

# Determining the Effects of ITAR Regulation on the Commercial Space Manufacturing Sector

Ryan J. Zelnio

*School of Public Policy, George Mason University, Finley Building, 4400 University Drive, Fairfax, VA 22030, USA*

## Abstract

Within a global economy, export controls play a large role in the proliferation of high technology. A company operating in a country that operates under stricter export controls is at a serious disadvantage competing. This has been the case for commercial satellite manufacturers in the United States since 1999, when Congress redefined commercial satellites and all technologies associated with it from a dual-use export under the jurisdiction of the Department of Commerce to a munitions export that falls under the jurisdiction of the Department of State. Following this was a drastic drop in market share of United States commercial satellite manufacturers in comparison to European manufacturers which continued to define satellites as a dual-use technology. The hypothesis of the paper is “the major reason for this decline in market share is directly, and primarily, due to the fact that the U.S. sector is now operating under a stricter export regulatory environment than its competitors.” As a secondary effect of this policy change is that U.S. companies are now losing their technical lead. To test this hypothesis, a cross tabular analysis is performed on a data set of all geosynchronous satellite contracts through September, 2006, a population of 982 contracts.

## Introduction

Complex and advanced technology is an area that the U.S. manufacturing still commands a leading edge in the international marketplace. The U.S. retains a large part of this leadership due to vast amount of dollars poured into its development by the federal government, most notably investing in technologies that are dual-use in nature. These dual-use technologies can be regulated in one of two ways, as either a munitions controlled by the Directorate of Defense Trade Controls within the Department of State (DoS), or as a dual-use technology control by the Bureau of Industry and Security within the Department of Commerce (DoC). The underlying rationale of these two institutions differ in that Commerce has a role is to promote U.S. business interests abroad, while State’s role is to ensure that sensitive U.S. technology is not proliferated around the world. These underlying rationales make it is easier to export technologies that fall under Commerce’s jurisdiction than State’s. Many countries have a similar export control on both munitions and dual-use items. However in some cases, countries differ in defining technologies as either a munitions or dual-use. This definition is important in international trade relations as a country which places a technology under dual-use controls has a trade advantage over a country which defines a technology as a munition.

It is the hypothesis of this paper that this trade advantage may be used to gather a greater market share, which in turns leads to further enhancement of a technology. The long term implications of this theory is that once such an advantage exists, it would be hard for any country with more stringent export controls to continue to compete in a global market place. A case study of this effect can be found in the manufacturing of commercial satellite platforms.

The United States has been the historic leader in the manufacturing of commercial satellite platforms. However, that lead has shrunk considerably in recent years. A leading theory is that this loss in marketplace can be attributed to the movement of commercial satellites and the technologies behind them from the jurisdiction of the Commerce Department to the State Department in 1999. This move has had the unintended side effect of isolating customers with a previous relation with U.S. manufacturers, thus lessening their incentive to continue commercial relations. It has also provided an incentive for foreign manufacturers to increase their own technology base in order to not be subject to the U.S.'s stricter export regulations and be more competitive globally.

This paper seeks to test this theory by performing a cross tabular analysis on contract awards both before and after the change in export regulation to determine and measure the effect this change has had. It will look at factors associated with technical complexity, foreign relations between customer and U.S. government, and previous relationships between the customer and manufacturer. The paper concludes with a discussion of results, followed by policy implications and an examining of possible further research.

## **Research Question & Hypothesis**

There is existing literature that implies that there is a connection between US market-share and the level of export restrictions<sup>1</sup>. What has been lacking in the literature is a quantitative analysis on how much of an impact tighter export restrictions on a technology would have on market-share while foreign competitors are not held to the same restrictions. The commercial satellite manufacturing sector provides a unique opportunity to be able to examine the effect on market-share when a technology is listed as either under the dual-use regulations of the Commerce Department or the munitions regulations of the State Department. The regulations of export controls for the commercial space manufacturing is thus broken into three separate phases<sup>2</sup>: State Control prior 1992, Commerce Jurisdiction 1992-1999, ITAR Jurisdiction 1999 to present.

Hypothesis 1: That the US space manufacturing sector was able to grow and retain its market dominance when competing with foreign manufacturers operating under similar export controls.

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<sup>1</sup> See Parkhe (1992), Garcia-Alonzo (2000), Giget, et. al.(1996), Peeters (2002), Lewis (2002), and Choi & Niculescu (2006)

<sup>2</sup> For a complete history of export policy, see Zelnio, R. (2006). "A Short History of Export Control Policy," The Space Review, <http://www.thespacereview.com/article/528/1>

Hypothesis 2: That the US space manufacturing sector was not able to retain its market-share when having to compete against foreign competitors that operated under a more relaxed export control regime.

As a side effect of U.S. market share loss, two other hypotheses emerge from the literature review that will also have an effect on U.S. manufacturer's market share:

Hypothesis 3: Previous relationships between foreign customers and U.S. manufacturers will play a lesser role over time.

Hypothesis 4: More stringent export controls provide an incentive for foreign manufacturers to increase their own technical complexity.

## **Methodology**

To test the hypotheses, cross tabulation analyses are performed on a database of all commercial satellite manufacturing contract awards. Each cross tabular analysis has two parts, the first is performed on awards up to 1999 to test the first hypothesis and the second on awards that took place after 1999. The database consists of a total of 989 records and shall be narrowed to include only those that are competitively selected.

