2013 U.S. Propulsion Industrial Base Health Metrics Survey Preliminary Results

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Over the past few decades, as the number of propulsion systems development programs have declined, there has been an adverse effect on the health of the propulsion industrial base of the United States and its ability to develop new propulsion systems for civil, military and commercial uses. While there have been many studies documenting these effects, the US government needs a method to track the overall health of the industrial base over time. The National Institute for Rocket Propulsion Systems (NIRPS) recently conducted an Industrial Base Health Metrics Survey to track the health of the US propulsion industrial base over time. The data collected will allow NIRPS to develop "critical indicators" that will be used to predict the possible effects of policy decisions made by the Government. Additionally, the data will be used to inform senior leadership within the Government regarding decisions on policy, propulsion technology development and acquisitions. This paper will provide the preliminary data and analysis of the 2013 Propulsion Industrial Base Health Metrics Survey conducted by NIRPS.

I. Introduction

The propulsion industrial base is a crucial capability to the United States for national security, scientific research, human exploration, and economic growth and development. Over the past decade, numerous studies have pointed out the challenges facing the United States rocket propulsion industrial base (URSPIB) and highlighted the need for the Nation to maintain a viable propulsion industrial base. These studies were analyzed and implications of the increasing challenges to the USRPIB were summarized in a previous paper by the authors[1].

Propulsion enables access to space for defense and intelligence purposes as well as for human exploration, earth observation, weather and space weather forecasting, communications and navigation, and numerous other uses. Propulsion also provides the DoD the means to deliver payloads to targets for both strategic and tactical purposes. The loss of these critical technologies would have a seriously adverse effect on U.S. defense capabilities, space exploration potential, and economic health.

In order to develop national policies to include mitigation and development strategies that will preserve the USRPIB, policy makers, government and industry executive and academic leaders must first understand the current state of the health of the USRPIB and any imminent trends and demands on the industry.

The National Institute of Rocket Propulsion Systems (NIRPS) developed a preliminary set of metrics to be used to determine the health of the USRPIB and implemented a program to collect and analyze data on this subject. This paper will explain the development of the health metrics, as well as the associated survey (see Appendix), and will present preliminary results. It will also discuss the gaps in the data and data collection methods and the prudent next steps in this effort to determine the current health of the USRPIB to inform policy and decision makers.

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II. Background

Over the course of the last four decades the number of active rocket engine developments steadily decreased, with small peaks when a new system was developed, as shown in Figures 1 and 2. The charts illustrate that the number of development programs, in both solid and liquid fueled propulsion systems, have faced a steady decline since the dawn of the space age.

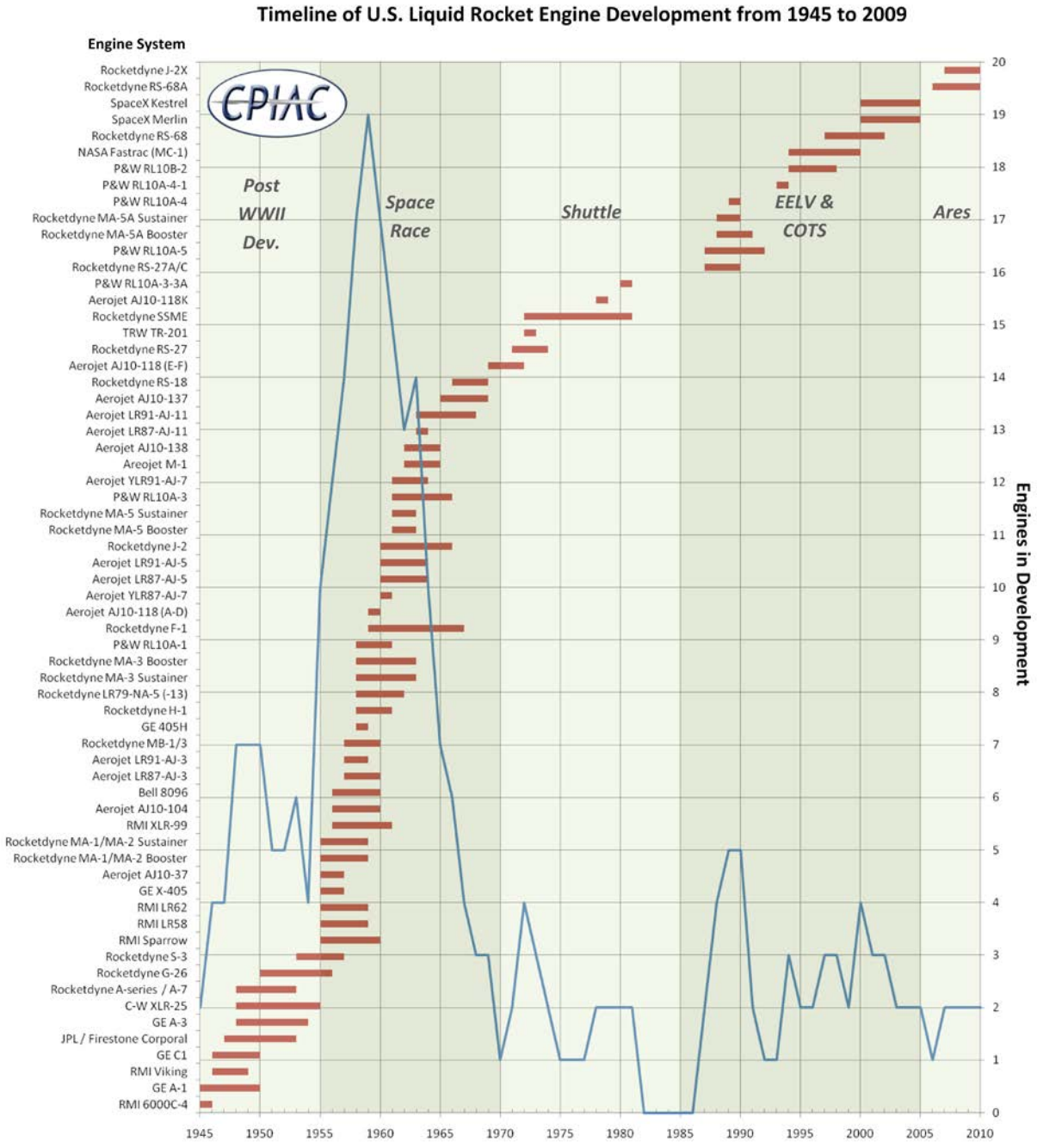

Figure 1. Rocket engine development 1945-2009[2].

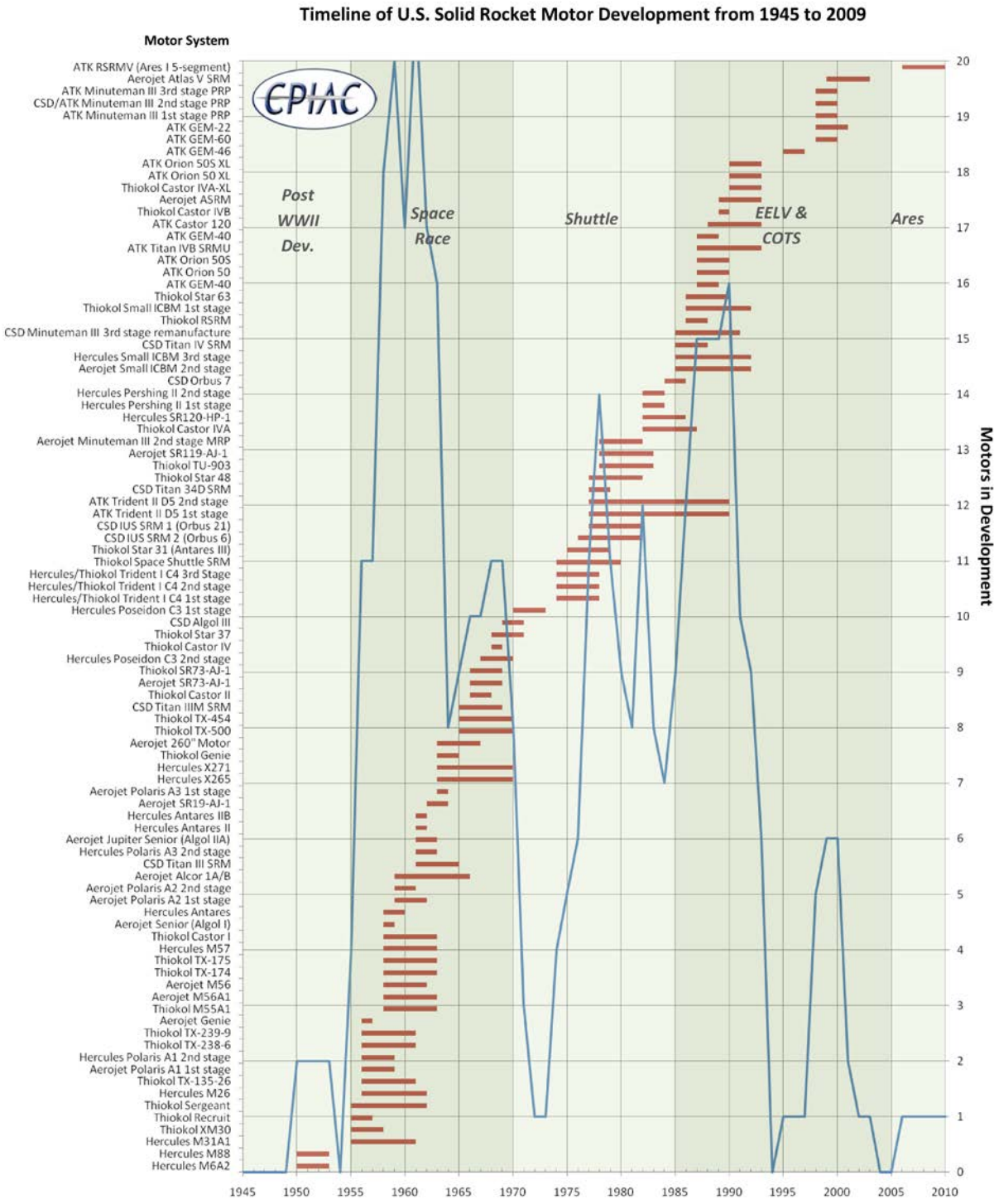

Figure 2. Solid rocket motor development 1945-2009[3]

[3] SRM development chart was derived by CPIAC as a response to the CPIAC journal article in reference 2.

