

MIT Open Access Articles

The Global Impact of ITAR on the For-Profit and Non-Profit Space Communities

The MIT Faculty has made this article openly available. **Please share** how this access benefits you. Your story matters.

Citation: Dwyer, Morgan, Gwen Gettliffe, Whitney Lohmeyer, Annie Marinan, Erik Stockham, Annalisa Weigel, and Kerri Cahoy "The Global Impact of ITAR on the For-Profit and Non-Profit Space Communities." 25th Symposium on Space Policy, Regulations and Economics, IAC-12. International Astronautical Federation, 2012.

As Published: <http://www.iafastro.net/iac/paper/id/14466/summary/>

Publisher: International Astronautical Federation

Persistent URL: <http://hdl.handle.net/1721.1/80837>

Version: Author's final manuscript: final author's manuscript post peer review, without publisher's formatting or copy editing

Terms of use: Creative Commons Attribution-Noncommercial-Share Alike 3.0



The Global Impact of ITAR on the For-Profit and Non-Profit Space Communities

Morgan Dwyer, Gwen Gettliffe, Whitney Lohmeyer, Annie Marinan, Erik Stockham, Annalisa Weigel, Kerri Cahoy
May 10th, 2012

1. Introduction

Under the United States Arms Export Control Act, the International Traffic in Arms Regulations (ITAR) control the export of technologies that are specified as defense articles on the United States Munitions List (USML). The Directorate of Defense Trade Controls (DDTC) within the Department of State (DoS) interprets and enforces these regulations in an effort to safeguard national security by denying advanced military technology to potential competitors.

ITAR is a far-reaching set of regulations that encompasses most areas of technology that have potential military value. To prevent unauthorized export of technology, ITAR requires that whenever a defense article or technical data on a defense article is exported, a license must be obtained from the DDTC. ITAR defines “export” to include the entire spectrum of technical activities, from design, development, and production to operation, repair, and maintenance [1]. Currently, all spacecraft are classified as defense items on the USML; therefore, disclosing or transferring technical information, assistance, or hardware during any phase of a spacecraft’s lifecycle requires a license.

Export control attempts to maintain technical advantage by sheltering defense-critical technologies. However, effective export control policies must not only limit technologies’ dissemination into the international marketplace but also consider how control-induced marketplace distortions hinder the domestic innovation that is necessary to maintain technical advantage in the international market. In recent years, officials from both the for-profit and the non-profit space communities have reported that the USML’s broad classification of spacecraft as munitions has significantly and unnecessarily limited research and commercial activities; the undesirable consequences have motivated both communities to issue calls for export control reform.

This paper identifies the difficulties that have been faced by each community and provides suggestions for future policy changes. We introduce our discussion by first presenting the history of export control in the post-Cold War era. Next, we define the policy’s main stakeholders and provide a focused discussion of the for-profit and non-profit space communities’ interests in reform. Finally, we define and analyze a trade space of export control regimes and make policy suggestions that will enable ITAR to become more effectively aligned with its stakeholders’ interests.

2. Historic Export Control Regimes & Attempts at Reform

Many reform advocates suggest that spacecraft were more effectively controlled in the past and recommend that current export control regulations be reformed to reflect the positive aspects of past forms of control. In light of these recommendations, we propose that understanding the evolution of export control policy is critical to identifying and evaluating options for reform. Furthermore, a review of export control history contextualizes the regulations within their larger geo-political and national security environment and motivates our subsequent suggestions and evaluation of opportunities for reform. In this section, we review the major epochs of spacecraft-related export control and discuss the political and national security motivations associated with the various epoch shifts.

With respect to spacecraft, export control can be characterized by three distinct epochs: 1976 to 1992, 1992 to 1999, and 1999 to the present day. The differentiating factor between these epochs is the Department responsible for monitoring or controlling the export of spacecraft: this responsibility has shifted from the Department of State (DoS) to the Department of Commerce (DoC) and back again. The main responsibility of the DoS in export control policy is to protect sensitive U.S. technology from acquisition by foreign countries, whereas the primary task of the DoC is to internationally promote U.S. business interests [2].

In this section, we discuss each epoch of export control and focus on the historic events that motivated epoch shifts and the degree to which each Department controlled and limited the export of spacecraft. A pictorial representation of the history discussed in this section is provided in Figure 1.

2.1 Export Control Epoch 1 (1976-1992)

ITAR was initiated by the 1976 Arms Export Control Act and implemented by the 1979 Export Administration Act. The Arms Export Control Act states that the DoS will regulate the export of defense articles through ITAR. As in today's regime, in this Cold War epoch, spacecraft were classified as munitions and their export was tightly controlled by the DoS.

In 1984, President Reagan relaxed the DoS's control by granting American companies license to export communications satellites (COMSATS) to France for launch on European rockets [3]. Regan further relaxed the control of COMSATS when he signed an agreement with China that allowed U.S. companies to launch COMSATS on Chinese vehicles [3, 4]. Presidential support for reduced export control of commercial satellites continued in the Bush administration: in 1990, President Bush ordered dual-use items to be removed from the USML, unless their technology or hardware threatened national security [4]. The DoC defines dual-use items as those which can be used for peaceful scientific and technological purposes and which can also potentially serve as defense articles; all dual-use items require a license for export under the Export Administration Regulation (EAR) [5].

In response to Bush's request, the DoS and DoC evaluated their policies and concluded that a subset of COMSAT technologies was better monitored under the DoC. Therefore, in 1992, Congress transferred those items from the DoS's USML to the DoC's broadly-applicable Commerce Control List (CCL) [3, 4]. While the CCL controls a wide variety of technology, the

EAR requires less effort to legally export a dual-use item and does not impose the severe liability that exists under ITAR. (Shortly thereafter, in Epoch 2, DoS transferred all remaining COMSAT components to DoC control when President Clinton requested this action in 1996.)

2.2 Export Control Epoch 2 (1992-1999)

The second epoch begins with George H.W. Bush's request to transfer some COMSAT components to the DoC's jurisdiction, includes the full transfer of COMSATS to the DoC in 1996, and concludes with the decision to return all spacecraft to the USML under the DoS's control. Two major events during this period motivated the shift from the DoC to the DoS: in 1995 and 1996, two major U.S. satellite providers, Hughes and Space Systems Loral, were charged with ITAR violations when they provided technical assistance to the Chinese government. Specifically, the companies collaborated with the Chinese government during an investigation of Long March rockets that failed to deliver Hughes' and Loral's payloads to orbit. Although both Hughes and Loral obtained DoC approval for their activities, only COMSATS, not launch vehicles, were under the DoC's jurisdiction, so the Congressional Cox Committee determined that the launch failure investigation was a violation of ITAR. As a result of this decision, both companies were heavily fined. Congress took action to tighten export controls on spacecraft technology, and the 1999 Strom Thurmond National Defense Authorization Act returned COMSATS to the USML [2, 3, 4, 6].

2.3 Export Control Epoch 3 (1999-)

Since 1999, all spacecraft have remained classified as munitions and are controlled by the DoS DDTC. This broad classification of spacecraft as munitions has significantly impacted both the for-profit and the non-profit space sectors. While a detailed account of these impacts is presented in Sections 4 and 5, an overview of the recent, most impactful reforms is provided here.

The non-profit space community was significantly impacted by the 1999 Department of Defense Authorization Bill. Spacecraft-related research activity previously subject to the fundamental research exclusion under National Security Directive 189 became subject to ITAR's strict export controls. This reform negatively impacted many actors within the non-profit space sector from national research labs to NASA to academic research facilities. The fundamental research exemption still existed, but it became much more difficult to reconcile with research projects [7]. In 2004, the Department of Commerce Inspector General made a series of recommendations regarding the regulation of dual-use items which put further restrictions on access to those items by foreign nationals. A consortium of provosts from twelve universities, led by MIT, sent a letter to the DoC expressing the negative impacts of these regulations and voicing the academic community's serious concerns with the increased controls [8]. Defining and protecting the fundamental research exemption in ITAR continues to be of major concern to many non-profit space actors today.

The for-profit space community was significantly impacted by the Strom Thurmond National Defense Authorization Act's return of COMSATS to the USML. Since this re-classification, industry advocacy groups continue to lobby law-makers to return COMSATS to DoC control. Two of the most recent attempts at reform are the H.R. 2410 *The Foreign Relations Authorization Act* and H.R. 3288 *Safeguarding United States Satellite Leadership and Security Act*. H.R. 2410 would have transferred the authority to remove satellites and related components from the USML to the President [9]; this bill passed the House but not the Senate [10]. H.R.

3288 is similar, but applies to commercial satellites only [11]; this bill was referred to the House Foreign Relations Committee in November 2011 and currently awaits action [10].

Although the space communities' recent attempts at reform have yet to impact ITAR's application to spacecraft, in 2010, the Obama Administration announced a plan to modernize the export control regime by replacing its convoluted, multiple-agency structure with a single control list, enforcing agency, information technology system, and licensing agency. Additionally, in the National Defense Authorization Act of 2010, Congress requested that the DoD and DoS undertake a formal assessment of the risks associated with removing certain space-related components from the USML [12]. These actions indicate that both Congress and the executive branch recognize and the need for export control reform and suggest that the current political environment may be particularly favorable to near-future attempts to reform.

2.3 Historical Synthesis

Throughout the space age, the control of spacecraft exports has oscillated between epochs of high control under the DoS to epochs of reduced control under the DoC. Epoch shifts were induced when these extreme forms of export control negatively impacted the interests of the national security or the space community. Specifically, under the DoC regulation, U.S. security interests were compromised and under DoS regulation, the space community's activities continue to be unnecessarily hindered.

Export control policy has also been affected by two major trends that distinguish the Cold War competitive environment from the present day. First, the national security environment has changed from a bipolar strategic balance environment to a multipolar world. In the early Cold War era, national space programs were tightly coupled with military capability and the strategic balance because they translated directly to strategic weapon delivery, missile warning, and reconnaissance. Maintaining technology parity eventually cost the Soviets more than they could afford. In the modern era, the national security space sector is only a part of the space technology market and national security is threatened by a wide range of actors but not by a peer competitor. Second, the commercial sector has expanded to the present state where space services are integrated into the daily lives of both the developed and, increasingly, the developing world. Other nations can produce capabilities in space that far exceed some of those the US was trying to protect with late Cold War technology restrictions. During the Cold War, space technology itself was a weapon and needed to be protected from Soviet espionage and countermeasures; now space technology is more often capable of dual-use for both commercial and military purposes.

This historical experience suggests the need for a more nuanced approach to export control that exists between these historical extremes and is capable of balancing both national security and space community needs in the context of the evolving global security environment and commercial market.

In the next section, we provide a general overview of the stakeholders that are interested in and impacted by future attempts at ITAR reform and identify metrics to represent stakeholder values that reflect the balancing act that we illustrated through the preceding historical overview.