The analysis is only performed on satellite contracts that are open for all to compete. The reason is that this study is an investigation of how domestic companies compete with foreign companies in the open market. Therefore contracts awarded only to bidders existing within their countries' borders by their national governments and those considered intra-company sales are excluded from the analyses as they are commercially competitive. Additionally, due to launch failures, an insurance company may require that a satellite be rebuilt by the manufacturer so the contracts associated with those settlements are also excluded.

To test to see if there is support for hypothesis 1, it is anticipated that analyses performed on contracts awarded up to 1999 will show a clear dominance of contracts being awarded to domestic manufacturers. For hypothesis 2, it is anticipated that this dominance will be considerably lower for contracts awarded after 1999 after the rule for awards is liberalized. To test hypothesis 3, it is anticipated that the significance of previous relations between a customer and manufacturer will lessen during the three distinct time periods of export regulation. To test hypothesis 4, it is anticipated that foreign manufacturers market share of more technically complex spacecraft will increase after the regulation change in 1999.

## **Testing, Analysis and Results**

The first challenge was in the creation of the database. Data gathering relied heavily on a variety of sources including manufacturer and customer websites, press releases, and one of the largest public collections of satellite descriptions, Gunter's Space Page [16]. From this information the database was populated with 982 contracts for geosynchronous satellites dating back to 1961 with information on the customer, customer origin, manufacturer, satellite bus, award date, and the satellite's power and mass. Not all this information was available, more notably 339 of these contracts did not have award dates associated with them, however all of these contracts were awarded prior to 1992 so the loss of this information is not vital to the analysis that was carried out.

The rest of the variables were easily derived from the gathered data with the exception of competitive bid and technical complexity.

**Table 1 - Customer Origin's Relation To U.S.**

<b>NATO &amp; European Partners (1)</b>	<b>Non-NATO Developed Country(2)</b>	<b>Third World country(3)</b>	<b>Poor relation(4)</b>
Australia Canada Greece International Intelsat Inmarsat Worldspace Italy Luxembourg Norway Spain Sweden	Japan Russia South Korea	Africa Argentina Brazil Egypt Hong Kong India Indonesia Malaysia Mexico Nigeria Philippines Saudi Arabia Singapore Thailand Turkey United Arab Emirates Vietnam	China Venezuela

### **Determining Competitive Bid Status**

Deriving the competitive bid status of contracts posed several challenges. The first was in determining intra-company sales. It has been a common practice for a parent company to have both a satellite manufacturer and a satellite operator subsidiary in the United States. Within Europe, Eutelsat was created as a quasi-private entity that only awarded contracts to European companies until it was privatized. Table 2 outlines the time periods in which satellites ordered by a private company are considered to be an intra-company sale.

**Table 2 - Intra-Company Sales Time Periods**

<b>Satellite Customer</b>	<b>Satellite Manufacturer</b>	<b>Time Period</b>	<b>Reason</b>
RCA/GE/SES Americom	Lockheed Martin	Prior 2001	Sold to SES 11/2001
DirecTV, Hughes Satellite & Galaxy	Boeing Satellite Systems	Prior to 2000	Spun off when Boeing Acquired Hughes
PanAmSat	Boeing Satellite Systems	1996-2000	Merged with Galaxy in 1996 and spun off when Boeing Acquired Hughes
Loral Skynet, Cyberstar, XTAR & Europestar	Space Systems/Loral	1995-present	All under same parent company, Loral Corp.
Eutelsat S.A.	Astrium and Alcatel	Prior 2001	Privatized 7/1/2001

The categorization of satellite contracts for some countries proved to be a challenge as not all contracts in a series of satellites were open to competition. One such

case was Chinasat, which is owned by the Chinese government. In some cases, it chose to build the satellite internally, and in others it chose to partner with a non-Chinese manufacturer. Contracts were considered competitive only if it went to a manufacturer outside of its borders. Another was MTSAT, a series of spacecraft that have both a communication and meteorology payload that is owned by the Japanese government. The first one was competitively awarded to SS/L but the second one went to a Japanese company, Mitsubishi Electronics. It was determined though that as the Japanese government also solicited bids for the second contract with US companies, it was considered to be a competitive bid.

There is also an issue of whether or not to include a contract that was won then cancelled. There are a multitude of reasons of why a contract could be cancelled. However, since this research is looking at a company's chance to win a competition, those contracts that were cancelled after they began and some money had changed hands are included. This includes 12 competitive commercial contracts during the Commerce era and 10 contracts during the recent ITAR era. These contracts are spread among all 5 major satellite manufacturers. These major satellite manufacturers include Boeing Satellite Systems, Lockheed Martin and Space Systems/Loral in the United States, and Alcatel Alenia Space Systems and EADS Astrium in Europe.