While some of this decline in development is expected as the industry matures from inventing new technology to a steady production state and mature field, it also illustrates the absence of many new programs in both the government and commercial propulsion sectors. The decline of new development programs leads to a propulsion industrial base that may not have experience in developing a propulsion system throughout the life cycle, from concept development through design, manufacturing, and regular operations. This lack of experience and capability is of particular concern at this time, when customers, both government and commercial, are demanding greater reliability, higher performance, and reduced costs from the propulsion industrial base. Using mature systems will not significantly improve performance or cost; new rocket engines must eventually be developed. In addition, the retirement of the Space Shuttle and the transition of the Constellation Program have left the United States without a human rated launch system, and addition propulsion development will be needed to meet human launch requirement to beyond low earth orbit (LEO) destinations.

III. Survey Development

NIRPS is a multi-sector, multi-agency organization that seeks to address the competiveness of the USRPIB and is focused on responding to six "Grand Challenges" facing the propulsion community in the United States. The Grand Challenges are identified as:

1) Reduce development and sustainment costs for missile and rocket systems
2) Support the competitiveness and resilience of the industrial base
3) Foster access to facilities and expertise across government, industry, and academia
4) Develop and implement an integrated science and technology plan for propulsion systems
5) Invigorate the Science, Technology, Engineering and Mathematics (STEM) pipeline
6) Collaborate across agencies for missile and rocket propulsion system development.

Addressing the Grand Challenges (GC) will enhance the competiveness and responsiveness of the entire propulsion community in the United States. A key first step in addressing all of the GCs, particularly GCs 2 and 5 is to determine the current state of the propulsion industrial base in the United States and to develop metrics to track the USRPIB health. A defined set of USRPIB heath metrics will allow decision and policy makers to measure the effectiveness of their actions over time. Defining and tracking the USRPIB health metrics is a high priority goal for NIRPS for FY13.

A. Definition

In order to properly gauge the health of the USRPIB, we needed a definition that was encompassing of all of the activities needed to design, develop and field propulsion systems. This includes human capital (engineering and skilled labor) as well as design, test and production facilities. The definition we used for this survey activity is shown below:

> *The term "rocket propulsion industrial base" (RPIB) refers to the nation's capability to conceive, design, develop, manufacture, test, and support missions using liquid rocket engines and solid rocket motors that are critical to its national security, economic health and growth, and future scientific needs. The RPIB encompasses US government, academic, and commercial (including industry primes and their supplier base) research, development, test, evaluation, and manufacturing capabilities and facilities. The RPIB includes the skilled workforce, related intellectual property, engineering and support services, and supply chain operations and management. This definition touches the five main segments of the U.S. RPIB as categorized by the USG: defense, intelligence community, civil government, academia, and commercial sector.*

B. Metric Development

Recent efforts from other organizations attempted to characterize parts of the Aerospace or Spaceflight Industrial base. In 2010 NASA commissioned the Department of Commerce to conduct a Human Spaceflight Survey. This

survey endeavored to characterize the industrial capability needed to continue to execute NASA's Human Spaceflight Mission. In 2012, NASA and the Department of Defense jointly sponsored the US Space Industry "Deep Dive" Survey, which was completed in 2013. These studies were exhaustive and required significant resources to complete and therefore would be impractical to administer on a yearly basis. In addition, these surveys are not narrowly focused on propulsion and require a great deal of data analysis to glean actionable data about the USRPIB.

A small team consisting of representatives from NASA, the Department of Defense, industry and academic representatives developed the metrics and the survey instrument to determine the health of the USRPIB. The academic community concluded that, due to the special and limited role of by academia in the propulsion field, separate metrics are required to determine the effects of academia on the health of the USRPIB. These separate metrics for academia are being developed and validated by an academic task force.

While the team to determine the USRPIB health metrics was small, the government representatives included experts in manned and unmanned space flight as well as tactical and strategic defense systems. Industry representatives from propulsion systems developers, systems integrators, as well as component and materials suppliers were also included as members of the team. The goals of the team were simple and as follows:

1) Develop metrics that are a good indicators of the state of health of the propulsion industrial base
2) Minimize burden on respondents to the survey
3) Understand the dependence of non US suppliers for critical items
4) Understand any "at-risk" or single source suppliers

The team decided, after much deliberation, to focus on three broad areas that would allow for the determination of the USRPIB health. These three focus areas were:

1) Human Capital
2) Production, Research and Sales (PR&S)
3) Supply Chain.

1. Human Capital Metrics

The decline of the overall technical and engineering workforce in the United States from a demographic standpoint has been well documented. The Nation's engineering workforce is aging and not enough new employees are replacing them. The following questions were designed to look at the age and experience profile of current employees in the USRPIB as well as their current level of education. Developing, manufacturing and fielding rocket propulsion systems requires skilled labor, in addition to science and engineering staff, and attempted to collect this data as well. The Human Capital questions of the USRPIB survey are below

> *Please provide a breakdown of number of degreed* (broken out by BS, MS and PhD) *and number of non-degreed STEM (Science, Technical Engineering and Mathematics) employees for Rocket Propulsion Systems (RPS) versus years of experience, in 5 year increments, as of 1 October 2002, 2007, and 2012. Please provide age demographics as well.*
>
> *a. Average number of job offers from your company or organization received and accepted by STEM graduates for RPS positions*
>
> *b. Retention rates for STEM hires (years of service) of record 1 October 2002 and 2007*

2. Production, Research and Sales Metrics (PR&S)

The team worked through numerous potential survey questions regarding Production, Research and Sales Metrics (PR&S) in the USRPIB. Ultimately the team objective was to define metrics that would give useful information, which could be easily understood by decision makers who may not be familiar with the USRPIB. The team determined that propellant produced for production and development motors, or for liquid engine systems gave a good indication of the field utilization of propulsion systems. Additionally, the number of production and development motors and engines produced signaled the capacity utilization and production capability of the USRPIB. The amount of research and development funding, both internal to the company/organizations and externally funded, was a good leading indication of potential future programs and production activity. The team also asked for overall rocket propulsion systems sales and number of live fire tests. The PR&S question portion of the survey included:

For the periods Government Fiscal Year (1OCT- 31SEPT) GFY02, GFY07 and GFY12, please provide:

a. *The number of rocket engine/motor live fire tests conducted, broken down by liquid, solid, or other.*
b. *Total pounds of solid propellant or storable liquids or cryogenics produced for use development programs (including Independent Research and Development (IR&D))*
c. *Total pounds of solid propellant or storable liquids or cryogenics produced for production motors.*
d. *Number of Development motors or Liquid Rocket Engines (LREs) produced.*
e. *Number of production motors or LREs delivered.*
f. *The IR&D (in $'s) devoted to RPS by your company or organization.*
g. *IR&D devoted to Rocket Propulsion Systems (RPS) as a % of total sales.*
h. *The externally funded R&D value (in $'s) for RPS for your organization.*
i. *Total RPS sales ($M)*

3. Supply Chain

The health of the entire supply chain, including the lower tiers, is also a critical factor in determining the health of an industry. The retirement of the Space Shuttle, transition of NASA's Constellation program, and other changes in demand for rocket propulsion system items from the federal government has led to anecdotal evidence of numerous lower tier (component and material) suppliers either going out of business or discontinuing the production of components for rocket propulsion system applications. Additional anecdotal evidence points to the need for single source or foreign source suppliers for critical items. The team designed the following questions to quantify this supply chain challenge to the health of the USRPIB:

Do you have an active supply chain management system in place for your lower-tier RPS vendors (tier 2 and 3, not just first level suppliers)?

a. *How many sole or single source suppliers did/do you have for GFY 2002, 2007, and 2012? Of these, how many are US and how many are non-US? If non-US, please identify country.*
b. *Identify the percentage of non-US components used in your RPS products (treat each part, ingredient, circuit board, etc. equally as a single component).*
c. *For the years GFY2002, 2007, and 2012, how many sub-tier suppliers left the market? How many entered the market? How many re-qualifications occurred because of a supplier change or process change? Provide data for your company or organization only.*
d. *Are your production capabilities dependent on a stockpile of material? If so, what stockpiled material? Are there plans to develop a capability to produce the material?*
e. *How dependent is your sub-tier supply base on revenues from the rocket propulsion market? Identify vendors where RPS revenues are >50% of their revenue portfolio.*

If data is not available for any of these, please indicate what's missing.

The questions in the survey represent *proposed* USRPIB health metrics. Because this type of data and metric development had never been done before for the USRPIB, the team determined that an analysis of preliminary survey results was necessary to determine the quality of the metrics, or there would even be enough available data to decide which of these items would make suitable long-term metrics.

C. Other Concerns

The process of building the survey and proposed metrics yielded several concerns among the team. The first of these was protecting the proprietary nature of the data and ensuring the trust of our respondents. Industry was well represented on the team and helped us determine how to develop useful metrics, while respecting the sensitivity of the data. We took several steps in ensuring the protection of the data:

1) The proprietary data was and is only accessible to U.S. Government Civil Servants
2) Data was submitted in an encrypted manner to the authors of the paper or hand delivered as hard copy
3) The data was normalized to GFY2002, and all data was plotted relative to the base year

The almost constant consolidation of the aerospace industry and of propulsion related suppliers left the current industry with a limited ability to access legacy data from older entities. This led the team to limit data collection to the beginning of the decade.

IV. Survey Distribution and Responses

The team decided to publish the survey as a "Request for Information" (RFI) using the resources of the NASA Procurement Office. An RFI allows the Government to solicit information without committing to any procurement actions. The RFI was chosen to give any and all interested parties a chance to respond to the survey and to help NIRPS develop these important health metrics. As a normal part of the process the questions were published on the Federal Business Opportunities (FedBizOpps) website. The NIRPS team also publicized this effort at team meetings and outreach events.

The response to the survey was limited, but did include a representative cross-section of U.S. Government, established propulsion systems developers, component and material suppliers, and system integrators. As stated previously, a separate future effort is planned for academic institutions.

D. Survey Results

As stated previously, the team combined the raw data and normalized it to the GFY2002 data. The following graphs represent respondent data the team considered reliable. Some data was excluded due to unexplained inconsistency from year-to-year, low sample size, or known gaps in the data response. The team determined that the key indicators of USRPIB health are the trend of the metric, not the raw data numbers.