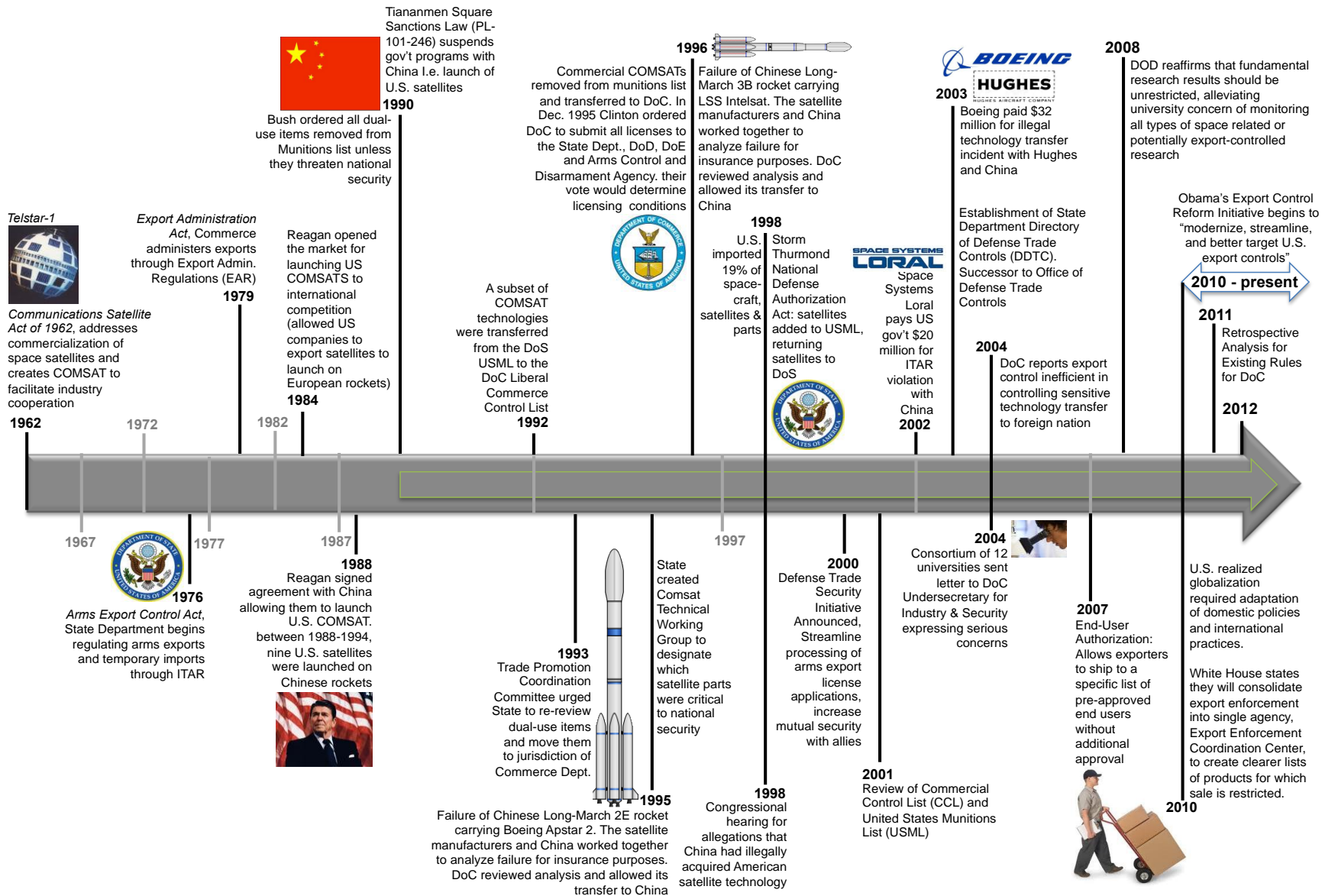


Figure 1: ITAR Timeline

3. General Stakeholder Identification and Motivation

In order to examine the interests and impact of ITAR on different stakeholders in the spacecraft research, development, manufacture, sale, and data-using markets, we define six stakeholder values and represent these values as metrics. The metrics were derived from stakeholder written opinions and their stated objectives or goals for attempted or desired reform efforts. The metrics represent observed shortfalls in stakeholder satisfaction and/or requirements for a successful export control regime that protects national security while minimizing adverse consequences. These metrics, which are used to evaluate the policy reform options presented in Section 6, are defined as follows:

Collaboration describes the extent to which employers can build a team from the entire pool of available talent, including non-Americans. In highly collaborative environments, stakeholders can hire or partner with non-American individuals or groups; this results in additional employment opportunities within the U.S. as well as increased intellectual productivity. Involvement of non-U.S. persons in a collaborative project on U.S. soil is still deemed export under the ITAR, thus the present regime restricts non-U.S. person activities within the U.S. just as strictly as shipping components to foreign soil.

Market Flexibility is the degree to which stakeholders can access a free market with open competition for complete spacecraft, subsystems, components, and launch services. In a fully open market, and produced can sell to any customer without restriction. It includes the ability to share costs on large projects between multiple international parties or countries.

Compliance Transparency represents how understandable the export regime is, both in assigning jurisdiction to either the DoS or DoC and how clear and easy-to-follow its licensing process is. Reforms that increase Compliance Transparency should produce fewer commodity jurisdiction requests. Commodity jurisdiction requests are requests made by exporters for the DoS to determine if a particular technology is subject to ITAR due to ambiguities and confusion surrounding the definition of covered technology. Compliance Transparency also reduces the tendency for exporters to overprotect technology due to an unnecessary fear of liability for accidental violations.

Licensing Efficiency measures the cost for stakeholders to acquire licenses, including fees and any lost profits due to waiting on license issuance. Reforms that increase Licensing Efficiency should reduce the amount of time it takes to acquire a license.

National Security refers to technology protection and industrial base capability. Technology protection prevents degradation of a technology-enabled U.S. military capability by unauthorized disclosure to potential adversaries. Industrial base capability has long been recognized as vital to national security; to retain human and financial capital for developing future spacecraft technology, US aerospace firms need to be competitive in the expanding global satellite market.

Policy Transformability describes how easily a policy reform suggestion can be implemented

through changes to legislation and regulation. Transformability depends heavily on the amount of policy change required for a certain reform suggestion and on whether any influential stakeholders would actively oppose it.

As defined above, each of our six metrics is positive: an ideal reform would impact stakeholders by increasing the metrics for Collaboration, Market Flexibility, Licensing Efficiency, National Security, and Policy Transformability. The stakeholders that are impacted by these measures are numerous and varied; Table 1 identifies each of these stakeholders and maps them to their primary values as represented by our six metrics.

In the subsequent sections, we focus specifically on the needs of two large groups of stakeholders, the For-Profit community and the Non-Profit community, which are of particular interest for several reasons. First, these communities represent a large fraction of the current lobbyists for export control reform; as discussed in Section 2, both for-profit and non-profit advocacy groups have actively vocalized their experiences with ITAR and their suggestions for reform. Second, together, these communities' primary values capture many of the values held by other stakeholders; thus, by focusing only on these groups, we are still able to capture other stakeholders' varying perspectives on reform. And finally, we are able to capture two of the Government Oversight Bodies' primary values by retaining the National Security and Policy Transformability metrics during our subsequent policy evaluation.

Table 1: Stakeholder Breakdown and Policy Metrics

Stakeholders	Stakeholder Description	Stakeholder Examples	Collaboration	Market Flexibility	Compliance Transparency	License Efficiency	National Security	Transformability
For-Profit Stakeholders								
US Satellite Manufacturers	US companies that build satellite platforms	Boeing, Orbital Science, Lockheed Martin, Space Systems/Loral		X	X	X		
US Satellite Operator	US companies and government agencies that provide satellite based services such as telephone and radio	Intelsat, DirecTV, XM Satellite Radio Holdings Inc.		X	X	X		
US Subcontractors	US companies that are contracted to provide products or services to satellite manufacturers	Northrop Grumman, Texas Instruments, Allied-Signal Aerospace		X	X	X		
US Launch Service Providers	US-based space launch companies or agencies with indigenous ability to launch payloads to orbit	United Launch Alliance, SpaceX, Orbital Sciences		X	X	X		
Non-US Launch Service Providers	Non-US-based space launch companies or agencies with indigenous ability to launch payloads to orbit	Arianespace, China Great Wall Industry Corp, Indian Space Research Organization, International Launch Services		X	X	X		
Non-Profit Stakeholders								
US Technical University Institutions	US higher education research institutions that engage in technical research and compete for R&D contracts that may be subject to export control	MIT, University of Michigan, University of Maryland	X		X	X		
Non-US Technical University Institutions	Non-US higher education research institutions	Indian Institutes of Technology, Cambridge University, Tokyo University	X					
Non-American Researchers/Engineers Working in US	Technically trained non-Americans who have a visa to work in US	Non-American graduate students, visiting scholars, professors	X		X			
Non-American Researchers/Engineers Trying to Find Work in US	Technically trained non-Americans attempting to find a job in/visa to work in US	Non-American undergraduate students or graduates of American universities, non-American researchers trying to find a job in US	X					
Non-American Researchers/Engineers Living Outside US	Technically trained non-Americans working at non-US institutions or companies	Non-American graduate students, professors, and employees at non-US universities and companies	X					
FFRDCs/UARCs/Other Not For-Profit Labs	US research and development not-for-profit institutions that often engage in export controlled work and contracts	MIT Lincoln Laboratory, The Aerospace Corporation, Sandia National Laboratories, Applied Physics Laboratory, Georgia Tech Research Institute, Draper Laboratory	X	X	X	X		
NASA	US civil space agency, National Aeronautics and Space Administration		X	X	X			
Government Oversight Bodies								
US DoD/Intelligence Community	U.S. Federal Department in charge of national security and the United States armed forces and other national security stakeholders						X	
US Government Oversight	American policymakers and executive departments with impact on and control over export control policy	US Congress, State Department, Department of Commerce, Executive Branch			X		X	X
Other Countries/International Agencies								
China			X					
Non-US Space Agencies		ESA, Roscosmos, CSA, JAXA	X					
Non-US Satellite Manufacturers	Non-US companies that build satellite platforms	Thales Alenia (France), EADS Astrium (France), JSC Information Satellite System	X	X				
Non-US Satellite Operator	Non-US companies and government agencies that provide satellite based services such as telephone, radio, and environmental observation	Eutelsat, SES Astra, Inmarsat, etc.	X	X				
Non-US Subcontractors	Non-US companies that are contracted to provide products or services to satellite manufacturers	Clyde Space (Scotland), TNO (Netherlands), e2v (UK)	X	X				
Other								
US Taxpayers	American taxpayers whose taxes fund federal programs and agencies					X	X	
Customers/Data Users	Entities that pay for or use tangible benefits derived from satellite system	Weather prediction services, Researchers, GPS users, communication service subscribers	X		X			

4. For-Profit Stakeholder Analysis

The impact of ITAR on the For-Profit Stakeholder community, which primarily consists of major systems integrators and their subcontractors, has been well-documented by independent advocacy groups, industry-wide associations, and U.S. government agencies [13, 14, 15, 16, 17, 18]. These reports generally agree that the For-Profit Stakeholder's loss of global market-share is the most significant deleterious impact that ITAR has had on the For-Profit Stakeholder. The U.S. Air Force and Commerce Department's *Defense Industrial Base Assessment* reports that prior to ITAR's 1998 implementation, U.S. space manufacturers claimed 63% of the global market-share; after 2002, U.S. manufacturers have only been able to capture 42% of the global space market [13]. Similarly, in the GEO COMSAT sector, where the U.S. has traditionally been the dominant manufacturer, the U.S. claim on the global market-share decreased from over 70% in 1995 to less than 30% ten years later; this effect is demonstrated in Figure 2 below [14, 19]. The revenue generated by the commercial satellite industry has been similarly affected.

