HTPB).

(8) Triethylamine as an igniting agent.

ANALYSIS:

The MTRC Annex lists a number of specific propellants and chemicals potentially useable as components of propellants or as additives or binding agents. The Chinese control list concentrates on the most important and commonly used types of solid and liquid propellants and their constituent components. The Chinese list omits some exotic (but potentially useable) fuel components such as beryllium particles, a few oxidizers such as dinitrogen trioxide and ammonium Dinitramide (ADN), some binding agents such as Polybutadiene-acrylic acid-acrylonitrile (PBAN), and most of the additives used to stabilize and modify the burn rate of propellants.

The Chinese list covers the key propellants and chemical constituents, but omits some chemical constituents with missile/rocket propellant applications. A few of the omitted chemical constituents, such as PBAN, have no commercial applications. On balance, the Chinese list covers the most important propellants and components, but would permit the license-free export of some chemicals that could supplement indigenous efforts to develop propellants.

MTCR Annex Item 6 Equipment and Procedures for production of structural composites

(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;

Chinese Missile Export Control List:

Part II, 4, (c)

(c) Adapters and modification kits of weaving machines for fibre structure composites;

ANALYSIS:

Multi-directional, multi-dimensional weaving machines are used to make critical missile parts such as reentry vehicle nose tips and rocket nozzles that are exposed to high temperatures and stress. Carbon fiber weaving machines are used extensively in the manufacture of propulsion tanks and rocket motor casings. They also have a wide range of commercial applications. The Chinese list includes adapters and modification kits of weaving machines for fiber structure composites, but omits the actual weaving machines themselves. It is not clear that weaving machines are produced in China.

MTCR Annex Item 8 (Structural Materials)

(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 100×10^{-6} m (100 microns) or less), pyrolytic, or fibrous reinforced graphites usable for rocket nozzles and reentry vehicle nose tips;

Chinese Missile Export Control List:

Part II, 7, (3)

- (3) Fine grain bulk artificial graphites having the following features measured at 20 °C:
- (a) With a bulk density of at least 1.72 g/cm³;
 - (b) With a tension rupture strain of at least 0.7 percent;
 - (c) With a heat expansion coefficient of at least 2.75×10^6 (measured at temperatures from 20 °C to 982 °C).

ANALYSIS:

Fine-grain recrystallized bulk graphites are used for reentry vehicle nose tips, thrust tabs, and nozzle throats.

The Chinese regulations specify a different temperature measurement standard, which would allow the export of slightly denser artificial graphite without a license. The significance of this difference—if any—is unclear.

MTCR Annex Item 8 (Structural Materials)

(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 1.5×10^9 Pa or greater, measured at 20 degrees 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).

Chinese Missile Export Control List:

Part II, 7, (5)

Omitted. The Chinese export control list has no specific mention of “maraging steel” (which is translated as “*mashiti shixiaogang*” (马氏体时效钢) in the Center for Nonproliferation Studies [glossary of Chinese nonproliferation terms](#)).

ANALYSIS:

Maraging steel is high-strength steel that can be used to make solid rocket motor cases, propellant tanks, and interstages. It can also be used in special aircraft parts, submarine hulls, fencing blades, pipes, and reactors in the chemical and nuclear industries. Because of its nuclear applications, maraging steel is also covered by Nuclear Supplier’s Group trigger lists.

China is not a member of the Nuclear Supplier’s Group, but has stated its adherence in principle to NSG trigger lists that cover maraging steel. It is possible that maraging steel is omitted from the Chinese missile technology export control list because it is already covered under June 17, 1998 PRC regulations governing Dual-Purpose Nuclear Goods and Correlated Technologies (<http://www.nti.org/db/china/engdocs/nduregs.htm>).

This is potentially a significant omission, but note that the Chinese export control list covers two specific missile applications of maraging steel: (Part I, 3) “Interstage mechanisms for space launch vehicles and the specially designed production equipment therefor” and (Part I, 4)

“Rocket motor cases and the specially designed production equipment therefor.” The Chinese export control list does not specifically address the possible export of maraging steel for use in propellant tanks. This omission, coupled with the omission of composite weaving machines (which also have propellant tank applications), is suggestive.