E. Human Capital

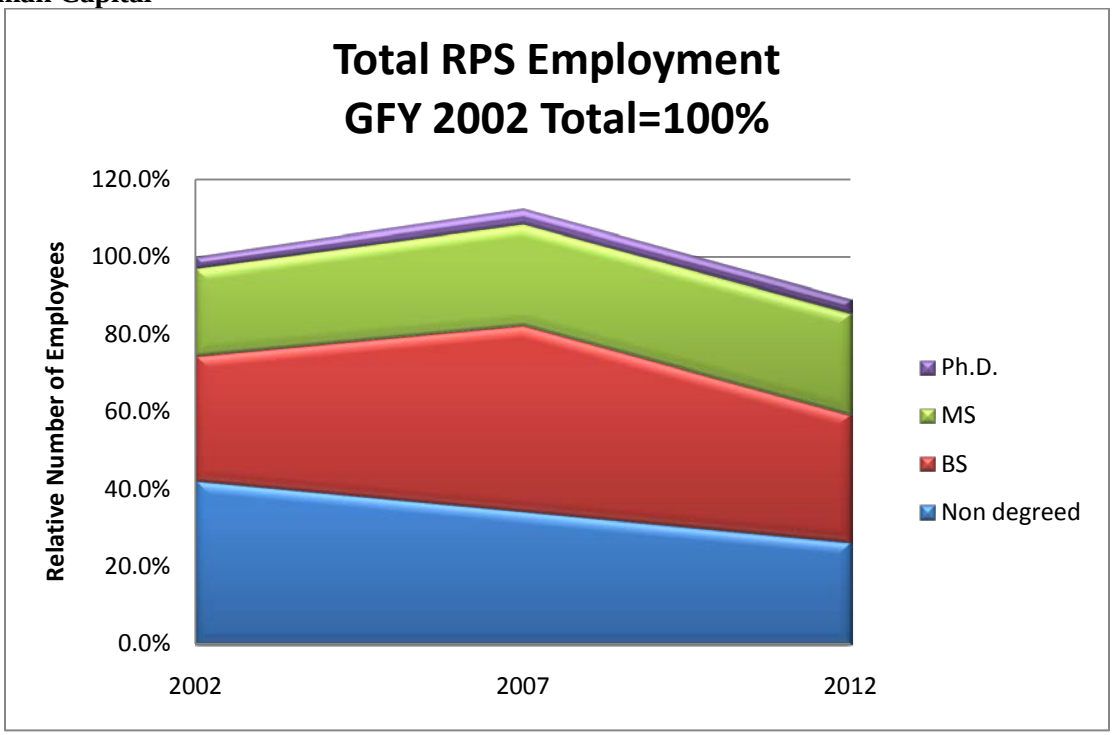

Figure 3. Total RPS employment relative to base year.

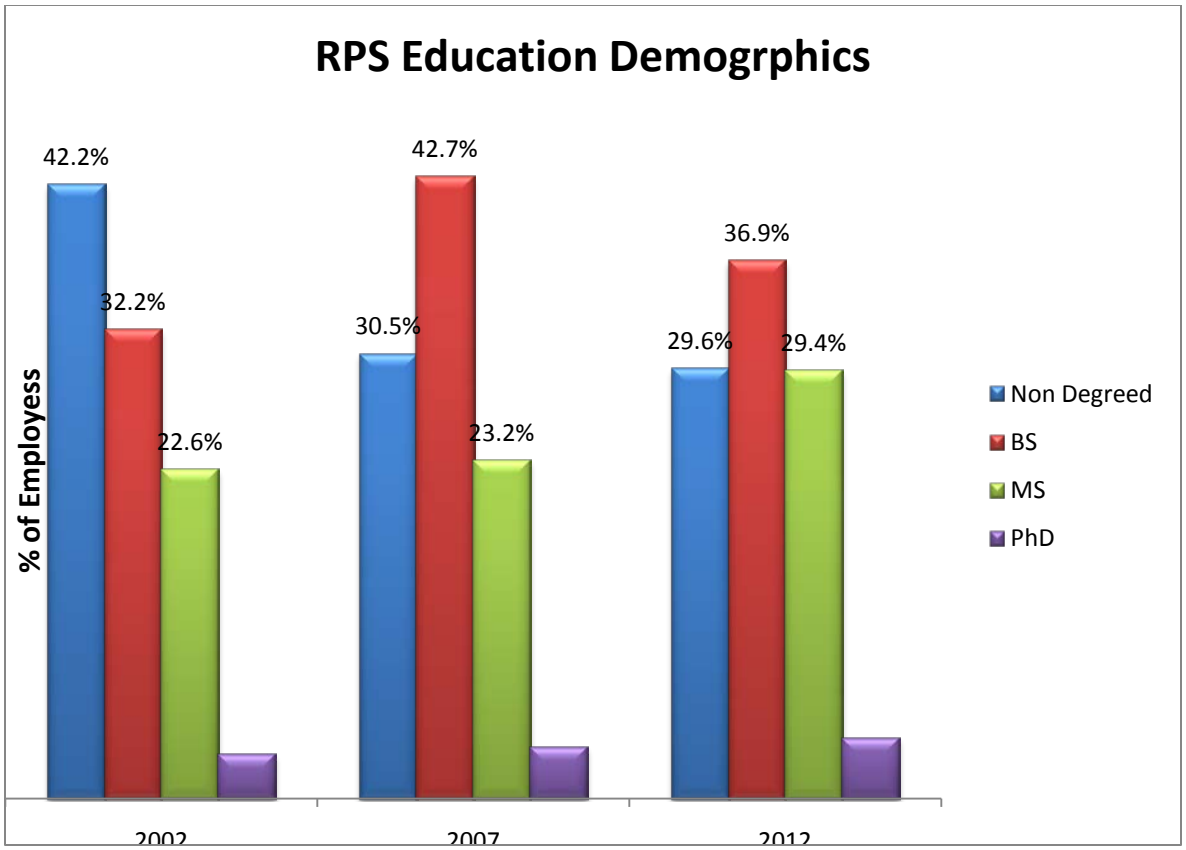

Figure 4. Education demographics of the work force over the survey period.

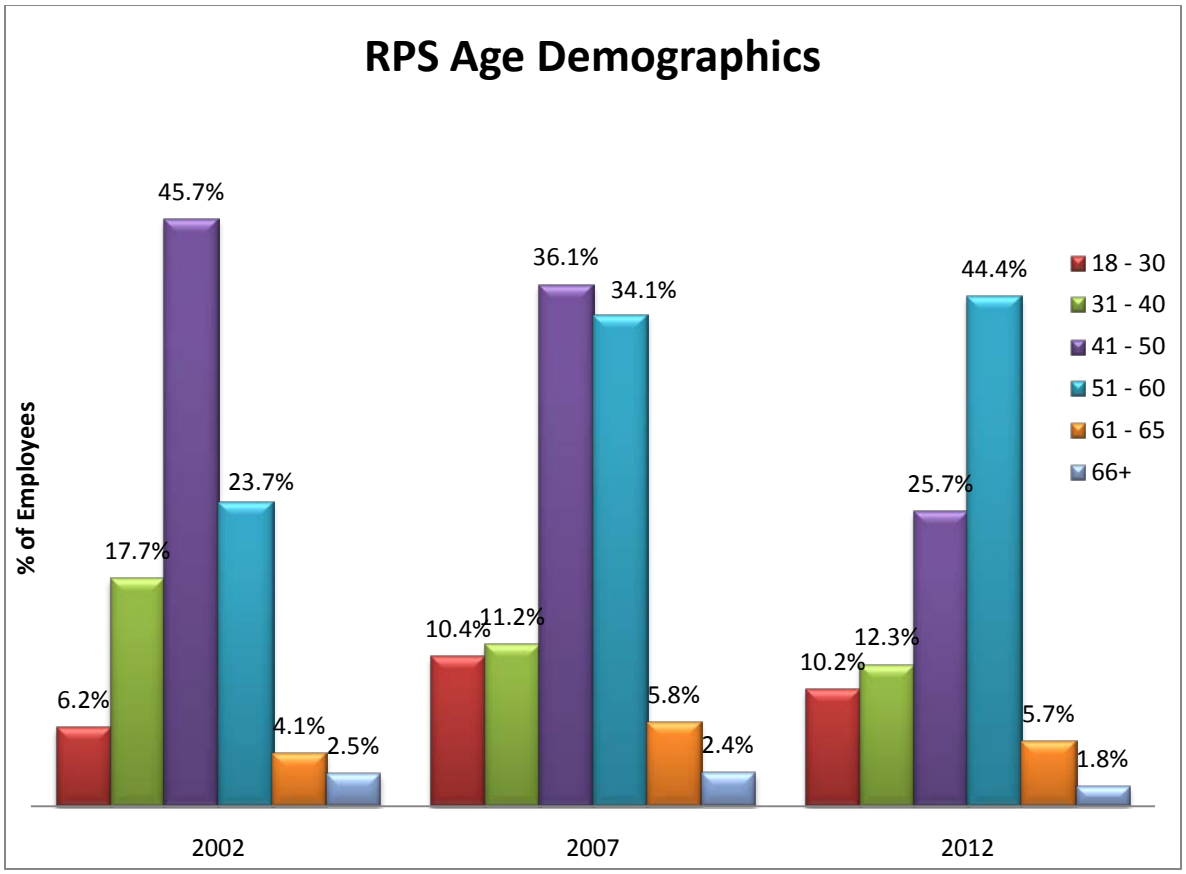

Figure 5. RPS work force age distribution over the survey period.