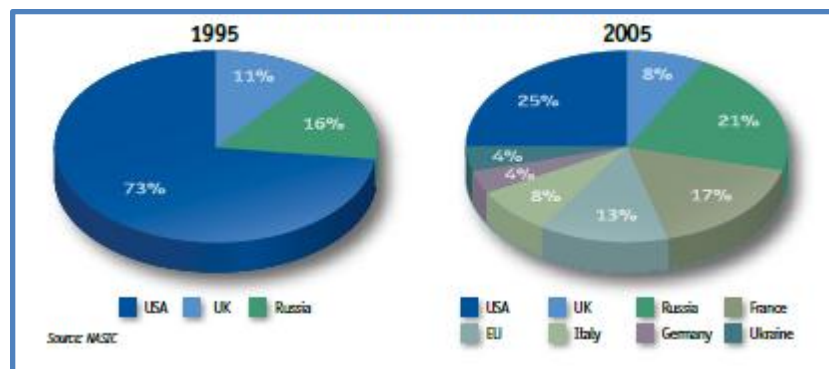


Figure 2: Worldwide Share of Satellite Exports [14, 17]

We characterize the For-Profit Stakeholder's loss of global market share as a *symptom* of ITAR's negative effect on the stakeholder community and suggest it can be ameliorated by specifically addressing the symptom's *root causes*. In the subsequent subsections, we present these root causes and map them to the reform evaluation metrics that were presented in Section 3.

4.1. Relationship with International Competitors

One of the root causes of the For-Profit Stakeholder's loss of global market share is the inability of the For-Profit Stakeholder to effectively compete with increasingly capable international firms. Although the intent of ITAR is to protect U.S. technological advantage for national security, the Institute for Defense Analysis reports that ITAR's implementation coincided with a surge in European commercial space activity and technical evolution [15]. Importantly, some of this evolution was motivated by the constraints imposed by ITAR; for example, ESA has sponsored several technology development projects with the intent of eliminating European reliance on ITAR-regulated goods [13]. Many European manufacturers have also begun advertising satellites that are "ITAR-free" and can attractively spare their customers from the headaches of U.S. export control.

As a result of this surge in European commercial space activity, the technical capabilities of international firms have evolved and the U.S.'s technical advantage has eroded. By applying a

blanket regulation to all satellite technologies, ITAR continues to control U.S. technologies even when an equivalent capability exists in the international marketplace. In these cases, when international customers can obtain equivalent, unregulated goods from non-U.S. manufacturers, ITAR often deters prospective customers from purchasing U.S. products. In order to address this specific condition, the For-Profit Stakeholder values future attempts at reform that increase their Market Flexibility. The negative impact on National Security can be minimized if restrictions are lifted solely on technology that is already within the capability of foreign developers. Specifically, reforms should recognize the capabilities of international firms and in that context, should strive to increase the For-Profit Stakeholder's ability to effectively participate in the increasingly competitive global marketplace.

4.2 ITAR's Impact on Competitive Bidding

Another root cause of the For-Profit Stakeholder's loss of global market share is ITAR's adverse impact on traditional commercial bidding processes. One particular challenge is the extent to which Technical Assistance Agreements (TAA) constrain competitive activities: in order to initiate any technical communication, including exchanges for marketing, bidding, or proposal purposes, U.S. companies must obtain a TAA from the DoS. This requirement is particularly challenging in the commercial satellite industry, where contract initiation activities have shortened timelines that often cannot accommodate the DoS' processing time [14]. According to a report by the Space Foundation, U.S. companies attribute this TAA requirement to their inability to effectively respond to proposal requests in foreign markets [14].

Even when U.S. companies are able to compete for foreign contracts, ITAR's TAA requirement often makes U.S. technology appear unattractive in comparison to less-regulated components from other countries. For example, foreign companies are often discouraged from purchasing U.S. technologies because any subsequent interactions with U.S. manufacturers (such as requests for additional information or assistance with repairs) require additional licenses [17]. Additionally, delays in acquiring export license approval (both for initial purchase and for subsequent interactions) have led international customers to cancel orders with U.S. firms and to seek technologies elsewhere [19]. In order to address these conditions, future attempts at reform should increase the current export control regime's Cost Efficiency and Market Flexibility. Specifically, the For-Profit Stakeholder is interested in reforms that increase their ability to effectively participate in traditional commercial bidding processes and in reforms that improve the desirability of their products by reducing unnecessary and undesirable compliance measures.

4.3 ITAR's Impact on the Cost of Compliance

A final root cause of the For-Profit Stakeholder's loss of global market share is the cost of complying with the current export control regime. ITAR places the burden of compliance on the exporter and thus levies a cost of compliance that reduces domestic companies' profits and limits their ability to compete for a share of the global market. Specifically, the Center for Strategic and International Studies reports that compliance costs U.S. companies approximately \$50 million per year [19]; these funds are typically spent on hiring export control compliance officers, consulting external legal counsel, and training employees on compliance practices. In many cases, smaller firms that are unable to afford compliance costs are displaced from international competition or from the industry altogether [13, 16]. In order to address these conditions, future attempts at reform should increase the current export control regime's Compliance Transparency and Cost Efficiency. Specifically, the For-Profit Stakeholder is interested in reforms that will

reduce the amount of financial and human resources that they must invest in order to insure compliance.

5. Non-Profit Stakeholder Analysis

Agencies or institutions including universities, federally funded research labs, and governmental acquisition and operations agencies define their mission in terms other than profit and shareholder value, but they are still subject to export control restrictions that limit their communication, collaborations, and workforce. In this section, we focus on the university sector of the Non-Profit stakeholder group; this is a small but vital part of the space community that faces unique challenges under ITAR. Universities are just as dependent on the award of contracted work as are commercial entities, and they often face the additional challenge of meeting their commitment to providing equal education opportunities for all of their students while engaging in projects that require them to interface with vendors of ITAR-restricted products. The fundamental research exemption alleviates some of these challenges, yet its ambiguity and conditional nature pose difficulties to universities.

In this section, we discuss the impact of ITAR on the university research community in terms of the previously defined stakeholder areas of interest, focusing on Compliance Transparency, Cost Efficiency, and Collaboration. We identify trends and present specific examples to illustrate impacts the ITAR has had on universities and by extension their students and faculty and the organizations with which they collaborate.

5.1 Ambiguity in Exemptions - Compliance Transparency

Universities face many of the same challenges with ITAR compliance as any other stakeholder, but their unique focus on fundamental research and commitment to unrestricted research and access by foreign nationals causes the university stakeholders to focus on Compliance Transparency as a primary desired value. Much of ITAR is vaguely written and is at times self-contradicting, and unlike many commercial ventures, university communities do not have the infrastructure in place to constantly support ITAR compliance efforts with specialized staff or contracted legal services. As a result, many universities encounter difficulties when it comes to Compliance Transparency within ITAR, particularly when it comes to the applicability of the fundamental research exemption.

ITAR defines fundamental research as “basic and applied research in science and engineering where the resulting information is ordinarily published and shared broadly within the scientific community as distinguished from research the results of which are restricted for proprietary reasons or specific U.S. Government access and dissemination controls.” There are two cases in which university research is not considered fundamental:

- (i) The University or its researchers accept other restrictions on publication of scientific and technical information resulting from the project or activity, or
- (ii) The research is funded by the U.S. Government and specific access and dissemination controls protecting information resulting from the research are applicable [20].

The distinction between cases that can be defined as fundamental research and those that cannot

can be ambiguous, particularly with collaborations between universities and other entities. Organizations with internal proprietary restrictions and export regulations have to reconcile any internal intellectual property regulations with the “fundamental research” requirement of putting all information in the public domain. Any foreign student involvement may also negate the exemption of fundamental research and require ITAR licensing even if the project is within the public domain [7]. Software, physical goods, and work done without the intent to publish all do not count as fundamental research. License applications are handled on a case-by-case basis, so even in organizations with a history of collaborations it can be difficult to confidently determine the applicability of ITAR licensing to any one project.

Regardless of its ambiguity, the language of the fundamental research exemption as created under President Ronald Reagan in 1985 [21] is the one major protection that university research has for open publication and education. Over the thirteen years since the 1999 addition of satellites to the USML, the American Association of Universities (AAU), a coalition of 61 research universities, has written numerous letters to policymakers requesting clarification and reaffirmation of commitment to the fundamental research exemption as various clauses and recommendations in Department of Commerce and Department of State publications appear to threaten that exemption. For example, in response to the 2004 recommendations by the Department of Commerce, twenty-two research university presidents expressed concern over the “proposed narrowing of the definition of ‘fundamental research’ and widening of the definition of ‘deemed exports’ when foreign nationals engage in certain research or study” in documentation and reviews by multiple Department Inspector Generals [22]

The need for a smoother, more understandable compliance process from the DoD has been acknowledged from many sides. The DoD depends on universities to do a great amount of research and development work. The Under Secretary of Defense for Acquisition, Technology and Logistics, John J. Young Jr., released a noteworthy memo in 2008 that urged DoD program managers to take on some of the burden of identification by writing solicitations that make the inclusion (or not) of restricted work clear and by “regularly monitoring the performance of contracts and grants for fundamental research so that appropriate action may be taken if the character of the research changes” [23]. Given how crucial this fundamental research exemption is for many projects and for the sustainment of research universities, Compliance Transparency is the driving metric for this stakeholder.

5.2 Licensing Efficiency

In the cases when the fundamental research exemption does not hold, universities must apply for and receive export licenses for all technology that falls under ITAR (i.e. all spacecraft and associated technology and information). Increased Licensing Efficiency is highly desired by the university stakeholders to save time and costs in what is already a complex regulatory environment.

Collaboration between industry and universities is a common occurrence, and establishing ITAR control measures can have a significant impact on the scheduling and budget of these projects. Licensing Efficiency has an economic effect resulting from both the cost of compliance and the potential loss of projects due to conflicting policies on accepting controlled information. For university research communities, there is a further, subtler educational cost attributed to the need for licensing any projects that involve satellite technologies contained on the USML.

The licensing process is an involved, daunting task, especially for universities and organizations that are not accustomed to working with ITAR. The multiple-step license acquisition process can potentially take up to six months, and mistakes and complications in the application would only extend that process. On top of that, working with external collaborators may require Technical Assistance Agreements, Manufacturing License Agreements, and Distribution Agreements, adding an additional two months to the process [24]. Existing workshops from the Department of State and Defense are geared more toward industry, because commercial companies tend to submit more license requests, so universities must spend time and money to train staff in the ITAR regulation process or bring in outside experts. Fortunately, major research universities have deemed their own participation in space research worth the additional cost and hassle of complying with ITAR and obtaining licenses, but the process is not an efficient use of resources. The Office of Management and Budget restricts the amount of money that the federal government can reimburse universities for compliance costs, and these costs are the fastest-increasing expenditure in research areas [25].

