The Top Ten in PNT

National Space Competitiveness

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More GNSS systems are on-line or in the pipeline than ever before. But not every space-based PNT provider can rely on supportive government policies, generous funding, abundant skilled technicians, or a strong national economy. In this article, analysts from a noted management and market intelligence consultancy examine the current and projected capabilities of the world's GNSS system operators and rank the top 10.

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Since the dawn of humanity, the sky and stars have stimulated our imagination and curiosity. As our understanding about outer space increases, so does our passion and drive to explore beyond the reaches of our own planet — and to use space to understand our own planet.

Just as communications satellites have emerged as a critical backbone of our telecommunications networks, our daily lives are enhanced considerably by services such as weather forecasting, global positioning, satellite imagery, and other space-enabled applications. A mere half-century after the launch of the first satellite, space infrastructure has become central to the way we live, work and play.

Each year Futron Corporation collects and analyzes data, statistics, and indicators for leading space-faring nations that align to the underlying drivers of space competitiveness: government, human capital, and industry. Incorporating this data into our competitiveness model year after year provides Futron's analysts a unique quantitative framework with which to interpret and assess respective strengths, weaknesses, opportunities, and threats among international space actors: leading nations such as Brazil, Canada, China, Europe India, Israel, Japan, Russia, South Korea, and the United States, and emerging nations such as Australia, Iran, North Korea, Singapore, and South Africa.

Futron's complete *Space Competitiveness Index* explores the relative strengths of these actors overall (see **Figure 1**) and in five in-depth segment analyses. This article will focus on one of those segments: space-based positioning, navigation, and timing (PNT), which are largely a function of a space nation's involvement with GNSS programs, technologies, and applications.

Overall Space Competitiveness

Before taking up the PNT segment per se, however, some comments on the metrics researched in Futron's 2009 Space Competitiveness Index — and our associated conclusions — may provide useful context.

- The United States maintained its leadership in all three categories of competitiveness drivers (government, people, and industry) as well as in the overall index. However, the country's relative competitiveness declined slightly due to strategic drift and the heavy reliance on defense funding, which under cur-

rent export controls, cannot be commercialized.

- European space progress continues as the countries of Europe deepen and broaden regional space institutions with the key challenge being retention of efficiency and flexibility within a complex policy-making environment among the European Union (EU), European Defense Agency (EDA), European Space Agency (ESA), and respective member-states.
- As a space pioneer, Russia has stabilized its third-place position, but needs to move quickly to develop a commercial space industry by building on its legacy capability, overcoming current economic obstacles and leveraging international partnerships. As a lead partner in the International Space Station (ISS), Russia's strategic relationship to the United States — actually a two-way dependency — will affect its space competitiveness.
- Japan was a clear winner in the 2009 Space Competitiveness Index, highlighting the value of a sound and transparent law- and policy-making apparatus — in particular because new legislation permits the nation to engage in military space activities.
- The displacement of China from fourth to fifth place may be surprising, given that country's notable space successes during 2008. This re-positioning traces back to two underlying, and noteworthy, weaknesses in the Chinese space program: lack of transparency and market access, including obstacles for space applications such as satellite communications, broadcasting, and satellite radio.
- Canada, while retaining its sixth position, made important moves to increase competitiveness. Canadian human capital, international cooperation, and investment in strategic niches such as remote sensing and robotics sustain its clear competitive strengths, in part tied to its unique partnerships with both the United States and ESA.

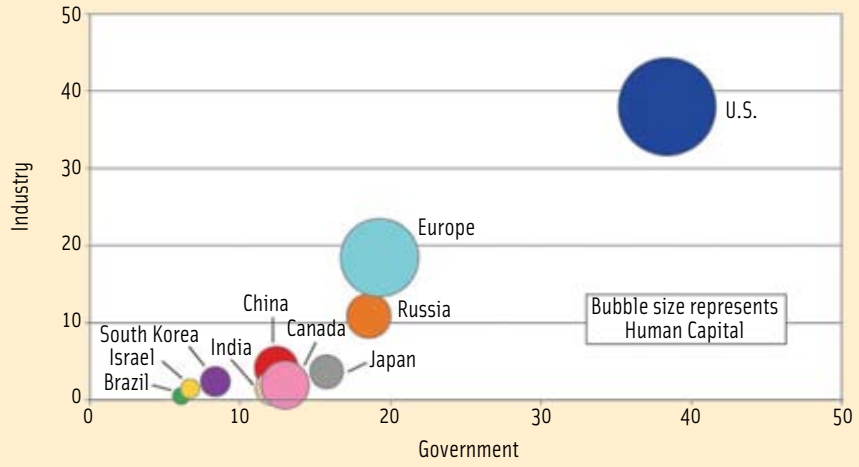

FIGURE 1 2009 Space Competitiveness Index Country Comparisons

- India's space program, now ranked seventh, is poised for continued growth and enhancements to its competitiveness stance based on expanded commercial and international partnerships with the United States, Israel, and others.

Market Segmentation

The space industry is complex — comingling military, civilian, and commercial roles across the satellite, satellite services, spacecraft, spaceport, and launch vehicle environments. To provide analytical insight into these and other areas of space activity, Futron's 2009 Space Competitiveness Index examines them in terms of their key actors, applications, and economic drivers — the who, what, and how of space competitiveness.