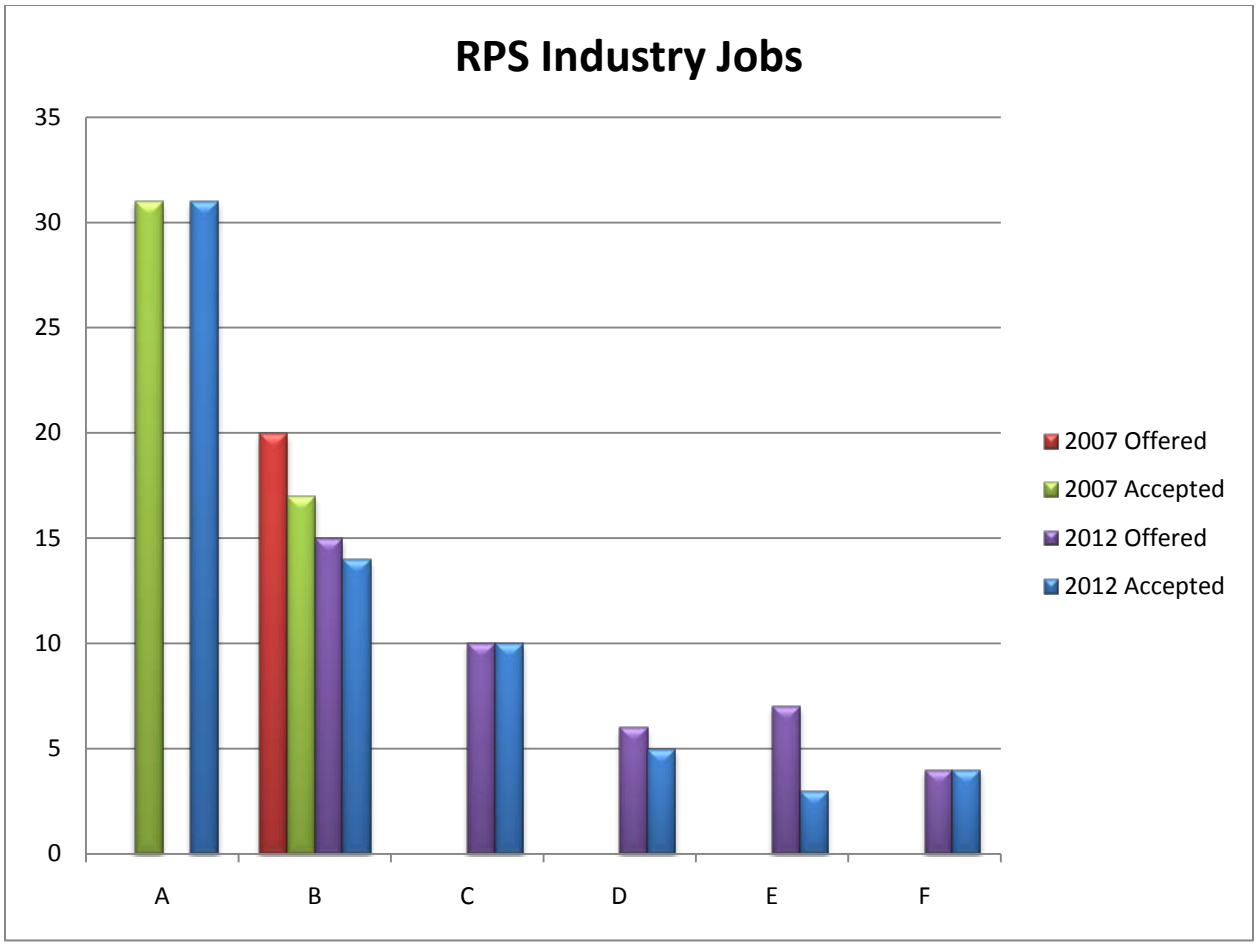

Figure 6. Job Offers and Acceptances.

The Human Capital survey results show a peak in employment in GFY 2007 and a significant drop off by GFY 2012. This time period corresponds with the retirement of the Space Shuttle and the transition of the Constellation program to the Space Launch System (SLS) launch vehicle development. The overall launch rate for Shuttle Evolved Expendable Launch Vehicles (EELV) and other U.S. launch vehicles is show in Figure 7 below. The Human Capital data also show the aging of the workforce, with GFY 2012 data exposing that over half of the RPS workforce is over 50 years of age and that hiring in the younger age brackets has fallen off in recent years. This situation means that much of the workforce with expertise in the complete life cycle of a rocket propulsion development program, from conceptual design to operation, is "retirement eligible". Unless ways to pass on this knowledge to the younger workforce are made a priority, developing a new RPS system will likely be more difficult and resource intensive in the U.S., than currently. Limited data regarding job offers and acceptances, shown in Figure 6 is inconclusive in determining a trend for the workforce. None of respondents provided data on employee retention rates.

This Human Capital data also shows the number of non-degreed RPS workers steadily decreasing. Because these are more apt to be production workers and skilled labor, this decline is likely attributable to lower production rates overall and improvements to efficiency at production sites.

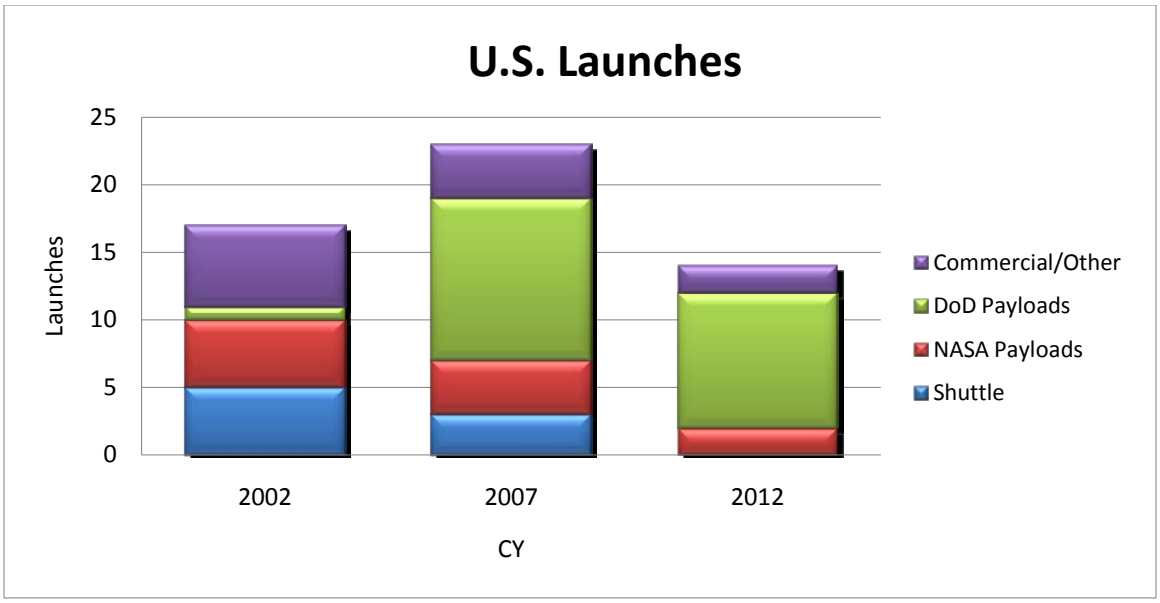

Figure 7. US launch rates over the survey period

F. Production Research and Sales (PR&S)

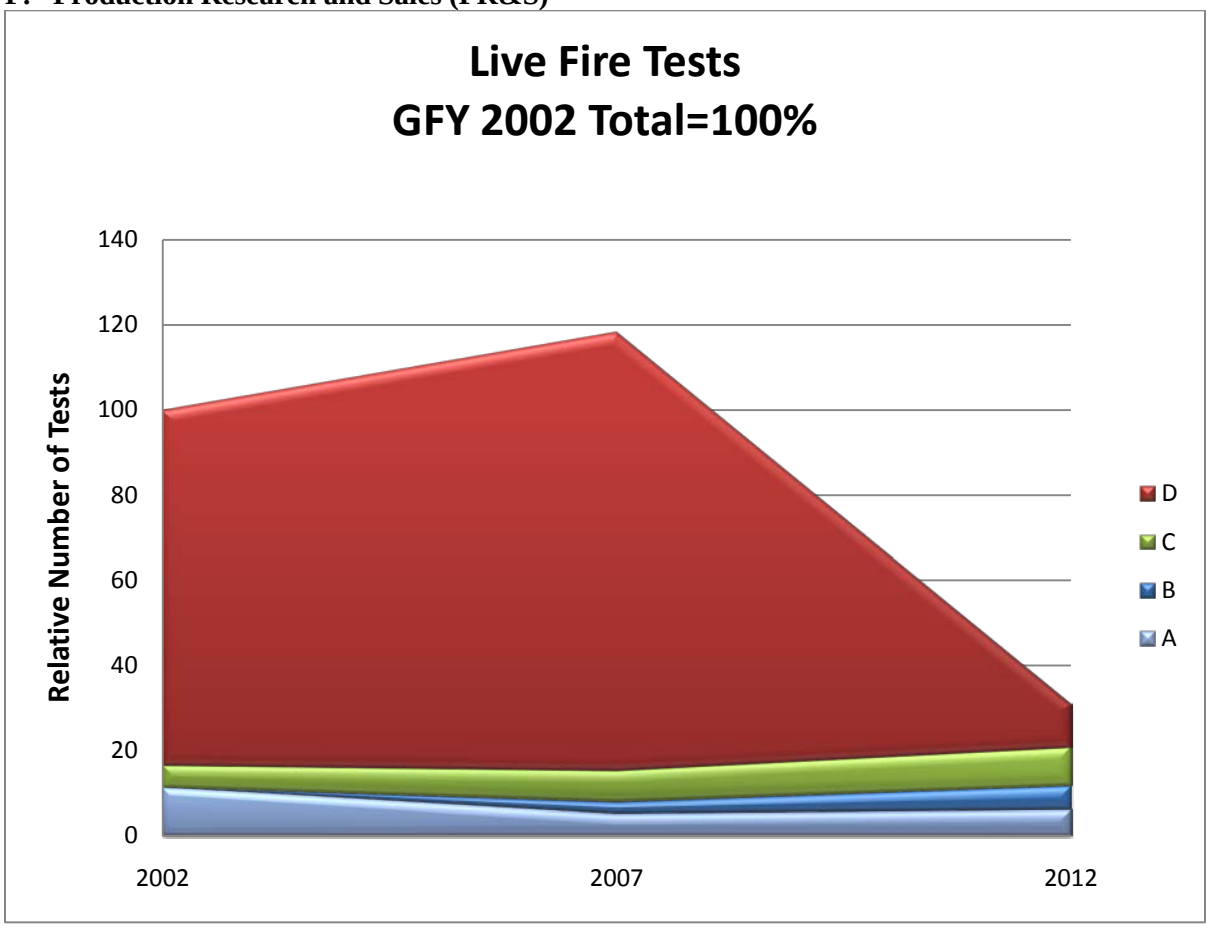

Figure 8. Normalized Live fire tests.

