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TECHNICAL EVALUATION OF MILITARY GROUND SYSTEMS FOR EXPORT LICENSING: *A METRIC APPROACH*

Mrinal K. Mukherjee

Technical evaluation is one of the key components of the Department of Defense (DoD) export license application review process. This article presents an overview of a metric approach to technical evaluation, using military ground systems as a case study. The metrics provide a summary of specific technology attributes associated with the system, subsystem, or components, and can be used to identify sensitive technologies which must be controlled to protect against potential proliferation. Metrics will assist in licensing decisions, which are extremely critical for protecting our technological advantages and maintaining technological superiority on the battlefield.

The development of metrics requires joint participation of industry, military services, and Department of Defense (DoD) agencies. The major advantages of a metric approach are: (1) metrics provide a baseline of the technology status and identify sensitive technologies in a summary format, (2) metrics help reduce license application processing time, and (3) metrics provide consistent and jointly agreed DoD and industry positions with regard to the export of technical data, hardware, or software.

With the decline in defense procurement of new systems and the continuous search for greater market share, defense industries are increasingly seeking to export their products (technical data, hardware, or software) to foreign customers. As a consequence, export license applications, originated at the Department of State (DoS) for United States Munitions List (USML) defense articles and defense services, have increased 22 percent between 2000 and 2004, from 46,000 to 56,000 (GAO, 2001). The Defense

Technology Security Administration (DTSA) is responsible for providing the DoD license recommendation to the DoS for export license applications. In order to reduce DoD license processing time and to provide consistent license recommendations, while also ensuring military technological superiority, this article proposes a metric approach to the technical evaluation of export license applications.

Export license applications for military systems include technical data, hardware and software, or technical data related to a proposed technical assistance or manufacturing license agreement with foreign governments or companies. Technical data for defense articles consists of information which is required for the design, development, production, assembly, repair, testing, maintenance, or modification of defense articles, classified information related to defense articles, or software directly related to defense articles (International Traffic in Arms Regulations, 2004).

Within DTSA, an organization under the Office of the Under Secretary of Defense (Policy), the Technology Directorate (TD) is responsible for the technical evaluation of each license application. The technical evaluation process consists of: (1) identification of technologies associated with export license applications (for technical data, hardware, or software), (2) assessment of the military capabilities provided, (3) evaluation of the critical technologies that allow U.S. military superiority, (4) analysis of foreign capabilities for similar systems/subsystems, and (5) recommendation of technical conditions/provisos to preserve U.S. military technological advantage and prevent identification of technological limitations. The product of the TD evaluation process is a technical position that is provided to a licensing analyst in the DTSA Licensing Directorate. The licensing analyst also receives positions from the DTSA Policy Directorate, the military Services, and other DoD agencies. After thorough review and consultation with all parties to resolve conflicting positions, the Licensing Directorate submits a final DoD license recommendation for each export license application to the DoS that encompasses technical, policy, and regulatory issues.

DEVELOPMENT OF TECHNOLOGY METRICS

Applying a metric approach to the technical evaluation of export license applications for a system or a subsystem requires five general steps:

- Develop a Work Breakdown Structure (WBS) for the system or subsystem under review. Development of a WBS involves breaking down the system into its subsystems and major components.

- Establish functional areas of evaluation, which may include material technology, design methodology, manufacturing process, and integration/test function.

- Classify technologies that may include dual use, defense unique, proprietary, and sensitive or critical technology for U.S. military superiority or that could allow the identification of system limitations.

- Identify and evaluate technologies associated with each element of the WBS and for each functional area.
- Develop metrics for the system or subsystem, using the WBS, functional areas, and technologies associated with each element of the WBS and identify sensitive technologies.

GROUND SYSTEM WBS

A WBS is a graphic representation that completely defines a product. It is a product-oriented family tree of hardware, which displays second and third or more levels of the product structure depending upon the system complexity (MIL-HDBK, 1998). Level 1 is the system itself, Level 2 relates to the major subsystems, and Level 3 consists of major components in the subsystems. A typical ground system (tracked vehicle) includes the structure, suspension, engine, drive train, fire control, and armament as the Level 2 subsystems, with major components of each subsystem as the Level 3 subsystems. A generic example of ground system (tracked vehicle) WBS to Level 3 with major components is shown in Figure 1.

FUNCTIONAL AREAS OF EVALUATION

The functional areas of the technical evaluation process may include the following: material technology, design methodology, manufacturing processes, and integration and test (Department of the Navy, 1986).