This approach, depicted in the Table 1, permits Futron to perform not only country-by-country evaluations of national space competitiveness, but also to examine specific market and industry cross-sections: their status by the numbers, the conditions across the 10 leading space participant countries, and the underlying structural forces shaping them.

Global PNT: An Overview

Space-based positioning, navigation and timing (PNT) capabilities are truly a global utility that positively affect the daily lives of many people around the globe. PNT services provide improved economic, transportation, and security efficiencies that were previously unattainable.

In PNT's simplest form, GNSS satellites produce one-way communications signals with embedded source, orbital position, and timing information that enable a receiver to calculate its position anywhere on or around the entire planet. In order to improve accuracy and integrity — in particular, vertical location or altitude — as well as eliminate

Space Competitiveness Segmentations: A Framework for Understanding

Key Actors (Who)	Applications (What)	Drivers (How)
Military Civilian Government Commercial Enterprise Non-profit Organizations Individuals	**Science and Exploration** Communications **Earth Observation** **Positioning, Navigation, and Timing** Manufacturing Launch Space Services	Government Policies & Leadership Human Capital and Experience Corporate Structure and Operations **Technology and Innovation** Investment and Spending

TABLE 1. Illustrative List of Space Competitiveness Actors, Applications, and Economic Drivers

Bold indicates the inclusion of segment analysis included in full report

signal gaps, PNT systems incorporate augmentation infrastructure, which include both space- and ground-based assets, ground systems and communications infrastructure.

Some GNSS constellations include data communications and value-added services. By tracking location and movement over time, and overlaying mapping technology, these satellites make possible a diverse set of PNT applications — military, civilian, and consumer — resulting in a rapidly growing, dynamic marketplace for PNT-based products, services, and solutions.

Futron's Global PNT Index examines current PNT systems — both operational and planned — to develop an overall assessment of the sector's impact on space competitiveness, as well as an analysis of the evolving PNT industrial base. Our evaluation also integrates human capital and commercial factors to deliver a robust viewpoint.

By combining quantitative and qualitative metrics, the Global PNT Index provides insights into the relative economic advantages of the 10 leading space participant nations with specific regard to PNT capabilities. The key trends identified in this focused PNT segment analysis, some of which have not changed over the past year, may be summarized as follows:

- The U.S. Global Positioning System (GPS) provides the U.S. military with a significant logistical, operational, and command and control advantage, which, in turn, rationalizes the development of similar systems by Russia, Europe, China, and India.
- As other countries seek PNT capability, either independent of GPS or in augmentation of it, there will be massive investment in satellites, ground infrastructure, user equipment, and operational expenses representing tens of billions of dollars.
- The U.S. is the current commercial leader of the GPS products and services market.
- Russia has appreciably enhanced its strategy and organizational capability, as its program to replenishment the GLONASS constellation progresses; modernized GLONASS-M satellites will have significantly enhanced performance, and a commercialization effort is underway.

China appears to be solidifying PNT Policy for COMPASS, a positive step toward integrating the regional programs and enabling augmentation services over Asia.

- EU ownership of Galileo and aligned PNT initiatives improves the chances of programmatic success; however, some redesign of end-user equipment as well as proposed licensing fees, could affect costs and ultimate commercial success.
- China appears to be solidifying PNT Policy for COMPASS, a positive step toward integrating the regional programs and enabling augmentation services over Asia.
- The United States and Europe signed an agreement in 2004 promoting cooperative efforts between GPS and Galileo, which established the foundation for future compatibility, interoperability, and fair trade in PNT markets.
- Given the scope of the Galileo initiative, European program managers will likely have difficulty executing their ambitious launch and operations plan on schedule and on budget.
- Other nations, in particular Taiwan and Japan, have made significant inroads in the manufacturing arena as Taiwan-based MiTAC expanded via acquisition and diversified Japanese consumer electronics manufacturers increase market share.
- The commercial GPS market is undergoing a period of mergers and acquisitions that include vertical as well as horizontal merger and acquisition activity, offset by innovative start-ups and small applications developers.
- Ground augmentation is a major focus of civilian government agencies, and will further enhance technology and facilitate innovation of additional applications.
- GPS applications have proliferated and matured, with increasing segmentation, niche product development, and value-added services.
- The global economic crisis that began in 2008 and continues into 2009 could derail or delay the development of PNT infrastructure in some countries; however, U.S. policy-makers do not currently foresee major changes in policy, investment, or operations of U.S. space-based PNT constellations or infrastructure due to the recession.

Recent Developments

The premier space-based PNT system remains the U.S.-owned and operated GPS. During 2008, however, several additional space powers codified plans to develop similar systems.

Russia, which has the second longest-running system, promoted commercial use of GLONASS-based PNT. Several Russian and additional international manufacturers entered the market for GLONASS-based products and services. GLONASS receivers have been commercially available since the 1990s, with several Western companies maintaining substantial design and engineering operations in Russia. Domestic Russian commercial activity has lagged until recently.

We should emphasize that little connection exists between operating a governmental PNT system and having a competitive market for user equipment and services. For example, Japan has been a leader in GPS user products even though the government is not directly involved in the GPS program.

Similarly, the restoration and modernization of GLONASS will not necessarily help Russian user equipment manufacturers. Because the basic intellectual property of the technology is public — in the form of interface con-

trol documents — anyone can make a GPS-GLONASS receiver; so, the rise of a Russian or European GNSS system is unlikely to erode a GNSS manufacturer's market position.