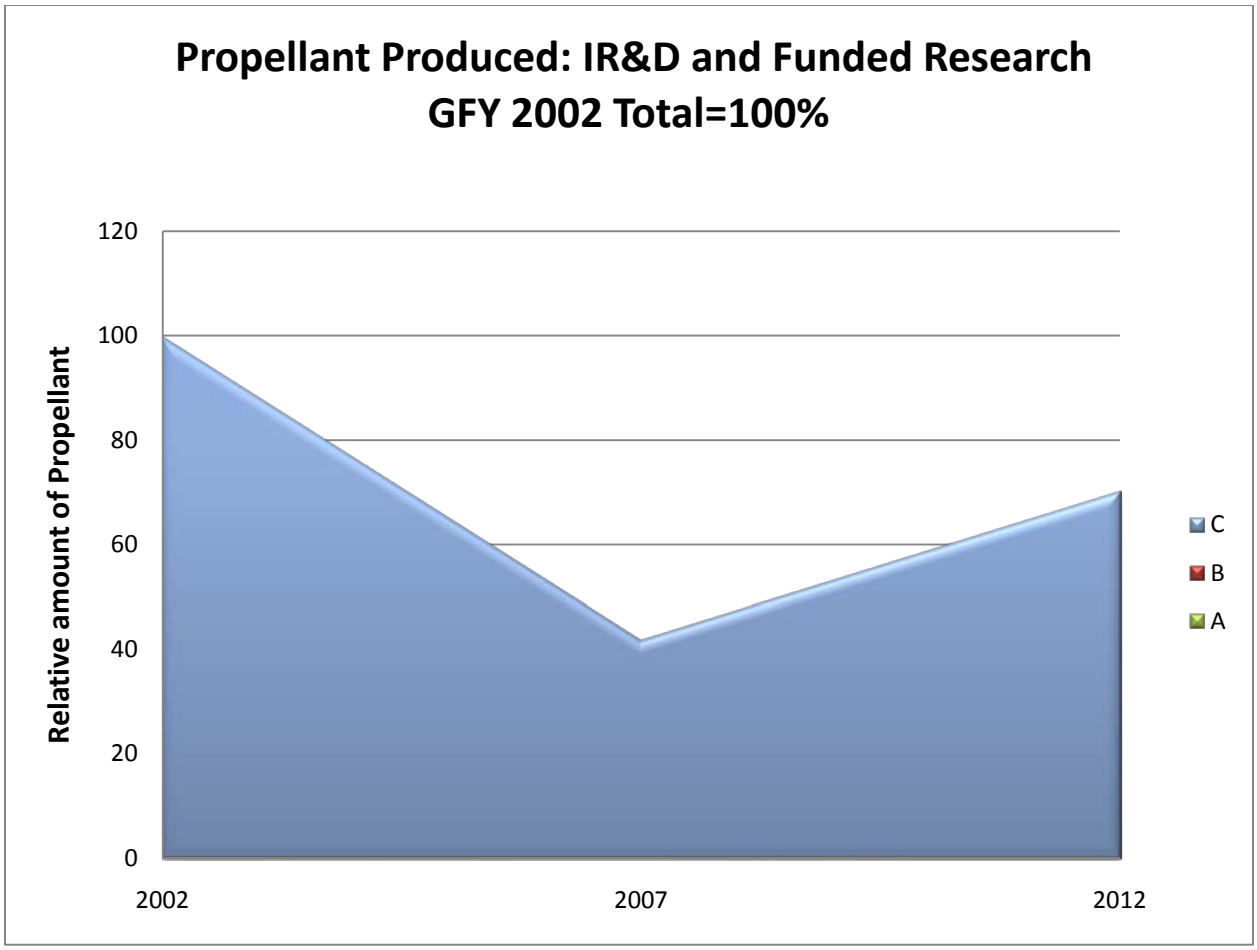

Figure 9. Normalized propellant production for Independent Research & Development (IR&D) and Customer Funded Research.

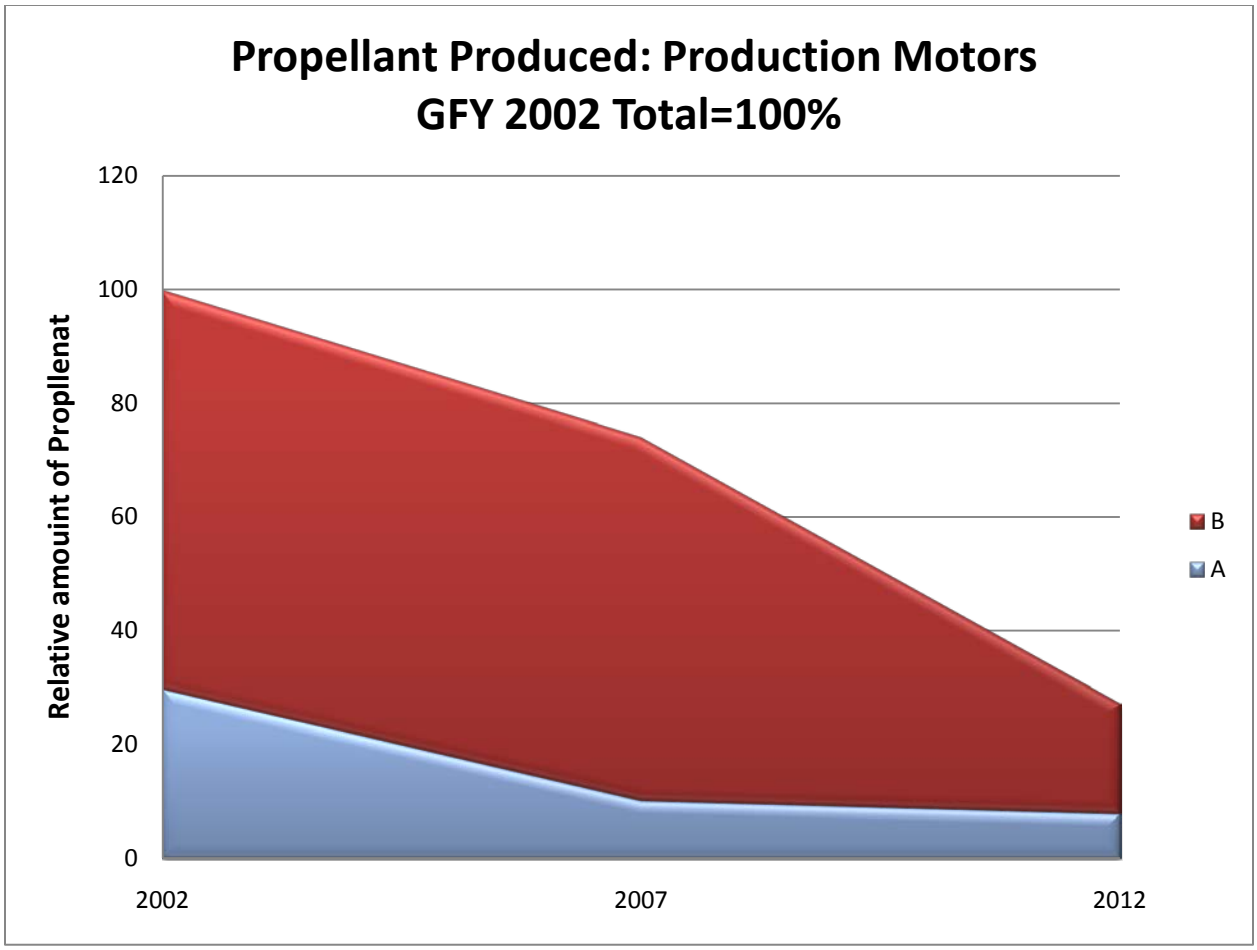

Figure 10. Normalized propellant produced for Production Motors.

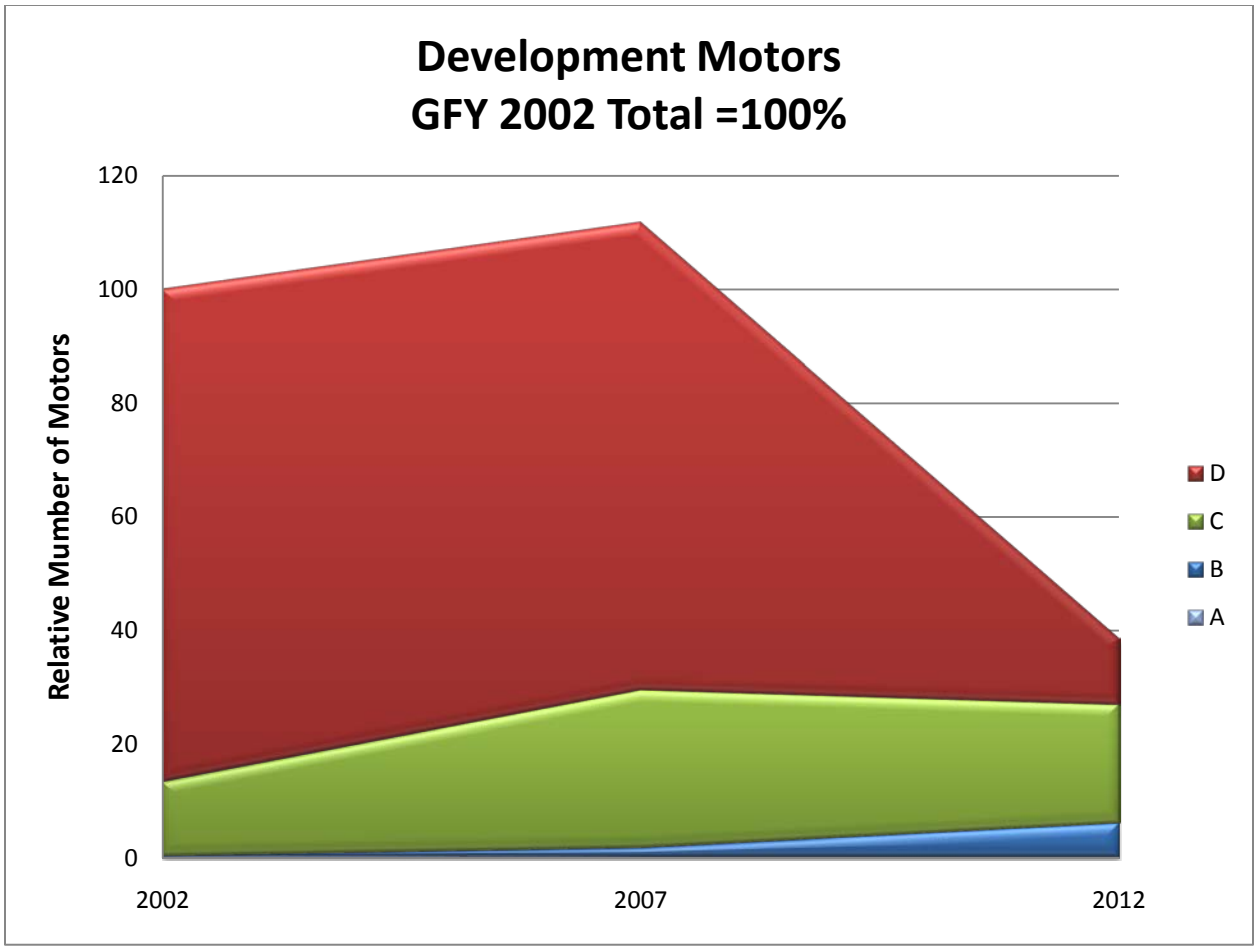

Figure 11. Normalized development motors produced.