MTCR Annex Item 9 (Navigation Equipment)

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;
- (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; at over 100 g.
- (g) Production equipment and other test, calibration and alignment equipment, other than that described in 9(h), designed or modified to be used with equipment specified in a-f above, including the following: (ii) IMU Platform Tester;
- (h) Equipment as follows:
 - (1) Balancing machines having all the following characteristics:
 - (2) Indicator heads (sometimes known as balancing instrumentation) designed or modified for use with [Balancing machines]
 - (3) Motion simulators/rate tables (equipment capable of simulating motion) [with specified characteristics]
 - (4) Positioning tables (equipment capable of precise rotary positioning in any axes) [with specified characteristics]
 - (5) Centrifuges capable of imparting accelerations above 100 g and having slip rings capable of transmitting electrical power and signal information.

Chinese Missile Export Control List:

Part I

- 2. (10) Guidance sets capable of achieving system accuracy of 10 km or less (CEP) for ballistic missiles with a range of 300 km;
- 5. Hydraulic, mechanical, electro-optical, or electro-mechanical flight control systems specially designed or modified for the systems in Item 1 of Part I.
- 6. Attitude control equipment specially designed or modified for the systems in Item 1 of Part I.
- 8. Design technology for integration of the guidance, flight control, and propulsion data into a flight management system for optimization of trajectory of ballistic missiles or space launch vehicles.
- 10. Apparatus and devices designed or modified for the handling, control, activation and launching of the systems in Item 1.

Part II, 5 (Guidance and Control Set, Components and Related Technologies)

- (5) Gyros with a rated drift rate stability of less than 0.5 degree per hour;
- (19) Accelerometers with a proportional error of 0.25 percent or less;
- (22) Specially designed test, calibration, and alignment equipment for gyro or accelerometer.

ANALYSIS:

The Chinese control list includes most but not all of the specific items listed under MTCR Annex Item 9. The Chinese control list adopts a somewhat different philosophy by including broad specifications on guidance sets and flight control systems that could be used on missiles rather than specifying all individual components. Items 2, 5, 6, 8, and 10 in Part I of the Chinese control list would cover most integrated flight instrument systems listed in Item II (d) and Item 9 (a) of the MTCR Annex.

The Chinese control list covers gyros and accelerometers that exceed the accuracy limit specified in the MTCR Annex. It includes a general listing for gyro and accelerometer test, calibration, and alignment equipment rather than specifying all the individual test equipment that might be used.

The Chinese control list omits high-acceleration gyros and accelerometers (over 100 g). These control systems can potentially be used as fuses in re-entry vehicles (RVs), and in guidance sets that steer maneuvering RVs as they evade defenses or terminally guide themselves to a target. Because of the short period of operation of such systems, high accuracy gyros and accelerometers are not required for this application. Both China and Russia produce this type of equipment. It is possible that these items were omitted to facilitate potential Chinese cooperation with Russia in developing maneuvering RVs that could evade future U.S. missile defenses.

The Chinese control list includes most of the specific test, calibration and alignment equipment listed in MTCR Annex Item 9 (g), with the exception of an Inertial Measurement Unit (IMU) Platform Tester, which is used to test the accuracy of an IMU. The IMU platform tester, also known as a rate table, is the single most important piece of equipment for design, production, and flight testing of gyros. Alignment and calibration equipment (precision mirrors, theodolites, laser autocollimators) is nearly as critical. It may be important that these items are not specifically mentioned in the Chinese control list. The Chinese control list also omits the list of specific test, calibration and alignment equipment in MTCR Annex Item 9 (h), which can be used for similar purposes. However the Chinese control list does include “specially designed test, calibration, and alignment equipment for gyro or accelerometer,” which would appear to cover this type of test equipment. Given this broad reference to test equipment, the omission of the IMU platform tester is curious.