Because ITAR's purpose is to protect national security, there are strict penalties for violations. Criminal sanctions yield a fine of up to \$1,000,000 per violation, and civil sanctions yield a fine of up to \$500,000 per violation. In addition to the fine, the guilty party may face either of or both the denial of export privileges and a seizure or forfeiture of goods [20]. The ambiguity and uncertainty of ITAR applicability coupled with the consequences of not adhering to proper policy frequently lead organizations to be overly cautious and implement restrictions that they may not have needed in the first place. There is an inherent trade-off between the time it would take to determine if a project is actually ITAR-controlled and the restrictions that would come with the license. Universities often work on compressed timescales as compared with commercial entities (because research grants are often calendar-driven instead of project schedule-driven) and are thus more likely to err on the side of caution.

Academics face the threat of very serious personal liability for ITAR violations that is inconsistent with the educational mission of open inquiry, research, and teaching. The fear of violating ITAR drives professors in the aerospace field to limit the scope of their lectures to avoid accidentally disseminating any controlled information to foreign students [26]. Professors sometimes limit their interactions with foreign graduate students, and are restricted outside of the classroom on the information they can present at conferences or discuss with outside parties. This has a significant impact on the advancement of U.S. space technology and ultimately hurts the capabilities of the research universities [27].

There are a few different ways in which universities choose to deal with ITAR compliance. Many leading research universities like MIT and the University of Maryland have published commitments to maintain a policy to keep research open and available to all. Universities like these that make a commitment to "openness of research" may acquire licenses to do otherwise restricted work, but they may not have facilities and information on campus that restrict access based on nationality [28]. Other universities accept projects with ITAR restrictions into specific ITAR-controlled laboratories; for example, the University of Michigan has some facilities that are U.S. citizen access-only [29, 30]. These ITAR-controlled universities can accept restricted work that universities like MIT and UMD cannot. A change in

the ITAR may positively benefit the work that universities like MIT and UMD can accept, but universities that have invested in restricted facilities and built their programs around such contracts stand to lose much of their work if more universities are able to compete for the projects.

Broniatowski et al. explored how many contracts schools like MIT and the University of California at Berkeley turn down due to clauses restricting publication or researcher nationalities: Due to such clauses, MIT has turned down more than three million dollars in research contracts within the past two years. The University of California at Berkeley similarly rejected half a million dollars from the Army Corps of Engineers rather than submit to foreign national restrictions. However, Broniatowski notes, both MIT and UC-Berkeley spend well over four hundred million dollars each year on research, meaning the rejected contracts are less than one percent of their total research budgets [31].

However, this conclusion is somewhat deceptive, since the majority of those declined research contracts are in engineering or computer science fields, most of them specific to technology with defense applications, meaning that departments like aerospace engineering end up with a disproportionately large amount of turned down contracts compared to their total departmental research budget. The number also does not account for contracts that were never applied for in the first place. Based on these data and individual testimonies about difficulties that universities all over the country are facing as a result of ITAR compliance, License Efficiency is another main area of concern for research universities.

5.3 Collaboration

Perhaps the most obvious and intentional consequence of the export control regulations as written is the inability of U.S. entities to interface with non-U.S. citizens on many technical projects, especially in the field of aerospace. Though there exists some precedent for exceptions being made for foreign-U.S. dual citizens with minimum-security clearances in their other countries, in general a U.S. entity cannot transfer technical data about spacecraft technology development to a foreign national without a license to export. Thus, when universities assemble research teams by hiring employees with relevant experience and skills or by forming collaborative agreements with other research institutions or agencies, they are limited in their choices of candidates. Teams with diverse backgrounds that come from varied schools of thought enhance creativity in research, so the restriction on foreign collaborators ultimately hurts U.S. research opportunities. As a result of the effects of ITAR, there are far fewer non-U.S. undergraduate and graduate students in aerospace programs than in other areas of study in the U.S., either because of limitations on their access to projects within the school or because they realize how difficult it is for non-Americans to find a job in aerospace upon graduating. [28]

As a result of trying to hire the best academicians in their fields, universities often have a large number of non-U.S. faculty members. In aerospace departments, hiring practices may be affected by the school's stance on ITAR-restricted research. In the case of sudden policy changes, professors can be evicted from their own projects. Professor Thomas Zurbuchen at the University of Michigan had such an experience in 1999 (when satellite technologies were placed on the USML) when he, at the time a Swiss citizen, was isolated from the MESSENGER spacecraft's Fast Imaging Plasma Spectrometer (FIPS) instrument project that he headed. He was able to rejoin the project once he obtained his green card, but it was the first incident in a

path that lead his lab to be a US-only environment with locked doors and computers to ensure ITAR compliance [29, 30].

As previously mentioned, the fundamental research exemption does not hold if a project collaborator holds internal restrictions on its technologies, as it would violate the “public domain” aspect of the research. Universities, especially those who maintain open research policies, would tend to avoid collaborating with companies who employ internal IP control as they would add license application cost and schedule to the collaborative project. Collaboration is an essential part of the research university culture – it fosters new ideas and the sharing and distribution of resources and responsibilities. As such, from the perspective of these organizations, export control policy should be reformed to optimize the potential for Collaboration.

6. Policy Options and Analysis

The preceding sections show that two of the primary stakeholders are not satisfied with the present U.S. Export Control Regime and that they broadly agree on the issues that should be addressed in future ITAR reform, including even the challenging balancing act between open markets and national security. Options for ITAR reform can include recommendations to improve stakeholder satisfaction by altering policy content or by improving the process by which it is implemented. This section presents several options for how regulations and implementation could be changed to address shortfalls in the system.

6.1 Export License Scope Trade Space

The present ITAR framework is transaction-based. First, the organization seeking a license must determine whether their proposed commodity transaction falls under ITAR jurisdiction (or submit a commodity jurisdiction request to DDTC). For covered technologies, the State Department DDTC determines whether that commodity can be licensed to the proposed foreign entity. This regulatory regime is inherently inflexible with respect to the covered technology and requires significant iteration: any change to a potential export during its design and development requires a new export license. Because each case is assumed to be unique, there is limited opportunity for decisions to be covered by precedent; therefore, it is nearly impossible to quickly navigate the approval process. Several changes to the individual transaction licensing system have been proposed.

In order to provide a full description of the available options, we construct a trade space for an expanded scope licensing decisions in two axes, shown in Figure 3. The two axes correspond to the two variables in an export license: the covered technology and the licensee. The first axis (horizontal) details the breadth and specificity of potential export control regulations, ranging from control of specific components to control at the subsystem or system level. The current export control regime, represented by the star in Figure 3, shows that current regulations apply at the specific component level.

The second axis (vertical) is the specificity of the approved foreign transaction partner (licensee). Licenses can be granted to individuals, teams, agencies, nations, or groups of nations. Moving

from bottom to top of the vertical axis indicates progressively broader licensee scope. The most expanded license may include export to all nations except states excluded due to embargo or other policy reasons, such as Cuba, China, and Iran. Currently, export control licenses are granted to end user organizations which are typically government agencies or commercial firms, but can sometimes include a wide range of end users within the authorized state. The gradients indicate tightness of security. Darker regions of the graph and axes denote more stringent regulations. In the white region of the graph, technologies are no longer regulated by the DoS and have instead been moved to DoC jurisdiction.

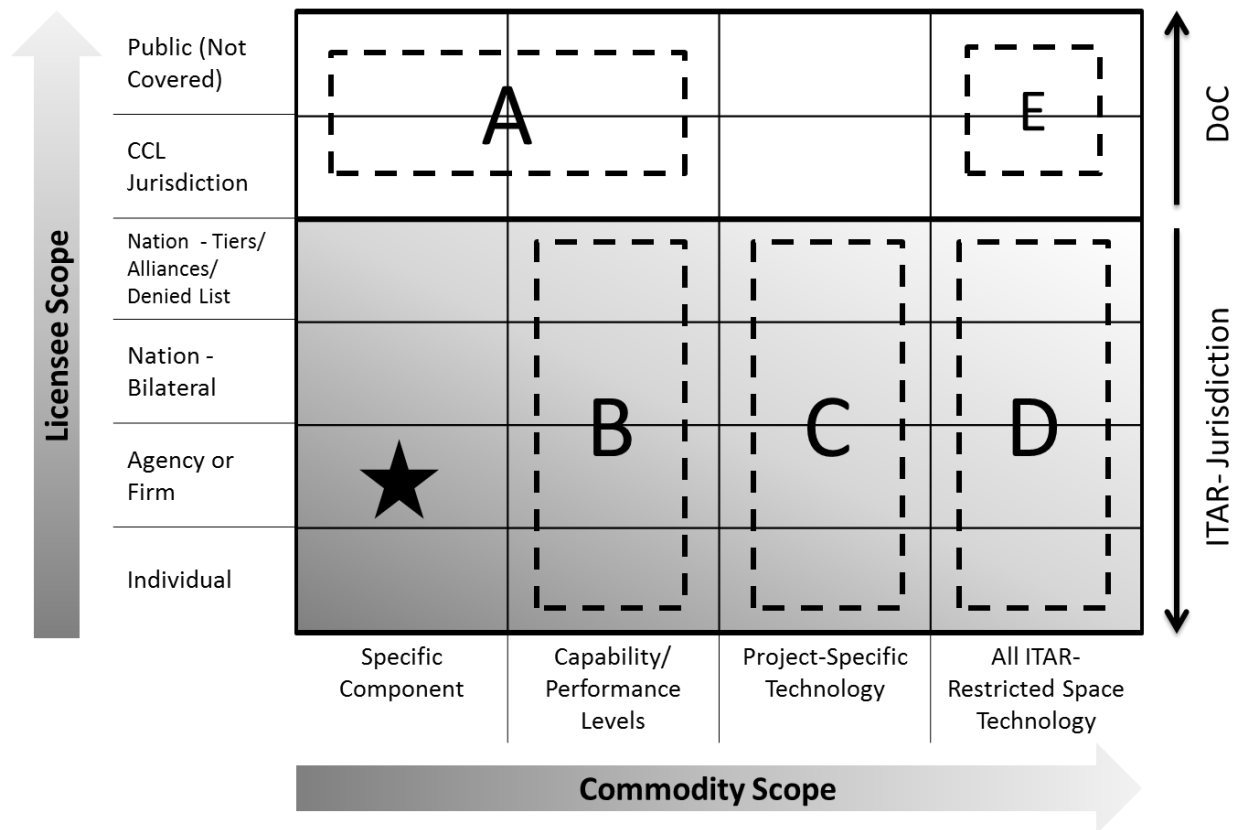


Figure 3: Policy Trade Space

Present licensing options can vary along the licensee axis but not greatly along the commodity axis. For example, a specific commodity can be licensed for transfer or export to an individual, agency, or a community such as the UK government. While some attempts have been made to broadly apply licenses to sets of technology, these are not actually as effective as intended, as discussed below.

From this representation we can see several options for increasing flexibility in the export licensing system beyond the present restriction to case-by-case assessment of each technology. The approximate scope of each option is identified by the dashed boxes in Figure 3.

Region A: Reclassification and Deregulation – In this region of potential policy actions, the government removes items from ITAR jurisdiction. This action may be undertaken for specific components or for components under a specific performance threshold [32]. This action requires

the government to revise or add additional USML performance standards so that lower-performing technology is moved to the CCL or is deregulated completely. Congress must legislate this broader flexibility in commodity jurisdiction, because that status of satellite technology is currently hardcoded in legislation.