Although shortages of chipsets hindered initial production and sales of consumer-oriented GLONASS receivers, media sources suggest stronger-than-anticipated sales. As a result, Russian industry may increase its long-term commercial competitiveness in the sector — but the economics of GLONASS remain untested.

Meanwhile, the Indian government approved development of its regional GNSS constellation. The EU has also agreed to finance (and take over programmatic control) of the Galileo initiative. Interestingly, European ministers have also endorsed a military role for Galileo, bringing the continent closer to U.S. policy regarding the dual-use nature of PNT systems. Given the prominent role of GPS via NATO platforms — as well as EU member-states' control over national use of the security-oriented public regulated service (PRS), however, the military utility of Galileo remains an interesting open question.

Despite the flurry of activity in support of all PNT programs, with ongoing plans in place to upgrade the GPS system and its augmentations, current U.S. activity ensures the nation's strategic leadership in the sector into the near-term and perhaps beyond.

GPS Market Growth

In the past year, the number of end-user GPS applications has continued to increase, particularly in the civilian and commercial arenas. Automotive solutions and handhelds remain the leading end-user devices, but other innovative applications suggest long-term revenue potential from tracking services provided, for instance, for individuals on parole and probation , endangered species, children, the elderly, and industrial assets. Continued robust growth can also be expected in transportation and agricultural applications tied to monitoring and controlling supply chains and optimizing production.

All told, by the end of 2008, GPS had been embedded in several hundred million devices worldwide. Qualcomm alone has already sold 300 million GPS-enabled cell phone chipsets. GARMIN International has delivered 48 million portable navigation devices (PNDs) to date, including some 16.9 million units during 2008.

While the diversity of the industry and a common definition of the PNT-specific added value in products and services make market estimates difficult, a consensus is arising that the value of the GPS market has surpassed $30 billion, a figure that includes revenue from manufacture of space-based assets such as satellites, ground-based infrastructure, and end-user devices, as well as PNT-based services.

The downstream financial benefit, which also has not been well documented, would likely result in tens of billions of dollars in economic value from increased productivity, reduced operating costs, and newly enabled services. In fact, our assessment of revenue among leading international PNT companies identifies some $10 billion in global annual revenue, a figure that is likely to increase if smaller companies and downstream services are included. As new systems (and corresponding products, applications, and downstream services) come on line, this figure will surely grow, raising key questions about the national economic benefit among the relative winners and losers in the marketplace.

A notable development in 2008 was the rise of virtual reference station (VRS) networks across the United States, mostly at the initiative of local and state governments, universities, and the private sector. VRS networks make centimeter-level GPS positioning available to a broad swath of users in local or regional areas.

Another key event during 2008 within the GNSS sector was the continuing effort to consolidate a global framework of national systems aligning interoperability, compatibility, and optimization of a global utility. This effort is ongoing and nowhere near complete.

A leading entity working in this area is the International Committee on Global Navigation Satellite Systems (ICG). Formed in 2006, the ICG met for the third time in 2008 (and, since our 2008 study was completed, a fourth time in Russia in September 2009). The ICG made incremental progress in 2008 compared to the prior years. The competitive, national and commercial framework, therefore, must also be viewed through a lens of an increasingly interconnected GNSS (also sometimes referred to as the "global navigation system of systems").

The cooperative GNSS concept is coordinated through the ICG with the support of the United Nations Office for Outer Space Affairs (UNOOSA), which serves as an executive secretariat. The ICG established a Providers Forum in 2007 to facilitate communications among nations, encourage compatibility and interoperability of GNSS systems, provide a forum for coordination with other relevant international organizations, facilitate policy and technical integration across nations, and more recently, engage the commercial and academic community.

An interesting note: several countries in the top 10 *Space Competitiveness Index* have weakly developed PNT policies and strategies. Israel, for example, is participating in the Galileo program, but only to a limited extent. Nonetheless, a consensus exists among Israeli military and industry leaders that the country needs a clear PNT strategy to ensure military superiority and capability independence.

Our assessment of revenue among leading international PNT companies identifies some $10 billion in global annual revenue, a figure that is likely to increase if smaller companies and downstream services are included.

	Brazil	Canada	China	Europe	India	Israel	Japan	Russia	South Korea	U.S.
PNT										
Official Government Policy Promulgated	N	N	Y	Y	Y	Y[1]	Y	Y	N	Y
System Name	n/a	n/a	Compass/ BeiDou	Galileo	IRNSS	n/a	n/a	GLONASS		GPS
Nominal Constellation	n/a	n/a	30	30	7	n/a		24		24
Current Constellation			5	2	0	n/a		19		30
Operational Date			2012 2015-20	2014	TBD	n/a		1995		1995
Coverage			Asia-Pacific	Global	India+ regional	n/a		2012		2014[2]
Cost				$5B	$300M	n/a				$14B[3]
Commercialized				Planned		n/a	✓	✓		✓
Augmentation Systems										
System Name		N[4]		EGNOS	GAGAN	n/a	MSAS[5] QZSS	SDCM		WAAS LAAS
Nominal Constellation				3	3	n/a	2 3	2		2
Current Constellation				3		n/a	2 0	0		2
Operational Date				2011	2011	n/a	2006 2010	TBD		IOC 2003
Coverage				Europe	India+	n/a	Asia/ Oceania	Russia		North America
Cost			$140M			n/a				$1.5B
										$720M