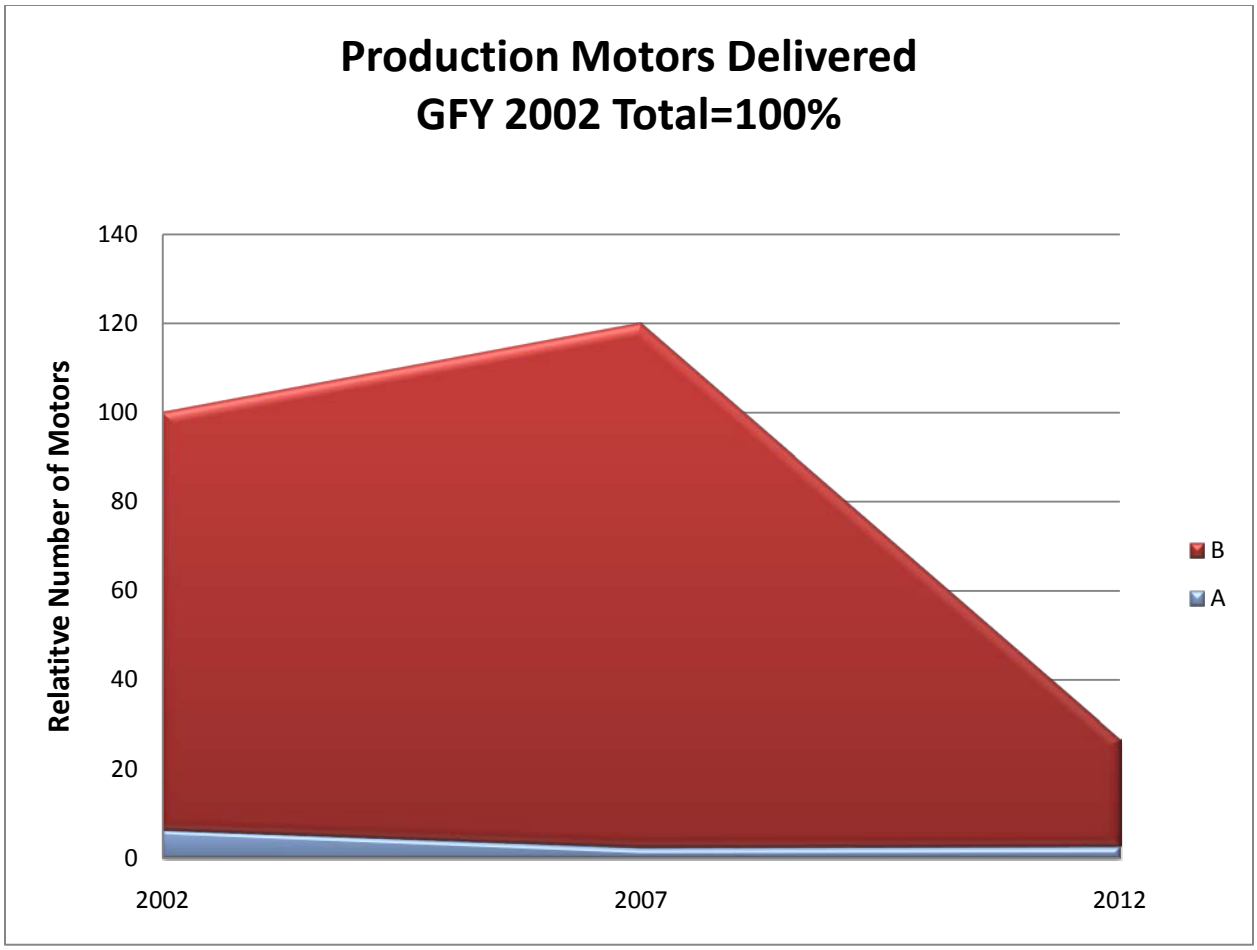

Figure 12. Normalized production motors delivered.

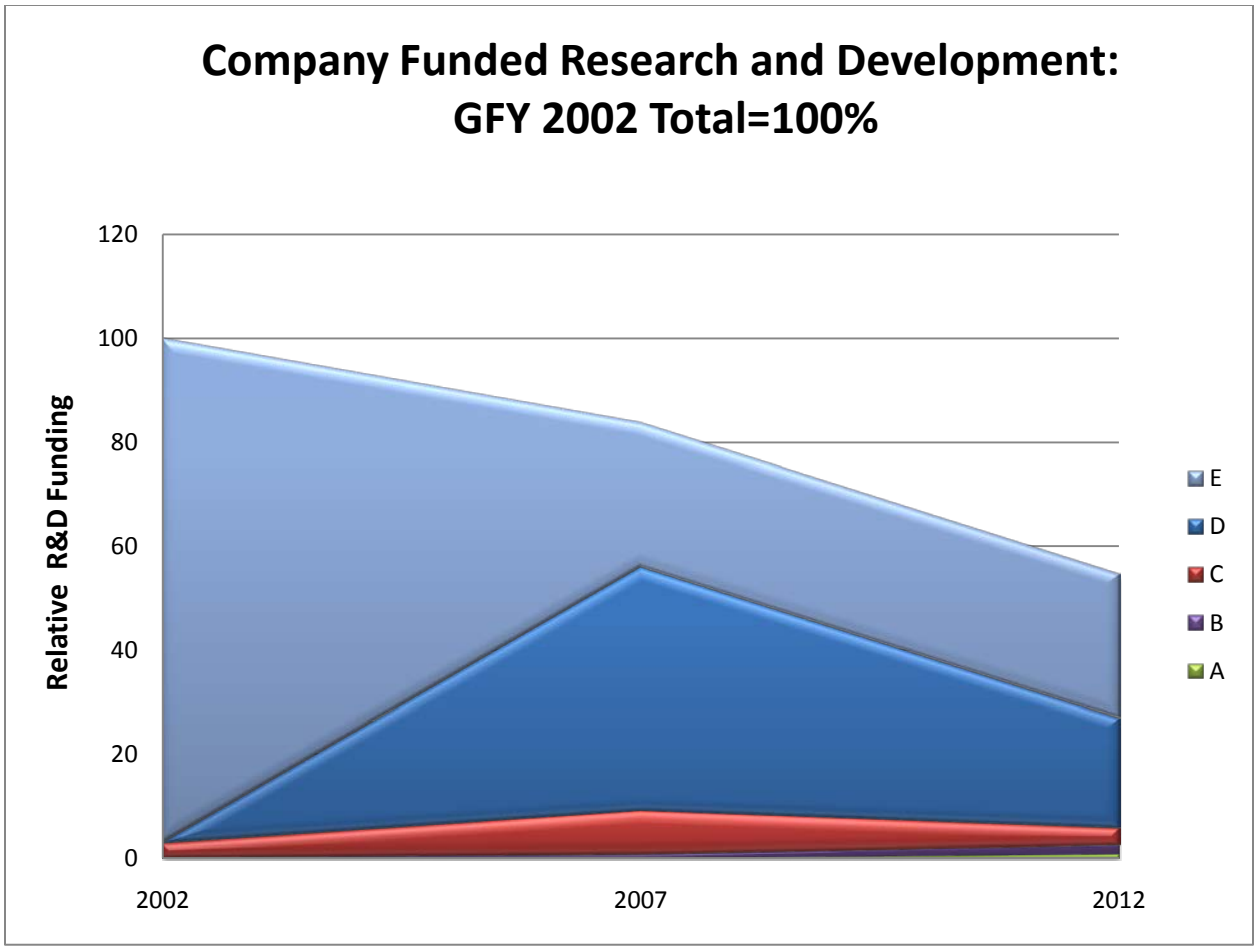

Figure 13. Normalized Company funded R&D expenditures.

These results are consistent with the Human Capital data, showing a peak in production in GFY 2007, followed by a steep drop off due to the retirement of the Space Shuttle and the transition of the Constellation program. However, the amount of company funded IR&D work did not drop off as precipitously as production and deliveries, which may be an indication of confidence in the industry that new technologies will find markets and that their primary customers may see a need for increased activity. In addition, these results show that smaller organizations are beginning to invest in IR&D, indicating the slow emergence of non-traditional contributors to the USRPIB. However, both of these indications are not enough to conclude that the USRPIB health is improving without more information and analysis. The respondents did not provide data for the other questions in this section.