MTCR Annex Item 11

- (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.

Chinese Missile Export Control List:

Part I, 13. Precision tracking systems:

(1) Tracking systems which use a translator [signal repeater or retransmitter] installed on the rocket system 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;

Part II, 6,

(6) Processors and software specially designed for processing navigation information;

ANALYSIS:

The Chinese control list does not specifically include GPS receivers, which can be used to improve missile accuracy. Chinese scientists are exploring ways to use GPS information to improve the accuracy of ballistic missiles, but there are some significant technical obstacles. China is reportedly interested in acquiring Russian GLONASS technology and may eventually operate its own GLONASS satellite system.

GPS receivers can be used in conjunction with other attitude sensors to improve missile pointing accuracy, but GPS resolution and receiver equipment constraints require complex algorithms that are difficult to implement on a production scale. Software specially designed for processing navigation information, which would be critical for this application, is specifically covered in the Chinese export control list.

GPS receivers are more likely to be used for orbit (position) determination by reporting position and velocity data back to ground tracking systems. This type of GPS usage appears to be covered in the Chinese export control List under Part I, Section 13 (see below). Note that the Chinese export control list refers to tracking systems which use a translator [*zhuanfaqi* (转发器)]. This term could also be translated as a “signal repeater” or “retransmitter” (e.g. a device that retransmits information from a GPS receiver on a missile to a ground tracking station).

GPS receivers have a host of other civilian and military applications. One important application is to provide guidance for precision-guided munitions (PGMs). The U.S. military makes extensive use of GPS-guided bombs. The omission of GPS receivers may be intended to make it easier to market Chinese precision-guided munitions or PGM strap-on kits for regular bombs.

MTCR Annex Item 12

(e) Precision tracking systems

(2) Range instrumentation radars including associated optical/infrared trackers and the specially designed software there-for 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.

Chinese Missile Export Control List:

Part I, 13. Precision tracking systems:

- (1) Tracking systems which use a translator installed on the rocket system 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) Software which processes post-flight, recorded data, enabling determination of vehicle position throughout its flight path.

ANALYSIS:

The Chinese control list does not specifically address range instrumentation radars, though it does address tracking systems and software in the items listed above. The omission suggests the control list might be worded to allow fulfillment of an existing contract.

MTCR Annex Item 14

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

- (b) Designed or modified for military use; [with particular specifications, including items with eight bit or higher resolution]

Chinese Missile Export Control List:

The Chinese control list uses different specifications for analog-to-digital converters, covering converters with an accuracy exceeding 1/10,000.

ANALYSIS:

Analog-to-digital converters are used in many areas of missile and spacecraft design to convert analog signals into a form useable by digital computers. With respect to guidance, the better the resolution (i.e. 8-bit, 16-bit,...) of the converter, the more precise the sensor processing will be. For instance, a smaller quantization error of the analog signal of a mechanical gyro will correspond to improved accuracy of a missile.

The accuracy specification in the Chinese control list would translate to an analog-to-digital converter with a 13-14 bit resolution. This difference would allow for license-free export of higher resolution analog-to-digital converters, which have a wide-range of commercial applications.

MTCR Annex Item 15 (Test Equipment)

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

Chinese Missile Export Control List:

Part II, 8 (2)

(2) Vibration test systems capable of providing a force of 100kN or more and incorporating a digital controller, as well as specially designed vibration test auxiliaries and software;

ANALYSIS:

Vibration test systems of this type are large and powerful equipment for simulating the flight vibrations and shocks that rockets and unmanned air vehicles (UAVs) experience during launch, stage separation, and normal flight. If vibration and shock are properly understood, flight vehicles can be made stronger and lighter because safety margins can be reduced. Use of such equipment also helps avoid costly test flight failures.

The Chinese regulations appear to allow the export of more powerful vibration test systems without a license. The practical difference in coverage is unclear, but might allow export of equipment that could be used to test missiles with slightly less thrust than a Scud missile. These more powerful vibration test systems would be most useful for countries with reasonably advanced ballistic missile programs, such as Pakistan, Iran, and/or North Korea.