MATERIAL TECHNOLOGY

Material technology is an important area of evaluation for system designers to meet the military performance requirements. The performance requirements and environmental conditions under which the ground system will operate are the key parameters for the selection of material. Weight and cost of the material is also a factor in the selection of the material. The high performance material allows the designer to design a system which meets military requirements. The technologies are in the areas of material characteristics and composition and material processing or shape. For example, armor for a ground system structure may include steel, aluminum, titanium, or ceramic composite. Each type of armor must have certain material composition and/or may require special manufacturing processes to provide material properties in order to meet the required ballistic resistance, e.g., tensile strength (MPa), density (g/cm3), or mass efficiency. Special material composition and/or process parameters may be the areas of sensitive technologies. Therefore, the review process will require analysis of the material technologies with regard to those commonly available in commercial industries or that have to be specially designed and/or manufactured for defense applications. For example, composite armor material requirements for ground systems may vary from

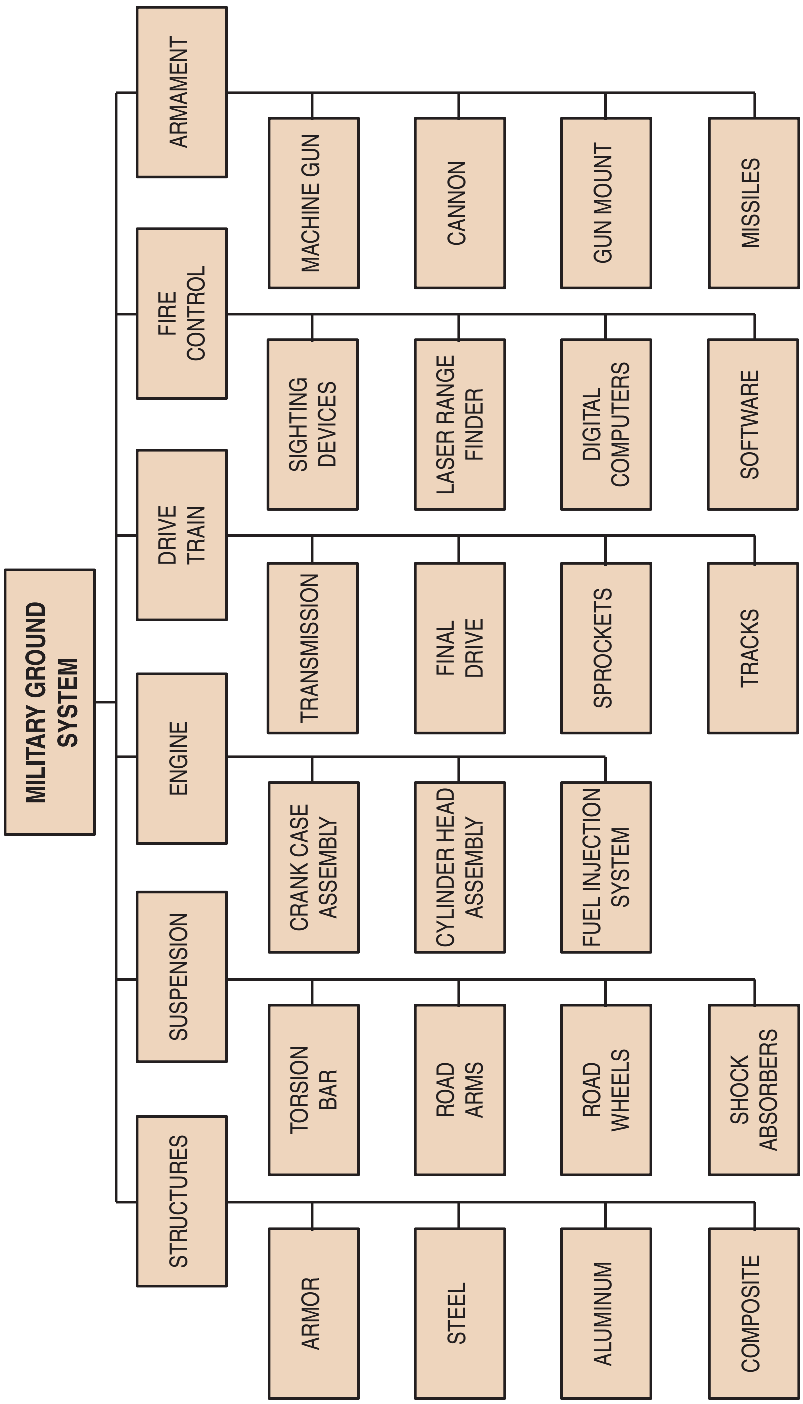


FIGURE 1. GENERIC WORK BREAKDOWN STRUCTURE

commercially available fiberglass or Kevlar composite to special ceramic armor with sensitive technologies.