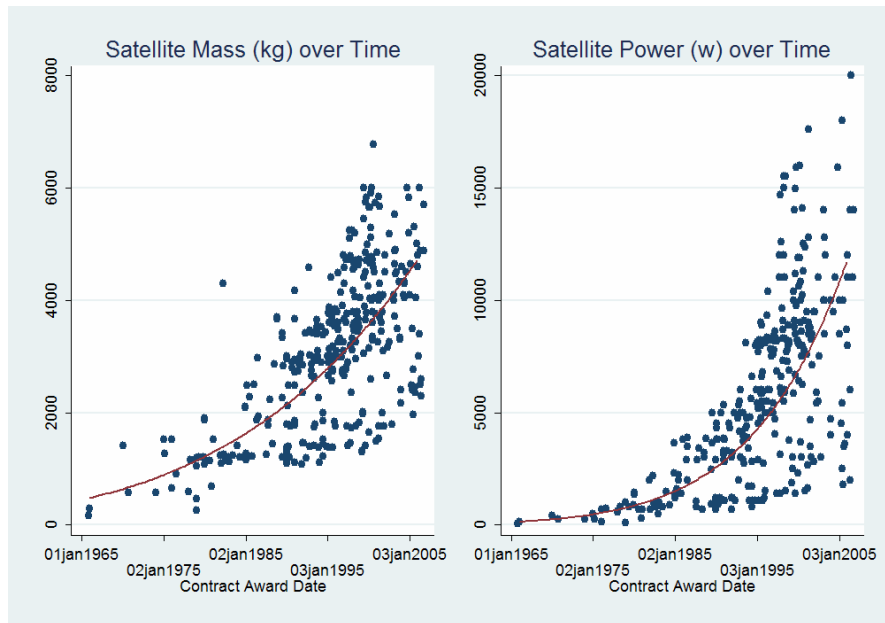
After categorizing the contracts, it was found that 404 contracts were commercially competitive: 162 contracts were from the 1<sup>st</sup> period of export control pre-1992; 111 contracts were from the 2<sup>nd</sup> era of export control under the Commerce department from October 10<sup>th</sup> 1992-Jan 1<sup>st</sup> 1999; and 131 contracts fell under the present era of export control. The difference of 20 contracts can be attributed partially to the fact that there is one year more of ITAR contracts than commerce contracts. Of those taken out of the analysis, Intra-company sales accounted for 116 contracts, 3 contracts were considered replacements due to launch failures, 170 contracts were for the US government, and 289 contracts were for foreign nationals only (165 of which were Russian).

### **Determining Technical Complexity Index**

Technical complexity proved to be the greatest challenge in classifying. Due to the limits of using public data, only mass and power at end of life are considered for technical complexity. Even using public data, not all spacecraft's mass and power was able to be determined. Of the 482 contracts considered commercial satellites, 20 of their mass and 37 of their power statistics could not be determined. Neither the mass nor power statistic could be determined for 12 contracts.

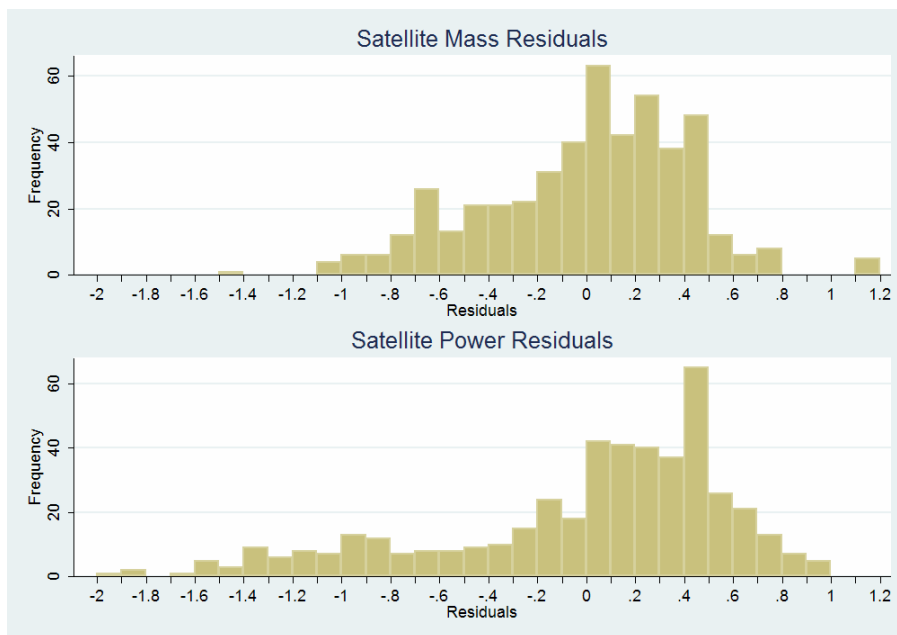
The next issue is that over time, satellites became more massive and powerful and any index created would have to take this into context. So the first step in creating an index involved finding this relationship. To determine this index, both power and mass were plotted over time to determine the type of relation (see Figure 1). To discount any special modification made to commercial buses for government programs, only those that have a value of 0 or 1 for competitiveness were used in determining the relationship. It was determined that the relationship was exponential with a goodness-of-fit  $R^2$  statistic of 0.6206 for mass and 0.7480 for power and both had a p-value of 0.0000.

**Figure 1 - Satellite Mass and Satellite Power over Time with exponential growth lines**



An ln/ln conversion was performed on the two graphs and a regression was performed. This regression gave the baseline for an average satellite for any given period of time. To determine how a satellite related to that baseline, the residuals for each satellite was computed and plotted on a histogram (see Figure 2).