TABLE 2. Status of PNT Systems by Country

IRNSS = Indian Regional Navigation Satellite System; EGNOS = European Geostationary Navigation Overlay Service; GAGAN = GPS-Aided Geo Augmented Navigation; MSAS = Multi-functional Transport Satellite (MTSAT) Satellite-based Augmentation System (MSAS); QZSS = Quasi-Zenith Satellite System; SCDM = System of Differential Correction and Monitoring; WAAS = Wide Area Augmentation System; LAAS = Local Area Augmentation System

1. Note: In July 2004, Israel signed an agreement with the EU to become a partner in the Galileo project but funding is limited, and the industry experts cite the need for a comprehensive PNT strategy.
2. Current U.S. Air Force plans call for launch of GPS III generation of spacecraft starting in 2014; 8 GPS IIIA, 8 GPS IIIB, and 16 GPS IIIC satellites are planned to maintain and upgrade the system.
3. Estimated total cost of GPS from 1974–2016 in constant 1995 dollars, including launch, ground systems, and operational expenses.
4. U.S. WAAS and LAAS systems cover portions of Canada and the Canadian government participates to a certain extent in the programs.
5. MSAS is dual use including meteorological services launched in 2006

Israeli industry, however, has shown limited activity in this area so far, with the notable exception of Rokar, a BAE Systems subsidiary that develops GPS equipment. Canada also lacks a comprehensive PNT strategy, although the country coordinates with the U.S. Wide Area Augmentation System (WAAS) and Local Area Augmentation System (LAAS) programs. Canada hosts several WAAS reference stations within its territory (as does Mexico), and a vibrant commercial PNT industry has developed within the country, both in terms of equipment and services development as well as academic expertise.

Both Brazil and South Korea lack either a clear PNT strategy or any large industry. However, domestic companies do customize GNSS products and services into local languages, and there is sufficient interest to host annual GNSS conferences. **Table 2** summarizes the current status of PNT systems.

Looking forward, by 2015 six national systems are projected to be providing primary or augmentation services using some 130 satellites, supporting increasing embedded solutions for a diverse customer base. The political and economic implications of this expanding sector could prove enormous.

Futron intends to use our PNT Index as a baseline to assess the industry over time and create a platform for ongoing discussions and analysis on the relative competitiveness within the PNT industry. We invite feedback and future collaboration to further develop its focused analysis in this segment.

Global PNT Segment Index

Futron has enhanced the PNT segment index for 2009 by more closely aligning the indicators to the overall Space Competitiveness Index, as well as including additional metrics as more information has become available. The PNT segment index, therefore, includes seven indicators grouped into the three underlying drivers of the market:

Category	Target Measure	Metric	Weight
Government	Ability for Government to Provide Structure, Guidance, and Funding		40%
		Forced ranking of PNT Policy	10%
		Number of GPS tracking ground stations	10%
		Number of PNT satellites as a proxy for government spending	20%
People	Ability for People to Develop and Willingness to Use Applications and Technology		20%
		Number of Organizations Providing GPS data to IGS as a proxy for user interest	10%
		Number of IGS associate members as a proxy for people engaged in PNT research and activities	10%
Industry	Ability for Industry to Finance and Deliver Space Products and Services		40%
		Revenue for Leading GPS Companies (US$)	20%
		Number of PNT Companies as a proxy of industry strength	20%

TABLE 3. Global PNT Index Model

Number of Operational Spacecraft – Navigation				
Country	Raw Number	Normalized	Weight	Score
Brazil	0	0	20%	0
Canada	0	0	20%	0
China	5	16	20%	3
Europe	2	7	20%	1
India	0	0	20%	0
Israel	0	0	20%	0
Japan	2	7	20%	2
Russia	29	94	20%	19
South Korea	0	0	20%	0
U.S.	31	100	20%	20

TABLE 4. Illustrative Metric Calculation

The *Government* metric represents the ability for government to provide structure, guidance, and funding for PNT initiatives and infrastructure, including augmentation and ground systems and incorporates:

1) Forced ranking of PNT policy
2) Number of GPS tracking ground stations as a proxy for government spending
3) Number of PNT satellites as a proxy for government capability.

The *People* metric measures the ability of people to develop and willingness to use PNT applications and technology, including usage, training, and civil society support and incorporates:

4) Number of organizations providing GPS data to the International GNSS Service (IGS) as a proxy for user interest. The International GNSS Service (IGS) is committed to providing the highest quality data and products as the standard for GNSSs in support of Earth science research, multidisciplinary applications, and education.
5) Number of IGS associate members as a proxy for people engaged in PNT research and activities.

The *Industry* metric assesses the capability for industry to finance and deliver space-enabled PNT products, and retain economic benefit from these activities

6) Revenue of leading PNT companies as a proxy for national industry size
7) Number of PNT companies as a proxy of industry strength.

The overall model and weights are summarized in the **Table 3**.

Futron selected these three categories and related metrics as drivers of the PNT segment because they allow qualitative and quantitative comparisons of the issues necessary to foster competitive PNT systems and industry. In many cases the metrics act as proxies for larger issues.

Government strategy is critical to marshaling public support and financing for initial system development, regardless of whether the constellation has a specifically military, civilian, or commercial application or some combination of the three.