DESIGN METHODOLOGY

The system design starts with the development of specifications based on system performance requirements. Design requirements include full and explicit statement of quantitative performance requirements. The design tools used for military systems are usually the same that are used for commercial hardware. The designers need requirements information, such as static and dynamic requirements, weight, reliability and maintainability, and proposed unit production cost for designing a system (Department of the Navy, 1986). The specifications of some of the subsystems or components for the military ground systems may well be similar to those required for commercial automotive requirements. For example, the design of propulsion and suspension components for military vehicles was derived from commercial applications. Some of the military design parameters may exceed the requirement of the commercial applications, in which case the design of the component or subsystem needs to be tailored to fit the defense application. For example, the design of the suspension and stabilization system for the Abrams tank is unique to military systems because of weight and fire-on-the-move capability with electrohydraulic/electromechanical gun drive systems.

MANUFACTURING PROCESSES

The technology associated with the manufacturing processes in the production of military hardware also needs careful evaluation. Manufacturing process technology is fundamental to the defense industrial production base. Various components of ground systems require special quality assurance requirements in order to meet military reliability, availability, and maintainability requirements. In most cases, manufacturing processes, equipment, and technologies are derived from commercial manufacturing practices. However, some of the modern weapon systems require special processing equipment, special tooling, or even special facilities to manufacture necessary subsystems or components. For example, hull and turret machining centers were specially designed and tooled for fabricating Abrams tank structures to meet the design tolerance and to achieve unit cost goals. A special rolling facility was required to manufacture depleted uranium armor. Another example is the torsion bar used in the Abrams suspension that requires a special shot peening process to achieve desired performance requirements. The critical technologies lie in the development of special manufacturing processes, manufacturing equipment, and tooling.

INTEGRATION/TEST

System integration and testing requires assembling different subsystems and their components, and the interfaces that link them together. The integration and testing process requires an understanding of what the effect of each hardware and software component has on the overall performance of the system when they are integrated

(Department of the Navy, 1986). Integration and testing is the final phase considered the most sensitive area of system development and production. The overall performance of the system depends on successful integration and testing. Manufacturers have developed system integration laboratories (SIL) to simulate the system integration and test process. The technologies associated with integration and test, and failure analysis and corrective action are considered sensitive technologies.

CLASSIFICATIONS OF TECHNOLOGIES

The technologies can be classified into four categories: (1) dual use, (2) militarily or defense unique, (3) proprietary, and (4) sensitive.

DUAL USE

Dual use technologies consist of products and know-how that were primarily designed and developed for commercial applications and subsequently adapted for military applications and vice versa. There are subsystems and components in military ground systems that are derived from commercial automotive technologies and used in military systems. For example, Cummins VTA 903T engines for Bradley fighting vehicles and Detroit Diesel 6V53T engines for M113 armored personnel carriers were originally designed and developed for commercial vehicles and subsequently adapted for military applications.

DEFENSE UNIQUE

The defense unique technologies are those products and know-how which were designed and developed exclusively for defense application. The technologies in this category either derived from commercial technologies and products that were significantly modified for defense applications or may require altogether special design, material, manufacturing process, tooling and test equipment or even a special facility. For example, design and manufacturing processes for the Abrams hull/turret slip ring or gun mounts for other ground systems can be categorized as defense unique since slip rings for Abrams and gun mounts for other ground systems were specifically designed, and manufacturing processes developed, for those applications.

PROPRIETARY

The proprietary technologies are those technologies developed by the manufacturers for a specific application. The design or manufacturing processes can be either funded by the government or by the manufacturers. The evaluation is performed for those proprietary technologies that are used for defense applications. The proprietary technologies may be in the areas of material, design, manufacturing process, or integration and test. For example, the special welding process of hull and turret structure for the Abrams tank is considered a proprietary manufacturing process.