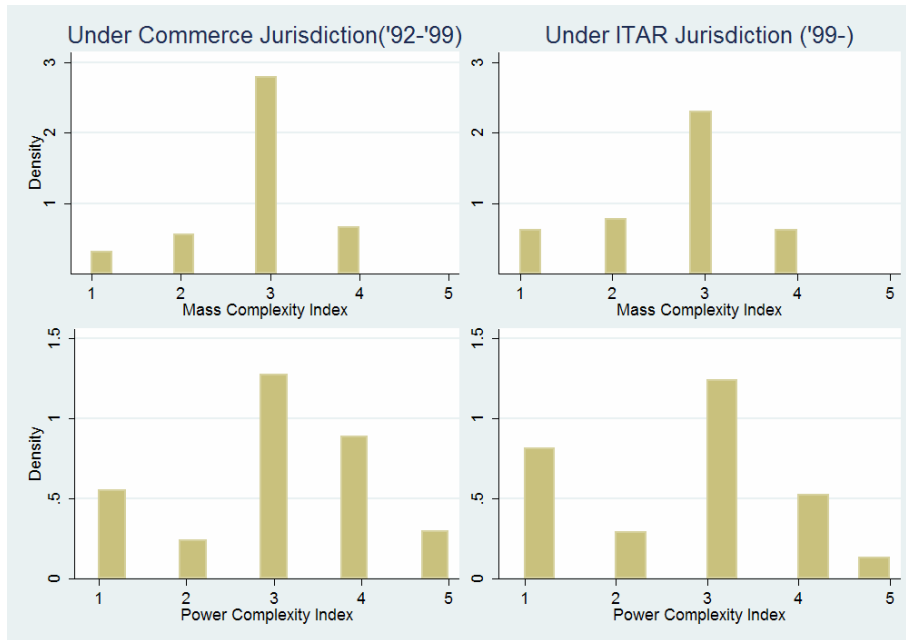
**Figure 2 - Residuals Histograms**



The tail leading off to the left in the histograms is expected as there is a niche market for a small powered satellite bus that is filled by the Boeing 376 bus, the Orbital Sciences Corporation Star bus and other smaller bus manufacturers.

To categorize power and mass into a technical index of 1-5, it was decided that residuals that were  $\pm 0.33$  of the computed mean would be the baseline category 3. Those that fell into the range between 0.33 and 0.66 would be categories 2 (negative residuals) and 4 (positive residuals) and satellites with residuals greater than 0.66 would be category 1 (negative residuals) and 5 (positive residuals). The results can be seen in Figure 3.

**Figure 3 - Power and Mass CI Histogram for Different Export Eras**



The histograms in Figure 3 help illustrate the fact that while the power and mass are related, combining these two indexes into a single technical index would be complex and beyond the scope of this analysis. Additionally, to create a more comprehensive technical index would require more detailed knowledge about the satellite that would include classifying types of payload, thermal requirements, pointing accuracy, and satellite life expectancy to name a few. For the sake of this analysis, the mass complexity index (MCI) and power complexity index (PCI) are thus measured as separate indices.

It is interesting to note that the mass MCI histogram shows that the demand for satellites with a high MCI has declined. All satellites with an MCI of 5 were created prior to 1992. The impact of this lack of demand will be discussed during the cross-tab analysis.

### **Cross Tabulation Analysis**

To gauge the effect of ITAR, three areas are examined separately using a three way cross tabulation analysis: customer's nationality, technical complexity and previous relationship.

To be consistent, all cross tab analyses were conducted with the same format and statistics. Each cell in the cross tab contains the frequency, expected frequency and column percentage. To determine the significance of the association, a chi-squared p-value is used and the Cramer's V statistic was used to determine the strength of the association. For a detailed explanation of cross tabular analysis, see Reynolds [17].

### Customer's Nationality

**Table 3 - Manufacturer and Customer Origins Cross-tab Analysis**

**Commerce Jurisdiction '92-'99**

Manufacturer	Customer		Total
	Dom	For	
<b>Domestic</b>	22.0	65.0	87.0
	18.8	68.2	87.0
	91.7	74.7	78.4
<b>Foreign</b>	2.0	22.0	24.0
	5.2	18.8	24.0
	8.3	25.3	21.6
<b>Total</b>	24.0	87.0	111
	24.0	87.0	111
	100	100	100

Pearson chi2 = 3.1906 P=0.074  
Cramér's V = 0.1695

**ITAR Jurisdiction '99-**

Manufacturer	Customer		Total
	Dom	For	
<b>Domestic</b>	37.0	42.0	79.0
	26.5	52.5	79.0
	84.1	48.3	60.3
<b>Foreign</b>	7.0	45.0	52.0
	17.5	34.5	52.0
	15.9	51.7	39.7
<b>Total</b>	44.0	87.0	131
	44.0	87.0	131
	100	100	100

Pearson chi2 = 15.6583 P=0.000  
Cramér's V = 0.3457

There are several interesting observations that can be made from this cross-tabulation analysis. The first is that the apparent dependence between customer and manufacturer origin has grown more significant (from p=0.074 to P=0.000) and the strength of the association has also grown from being a weak relationship (V=0.1965) to a more moderate-weak or stronger relationship (V=0.3457).

The growth of satellite contracts domestically has helped offset some of the loss of foreign satellite customers. There has been 83% growth in domestic orders, but 25% of this growth has gone to foreign manufacturers. This also does not bode well for domestic manufacturers as this means that the share of the domestic market going to foreign manufacturers has nearly doubled from 8.3% to 15.9%. It is worth noting that ITAR rules are primarily aimed at satellite manufacturers and it is much easier for a U.S. customer to discuss technology issues with foreign manufacturers than is the case for foreign customers to discuss issues with domestic manufacturers.

The total number of foreign customer contracts is the same between the two time periods but there is a drastic change in the distribution between the manufacturers. The amount of foreign customers going to foreign manufacturers has more than doubled. This is troubling as foreign customers account for two-thirds of the satellite contracts. To help explain part of this sudden shift in contracts, an analysis was performed between the customer's country of origin and its relationship to the United States. The results are shown in table 4.