Strategy is the vanguard for national policies, laws and regulations — key factors in the development of any industry. Yet accurate, comparable government spending on PNT programs assets, for example, is not available across all systems, and in some cases is accounted for differently. As a result, we use the number of operational satellites and ground stations as a quantitative metrics used as proxies for underlying spending.

In order to standardize data to create a common baseline, Futron normalizes data using a base 100 scale. Once data is normalized, the model weights each metric based on its relative percentage value, which provides the score that each country receives for each indicator. When the seven metrics are aggregated, we are able to rank national PNT competitiveness in both absolute and relative terms.

Table 4 provides an illustrative example using the number of operational navigation spacecraft as a proxy for Government capability.

Segment Findings

Using these metrics as a foundation for the Global PNT Index, the figure below compares the 10 countries analyzed in Futron's 2009 Space Competitiveness Index in their respective PNT space segments. The results show that while numerous countries have developed some degree of PNT policy and on-orbit capability, the United States and Europe have thus far outpaced others in terms of commercialization of PNT-driven equipment and services. **Figures 2** and **3** present a visual summary of our findings.

Of special interest is the relative change among the nations from 2008.

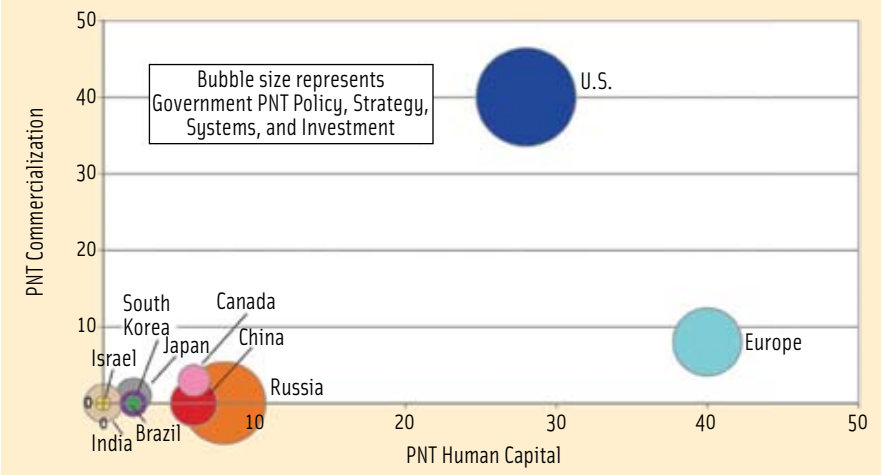

FIGURE 2 Global PNT Segment: Comparative Positions by Country

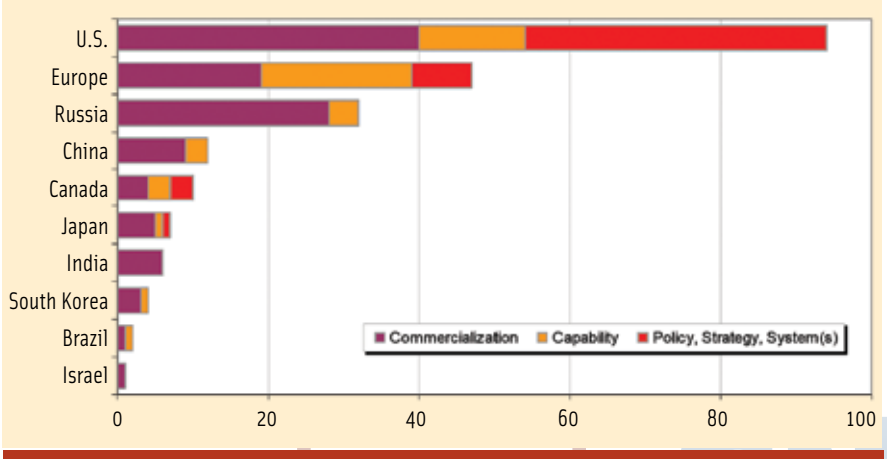

FIGURE 3 Global PNT Segment: Aggregate Scores by Country

While U.S. leadership remains apparent and significant, other countries have made substantial gains as well. In particular, Russia gained as a result of its reinvigorated program and commercialization efforts, gaining in both the Government and Industry categories. Europe, too, enhanced its position, largely due to the new role of the EU in GNSS activities that provide underlying support — both organizational as well as funding — for its initiatives.

Not on the list is Taiwan, which has become a focal point for many of the PNT consumer electronics, both as manufacturers such as MediaTek and brand ownership through acquisition of the Magellan consumer brand by MiTAC Digital Corporation. China, Japan, and India also made major strides in policy as well, which will increase investment and commercial activity in the near term and enhance overall PNT competitiveness in the longer term.

PNT Government Analysis

We conducted a qualitative examination of the level of support for national PNT activity in order to understand how the 10 leading space participant countries compare to each other in terms of governmental capability.

To determine the weighted points assigned for each country, Futron researched and summarized each country's relevant policy, law, and regulations, as well as system investment, international cooperation, and the development of augmentation systems.

The results were debated internally and validated by external experts. Our assessments highlight the advanced position of the United States based on its long-standing leadership in the PNT space segment, in addition to a well defined body of strategy, law, and regulation. Several other countries also enhanced their PNT policy, strategy, and systems — most notably Russia, Europe, China, and India during 2008.