SENSITIVE

The sensitive technologies consist of those products and know-how that provide performance superiority and subsequent military technological advantage and are not available elsewhere. In order to maintain military superiority and to prevent identification of system limitations, for national security reasons, these technologies must be protected against potential proliferation and therefore must be controlled for export. For example, second generation infrared thermal sights with long wavelength (i.e., 5 to 11 microns) mercury cadmium telluride detectors used in our main battle tanks and armored personnel carriers are superior in terms of detector sensitivity, range, and image resolution compared to other detector materials. The technologies associated with the design, manufacturing process, and integration and test of these thermal sights are considered sensitive.

TECHNOLOGY EVALUATION CRITERIA AND METRICS

For each element of the WBS and for each functional area (including material technology, design methodology, manufacturing process, integration, and test), associated technologies need to be analyzed, whether the technology is dual use, defense unique, or proprietary. Further analysis needs to be performed to identify which technologies are sensitive for national security reasons. The criteria for evaluating sensitive technologies are:

- whether the technology is proprietary for defense applications,
- whether the technology or the technical data package is government owned,
- whether material characteristics, design, or process parameters exceed the commercially available material, design, or process parameters,
- whether the material, design, or process with similar performance characteristics is available in foreign countries,
- whether the material technology, design, or process can be reverse engineered, and
- whether the recipient country poses a national security risk.

The details of the technology evaluation process for each functional area are presented in Figures 2, 3, 4, and 5. The technology evaluation process requires an integrated team effort with joint participation of system, subsystem, or components manufacturers, and representatives from the military services, DoD agencies, and DTSA. The team efforts will provide consistent and jointly agreed DoD positions with regard to export of technical data, hardware, or software.