**Table 4 - Customer Origin Relationship with U.S. Cross-tab Analysis**

**Commerce Jurisdiction '92-'99**

Manufacturer	US Relation					Totals
	0	1	2	3	4	
<b>Domestic</b>	22.0	28.0	13.0	20.0	4.0	87.0
	18.8	29.0	10.2	25.1	3.9	87.0
	91.7	75.7	100	62.5	80.0	78.4
<b>Foreign</b>	2.0	9.0	0.0	12.0	1.0	24.0
	5.2	8.0	2.8	6.9	1.1	24.0
	8.3	24.3	0.0	37.5	20.0	21.6
<b>Totals</b>	25.0	37.0	13.0	31.0	5.0	111
	25.0	37.0	13.0	31.0	5.0	111
	100	100	100	100	100	100

Pearson chi2 = 8.6343 P = 0.071

Cramér's V = 0.2789

**ITAR Jurisdiction '99-**

Manufacturer	US Relation					Totals
	0	1	2	3	4	
<b>Domestic</b>	37.0	23.0	10.0	9.0	0.0	79.0
	26.5	27.7	8.4	12.1	4.2	79.0
	84.1	50.0	71.4	45.0	0.0	60.3
<b>Foreign</b>	7.0	23.0	4.0	11.0	7.0	52.0
	17.5	18.3	5.6	7.9	2.8	52.0
	15.9	50.0	28.6	55.0	100	39.7
<b>Totals</b>	44.0	37.0	14.0	20.0	7.0	131
	44.0	37.0	14.0	20.0	7.0	131
	100	100	100	100	100	100

Pearson chi2 = 25.7552 P = 0.000

Cramér's V = 0.4434

The significance of the relationship is the same as before as expected, but what has changed is the strength of the relationship between the customer's country of origin and the United States, going from a moderately-weak relationship (V=0.2789) to a moderate relation (V=0.4434).

Table 4 does provide some interesting insights into how the market share of foreign manufacturers has grown. The first observation is the change in NATO countries growth. Some of this growth can be explained in the reclassification of Eutelsat, S.A. as a private company in 2001. Even though they are no longer a government entity bound to purchase satellites from European countries, the 7 satellites they have ordered since being privatized have all been awarded to European manufacturers.

A second observation is the growth of foreign satellite manufacturers share in group 2. Two of the four contracts are reflective of Mitsubishi Electronic Corporations entering into the commercial sector with the win of MTSAT-2 and its win of the Superbird 7 contract from the Japanese company Satellite Communication Corp. The other two are directly related to ITAR controls as South Korea's government chose to order 2 satellites from European manufacturers instead of United States. A plausible explanation is that each of these contracts had provisions in them for technology transfers to companies within South Korea that are not possible to do under the current ITAR.

The declines in categories 3 and 4 seem to most clearly show the effects of ITAR. As it becomes increasingly harder for those countries to do business with the U.S.

because of ITAR, they choose instead to go toward European manufacturers. Countries with poor relations no longer need to order satellites from the U.S. to fulfill their demand and can instead ordering them Alcatel Space, and Israeli Aircraft Industries. Additionally, the Chinese are now wooing countries with less than cordial relations to the United States like Venezuela for satellite contracts as evidenced by their capture of the VENESAT-1 contract in 2005.

## Technical Complexity

Table 5 – Mass Complexity Index with Manufacturer Cross-tab Analysis

### Commerce Jurisdiction '92-'99

Manufacturer	MCI					Totals
	1	2	3	4	5	
Domestic	6.0	10.0	54.0	17.0	0	87.0
	4.7	11.8	55.6	14.9	0	87.0
	100	66.7	76.1	89.5	0	78.4
Foreign	0.0	5.0	17.0	2.0	0	24.0
	1.3	3.2	15.4	4.1	0	24.0
	0.0	33.3	23.9	10.5	0	21.6
Totals	6.0	15.0	71.0	19.0	0	111
	6.0	15.0	71.0	19.0	0	111
	100	100	100	100	100	100

Pearson chi2 = 4.4754 P = 0.214  
Cramér's V = 0.2008

### ITAR Jurisdiction '99-

Manufacturer	MCI					Totals
	1	2	3	4	5	
Domestic	12.0	9.0	37.0	8.0	0	66.0
	8.3	8.3	40.1	9.4	0	66.0
	85.7	64.3	54.4	50.0	0	58.9
Foreign	2.0	5.0	31.0	8.0	0	46.0
	5.8	5.8	27.9	6.6	0	46.0
	14.3	35.7	45.6	50.0	0	41.1
Totals	14.0	14.0	68.0	16.0	0	112
	14.0	14.0	68.0	16.0	0	112
	100	100	100	100	100	100

Pearson chi2 = 5.4164 P = 0.144  
Cramér's V = 0.2199

As shown in Table 5, Mass is not significantly correlated to the ability of a manufacturer to win a given contract. The reason for this is also reflected in the MCI histogram, all manufacturers are building spacecraft of a similar mass. The reason for this is related to transportation. Rockets are required to place spacecraft into GEO and there has not been a significant reduction in the price per kilo that a rocket can launch into space. If one examines the percentage difference between satellite contracts under the different eras of jurisdiction, there is actually a trend to build satellites with a lower MCI. This is because the cost of space transportation is based off the mass of the payload (satellite).