U.S. leadership, however, is founded on more than two decades of consistent, forward-leaning policies to encourage commercial use of GPS and other space-based GNSS services. This foundation creates a stable and transparent policy environment. In fact, current U.S. space-based PNT Policy, which superseded a 1996 GPS policy, has been in effect since December 2004 in the form of a national security presidential directive.

The directive established a National Executive Committee for Space-Based PNT co-chaired by deputy secretaries of defense and transportation and a supporting staff in the interagency National Coordination Office (NCO) for Space-Based PNT.

Headed by a senior executive service member from the Department of Transportation, the NCO coordinates U.S. government policy and program efforts across the agency members of the executive committee, including the departments of state, interior, agriculture, commerce, homeland security, the Joint Chiefs of Staff, and NASA.

In conjunction with the State Department, the NCO coordinates U.S. policy positions with international members and organizations of the PNT world community. Efforts are coordinated within the U.S. government through various departmental GPS and PNT working groups. Given this administrative structure and the current standing of the GPS system, the United States has considerable influence in the evolution of international strategy, policy, and standards.

In Europe, after significant restructuring in 2007, the European Commission (EC) is now fully in charge. The EC owns the Galileo system itself as well as related GNSS initiatives, and work with ESA and member governments to coordinate activities.

Russia has also developed a coherent policy framework around GLONASS,

and the Chinese government has increasingly clarified its strategy, policy, and organizational structure. Both Japan and India have well-developed planning processes for their PNT systems. In 2009, Japan passed a new Basic Space Law that reorganized its management of space programs and authorized the nation to use space for defensive purposes.

At this point we should clarify the important distinction between service provider systems and GPS augmentation systems. The systems in Japan and India are wholly reliant on GPS, whereas GLONASS, Galileo, and COMPASS intend to be independent GNSS system operators and service providers. Yet, the GPS constellation remains the benchmark that other systems seek to emulate.

Our analysis also incorporated the issue of policies and assets required for ground and air augmentation of PNT systems, where the United States leads the push to provide ancillary signals and additional services to government and industry.

Europe, Japan, India, and Canada are pursuing similar initiatives at lower levels of funding and prioritization — in many cases under the auspices of regional or international initiatives. **Table 5** and **Figure 4** summarize the results of our qualitative PNT policy, strategy, and systems assessment.

Not surprisingly, the United States with its fully operational GPS constellation led the rankings. Russia, with its nearly full operational GLONASS system ranks a low second, followed by China and Europe as each has initiated test-bed satellites for their own systems.

Japan is focused on national positioning and augmentation services. India, Israel, Canada, South Korea, and Brazil, meanwhile, currently do not have operational or near-term in-development on-orbit GNSS assets, and have invested limited resources in other aspects of government capability.

Looking forward, a key facet of the PNT sector in 2009 will be China's plan to launch several PNT satellites, with more than 10 satellites to be launched over the next several years. In 2010, the Chinese system should be able to enhance its regional service Beidou-1, which has been providing regional PNT services for several years.

India now plans to launch its GSAT-4 into geostationary orbit in December 2009, which will have a dedicated transponder payload for the GPS-Aided Geo Augmented Navigation (GAGAN) system. GSAT-8 and GSAT-9, which also carry GAGAN payloads, will be launched soon thereafter.

Japan's Multi-functional Transport Satellite (MTSAT) Satellite-based Augmentation System (MSAS), with two spacecraft already up and running today, also remains a factor. Therefore, by 2010, three regional Asia PNT systems could be in place, which in turn could significantly affect the underlying industrial composition of the industry.

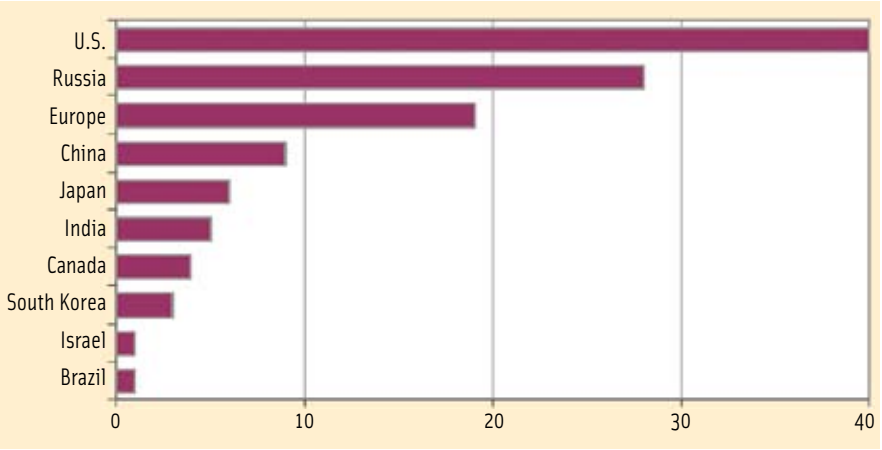

FIGURE 4 Government PNT Policy, Strategy, and Systems: Scores by Country

	Government Policy	Number of Ground Stations	Number of PNT Satellites	Weighted PNT Index		Change in Ranking
Country	2009 Score	2009 Score	2009 Score	2008 Score	2009 Score	2009
U.S.	100	100	100	40	40	-
Russia	75	20	94	24	28	
Europe	80	94	7	30	19	-
China	50	10	16	12	9	-
Japan	40	11	7	8	6	
India	45	2	0	10	5	-
Canada	10	31	0	4	4	-
South Korea	0	0	0	0	3	n/a
Israel	10	2	0	0	1	n/a
Brazil	0	5	0	0	1	n/a

TABLE 5. Government PNT Policy, Strategy, and Systems: Scores by Country

Note: Scores are normalized to 100, but represented in their appropriate 40-20-40 split in the Weighted PNT Index

PNT Human Capital Analysis

To assess the human capital capability of the 10 leading space participant nations, Futron uses a series of proxy metrics to gauge end-user interest and the strength of civil society. **Table 6** and **Figure 5** highlight our findings.