Region B: Capability-Based Licensing – In this region, the government applies selective export control restrictions based on performance of covered systems. A commodity is identified not by a specific description or part number but rather by the capability it delivers. Granting a license under this scope would then apply to any other commodity of equal or lesser capability to the same licensee or wide set of licensees.

Region C: Project-Specific Licensing – In this region, the government applies export licenses to all technology on an approved collaborative or international project. Here, the government chooses to trust a set of collaborators to protect the covered technology from further transfer and gives the responsible US entity exporter broad license to export any technology within the scope of the collaborative or international project. This process is similar to the process for contractor access to government classified information.

Region D: Trusted Partner Export – In this region, the government grants an effective US person status for the purposes of ITAR export licensing for spacecraft commodities (category XV defense articles). This can occur at any licensee level--from a bilateral agreement with a close ally to the certification of individuals or agencies as trusted collaborators. In this region, instead of licensing specific technologies, *people* are licensed to work with or to receive the export of sensitive technologies instead. This allows people (or agencies) who work on many collaborative projects to receive blanket certifications and avoids the need to license every technology that they work with. One way this could be achieved using existing legal status designations is by granting US Person status to trusted individuals who are expected to collaborate frequently on ITAR-restricted projects.

A step in this direction was implemented in 2012 with the US/UK Defense Trade Cooperation Treaty. The treaty establishes a UK Community of trusted agencies and facilities for which license exemptions are automatically granted to the exporter. However, the implementing agreement specifically excludes all USML Category XV items except for some XV(c) GPS commodities [33].

Region E: Abandon ITAR – This region represents the decision to remove all spacecraft technology entirely from the USML and to place it on the CCL or deregulate entirely. While this option would alleviate the current confusion over which items do and do not require an export license and essentially eliminate the negative cost and schedule impacts that arise from the ITAR compliance process, it puts national security at an unacceptable level of risk. For this reason, this is not considered to be a viable future policy option.

Star: Existing Licensing Process – This region represents the current export control regulations where the license process is limited to specific commodities and licenses have varying licensee scope. At present, re-classifying spacecraft technology by executive agencies as dual-use CCL items is not possible because their classification as munitions is written into law by Congress.

The remainder of this section discusses specific policy recommendations that correspond to the depicted regions A-D above and also presents options for reforming ITAR's implementation which can be applied to any region of the policy trade space.

6.2 Re-classification and De-regulation

The current export control regime controls all satellite technologies regardless of whether other countries have the capability to indigenously produce similar technologies or whether they are sufficiently diffused throughout the international marketplace. As a result, ITAR unnecessarily regulates technologies that are otherwise uncontrolled in the international manufacturer and customer community. A policy option that addresses this issue is to audit the USML to identify technologies that are not critical to national security due to their wide availability and either reclassify them as dual-use CCL commodities under the EAR or deregulate them entirely.

One suggested method for auditing the USML is through a comparison of domestic and international satellite manufacturer capabilities. An example analysis is performed in Table 2, where the technical specifications of major U.S. satellite integrators are compared to those of their European competitors. Although the data shown in Table 2 is limited to that which is publicly available [34-43], it provides an illustration of how the USML could be audited. For example, from the technical specifications listed below, policymakers could recognize that the components and capabilities of the power subsystems are similar across integrators. If a more detailed comparison between U.S and internationally manufactured power subsystem components reveals that they are in fact equivalent, then these components can be removed from the USML. This type of side-by-side manufacturing capability analysis can be applied to all levels of a spacecraft's architecture and could allow policymakers to remove items as small as a space-rated circuit and as large as an integrated satellite bus from the USML. Of course, in order to remove any technologies from the USML, it must be determined that such an action does not adversely impact national security. This disclaimer applies to all export reform suggestions throughout this paper, as we do not perform a comprehensive analysis of national security implications here.

Table 2: Satellite Bus Definition

Bus Type	Company Name	Country of Origin	Mass at Launch [kg]	Mission Life time [yrs]	BOL Power [kWatts]	Payload Power Capability [kW]	Solar Array Type	Battery Type	ACS Stability Mode	Propulsion Type (Transfer Orbit)	Propulsion Type (Orbit Maintenance)
GEOStar-2	Orbital Science	USA	800-1500	15	-	1-5.5	Multi-junction GaAs	Li-Ion	3-axis stabilized	Liquid bi-propellant	Monopropellant (hydrazine)
AlphaBus	Thales Alenia & EADS Astrium	France	8100	15	6-23 kW (BOL)	1.2-1.8	Triple Junction GaAs	Li-Ion	-	Liquid bi-propellant	XIPS
Spacebus 3000	Thales Alenia	France	2500-3000	15	5-13 (EOL)	3.5-6.5	Si	-	3-axis stabilized	Liquid bi-propellant	Bi-propellant (Platine/Rhodium) (Pt/Rh)
Spacebus 4000	Thales Alenia	France	4200-5400	15	10-20 kW (EOL)	4.2-9	Si and/or GaAs	LI-ion or NiH2	3-axis stabilized	Liquid bi-propellant	Bi-propellant (Platine/Rhodium) (Pt/Rh)
Boeing 702MP	Boeing	USA	5,800-6,160	15	13.6-18	6 - 12	Ultra-triple junction GaAS	Li-ion, 24-40 cells	Body-stabilized	Liquid bi-propellant	-
Boeing 702HP	Boeing	USA	4488-6330	15	14-18kW (BOL); 8.6-16kW (EOL)	2.426 - 8.664	Dual-junction, Triple-junction, Ultra Triple Junction GaAs cells	NiH, Li-Ion	Body-stabilized	Liquid bi-propellant	Bipropellant XIPS
A2100	Lockheed Martin	USA	4700-6000	15	-	-	Multi-junction GaAs	Li-Ion	3-axis stabilized	Liquid bi-propellant	Hall thrusters
Eurostar 3000	EADS Astrium	France	4500-6000	15	6-12 kW	4 - 14	Triple Junction GaAs	LI-ion or NiH2	-	Liquid bi-Propellant	XIPS
LS-1300	Space Systems/Loral	USA	2217-6910	17	12 kW - 18 kW	5 - 25	-	-	-	Liquid bi-propellant	Ion

A second suggested methodology for auditing the USML is by identifying and removing technologies that have sufficiently permeated the international marketplace. An example analysis is performed in Figure 4, where the payload frequency band for over 300 U.S. and internationally owned commercial communications satellites is shown [44-52]. The frequency-band in which each communications satellite operates determines the type of technology that is integrated into its payload. For example, if a satellite operates in the C-band, its solid-state amplifiers and transponders are unique to that bandwidth and cannot be integrated into a different satellite that intends to transmit in the Ka-band. Thus, if the U.S.'s commercial communications technology were unique, one would expect U.S.-satellites to be concentrated in an exclusive bandwidth. Figure 4 depicts the opposite: in the GEO COMSAT community, the use of each bandwidth (and its associated technology) is equally distributed between U.S. and commercial operators. From this information, policymakers might conclude that elements of the commercial communications payloads may be removed from the USML since they have sufficiently permeated the international marketplace. Like the manufacturing capability analysis discussed previously, this type of diffusion analysis can be performed at all levels of a spacecraft architecture and could allow policymakers to identify items that do not need to be protected by ITAR because they are commonly utilized by customers of all nationalities.

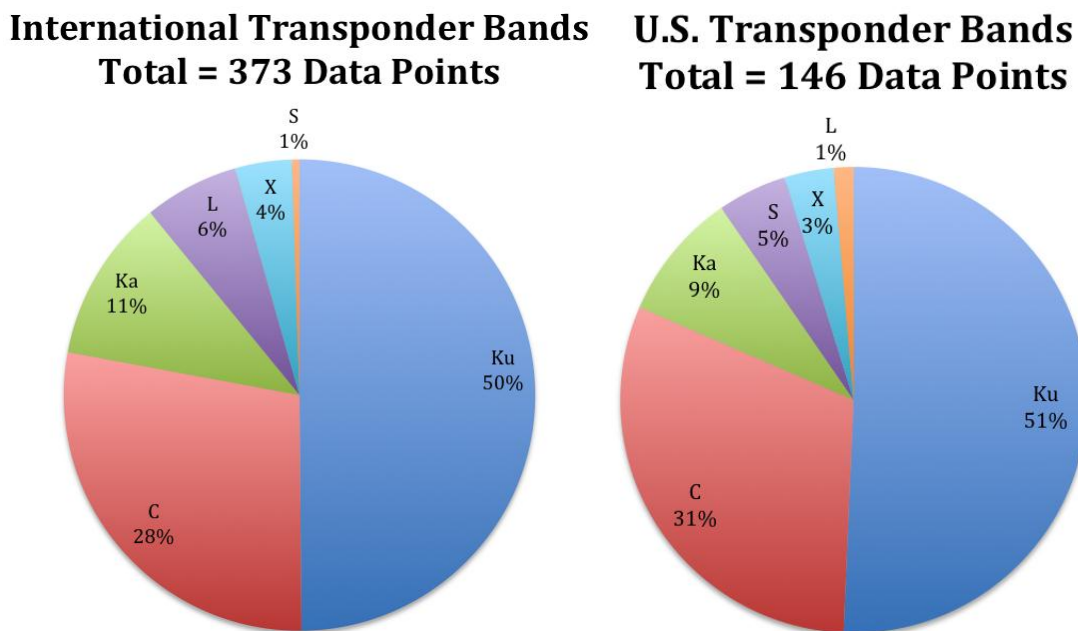


Figure 4: International and U.S. Transponder Bands

6.3 Capability-based Licensing

The current export control regime requires that a license be granted for each technology export regardless of the type of technology or the recipient. In its licensing process, the DoS does not differentiate between allied countries, countries where technology exports are frequent, or technologies that are commonly approved for export. As a result, there is considerable duplication in the licensing process that adds unnecessary time and compliance measures into the current export control regime. A policy option that addresses these concerns would reform ITAR to allow open licensing of technologies that perform common functions at standard performance

levels to particular countries and/or organizations within them. With this option, we suggest that ITAR be amended to allow the DoS to grant permanent export licenses of technologies that are commonly exported to countries that are either our allies or are our frequent customers.

Statistics on the current population of satellites in Earth-orbit suggests that by applying open licenses to a specific set of countries, policymakers will still be able to positively impact interested stakeholders. Figure 5 depicts a breakdown of the countries that own satellites in geostationary orbit collected from the Union of Concerned Scientists website [53]. From this figure, we conclude that outside of the U.S. and China, only a handful of countries dominate the marketplace. Specifically, Canada, Luxembourg, the Netherlands, Japan, Russia, and the United Kingdom own 22% of the current real-estate in GEO and another 13% (represented by “Multinational” in Figure 5) is owned by multiple European nations (typically ESA-members). From this and similar data on the current population of satellite technology in Earth-orbit, we suggest that policymakers can identify the countries that the U.S. frequently exports to and can reduce their licensing requirements in the future.