G. Supply Chain

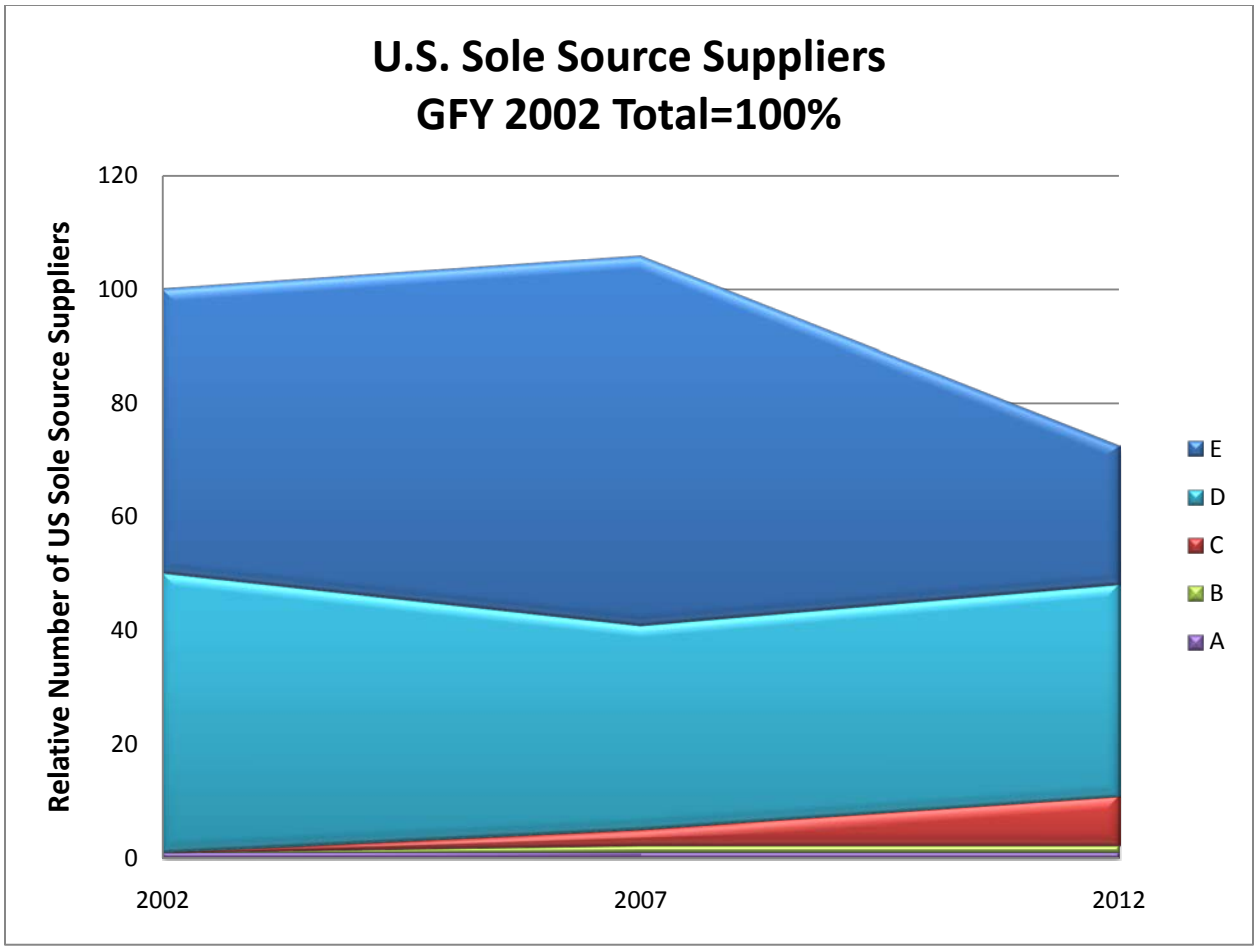

Figure 14. Normalized US- based sole source suppliers.

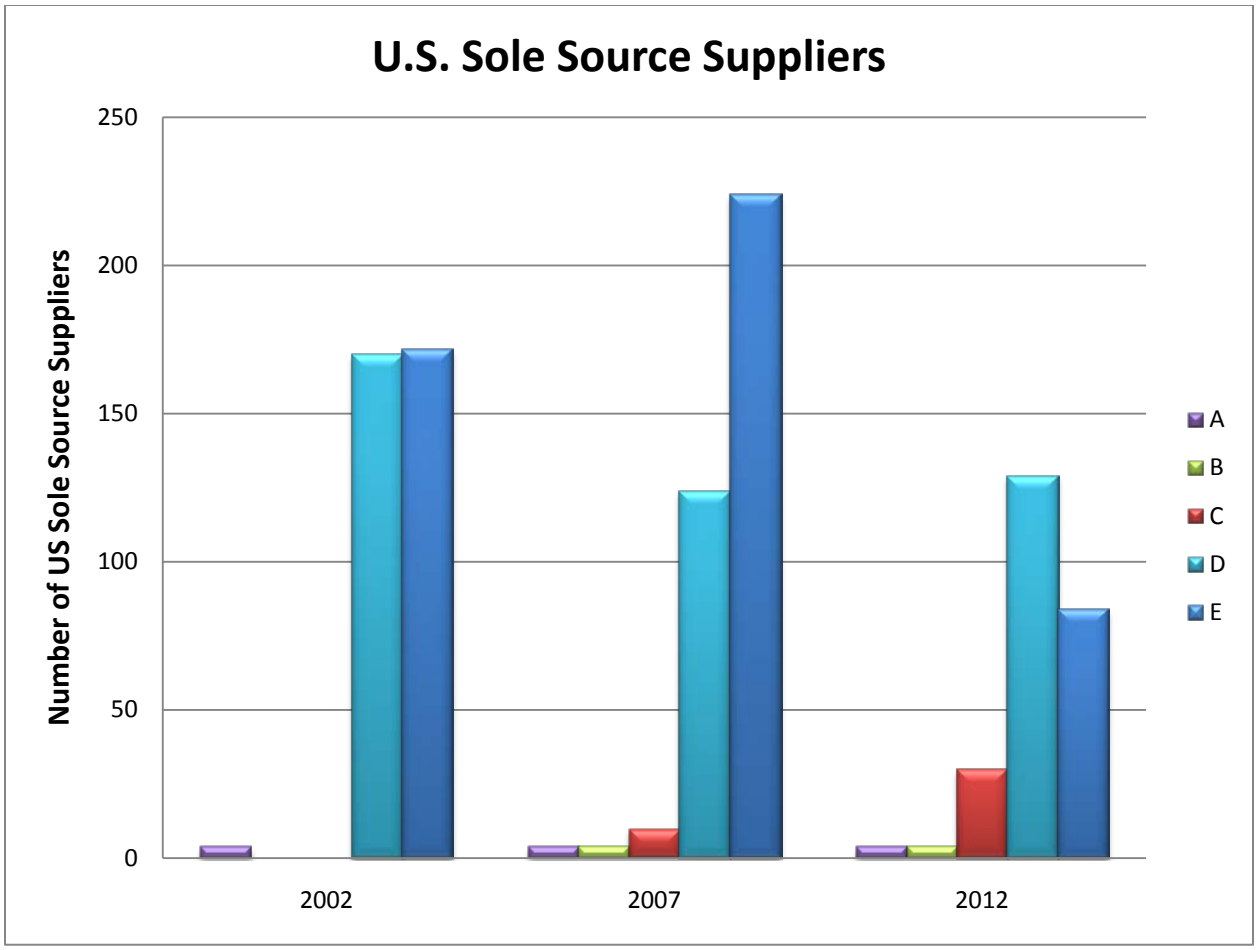

Figure 15. Number of U.S.-Based Sole Source Suppliers.

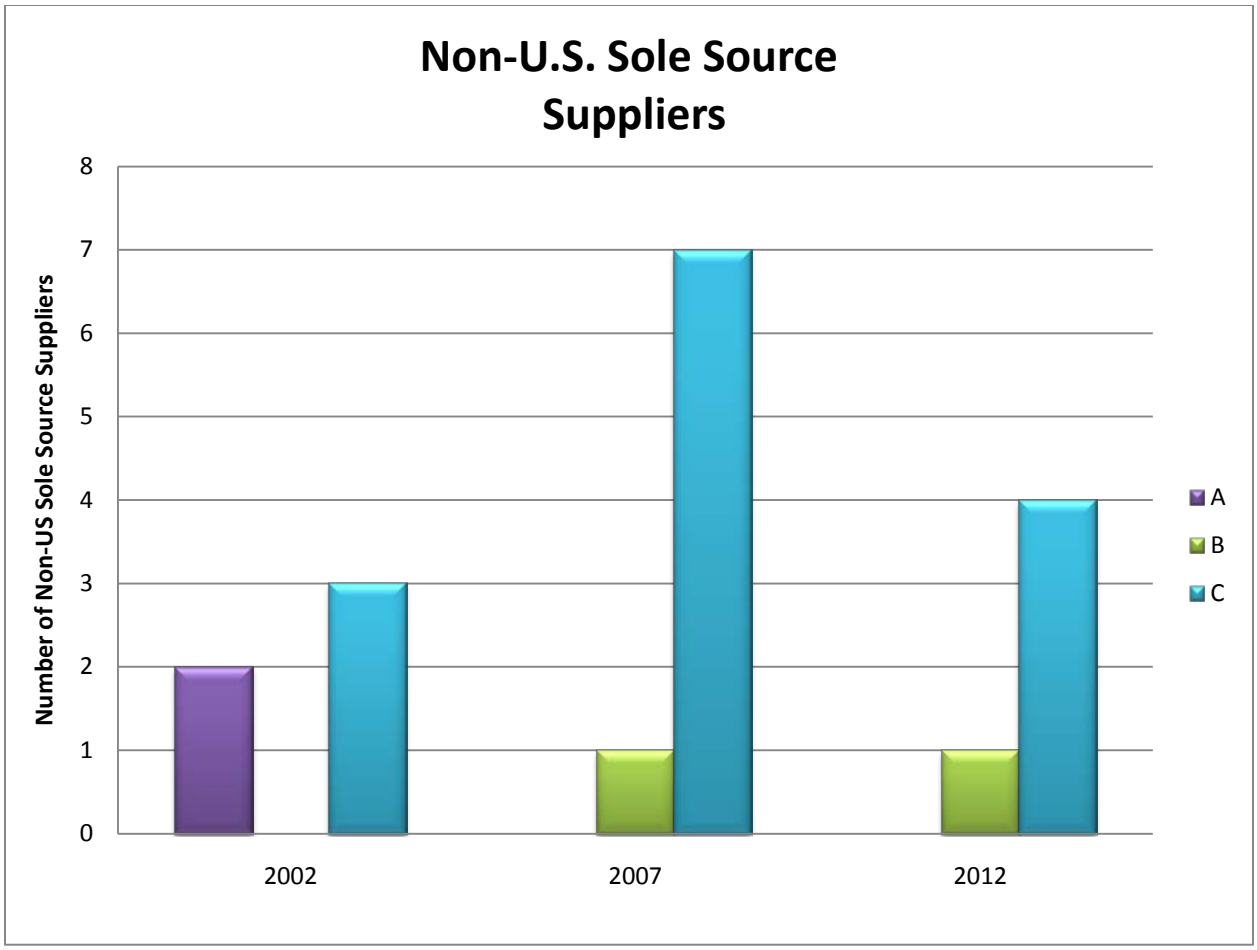

Figure 16. Number of Non-U.S.-Based sole source suppliers.