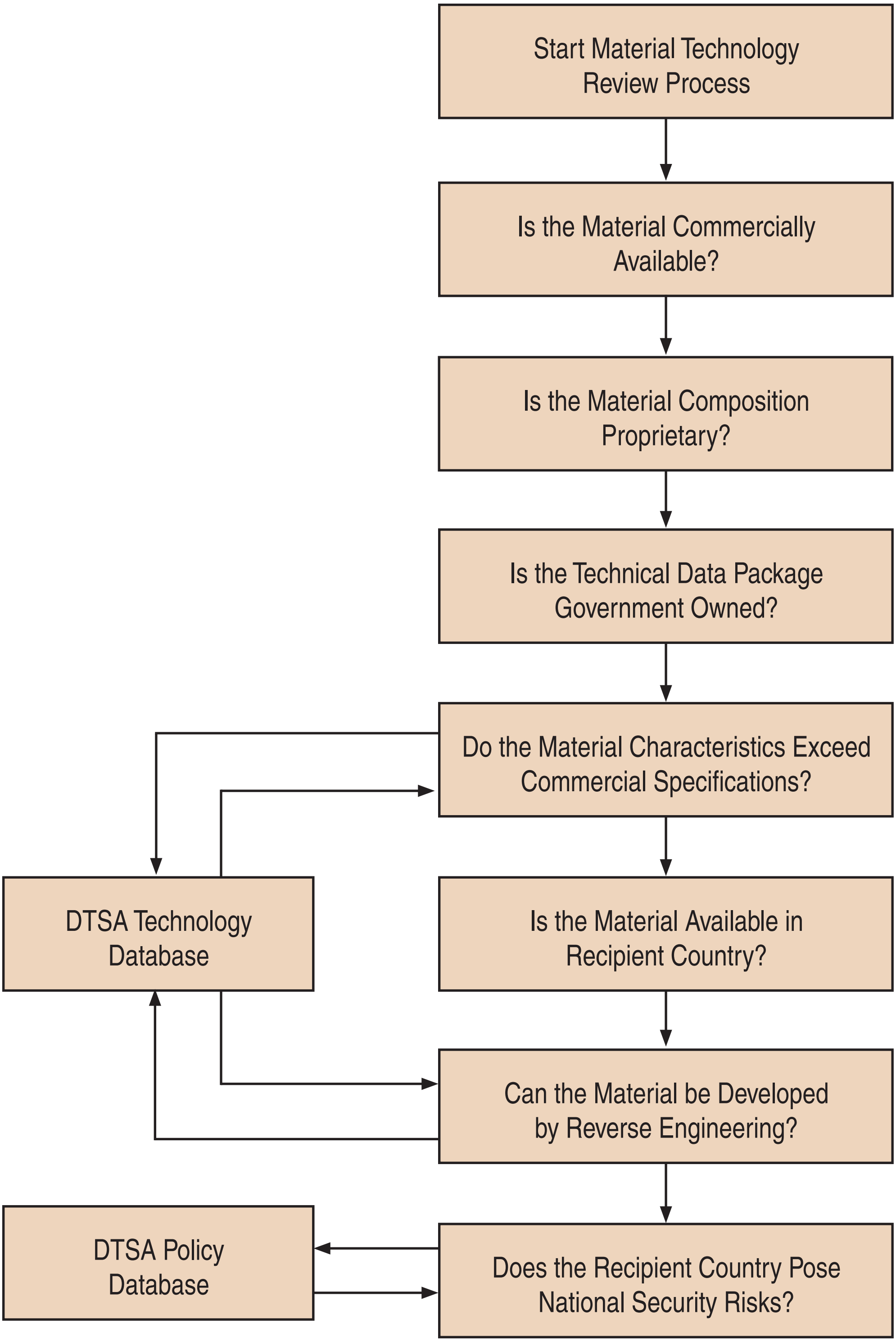


FIGURE 2. MATERIAL TECHNOLOGY REVIEW PROCESS

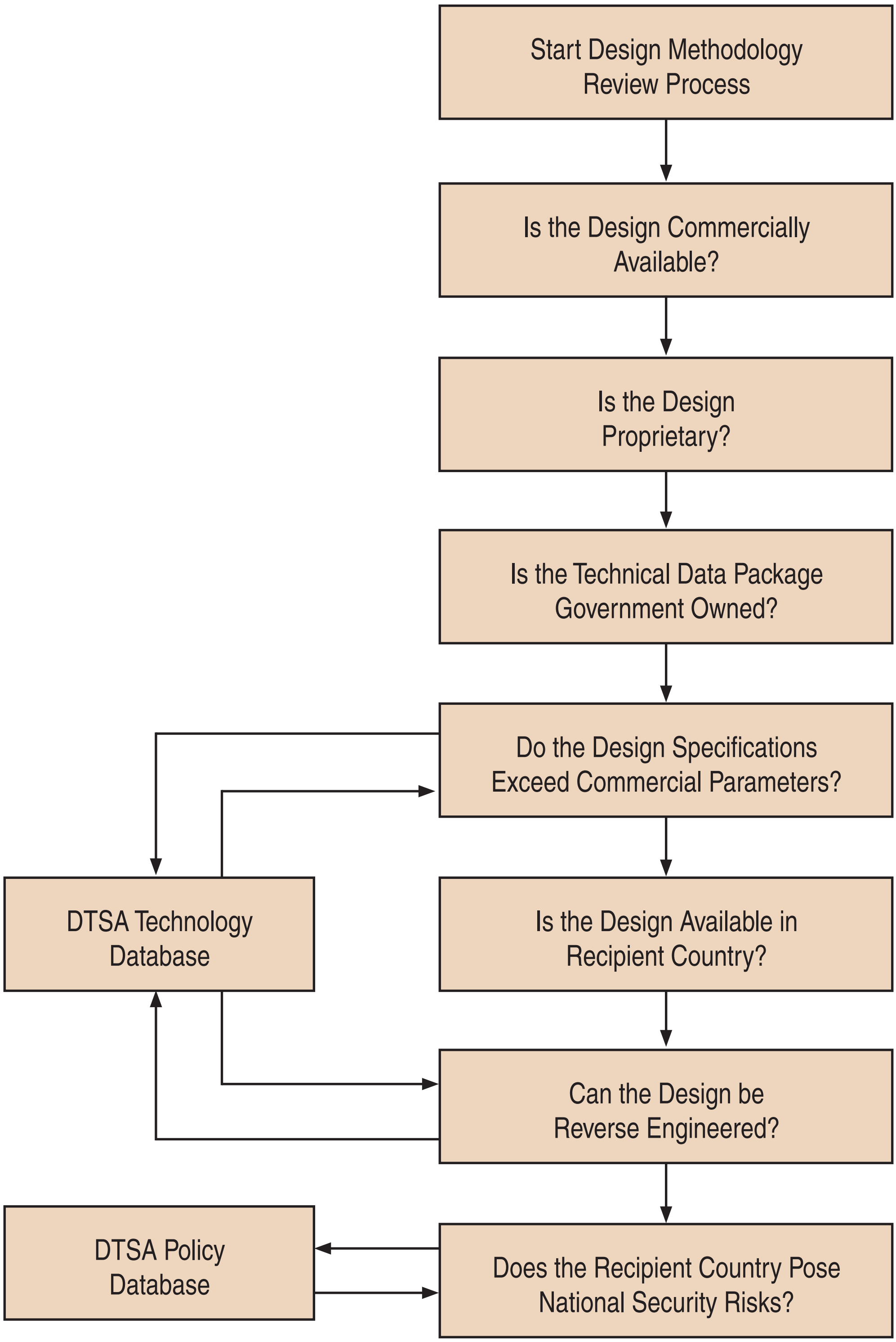


FIGURE 3. DESIGN METHODOLOGY REVIEW PROCESS

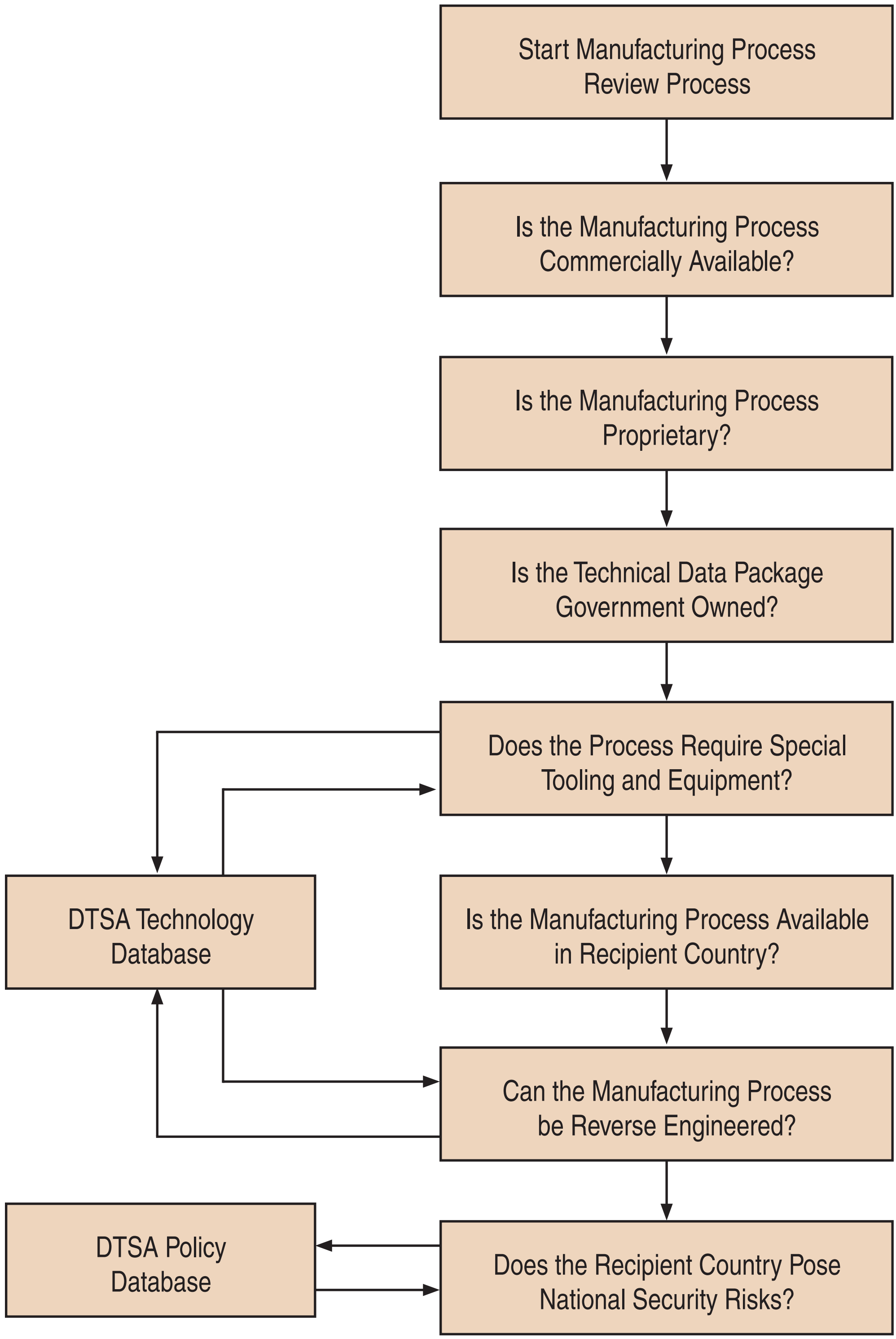


FIGURE 4. MANUFACTURING PROCESS REVIEW PROCESS

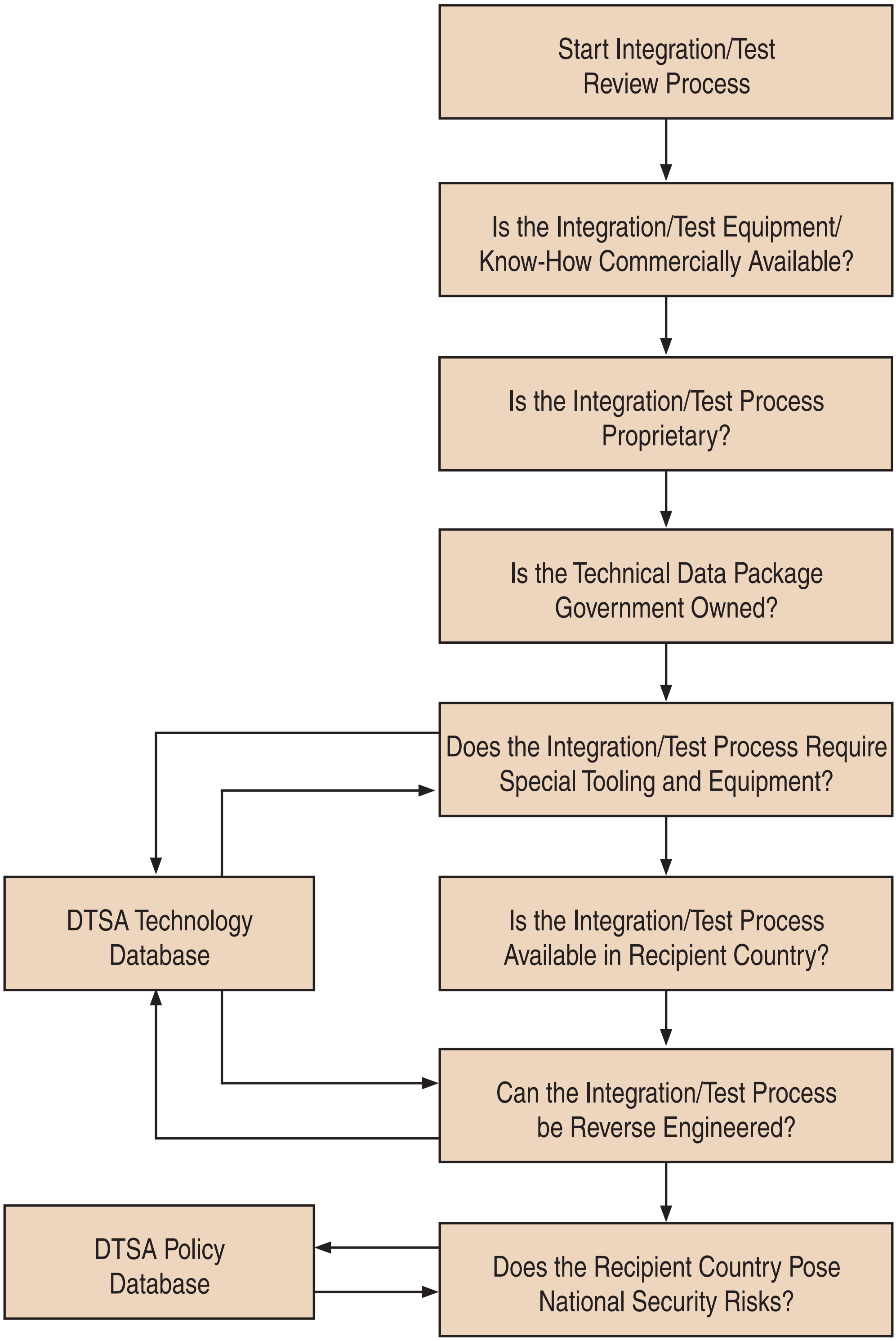


FIGURE 5. INTEGRATION/TEST REVIEW PROCESS

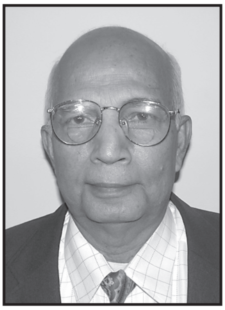
Company: ABC									
				Technology Assessment					
System: XYZ				Dual Use,Defense Unique, Proprietary, Sensitive	Material	Design	Mfg. Process	Integration/ Test	Remarks
	Vehicle								
		Structure							
			Armor						
			Steel	Dual use	X	X	X	X	Military technology adapted for commercial application.
			Aluminum	Defense unique/sensitive	X	X	X		Must be controlled.
			Composite	Defense unique/sensitive	X	X	X		Must be controlled.
		Suspension							
			Torsion Bar	Proprietary/sensitive			X		Must be controlled.
			Road Arms	Defense unique		X			Commercial technology adapted for Military application.
			Road Wheels	Defense unique		X			Commercial technology adapted for Military application.
			Shock Absorbers	Dual use		X			Commercial technology adapted for Military application.
		Engine							
			Crank Assembly	Dual use		X			Commercial technology adapted for Military application.
			Cylinder Head Assembly	Dual use		X			Commercial technology adapted for Military application.
			Fuel Injection System	Dual use		X			Commercial technology adapted for Military application.