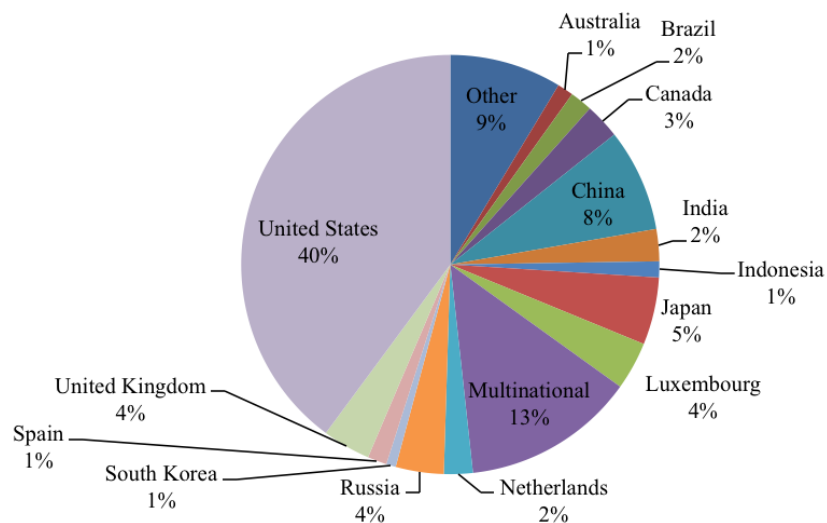


Figure 5: Current Satellites in GEO: Country of Origin

After specifying countries that are candidates for open licenses, policymakers can also specify the particular technologies to be covered by an open licensing regime. Given the industry-wide trend towards standardization, we suggest that policymakers identify technologies that have been standardized by U.S. manufacturers and that have equivalent forms on the international market and apply open licenses in these cases. Drawing from the data presented in Table 2, an example of a possible open export license would be the permanent licensing of Space Systems/Loral’s LS-1300 to customers in Luxembourg.

6.4 Project-Specific Licensing

Another potential reform would be the licensing of project-specific partnerships between U.S. and foreign collaborators, such that technology relating to a project can be shared freely between members of the project team without restriction or the need to apply for multiple licenses for technology transfer between the same parties. An example of where this type of licensing is clearly valuable is the International Space Station, which is currently classified as dual-use. If there is a crisis and real-time data needs to be shared between ISS partners, not having to worry

about what data is able to be shared is critical to problem-solving. Additionally, this reform option would especially benefit research and development collaborations such as exploration missions wherein the technology being transferred is not clearly defined and thus difficult to apply to license in a timely manner.

Project-specific licensing for a large project like ISS could be implemented as a treaty, but not without changes in the implemented NDAA. Precedent exists in other technology areas covered by defense cooperation agreements such as the Joint Strike Fighter cooperative development. Importantly, the export of specific technologies to collaborators in such an agreement is at the discretion of the US technical management, and the risk for unauthorized export is much higher than with micromanagement of licenses by the DDTC.

6.5 Trusted Partner Export

An extrapolation of Project-Specific Licensing is the licensing of foreign partners beyond specific projects to access, or be “cleared” for, ITAR-restricted information, specifically satellite-related USML items. These partners, be they nations, agencies, or just individuals, would be responsible for protecting this technology as an authorized end user from export to non-“trusted partners”. This may require an added start-up cost and regulatory burden to track trusted individuals, but keeping in mind the duration of a career in aerospace, the costs of licensing individuals for all technology transfer compared to that of licensing individual technologies could balance out or even be lower. In Sections 6.5.1 through 6.5.3, we will discuss suggested reforms and adaptations of precedent for each of partner nation, agency, and individual person licenses.

6.5.1 Trusted Partner Nations

Current US/UK and US/AUS Defense Trade Cooperation Treaties are much more limited in scope than they first appear, providing automatic exemptions only for specific certified end user agencies for end uses generally related to cooperative military development or combined operations, and furthermore excluding almost all satellite technology. However, the process of negotiating cooperation treaties does create precedent for a much more expansive cooperation agreement.

A more robust treaty could be implemented by marking all ITAR-restricted unclassified technology as releasable to the United Kingdom. The UK and NATO already have a regulatory process for protecting national security information with a Restricted classification that has no direct analog in the US (it is applied to a variety of dissemination controls for unclassified information) but would effectively prevent re-export by a partner country. Such a policy would greatly reduce the compliance burden on US exporters for sharing information with partners in the UK while trusting that the internal controls are sufficient to protect the sensitive ITAR information. At the far end of cooperation on space technology, it would be possible to provide automatic exemptions to AUS, CAN, and the UK in order to eliminate the need for export licenses between these countries.

6.5.2 Trusted Agencies

National space or other government agencies often have a rigorous screening process for employees, so a reform more narrow in licensee scope would be to grant specific agencies of trusted nations licenses for access to USML spacecraft technology, such that any and all future

partnerships are not limited by the need to apply for additional licenses. Such an agreement would approve the end user agency for a wide scope of covered space technology exports. This does not affect U.S. classified information, which would still be protected from release to anyone without appropriate clearance.

The trusted agency option is a more realistic policy change because it directly leverages partner nation infrastructure in protecting sensitive technology with potential military applications. For example, the Canadian Space Agency (CSA) could receive a wide-scope partner export license, allowing all CSA employees access to all USML spacecraft technology. This would remove the need for individual license requests between the most trusted and frequent foreign partners, allowing direct collaboration with NASA and other US entity partners (excluding US classified information).

6.5.3 Trusted Persons

In addition to creating a new administrative system for granting broad access to ITAR commodities, many of the same effects could be achieved by expanding the pool of U.S. Person employees. While changes to the visa and immigration policy regime may have unintended effects external to ITAR, specific limited reforms may be valuable.

One potential reform that would allow employers to hire from a broader pool as well as encourage skilled technical students to stay in the US post-graduation is to speed up the process of or lower the price of employer sponsorship for US permanent residency (a “green card”) for students who earn technical doctorates from an ABET-accredited university in the U.S. The accreditation stipulation is in place to deter “diploma mills” from taking advantage of any provisions made for graduates of American higher education. In 2009, 44.9% of aerospace engineering PhD recipients were foreign nationals, as were 20.8% of aerospace engineering masters recipients [54]. The U.S. has invested significantly in the training of these students, and it is in our best interest as a nation to retain their talent after they graduate, instead of making it incredibly difficult for them to stay and contribute to our economy.

The progression of visas for foreign national students studying in the US is first an F1 visa during their studies, then an “Optional Practical Training” (OPT) visa for a maximum of 29 months (12 months plus one-time 17 month extension for certain STEM degree recipients) that enables them to work in the U.S. during or after their studies in jobs directly related to their field of study. The F1 and the OPT are not “green card track”, or immigrant visas; in order for a foreign national graduate to continue working in the US beyond the extent of their OPT status, they must apply for and obtain an H-1B visa with the sponsorship of a U.S. employer. After obtaining and spending at least a year on an H-1B visa, an employee can apply for a green card with the sponsorship of their employer. Some foreign students are able to apply directly for an H-1B from an F1 if they find a willing sponsor during their studies to sponsor them upon graduation, but given the length of time for an H-1B application to be accepted, usually they must have an OPT visa in the interim.

Sponsorship is expensive, both in application filing fees (\$2000-2750 for H-1B, depending on size of company, with an additional \$1225 for expedited processing [55] and at least \$1485 for green card application, not including mandatory advertising for a position if applying for a green card though the labor certification process) and in legal fees to immigration lawyers (\$4000 or

more in legal costs per application for green card [56] and companies with many applications may retain a full-time attorney for that purpose). The availability of employers able to afford and willing to sponsor H-1B visas is thus understandably limited.

There is a regular cap on the number of H1B visas per year (65,000) just as there are on green cards, but there is a separate Advanced Degree Exemption (ADE) cap of 20,000 beyond the regular cap that is limited to U.S. university graduates with a masters or higher degree, providing them an extra opportunity to get an H1B over other, non-advanced degree holders [57]. This gives some boost to the number foreign graduates of American universities who are able to stay in the US and work, but the process is still difficult, expensive, and time-consuming and there is no guarantee of permanent residency in a timely manner or at all. There are multiple additional ways that the US could make the process of acquiring a green card simpler and thus entice and retain foreign graduates of American universities:

- 1) Make it free for employers to sponsor employees with doctorates in technical fields for H-1B visas and/or green card applications (free or reduced price sponsorship)
 - a) Employers would be more inclined to hire foreign nationals without the financial burden
 - b) Foreign students would have easier time finding employment immediately post-graduation, making them more likely to stay in the US
- 2) Have PhD-holding employees go straight from OPT visa to green card track once hired (skipping 1+ year wait time on H-1B visa)
- 3) Increase the ADE green card quota or implement a separate one just for PhD-holding applicants, with priority given within that group to PhDs from American universities, but include foreign PhDs as valid for quota too
 - a) The National Foundation for American Policy (NFAP) has recommended exempting foreign graduates with an American university masters degree or higher from the employment-based green card quotas entirely. Masters recipients are included within the NFAP recommendation because of the inclination of doctoral recipients to work predominantly in academia – masters-only recipients will infuse more broadly into the private sector. Also, exempting masters students from the employment-based quota will remedy the backlog and long wait more than just exempting PhDs, since PhDs do not wait as long for a green card anyway under such provisions as the Outstanding Researcher (EB-1) category [54].
 - b) Our recommendation is not to entirely do away with a quota, such as to not encourage engagement in higher education just for the sake of gaining U.S. residency. Only requiring a masters degree for an employment-free green card, a degree often just two years in duration or effort, would make that potential motivation all the stronger and dilute the pool of graduate school applicants who are truly interested in a career in the field they are pursuing
- 4) Make the F1 visa an immigrant visa, which would allow doctoral graduate students at US institutions to apply for a green card partway through their PhD, such that students can acquire permanent residency without needing to find a sponsor.

6.6. Bureaucratic Process: Other Reform Options

The License Scope Trade space is a useful representation for analyzing the potential changes to the export control policy, but it does not capture all policy reforms that could improve

stakeholder satisfaction. The model addresses the “what” of an export decision (and to some extent the “why”), but not the “who”, “where”, and “how” a decision is made.

An important reform that is not represented by Figure 3 is the need to streamline and simplify the licensing process itself. Several options are recommended:

- The DoS and DoD could be realigned so that their actions with respect to export control are complementary and coherent.
- The EAR and ITAR regulations could be combined and implemented by a single, streamlined commodity administration process. This would remove the need for exporters to make difficult commodity jurisdiction decisions with each export.
- The export licensing process could be improved to make it more transparent and expedient. To do this, precedent could be more effectively used to make licensing decisions.
- Finally, the process for obtaining license-approval could be improved by adding additional support staff with technical backgrounds to process license requests more efficiently.

Because the above suggestions are process improvements, they can be applied both to the current export control regime and to the other options for export control that are represented in Figure 3. In the next section, we evaluate Figure 3’s policy options with respect to our pre-defined stakeholder metrics; however, we recommend that any new policy option be coupled with some or all of the process improvements suggested above. By coupling these process improvements with the options presented in Figure 3, policymakers have the greatest potential of increasing the degree to which Compliance Transparency and Licensing Efficiency increase.

7. Policy Evaluation

The policy prescriptions described in the previous section are designed to improve stakeholder satisfaction in one or more objectives. This section will formally assess the effect that each of the policy options depicted in Figure 3 has on the set of metrics that were presented in Section 3.