While the cost of space transportation provides an incentive for companies to buy smaller satellites, the large cost of satellites and the associated costs of transportation provide an incentive to pack as much power into a satellite as possible for it to be able to serve more customers and thus earn more money for the owner. Table 6 examines the supply side of this situation.

**Table 6 – Power Complexity Index with Manufacturer Cross-tab Analysis**

**Commerce Jurisdiction '92-'99**

Manufacturer	PCI					Totals
	1	2	3	4	5	
<b>Domestic</b>	13.0	5.0	24.0	32.0	13.0	87.0
	10.3	6.3	32.4	26.9	11.1	87.0
	100	62.5	58.5	94.1	92.9	79.1
<b>Foreign</b>	0.0	3.0	17.0	2.0	1.0	23.0
	2.7	1.7	8.6	7.1	2.9	23.0
	0.0	37.5	41.5	5.9	7.1	20.9
<b>Totals</b>	13.0	8.0	41.0	34.0	14.0	110
	13.0	8.0	41.0	34.0	14.0	110
	100	100	100	100	100	100

Pearson chi2 = 21.4895 P = 0.000

Cramér's V = 0.4420

**ITAR Jurisdiction '99-**

Manufacturer	PCI					Totals
	1	2	3	4	5	
<b>Domestic</b>	19.0	2.0	21.0	14.0	3.0	59.0
	14.8	4.1	26.6	11.8	1.8	59.0
	76.0	28.6	46.7	70.0	100	59.0
<b>Foreign</b>	6.0	5.0	24.0	6.0	0.0	41.0
	10.3	2.9	18.4	8.2	1.2	41.0
	24.0	71.4	53.3	30.0	0.0	41.0
<b>Totals</b>	25.0	7.0	45.0	20.0	3.0	100
	25.0	7.0	45.0	20.0	3.0	100
	100	100	100	100	100	100

Pearson chi2 = 11.5809 P = 0.021

Cramér's V = 0.3403

While the cross-tab analysis would appear to show a significant correlation that is moderately strong, it violates one of the golden rules of cross-tab analysis in that 80% of the cells in the analysis must have a value greater than 5 for it to be valid. Table 7 addresses this by combining the two eras into a single analysis and indeed there is a significant correlation (P=0.000) that is moderately strong (V=0.3822). By doing this extra step, the statistical relevance of the associations found in table 6 is confirmed.

**Table 7 – PCI with Manufacturer Cross-tab Analysis 1992-present**

Manufacturer	PCI					Totals
	1	2	3	4	5	
<b>Domestic</b>	32.0	7.0	45.0	46.0	16.0	146.0
	26.4	10.4	59.8	37.5	11.8	146.0
	84.2	46.7	52.3	85.2	94.1	69.5
<b>Foreign</b>	6.0	8.0	41.0	8.0	1.0	64.0
	11.6	4.6	26.2	16.5	5.2	64.0
	15.8	53.3	47.7	14.8	5.9	30.5
<b>Totals</b>	38.0	15.0	86.0	54.0	17.0	210
	38.0	15.0	86.0	54.0	17.0	210
	100	100	100	100	100	100

Pearson chi2 = 30.6765 P = 0.000

Cramér's V = 0.3822

What can be clearly seen from this analysis is that the U.S. manufacturing sector still retains a clear dominance in satellites with a high PCI factor. However as table 6 shows, that dominance is being eroded as foreign manufacturers are beginning to build more satellites with a PCI of 4.

To gain a complete understanding of the effects of PCI, an analysis of the demand side of the equation was also performed in table 8. As with the analysis of the manufacturers, the customer analysis also violated the 80% rule so the solution was the same as demand and the results are shown in table 9.

**Table 8 – Power Complexity Index with Customer Demand Cross-tab Analysis**

**Commerce Jurisdiction '92-'99**

Customer	PCI					Totals
	1	2	3	4	5	
<b>Domestic</b>	0.0	1.0	1.0	13.0	8.0	23.0
	2.7	1.7	8.6	7.1	2.9	23.0
	0.0	12.5	2.4	38.2	57.1	20.9
<b>Foreign</b>	13.0	7.0	40.0	21.0	6.0	87.0
	10.3	6.3	32.4	26.9	11.1	87.0
	100	87.5	97.6	61.8	42.9	79.1
<b>Totals</b>	13.0	8.0	41.0	34.0	14.0	110
	13.0	8.0	41.0	34.0	14.0	110
	100	100	100	100	100	100

Pearson chi2 = 29.5233 P = 0.000

Cramér's V = 0.5181

**ITAR Jurisdiction '99-**

Customer	PCI					Totals
	1	2	3	4	5	
<b>Domestic</b>	9.0	0.0	13.0	12.0	0.0	34.0
	8.5	2.4	15.3	6.8	1.0	34.0
	36.0	0.0	28.9	60.0	0.0	34.0
<b>Foreign</b>	16.0	7.0	32.0	8.0	3.0	66.0
	16.5	4.6	29.7	13.2	2.0	66.0
	64.0	100	71.1	40.0	100	66.0
<b>Totals</b>	25.0	7.0	45.0	20.0	3.0	100
	25.0	7.0	45.0	20.0	3.0	100
	100	100	100	100	100	100