		Drive Train							
			Transmission	Dual use		X			Commercial technology adapted for Military application.
			Final Drive	Defense unique		X			Commercial technology adapted for Military application.
			Sprockets	Dual use		X			Commercial technology adapted for Military application.
			Tracks	Dual use		X			Commercial technology adapted for Military application.
		Fire Control							
			Sighting Devices	Defense unique/sensitive		X	X	X	Must be controlled.
			Laser Range Finder	Defense unique/sensitive		X		X	Must be controlled.
			Digital Computers	Dual use		X			Commercial technology adapted for Military application.
			Software	Proprietary/sensitive		X			Source code must be controlled.
		Armaments							
			Machine Gun	Defense unique/sensitive		X			Must be controlled.
			Cannon	Proprietary/sensitive		X	X		Must be controlled.
			Gun Mount	Defense unique/sensitive		X			Must be controlled.
			Missiles	Defense unique/sensitive		X	X	X	Must be controlled.

FIGURE 6. TOP-LEVEL GENERIC GROUND SYSTEM TECHNOLOGY MATRIX

The results of the technology evaluation process will be documented as technology metrics in a spreadsheet format (matrix). An example of a top-level generic ground system technology matrix is shown in Figure 6. As can be seen, completion of the technology matrix allows easy assessment of the controlled technology and assists in the definition of specific technical conditions or provisos that become part of the issued license. The license provisos allow the applicant