Human capital represents Europe's strength in the PNT segment, highlighting an on-the-ground interest in PNT activities by both organizations and individuals. Within Europe, Germany is the clear leader according to our indicators.

Although not directly accounted for in the index, several European institutes have developed academic PNT curricula and intend to organize specific university programs. The United States follows Europe in human capital indicators. Subsequent rankings include Russia, China, and Canada.

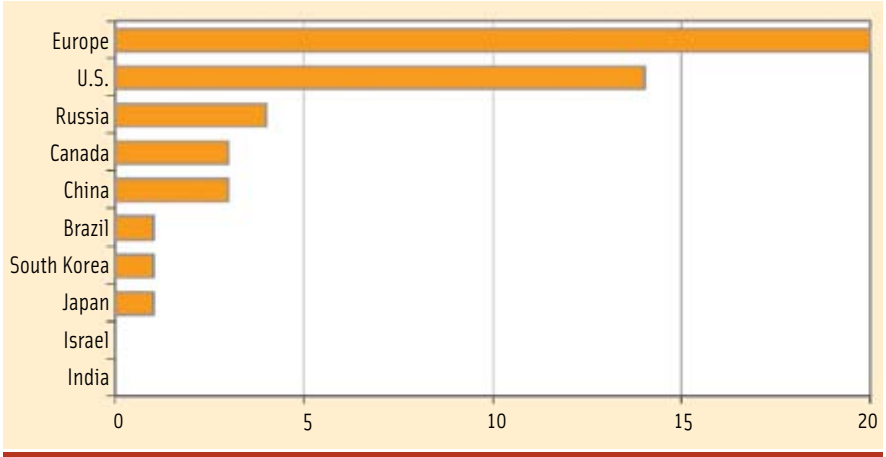

FIGURE 5 Human Capital PNT Capability Scores by Country

	Number of IGS Data Providers	Number of IGS Members	Weighted PNT Index		Change in Ranking
Country	2009 Score	2009 Score	2008 Score	2009 Score	2009
Europe	100	100	n/a	20	n/a
U.S.	54	86	n/a	14	n/a
Russia	26	12	n/a	4	n/a
China	14	12	n/a	3	n/a
Canada	6	20	n/a	3	n/a
Japan	9	5	n/a	1	n/a
South Korea	3	5	n/a	1	n/a
Brazil	4	3	n/a	1	n/a
India	3	2	n/a	0	n/a
Israel	3	0	n/a	0	n/a

TABLE 6. Human Capital PNT Capability Scores by Country

Note: Scores are normalized to 100, but represented in their appropriate 40-20-40 split in the Weighted PNT Index

PNT Industry Analysis

Futron analyzed the commercial PNT marketplace and its related equipment and service market, developing a list of leading manufacturers of revenue and companies for leading products, developers, software providers, and applications. The United States and Europe are leaders, but interestingly the U.S. position advanced in the commercial space (see **Table 7** and **Figure 6**).

In contrast, the degree of PNT and GPS commercialization in the remaining countries that we analyzed, as measured by revenues accrued, remains substantially less. This may, in part, reflect a previous lack of strong PNT industry organizations and transparency in financial reportage for some regions.

Looking forward to 2010, however, Russia will likely gain as GLONASS revenue figures become available with government buyers probably driving early commercial revenue.

Notable PNT commercialization trends include merger and acquisition activity such as recent combinations of hardware and software providers, creating vertical commercial players. The integration of GPS into the mobile telephony market represents a noteworthy development, with Nokia becoming a significant player aided by its acquisition of NAVTEQ, a leading developer of navigable digital maps. GARMIN, a leading GPS equipment manufacturer, also introduced a GPS cell phone product.

GPS pioneer Trimble has started to market a range of products that incorporate GLONASS technology and in 2009 announced a joint venture with a Chinese company to produce Compass receivers. Other GNSS receiver manufacturers also offer GLONASS-capable receivers, and several satellite signal/constellation manufacturers offer products that support product development for all GNSS systems and augmentations. These developments suggest a continuing diversification of end-user applications and hardware options.

The table and chart below summarize our data for our industry indicators, noting in advance that Russia should rank significantly higher — perhaps third. Indications suggest that the internal Russian market is growing and that GLONASS products are gaining market traction. However, raw data on Russia's commercial PNT industry is not available, which undermines the country's position in our index.

Some interesting notes on the market suggest that the overall demand for European PNT devices may have peaked. TomTom, a leading European manufacturer, announced that in late 2008 its sales in Europe declined 7 percent year on year, while they increased 12 percent in North America over the same period.