Note that although we have identified Policy Transformability as a critical metric, we do not use it to evaluate the space of policy options discussed below. An assessment of Policy Transformability requires an analysis of the political and bureaucratic forces in place at the time of an attempted reform. These factors are both transient and highly complex and as a result, we exclude them from our present analysis but recognize their criticality in assessing a proposed policy’s potential for successful implementation.

7.1 Metric Evaluation in Licensing Scope Trade space

Using the license scope trade space, we can generalize how departures from the current limited-scope export license process affect the stakeholder objectives. Generally, increasing the potential scope of an export license decision to apply to a wider set of commodities or to a wider set of licensees improves the Collaboration, Market Flexibility, Transparency, and License Efficiency of the policy regime while decreasing the technology protection aspect of National

Security to some extent. The trends are depicted in Figure 6 and discussed in detail below.

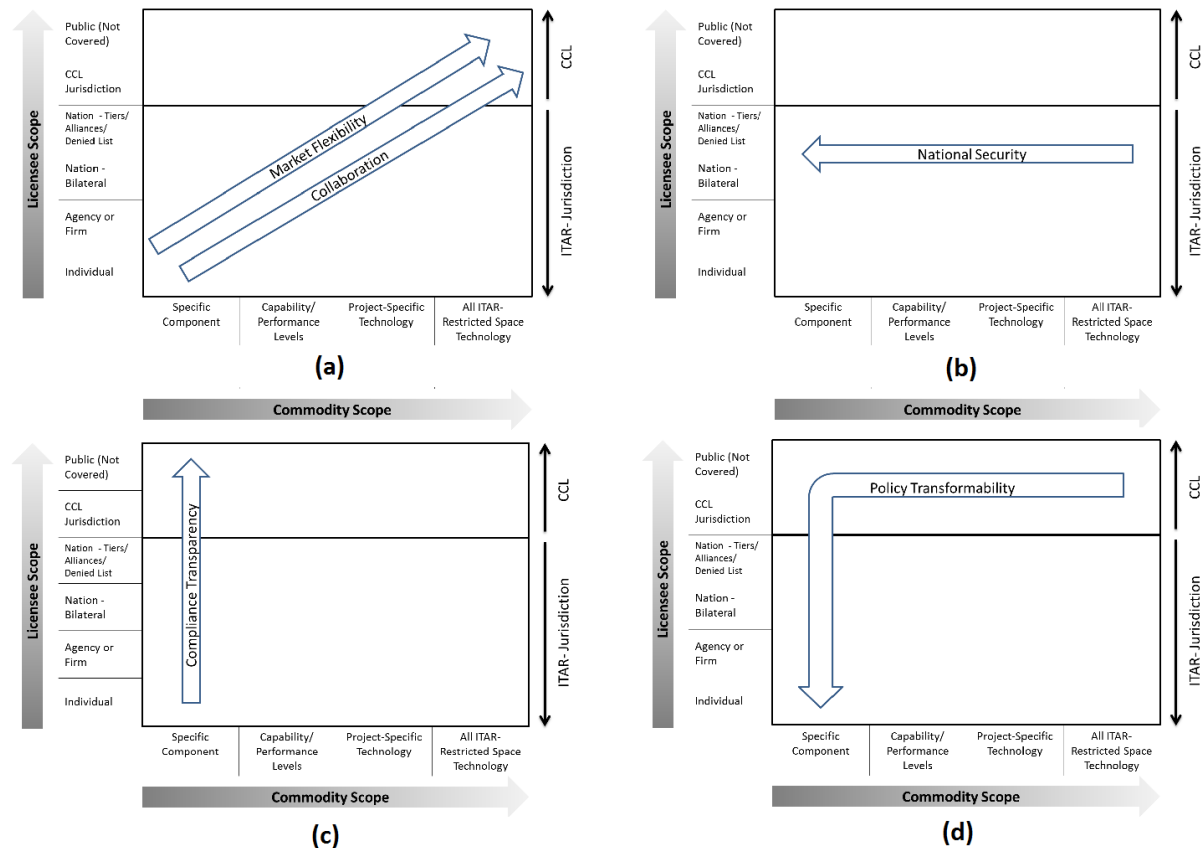


Figure 6: Metric Trends across the ITAR Policy Trade Space

Collaboration

- Increasing the Commodity Scope of export control increases Collaboration because it increases the number and types of technology on which U.S. and international people or agencies can collaborate. By increasing the ability of the export control regime to discriminate between sensitive and non-sensitive technologies, reform options that increase the Commodity Scope open up more non-sensitive projects to potential international collaboration.
- Increasing Licensee Scope increases Collaboration because it improves the ability of the regime to identify common collaborators and to grant them person or agency-specific licensee privileges. Essentially, these reforms reward successful past collaborations by granting collaborators continued licensing privileges that will incentivize them to continue working with U.S. organizations in the future.

Market Flexibility

- Increasing the Commodity Scope increases Market Flexibility because it reduces the number and types of technologies that are sheltered from market forces by removing export controls and releasing them into the international marketplace. For example, using a capability threshold for licensing photovoltaic cells immediately opens competition for PV cell manufacturers below the performance threshold, allowing access to other

potential system integrators.

- Increasing the Licensee Scope generally increases Market Flexibility because it allows the U.S. to identify specific international organizations or countries that are preferred partners. By granting such these countries and organizations elevated status with respect to export controls, the proposed reforms make it easier for U.S. and international organizations to collaborate and to share project costs. The exception to this statement is with Project-Specific Licensing, which grants one-time licenses to specific projects but does not affect how the technologies on those projects are impacted by market forces in the future.

Compliance Transparency

- Increasing the Commodity Scope only secondarily impacts Compliance Transparency because these reforms will still require exporters to make commodity jurisdiction decisions. Within the current regime, there is often question on whether certain technologies are controlled by ITAR or not. If a broader set of technologies were covered by each export decision, a jurisdiction determination would still be needed for each one. The benefit comes from subsequent license decisions.
- Increasing the Licensee Scope increases Compliance Transparency because it assigns exports licenses to specific people, groups, or countries. This removes the need to reassess each technology with each export and also eliminates confusion as to which technologies may be subject to ITAR jurisdiction by assigning easily identifiable agents export licenses instead.

National Security

- Increasing the Commodity Scope for de-regulation options has no impact on National Security because a prerequisite for removing technologies from the USML is an assessment that such an action will not adversely impact national security. However, granting export licenses for project-specific or unspecified technology export does increase the risk of unintended disclosure of protected technologies.
- Increasing the Licensee Scope decreases National Security because it raises the status of foreign persons, organizations, or countries and trusts that they will protect sensitive U.S. technologies that the government has not licensed elsewhere.

License Efficiency

- Both increasing the Commodity Scope and increasing the Licensee Scope increase License Efficiency by reducing the number of licenses that need to be granted. This reduces the time it takes to grant licenses and thus lessens the cost to exporters awaiting license decisions.
- As discussed in Section 6.6, process improvements will also increase License Efficiency, regardless of where the policy lies on the policy trade space.

These generalized effects are not surprising, as we have already established that export control policy represents a balance between the benefits of sharing technology and the need to protect military technology advantages from potential rivals. However, detailed analysis of the suggested reforms suggests several variations in the trend, where expected benefits may not be realized or harmful security impacts can be avoided; these impacts are summarized in Figure 7.

	Collaboration	Market Flexibility	Compliance Transparency	License Efficiency	National Security
Reclassification and Deregulation	+	+	0	+	0
Capability-Based Licensing	+	+	+	+	-
Project-Specific Licensing	+	0	+	+	-
Trusted Partner Export	+	+	+	+	-

Figure 7: Metric Evaluation of Main Policy Regions

Since all of the proposed reforms A-D involve movement up or to the right on the scope trade space, we should expect to see improvements in each “openness” metric and a decrease in national security for each option. As noted above, the exceptions are:

- Limited adverse National Security impact from reclassification
- Limited Compliance Transparency improvement from re-classification
- Limited Market Flexibility improvement from project-specific licensing

These exceptions, particularly the one related to National Security, make some options for ITAR reform more attractive than others. We use this analysis to motivate our final policy recommendation which is presented in the next section.

8. Conclusion

Our policy option trade space was constructed by reviewing the history of export control as applied to spacecraft, by identifying stakeholders and their values, and by focusing on the specific needs of two major stakeholder groups. By formulating policy-options in a trade space, we were able to present five different suggestions for export control, each of which contained a range of Licensee and Commodity Scopes, and evaluate them with respect to a set of defined metrics. While all the potential policy modifications would help address the common reform goals shared between the stakeholders, the lowest risk and therefore easiest to implement reform option is to remove from ITAR protection those technologies whose disclosure no longer threatens national security.

As identified in Section 7, the set of policy options contained in Region A positively impacted three stakeholder metrics without significantly negatively impacting national security. As emphasized throughout the paper, effective export control regimes are able to balance stakeholder and national security interests without negatively impacting either. Given this assessment, we suggest that law-makers consider reforming ITAR by auditing the USML and re-

classifying or de-regulating technologies based on the state-of-the-market evaluation presented in section 4. Common COMSAT technologies could be moved to the CCL with no adverse impact and would go a long way toward addressing the concerns of both for-profit and non-profit US stakeholders. For-profit developers would have access to world markets with greatly reduced administrative burden, and non-profit stakeholders could freely pursue collaborative activities related to de-regulated commercial spacecraft.

Spacecraft technologies that are available on the international market should not require export protection under the ITAR. The blanket protection placed on spacecraft technologies is an artifact of the long history of export control policy and the historical inseparability of space and defense technology. The export control regime needs to be more responsive to the present security environment and rapidly evolving technology

Although we make only one policy recommendation at this time, a key contribution of this paper is our formulation of the export control regime as a trade space of non-exclusive possible policy options. Using this formulation, lawmakers can identify more nuanced approaches to export control that, when assessed at a later date, may more effectively meet stakeholder needs than our current recommendation.