to receive a license for the requested export as long as specific critical technology conditions are incorporated, conditions that prevent transfer of technology that provide our military superiority such as stealth technology or prevent the release technology limitations. The final license recommendation and the provisos employed on each license can also be affected by the recipient country (level of technology that can be exported), the type of end user within the country (government or contractor), the recipient country's ability to protect U.S. technology through their own export control laws and history of technology transfer, and the U.S. national disclosure policies. The final license recommendation allows U.S. technology export while at the same time protecting the U.S. sensitive technologies for potential proliferation. Licensing decisions are extremely critical for our national security, our warfighters, and our allies since licensing decisions protect our technological advantages and maintain technological superiority in the battlefield.

SUMMARY

The purpose of the metric approach is to provide visibility of technologies associated with the systems, subsystems, or components included in the license applications. Metrics will assist in licensing decisions, which are extremely critical for our national security and for our warfighters and allies. Metrics will assist in export control of sensitive technologies while identifying systems, subsystems, or components with matured technologies for potential offset purposes. Once the baseline metrics are developed, the metrics need to be updated as the technologies mature and new technologies evolve and systems are upgraded over time. The development of metrics requires a joint participation of system, subsystem, or component manufacturers, representatives from military services, DoD agencies, and DTSA. The manufacturers play the key role in WBS development and in identifying technologies associated with each WBS element and for each functional area. Defense industries, DoD Program Managers, technical reviewers, and Licensing Analysts can use the metrics database for safeguarding sensitive technologies from export and prevent potential proliferation. The proposed metrics approach for technical evaluation of export license applications has three major advantages: (1) metrics provide baseline technology status and identify sensitive technologies in a summary format, (2) metrics assist in significantly minimizing export license application processing time, and (3) metrics provide consistent and jointly agreed DoD and industry positions with regard to export of technical data, hardware, or software. This approach as a technical review process has potential for application for other sectors of our defense hardware (aircraft, missile, and space systems) and for various phases of the system acquisition process.



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