The specific limit suggests the control list might be worded to allow fulfillment of an existing contract.

MTCR Annex Item 15 (Test Equipment)

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

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

Chinese Missile Export Control List:

Part II, 8 (3)

(3) Wind-tunnel for supersonic (Mach 1.4 to 5) or hypersonic (Mach 5 to 15) speeds except those specially designed for teaching and those with the test area dimensions smaller than 25 cm (measured internally);

ANALYSIS:

Wind tunnels capable of exceeding Mach 0.9 are used to test rockets, supersonic UAVs, and reentry vehicles.

The Chinese export control list permits the export of higher-performance wind tunnels without a license, and includes clauses permitting the export of wind tunnels specially designed for teaching and those with small dimensions. The more permission regulations could allow license-free export of technology that could be used for short-range ballistic missiles or cruise missiles that travel at relatively low speeds. (Wind tunnels also have applications in the development of aircraft).

The specific limit suggests the control list might be worded to allow fulfillment of an existing contract.

MTCR Annex Item 15 (Test Equipment)

(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 2×10^{-5} N per square metre) or with a rated power output of 4 kilowatts or greater, for anechoic chambers.

Chinese Missile Export Control List:

Omitted.

ANALYSIS:

This equipment can be used to test the performance of missiles in the extreme conditions of space and the upper atmosphere. Results from these tests can be used to refine missile designs. Acoustic/anechoic chambers are critical in validating the design loads of fairing structures that cover satellites or missile payloads. Chinese launch vehicles (specifically the Long March vehicle) have had multiple payload fairing failures in the past.

This equipment is also commonly used to test the performance of satellites. This item might be omitted to facilitate potential international collaboration on satellite development. Alternatively, it might also be omitted to facilitate potential collaboration with Russia on missile re-entry vehicles.

MTCR Annex Item 15 (Test Equipment)

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

Chinese Missile Export Control List:

Omitted.

ANALYSIS:

This equipment can potentially be used to analyze missiles and missile components via X-ray images. X-rays allow for non-destructive testing of solid rocket motors in order to discover cracks or voids in the propellant grain, cracks or incomplete welds in the case, or incomplete bonds to the insulation or interior lining. The omission suggests the control list might be worded to allow fulfillment of an existing contract, possibly to export this type of X-ray system to Pakistan.

MTCR Annex Item 19

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.

Chinese Missile Export Control List:

Omitted.

ANALYSIS:

This clause extends the MTCR's reach to cover any rocket systems with a range equal or superior to 300 km, regardless of payload. [MTCR Annex Item 20 covers subsystems, production facilities, and production equipment for this class of missiles]. The Chinese control list does not include this provision, potentially allowing the export of shorter-range missiles that do not exceed the MTCR standard of 300 km range with a 500 kg payload. [This is different from the "inherent capability" issue, which refers to missiles inherently capable of reaching the 300 km/500 kg threshold].

This omission could potentially allow the export of missiles such as the M-7 (aka 8610 aka CSS-8) that might be covered under Annex Item 19.

Note that the Chinese missile technology export control regulations do include a clause stating the intent of the regulations is to "prevent the proliferation of missiles and other delivery systems listed in the Control List that can be used to deliver weapons of mass destruction." The missile regulations also include a catch-all clause (Article 16) that covers the export of missile-related items and technologies for systems "that can be used to deliver weapons of mass destruction" even if these items or technologies are not included in the control list.

MTCR Annex Item 20

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 8.41×10^5 Ns (1.91×10^5 lb-s) or greater, but less than 1.1×10^6 Ns (2.5×10^5 lb-s).

Chinese Missile Export Control List:

Omitted.

ANALYSIS:

This clause extends the MTCR's reach to cover any subsystems, production facilities, and production equipment for rocket systems with a range equal or superior to 300 km, regardless of payload.

See analysis of MTCR Annex Item 19 above.