Pearson chi2 = 11.7449 P = 0.019

Cramér's V = 0.4434

**Table 9 – PCI with Customer Demand Cross-tab Analysis 1992-present**

Customer	PCI					Totals
	1	2	3	4	5	
<b>Domestic</b>	9.0	1.0	14.0	25.0	8.0	57.0
	10.3	4.1	23.3	14.7	4.6	57.0
	23.7	6.7	16.3	46.3	47.1	27.1
<b>Foreign</b>	29.0	14.0	72.0	29.0	9.0	153.0
	27.7	10.9	62.7	39.3	12.4	153.0
	76.3	93.3	83.7	53.7	52.9	72.9
<b>Totals</b>	38.0	15.0	86.0	54.0	17.0	210
	38.0	15.0	86.0	54.0	17.0	210
	100	100	100	100	100	100

Pearson chi2 = 30.6765 P = 0.000

Cramér's V = 0.3822

As seen in table 9, there is a significant correlation ( $p=0.000$ ) between customer origin and PCI, and that the strength of the relationship is moderate (0.3822). This analysis motivates a few observations. The first is that while domestic customers have in the past demanded satellites with a high PCI, this demand has lessened and has become surpassed by foreign customers during the ITAR era. The second is that foreign customers are now driving the demand for high-end satellites with a PCI of 5. The last observation is that the majority of foreign customer demand is for mid-low end PCI satellites which any manufacturer can provide. While it would have been interesting to also do this analysis on U.S.-customer relations, the distribution of contracts among categories was not significant enough to support this analysis.

## The Effect of Previous Relations

**Table 10 - Manufacturer and Previous Relation Cross-tab Analysis**

Commerce Jurisdiction '92-'99				ITAR Jurisdiction '99-			
Manufacturer	Prev. Relation		Total	Manufacturer	Prev. Relation		Total
	No	Yes			No	Yes	
<b>Domestic</b>	32.0	55.0	87.0	28.0	51.0	79.0	
	35.3	51.7	87.0	27.1	51.9	79.0	
	71.1	83.3	78.4	62.2	59.3	60.3	
<b>Foreign</b>	13.0	11.0	24.0	17.0	35.0	52.0	
	9.7	14.3	24.0	17.9	34.1	52.0	
	28.9	16.7	21.6	37.8	40.7	39.7	
<b>Total</b>	45.0	66.0	111	45.0	86.0	131	
	45.0	66.0	111	45.0	86.0	131	
	100	100	100	100	100	100	

Pearson chi2 = 2.3586 P=0.125  
Cramér's V = -0.1458

Pearson chi2 = 0.2053 P=0.746  
Cramér's V = 0.0283

**Table 11 - Effects of Previous Relationship pre-1992**

Pre-1992 State Control			
Manufacturer	Prev. Relation		Total
	No	Yes	
<b>Domestic</b>	35.0	113.0	148.0
	38.4	109.6	148.0
	83.3	94.2	91.36
<b>Foreign</b>	7.0	7.0	14.0
	3.6	10.4	14.0
	16.7	5.8	8.6
<b>Total</b>	42	120	162
	42	120	162
	100	100	100

Pearson chi2 = 4.6247 P=0.032  
Cramér's V = -0.1690

The effect of previous relationship has become increasingly insignificant over time. To illustrate this, a cross-tab was performed on contracts pre-1992 and a significant correlation was found during that time period due in large part that there was no significant competition at that time. This shows that it reflects a pattern that no customer

is truly captured anymore and each contract is becoming increasingly competitive, which would seem to show some support for the third hypothesis. It also shows that there is no one dominant player in the field and that foreign manufacturers are just as able to win a competitive bid as domestic manufacturers are.

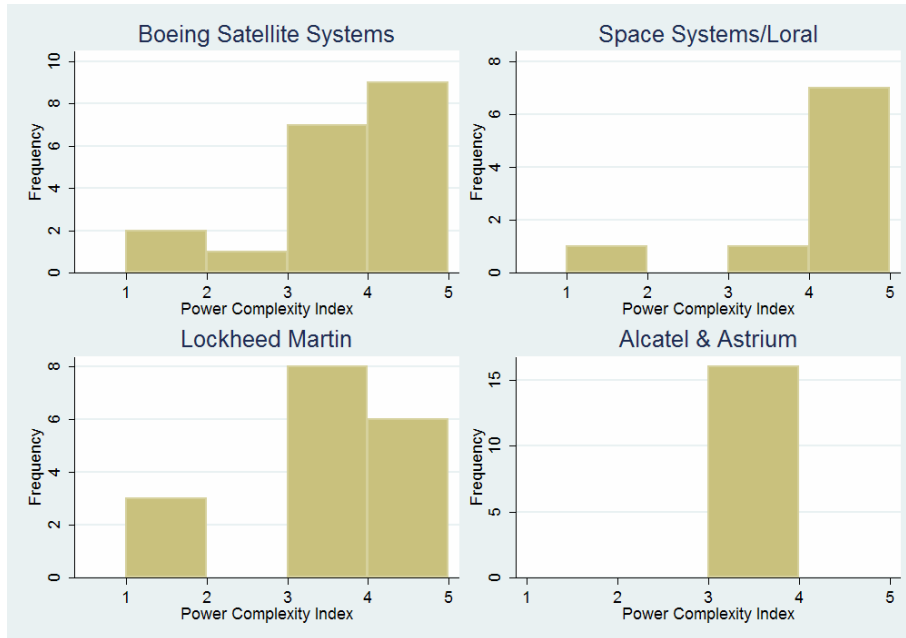
## **Discussion**

In analyzing the data another observation was made in looking at companies that use to be sister companies to manufacturers but are no longer. As discussed in the section “Determining Competitive Bid Status”, many of these sister companies were spun off around the turn of the century. This has had several effects.