References

- [1] Purpose and Definition, International Traffic In Arms Regulation 22 CFR pt 120.17
- [2] Zelnio, Ryan J. "Determining the Effects of ITAR Regulation on the Commercial Space Manufacturing Sector". Washington, D.C.: George Mason University. <http://www.cspo.org/igscdocs/Ryan%20Zelnio.pdf>.
- [3] Choi, Eric, and Sorin Niculescu. "The Impact of US Export Controls on the Canadian Space Industry." *Space Policy* 22 (2006): 29-34.
- [4] Zelnio, Ryan J. "Whose jurisdiction over the US commercial satellite industry? Factors affecting international security and competition." *Space Policy* 23 (2007): 221-233.
- [5] Johnson-Freese, Joan. "Alice in Licenseland: US satellite export controls since 1990". *Space Policy* 16 (2000): 195-204.
- [6] Cornell, Ariane. "Five Key Turning Points In the American Space Industry in the Past 20 Years: Structure, Innovation, and Globalization Shifts in the Space Sector." *Acta Astronautica* 69 (2011): 1123-131.
- [7] Rachel Lehmer Claus, Esq. "Space-Based Fundamental Research and the ITAR: A Study in Vagueness, Overbreadth, and Prior Restraint." *Santa Clara Journal of International Law*, vol. 2, 2003, p. 1 – 40.
- [8] Gast, A.P., et al, "Provost Group's Letter on Commerce IG Report," Letter, sent to Hon. Kenneth Juster, Undersecretary for Industry and Security, July 30, 2004.
- [9] U.S. House of Representatives, *Foreign Relations Authorization Act, Fiscal Years 2010 and 2011*. 111th Congress, 1st Session. H.R. 2410.
- [10] "GovTrack." Available online: <http://www.govtrack.us/>. Accessed 12 April, 2012.
- [11] U.S. House of Representatives. *Safeguarding United States Satellite Leadership and Security Act of 2011*. 112th Congress, 1st session. H.R. 3288.
- [12] "President Obama Lays the Foundation for a New Export Control System to Strengthen National Security and the Competitiveness of Key U.S. Manufacturing and Technology Sectors." The White House, Office of the Press Secretary. August 30, 2010. Available online. <http://www.whitehouse.gov/the-press-office/2010/08/30/president-obama-lays-foundation-a-new-export-control-system-strengthen-n> Accessed 4/11/2012
- [13] *Defense Industrial Base Assessment: U.S. Space Industry – Final Report*. Dayton, OH: United States Air Force, 2007. <http://www.bis.doc.gov/defenseindusTrialbaseprograms/osies/defmarketresearchrpts/exportcontrolfinalreport08-31-07master---3---bis-net-linkversion---101707-receipt-from-afrl.pdf>. Accessed 4 April 2012.

- [14] *Competing for Space: Satellite Export Policy and U.S. National Security*. Arlington, VA: Aerospace Industries Association, 2012. www.aiaaerospace.org/assets/CompetingForSpaceReport.pdf. Accessed 4 April 2012.
- [15] Van Atta, Richard. *Export Controls and the U.S. Defense Industrial Base*. Alexandria, Virginia: The Institute for Defense Analysis, 2004. www.dtic.mil/cgibin/GetTRDoc?AD=ADA490280. Accessed 11 April 2012.
- [16] *ITAR and the U.S. Space Industry*. Washington, D.C.: The Space Foundation, 2008. Available online http://www.spacefoundation.org/docs/SpaceFoundation_ITAR.pdf. Accessed 11 April 2012.
- [17] *Beyond 'Fortress America': National Security Controls on Science and Technology in A Globalized World*. Washington D.C.: The National Academies Press, 2009.
- [18] Cooper, Patricia. Written Testimony at the Hearing on Export Controls, Arms Sales, and Reform: Balancing U.S. Interests (Part II), House Foreign Affairs Committee. February 7, 2012. Available online: http://www.fas.org/programs/ssp/asmp/issueareas/us_arms_export_reform1/2009/coo040209.pdf. Accessed 11, April 2012.
- [19] Lewis, James A. & Erin Schlather. *Preserving America's Strength in Satellite Technology: A Report of the CSIS Satellite Commission*. Washington, D.C., The CSIS Press, 2002. http://csis.org/files/media/csis/pubs/020401_presrvng_satellite_superiority_sumry.pdf. Accessed 11 April 2012.
- [20] United States Department of State. International Traffic in Arms Regulations ("ITAR," 22 CFR 120-130), 22 U.S.C. 2778 of the Arms Export Control Act. Available online: http://pmdotc.state.gov/regulations_laws/itar_official.html. Accessed 11 April 2012.
- [21] The White House, "National Policy on the Transfer of Scientific, Technical, and Engineering Information", National Security Decision, Directive 189, Sept 21, 1985.
- [22] Vest, C.M, Baltimore, D., et al, "University Presidents' Letter to White House on Export Controls," Letter, sent to four White House advisors, Sept. 9, 2004.
- [23] Young, J.J., "Memorandum for Secretaries of the Military Departments: Contracted Fundamental Research", The Undersecretary of Defense for Acquisition, Technology, and Logistics, June 26, 2008.
- [24] "Introduction to U.S. Export Controls for the Commercial Space Industry." Department of Commerce and the Federal Aviation Administration. October 2008.
- [25] Smith, Tobin L., Josh Trapani, Anthony Decrappeo, David Kennedy. "Reforming Regulation of Research Universities." *Issues in Science and Technology*. Summer 2011, p. 57-64.

- [26] Weinberger, Sharon. "Export-control laws worry academics." *Nature*, vol. 46. September 10, 2009.
- [27] Finarelli, Margaret G., Joseph K. Rapporteur. "Space Science and the International Traffic in Arms Regulations: Summary of a Workshop." National Academy of Sciences, 2008. <http://www.nap.edu/catalog/12093.html>
- [28] Widnall, S.E, Chan, V.W.S, Friedman, J.I., Graves, S.C., Sapolsky, H.M. "In the Public Interest: Report of the Ad Hoc Faculty Committee on Access to and Disclosure of Scientific Information," Massachusetts Institute of Technology, June 12, 2002
- [29] Zurbuchen, T.H., *Capitol Hill Hearing on STEM Education, Aviation and Space: Hearing Before the Aerospace States Association*, Statement, March 9, 2009
- [30] Aerospace States Association. *Understanding the issues surrounding Export Control/ITAR: Hearing before the Aerospace States Association*, March 11, 2008
- [31] Broniatowski, D., Jordan, N., Long, A., Richards., M., and Weibel, R., "Balancing the Needs for Space Research and National Security in the ITAR," *AIAA Space 2005*, Long Beach, CA, August 2005. (AIAA-2005-6800)
- [32] Departments of Defense and State. "Risk Assessment of United States Space Export Control Policy" *Final Report to Congress: Section 1248 of the National Defense Authorization Act for Fiscal Year 2010*.
- [33] U.S./UK Defense Trade Cooperation Treaty. *Article 3(2): List of Defense Articles Exempted from Treaty Coverage*. Available online: http://www.pmdtcc.state.gov/treaties/documents/UK_Exempt.pdf.
- [34] "GEOStar Communications Satellites." *Orbital: Innovation You Can Count On*. Web. 12 Apr. 2012. <<http://www.orbital.com/SatellitesSpace/Communications/>>.
- [35] Wade, Mark. "Encyclopedia Astronautica." *Astronautix.com*. Web. 12 Apr. 2012. <http://www.astronautix.com/craft/fs1300.htm>>.
- [36] "Spacebus 3000 Platform." *Thales*. Web. 12 Apr. 2012. <http://www.thalesgroup.com/Portfolio/Space/space_product_spacebus3000/?pid=1500>
- [37] "Spacebus 4000 Platform." *Thales*. Web. 12 Apr. 2012. http://www.thalesgroup.com/Portfolio/Space/space_product_spacebus_4000/?pid=1568
- [38] "EuroStar Bipropellant Propulsion System." *Astrium: An EADS Company*. Web 12 Apr. 2012. ,<http://cs.astrium.eads.net/sp/spacecraft-propulsion/showcase/eurostar.html>>.
- [39] Eurostar series." *Astrium: An EADS Company*. Web 12 Apr. 2012. <http://www.astrium>.

eads.net/en/programme/eurostar-series.html.

- [40] Multimedia Satellite Equipment (Li-Ion Battery for GEO Satellites). *ESA: Telecommunications and Integrated Applications*. Web 12 Apr. 2012. <http://telecom.esa.int/telecom/www/object/index.cfm?fobjectid=1480>.
- [41] "Solar Array." *Astrium: An EADS Company*. Web 12 Apr. 2012. <http://www.astrium.eads.net/node.php?articleid=5397>>.
- [42] "Upcoming Launches." *Eutelsat Communications*. Web. 12 Apr. 2012. <<http://www.eutelsat.com/satellites/upcoming-launches.html>>.
- [43] Cathala, Michel. "The Alcatel Spacebus Family." *Proceedings of the Euro-Asia Space Week on Cooperation in Space – 'Where East & West Finally Meet', 22-27 November 1998, Singapore*. (ESA Sp-430, February 1999).
- [44] "Gunter's Space Page." Gunter Dirk Krebs, 2012. Web. 7 Apr. 2012. <<http://space.skyrocket.de/>>.
- [45] "Defense, Space & Security." *Boeing: Satellite Development Center*. Boeing Satellite Systems, 2012. Web. 1 Apr. 2012. <<http://www.boeing.com/defensespace/space/bss/factsheets/601/dbs/dbs.html>>.
- [46] Lindborg, Christina. "APStar." - *China and Communication Satellite Systems*. Web. 11 March. 2012. <<http://www.fas.org/spp/guide/china/comm/apstar.htm>>.
- [47] "Turksat 3A: 42° East." *Turksat 3A: 42° East*. Turksat, 2009. Web. 14 March 2012. <<http://www.turksat.com.tr/english/v2/satellite-fleet-and-specifications/turksat-3a-42-east>>.
- [48] "NileSat 201." *NileSat Satellite Technical Information*. NileSat, 2011. Web. 20 Mar. 2012. <<http://www.nilesat.com.eg/Satellite/NileSat201/TechnicalInformation.aspx>>.
- [49] "W4 -- Geosynchronous Ku-Band DBS Satellite Transponder Bandwidth Technical Launch Specifications -- Eutelsat." *Global Satellite Chart--Geo-Orbit Quick-Look--Western Hemisphere--C/Ku-Band Footprints/Coverage, Specs*. Web. 30 Mar. 2012. <<http://www.geo-orbit.org/easthemipgs/w4sheetp.html>>.
- [50] Smathers, Robert. South Scanner Satellite Services Chart Vol.11 Issue #1 Copyright Robert Smathers, Albuquerque, New Mexico USA, 1991-2002 September 29, 2002
- [51] "E3000 Second Generation Solar Array." *ESA: Telecommunications and Integrated Applications*. Web. 12 Apr. 2012. <<http://telecom.esa.int/telecom/www/object/index.cfm?fobjectid=14989>>.
- [52] "UCS Satellite Database." *Union of Concerned Scientists: Citizens and Scientists for*

Environmental Solutions. Web. 12 Apr. 2012. <http://www.ucsusa.org/nuclear_weapons_and_global_security/space_weapons/technical_issues/ucs-satellite-database.html>.

- [53] "UCS Satellite Database." *Union of Concerned Scientists: Citizens and Scientists for Environmental Solutions*. Web. 12 April 2012. Available online: http://www.ucsusa.org/nuclear_weapons_and_global_security/space_weapons/technical_issues/ucs-satellite-database.html.
- [54] Anderson, S., "Keeping Talent In America," National Foundation For American Policy, Arlington VA, October 2011. Available online: http://www.nfap.com/pdf/KEEPING_TALENT_IN_AMERICA_NFAP_October_2011.pdf
- [55] "H1B Visa Filing Fees and Costs," H1 Base. Available online: <http://www.h1base.com/visa/work/H1B%20Visa%20Fees/ref/1186/>
- [56] Offices of Eve Guillergan PLLC, "FEES FOR GREEN CARD AND NATURALIZATION," KnowYourVisa.com. Available online: <http://knowyourvisa.com/greenfees.php>.
- [57] "H-1B Visas reached Cap for the Fiscal Year 2012," Bilingual Weekly, December 5, 2011. Available online: <http://bwnews.us/2011/12/05/h-1b-visas-reached-cap-for-the-fiscal-year-2012/>