Much of this growth is tied to new car sales, and the downturn in 2009 in the automotive industry will likely affect the PNT industry during the year. GARMIN claims roughly one-third of the mobile/automotive PNT device market globally, while TomTom cites its market share in Europe at 46 percent and North American at 23 percent. TomTom recently expanded into Russia.

Another factor is the rapid uptake of so-called "smart phones" with integrated GPS technology that can be used with inexpensive downloadable navigation applications and location-based services.

Future Opportunities to Analyze the PNT Industry

During the second iteration of our PNT Index, we refined our model to include additional statistical factors. However, data for the PNT industry remains scarce;

so, going forward we hope to identify additional data points and metrics.

Acknowledgments

Futron would like to thank the validators of this study for providing invaluable insight into this assessment. Lastly, Futron would appreciate the opportunity for feedback on our effort. And we would like to hear from industry experts and organizations interested in partnering in this initiative going forward.

About Futron's Space Competitiveness Studies

The Space Competitiveness Index provides decision-makers — from lawmakers to policy advisors to industry executives — a dynamic framework from which to scrutinize the effects of macroeconomic, military, civilian, and commercial trends on space activity. Based on qualitative data and trending, leading space nations may set new space goals tied to changes in the underlying metrics to determine success.

Expanding international cooperation and greater coordination among commercial and non-governmental actors is critical, of course, but simultaneously leaders need to promote policies that ensure the continued technological, military, and strategic space advantages of people and industry within their borders. To find out more, visit our website at <http://www.futron.com/resource_center/store/Space_Competitiveness_Index/FSCI-2009.htm>.

Authors

Jay Gullish has more than 15 years experience in the communications, media, and government sectors in the United States as well as Africa, Latin America and South/Southeast Asia. An economist by training, Gullish has participated in a large number of financial transactions, assessments, due diligences, and forecasting. He has strong expertise in the ICT sector, including satellite telecommunications, information technology, outsourcing, contact centers, and business process outsourcing. Gullish has conducted strategy development and implementation at the senior level, including merger and acquisition activity – both as a party involved as well as an independent third party analyst. Prior to Futron, he was director of strategy and marketing for an Indian-based call center software development company, and before that worked at IBM, PricewaterhouseCoopers, and the U.S. Federal Communications Commission, International Bureau. Futron is based in Bethesda, Maryland.

David Vaccaro has 10 years of experience in space and telecommunications research and analysis involving satellite communications and ground infrastructure, national telecommunications policies, and international space programs. Prior to joining Futron, Vaccaro analyzed global telecommunications governance issues at the World Bank. He also has on-site work experience in emerging Asian markets, leading an Internet design team at an advertising firm in Nanjing, China, as well as managing public relations for a Chinese e-commerce portal. At Futron, Vaccaro has managed several teams of employees on individual projects ranging from comprehensive economic valuations of the satellite industry to quantitative analysis on behalf of multiple-year, multimillion-dollar federal government contracts. He has been a major contributor to reports on topics ranging from global space competitiveness to the national security implications of international telecommunications infrastructure. Vaccaro concentrated in science, technology, and international affairs at Georgetown University, where his studies focused on telecommunications as an avenue for economic development. IG

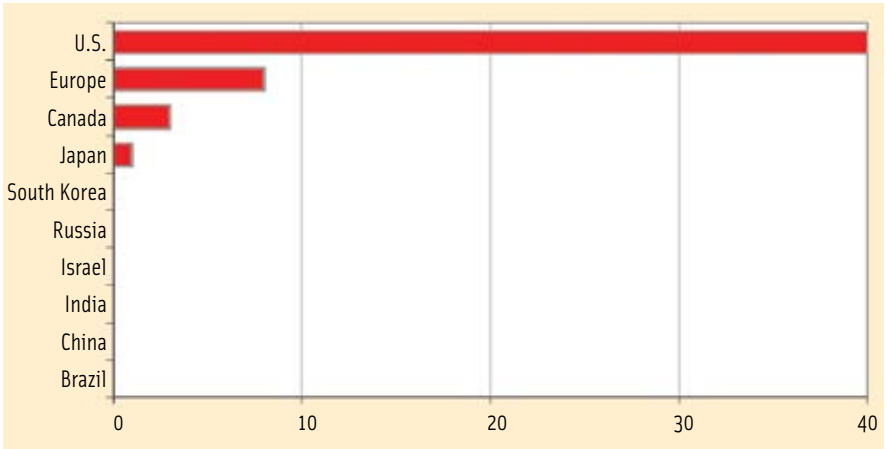

FIGURE 6 Industry PNT Commercialization Scores by Country

	Revenue of Leading Companies	Number of Companies	Weighted PNT Index		Change in Ranking
Country	2009 Score	2009 Score	2008 Score	2009 Score	2009
U.S.	100	100	40	40	n/a
Europe	17	26	17	8	n/a
Canada	1	14	0	3	n/a
Japan	3	2	0	1	n/a
Israel	0	2	0	0	n/a
Russia	0	1	0	0	n/a
China	0	1	0	0	n/a
India	0	1	0	0	n/a
South Korea	0	0	0	0	n/a
Brazil	0	0	0	0	n/a

TABLE 7. Industry PNT Commercialization Scores by Country

Note: Scores are normalized to 100, but represented in their appropriate 40-20-40 split in the Weighted PNT Index