The first is that the manufacturers who lost their sister company no longer have a captured customer and now have to compete openly for that award. This has had varying results. For Europeans, even though Eutelsat is no longer bound to award all contracts to European manufacturers, it has continued to do so. For Lockheed, this has meant that they had to competitively go after each contract put out by SES Americom. This is reflected in that they have only won 4 out of the 6 contracts put out by SES Americom since Americom became independent. Perhaps the most startling of all is what happened to Boeing Space Systems. Since PanAmSat was sold, not a single contract out of the 7 orders has been awarded to Boeing. In 2006, PanAmSat and Intelsat merged and if this new company continues that trend, the effects would be harmful to Boeing. DirecTV was also following this trend until they were purchased by News Corp in 2004 and the new management decided to add the 3 satellites that News Corp had previously been negotiating with Boeing to its new subsidiary DirecTV.

The second effect is that manufacturers no longer have a captured satellite operator that they can use to showcase more complex satellites. This is more often the case in the U.S. than in Europe as can be seen in Figure 4 by noting the large number of satellites ordered that have a PCI of 4.

**Figure 4 - PCI histogram of satellite contracts made by intra-company sales (1992-present)**



Another concern facing future competition will be the emergence of the AlphaBus. The AlphaBus is being developed jointly by Astrium and Alcatel Space will compete in the 12-18kw range and is being subsidized by both the European and French Space Agencies [18]. This new bus will directly compete with the U.S. manufacturer’s satellites that have a PCI of 5, the last area in which domestic manufacturers are dominant. Coupled with the fact that the demand for these spacecraft are increasingly coming from foreign companies and that buses this powerful fall under the most tight of ITAR restrictions, it is likely that if AlphaBus is successfully launched, it will take this market share away from domestic manufacturers.

The last area of concern that is affecting the satellite manufacturing market place is a combination of the privatization and the consolidation of the satellite operators. In the past 5 years, all satellite operators have become private companies and they have begun to consolidate. The two largest consolidations occurred when SES purchased Americom and Intelsat purchased PanAmSat. The long term effect of this consolidation and privatization has yet to be realized but already the effects have been felt as both SES and Intelsat have cancelled orders put out to manufacturers as they come to terms with their new organization structure.

## Conclusions

This research has shown that there is a significant correlation between the country of origin of satellite customers and the ability of a domestic manufacturer’s ability to win a given contract. It has provided evidence that supports the first two hypotheses that during the era of Commerce export jurisdiction, the domestic manufacturers were able to maintain a significant lead in the market place and that after the move to ITAR, there was a large decline in this lead as competitiveness of foreign providers grew. It has shown some support for the third hypothesis in that the significance of previous relations is

increasingly become irrelevant. The research has shown the link between the technical capabilities of company and its ability to win both domestic and foreign contracts. It has also shown that the difference in technical capabilities between domestic and foreign manufacturers has lessened considerably during the era of ITAR controls. These two facts combine to show support for the fourth hypothesis. As this lead has evaporated, the need for foreign manufacturers to subject themselves to ITAR has also lessened. This helps provide even more evidence to support the two hypotheses.

## **Policy Implications**

The policy implications of this research are that ITAR controls not only have not worked in stopping the proliferation of satellite technology, but that it has had the effect of driving increased competitiveness on the part of foreign competitors that have achieved an advantage in this highly competitive market place.

Zaphiriou (1992) created a “litmus test” that can be used to determine whether to impose more stringent export policies. He argued that strategic limitations imposed on technology transfer depend on: 1) evaluation of the importance of the technological information on national security, 2) On whether it is already known outside the United States, 3) On whether it will in any event be known within a short period of time, and 4) on the effect of the limitation on the United States economy. As can be seen from the analyses performed in this paper, commercial space manufacturing would not fit within his category as a technology that would require more stringent export policies.

To summarize, the controls have been too broadly applied and are now causing domestic manufacturers to lose not only their market lead, but their technical lead as well. These controls need to be modified and the only way they can be changed is through either congressional action or a presidential executive order. The longer it takes for this issue to be addressed, the further the market share will decline for domestic manufacturers.

## **Future Research**

This research focused on contract won and did not look at performance on the contract and the effect this has had on future contracts. For instance, were there any problems with ITAR on the actual implementation of a contract? In some cases, this will be obvious as ITAR is the primary reason that Chinasat 8 built by SS/L has yet to be delivered to China even though it was completed in 2001. In other cases it may be less obvious as many contracts with foreign government have provisions for the transfer of technology to their own local industries to supply components for the contract. There were also a number of contracts that were cancelled after awarded, how many of those contracts were cancelled because of ITAR issues or just because of poor business plans?

Each loss of a contract to a domestic manufacturer has a ripple effect through the economy. This provides another area that needs to be looked at which is the impact of ITAR on the second and third tier of manufacturers who build the components that make up a satellite system. It was brought up at the October meeting of the Federal Aviation Administrations bi-annual COMSTAC that this issue has been taken up by the Defense Science Board at the Department of Defense.

There are also other factors that need to be studied to determine their effects on the competitive satellite market place. Some examples include the rash of on orbit failures in the early 2000s and its effect on the price of insuring certain manufacturers' satellites like the Boeing 702, the effect of nation-to-nation talks in securing contracts for manufacturers within their own borders and the effect of vendor financing in winning contracts. This list is not exhaustive but hopes only to show the variety of other factors that can have an effect on competitively winning a contract.

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