This data shows that the USRPIB is lowering the number of sole source suppliers that they remain dependent upon. The team was unable to determine if this reduction in reliance upon sole source suppliers is driven by an active effort to develop alternate suppliers, redesign of production processes, or other factors. It is important to note that all sole source suppliers are not necessarily *critical* suppliers. An alternative may exist for these sole source suppliers, but the respondent may choose to have a single source for competitive business reasons. The loss of a supplier of this nature, may not necessarily lead to a loss or a delay in production.

V. Observations

The team has several observations regarding the inputs and what may qualify to serve as effective health metrics for the propulsion industrial base. These observations fall into the broad categories of data quality, data relevance, data validation and areas for improvement

A. Data Quality

At the onset of this activity, the team was concerned that the some of data may not be of the quality and consistency needed to build effective USRPIB health metrics. While the majority of the data provided in response to the survey was useful and consistent by organization, we did encounter the following issues:

1) Due to the consolidation of the industry, some data was unavailable for earlier years

2) Some organizations could not separate the RPIB efforts, investments and personnel data from the rest of their organization. This was especially true with a history of mergers or other forms of consolidation and reorganization. This was true for both Private Sector and Government organizations
3) We were unable to get data from some key organizations in the RPIB. This "data gap" means that we are missing some critical items, including data on the amount of liquid propellants (cryogenic and storable) produced in the survey time frame.

B. Data Relevance

As the team worked through the survey response data, it became clear that some of the data sets were simply too small to be indicative and representative of USRPIB health. For example, we only received input from two respondents regarding the amount and nature of stockpile materials and feel that this data, while useful, does not help us gauge the overall USRPIB health. All of the respondents were also unable to tell us other information about their supplier chain, regarding the dependence of their suppliers on the rocket propulsion business. This specific information, while interesting as a metric for USRPIB health, is not used by any of the suppliers to manage their supply chain, and therefore is not tracked or collected.

Sales data presented another problem. The major rocket propulsion systems suppliers in the industry are usually divisions or subsidiaries of publically traded companies. While sales data is available for the parent company, it is typically unavailable for specific business lines or subsidiaries, and often varies dependent upon the whole company structure. The smaller suppliers are often privately owned and are thus understandably reluctant to share this sensitive information. Due to these factors, the team determined that the overall revenue data collected is not an accurate, representative, and relevant measure of USRPIB health.

C. Data Validation and other sources of information

The collection and analysis of the survey data is only the beginning of this effort to completely assess the recent trends in, and current health of the USRPIB. The team will continue to validate the survey response data collected against other sources and begin the complete validation of the USRPIB heath metrics. Additionally, the Department of Commerce (DoC) recently performed extensive surveys on various aspects of the entire U.S. spaceflight industrial base. The first of these was a "Human Spaceflight Survey" which was to be sponsored by NASA in 2009 and began to collect data in the 2004-2009 timeframe. However, after the announcement of the transition of the Constellation Program, the DoC modified the survey to include the effects of these new circumstances. As a result of the modified survey, NASA and the DoC published the *Human Space Flight Industrial Base in the Post-Space Shuttle/Constellation Environment - Industry Viability, NASA-Dependent HSF Suppliers, Sustainable HSF Supply Chain* in late 2012[3]. This revised survey collected data from 536 companies identified as suppliers of the Shuttle, Constellation, and International Space Station programs, with a specific focus on 150 respondents who self-identified as being NASA-dependent.

The DoC conducted a follow-up to this survey, the "Space Industry Deep-Dive Survey" which collected data in 2012[4]. These DoC surveys collected an immense amount of data and were focused on the entirety of the space industry. Additionally, these DoC surveys collected data relevant to both suppliers and customers for the respondents, the dependence of space industry for the company's sales and relevant financial data. The DoC surveys will complement the NIRPS USRPIB health survey data, and allow the team to identify additional "at risk" suppliers and potential stress points in the supply chain.

The amount of data collected in these efforts is quite large, and the task of "mining" the data for use to validate our USRPIB survey will require significant future effort. The NIRPS team is currently building tools to access and analyses this data, while continuing to protect the proprietary and sensitive data submitted by the respondents.

The combination of the on-going USRPIB survey data and the use of relevant data collected by the DoC surveys will enable NIRPS to develop metrics that are focused on the overall health of the USRPIB and will give decision and policy makers an accurate snapshot into the current state of the industry. Complementing this effort, NIRPS is building tools and processes that will model the USRPIB supply chain for specific programs and proposed programs. These tools will allow program managers and senior agency leaders to understand the effects of proposed decisions on specific supply chains, and to perform scenario analysis to model the effects on the USRPIB for acquisition and policy decisions.

D. Areas for Improvement

The initial response to the survey yielded an encouraging starting point for the metrics, however the team identified several areas in which the effort can be improved. The first area for improvement would be to redesign the survey questions for more consistent data inputs from all respondents. In the initial survey, the team asked for a "demographic breakdown" but did not identify the specific categories in which the data should be presented. The resulting data was inconsistent between respondents; leading to a great deal of work by the team to render the data usable. In addition, this initial survey helped the team understand which data (such as employee retention rates, RPS sales, and certain supply chain metrics) are not currently collected by the industry. These metrics will be omitted from ongoing surveys. The team also recognized that more effort into promoting the benefits of the USRPIB health metrics survey to include outreach to a broader audience, such as new entrants to the USRPIB will be critical in future efforts to understand the current state of the overall industry. Additionally, with the numerous new entrants into the commercial crew and cargo space launch sector, the team recognizes the need to gather metrics from non-traditional new entrants to the USRPIB.

VI. Conclusion

During this effort, the team made a great deal of initial progress in developing a metric suite to gauge the health of the USRPIB. The preliminary indicators from this effort are that the USRPIB is on a downward trend, which is concerning, given the national need to develop propulsion systems in the near future. There are some positive indications from the preliminary results; however this is not indicative of an overall trend at the current time.

The team identified areas for improvement as discussed previously in order to increase the participation rate and to expand from traditional organizations in the USRPIB, to encompass new entrants, as well as non-traditional organizations. Necessary forward work includes thoroughly mining the Department of Commerce data and using this data to validate and improve the NIRPS USRPIB health metrics survey. In addition, integration of the Academic metric remains a key task to understand the health of the entire propulsion industrial base. NIRPS and the propulsion community remain committed to making this survey and results a useful tool for decision and policy makers, and the team looks forward to publishing additional results in the future.

Acknowledgements

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Appendix

Industrial Base (IB) Questions

1. Please provide a breakdown of number of degreed (broken out by BS, MS and PhD) and number of non-degreed STEM (Science, Technical Engineering and Mathematics) employees for Rocket Propulsion Systems (RPS) versus years of experience, in 5 year increments, as of 1 October 2002, 2007, and 2012. Please provide age demographics as well.
   - **a.** Average number of job offers from your company or organization received and accepted by STEM graduates for RPS positions
   - **b.** Retention rates for STEM hires (years of service) of record 1 October 2002 and 2007

2. For the periods Government Fiscal Year (1OCT- 31SEPT) GFY02, GFY07 and GFY12, please provide:
   - **a.** The number of rocket engine/motor live fire tests conducted, broken down by liquid, solid, or other.
   - **b.** Total pounds of solid propellant or storable liquids or cryogenics produced for use development programs (including Independent Research and Development (IR&D))
   - **c.** Total pounds of solid propellant or storable liquids or cryogenics produced for production motors.
   - **d.** Number of Development motors or Liquid Rocket Engines (LREs) produced.
   - **e.** Number of production motors or LREs delivered.
   - **f.** The IR&D (in $'s) devoted to RPS by your company or organization.
   - **g.** IR&D devoted to Rocket Propulsion Systems(RPS) as a % of total sales.
   - **h.** The externally funded R&D value (in $'s) for RPS for your organization.
   - **i.** Total RPS sales ($M)

3. Do you have an active supply chain management system in place for your lower-tier RPS vendors (tier 2 and 3, not just first level suppliers)?
   - **a.** How many sole or single source suppliers did/do you have for GFY 2002, 2007, and 2012? Of these, how many are US and how many are non-US? If non-US, please identify country.
   - **b.** Identify the percentage of non-US components used in your RPS products (treat each part, ingredient, circuit board, etc. equally as a single component).
   - **c.** For the years GFY2002, 2007, and 2012, how many sub-tier suppliers left the market? How many entered the market? How many re-qualifications occurred because of a supplier change or process change? Provide data for your company or organization only.
   - **d.** Are your production capabilities dependent on a stockpile of material? If so, what stockpiled material? Are there plans to develop a capability to produce the material?

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e. How dependent is your sub-tier supply base on revenues from the rocket propulsion market? Identify vendors where RPS revenues are >50% of their revenue portfolio.

If data is not available for any of these, please indicate what's missing.

DEFINITIONS:

- **The term "rocket propulsion industrial base" (RPIB) refers to the nation's capability to conceive, design, develop, manufacture, test, and support missions using liquid rocket engines and solid rocket motors that are critical to its national security, economic health and growth, and future scientificneeds. The RPIB encompasses US government, academic, and commercial (including industry primes and their supplier base) research, development, test, evaluation, and manufacturing capabilities and facilities. The RPIB includes the skilled workforce, related intellectual property, engineering and support services, and supply chain operations and management. This definition touches the five main segments of the U.S. RPIB as categorized by the USG: defense, intelligence community, civil government, academia, and commercial sector.**
- **RPS = Rocket Propulsion Sytems**
- **STEM = Science, Technology, Engineering and Mathematics (applied to degreed disciplines in engineering, physical sciences)**
- **CY = Calendar Year**
- **GFY=Government Fiscal Year (1 OCT-31SEPT)**
- **IR&D = Independent Research & Development**
- **LRE = Liquid Rocket Engine**

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