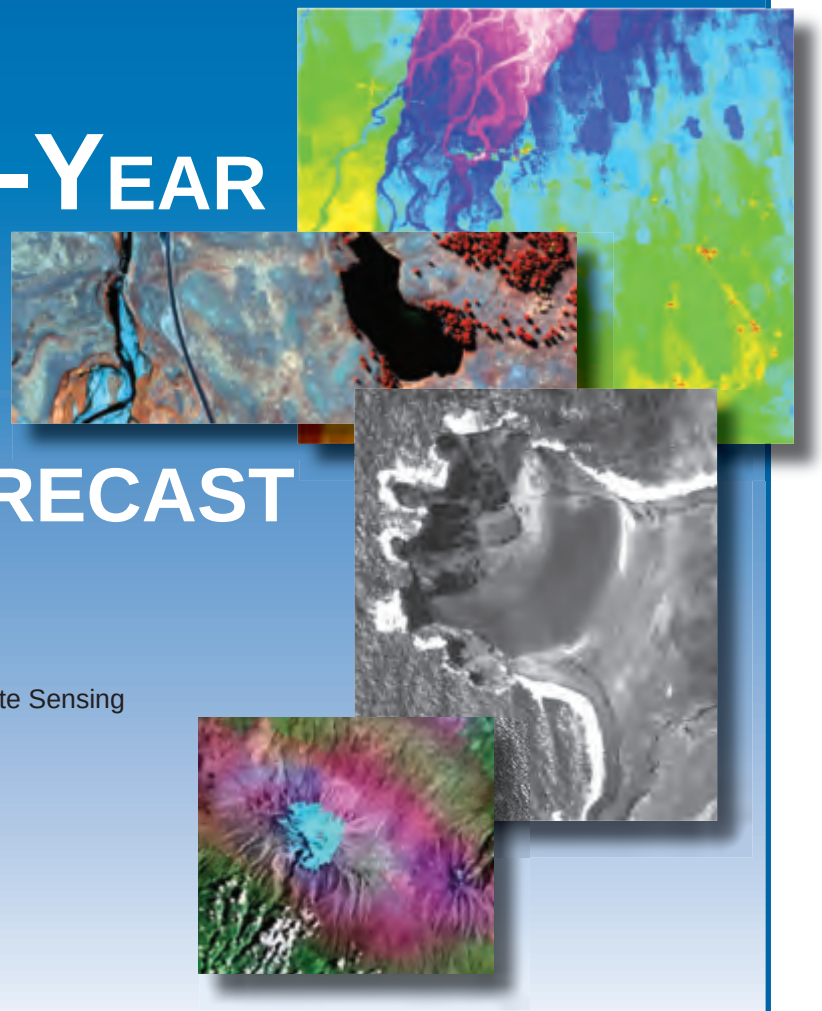
ASPRS Ten-Year Remote Sensing Industry Forecast

Phase V



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Richard Medina, *University of Utah*

Executive Summary

Phase V of the ASPRS Ten-Year Remote Sensing Industry Forecast is an extension of the previous four phases with respect to topical foci on industry workforce needs, economic conditions, evolving technology, and governmental policy. In addition, Phase V explicitly opened up to the international remote sensing community.

An internet survey was the primary tool for sampling from the combined membership rosters of the ASPRS and the ISPRS. The sample used for the analysis consisted of 512 responses from 58 nations. The majority of the respondents reside in North America and Europe having advanced degrees in remote sensing, geography, GIS and photogrammetry. Many of the respondents work outside of their resident nations, most in East Asia and South America.

Undergraduate and master's degrees are the most desired for new employees. The knowledge and technical areas most desired for new employees were application GIS tools, spatial database understanding, cartography/visualization, verbal and communication skills, and photogrammetry.

In relationship to Phase IV, Phase V results still show a strong percentage unsure of the future; however, the out years no longer highlight an expectation of a spending decline. When the responses are segmented by region, responses from most regions of the world indicate modest expenditures for the 2010 year.

Previous Forecast reports highlight that demand for the highest levels of resolution was clearly not met; data users wanted higher resolution content. Phase V shows that this trend continues in the global market. Digital aerial sensors, as well as the continued operation of high-resolution satellite systems have expanded the global demand for better than half meter data. Provision of data lower in spatial resolution than half meter is now an area of potential overcapacity.

Lidar, hyperspectral and IFSAR were identified as the three data sources that need exceeded current use. Data fusion appears to be considered more in these results than reliance on a single sensor or data source.

Satellite sources of data versus aerial sources are used more in developing regions of the world. Landsat 7 was the most utilized by respondents (74%), followed by Landsat 5 (66%), GeoEye-Ikonos and Digital Globe-Quickbird (both at 62%) and MODIS and SPOT 5 with about 44% of the respondents citing usage.

Restrictions on remote sensing data were viewed as a hindrance in every region of the world. However, the survey indicated that respondents from East and South Asia, Africa and Oceania felt that effects of restrictions on data, licensing and governmental controls most limiting on their activities.

The most significant issues that continue to represent large challenges and opportunities with the industry are: the demand versus cost in an uncertain economy for high spatial resolution and new sensor data, both aerial and satellite, meeting the increase in demand for a higher levels of education in GIS and newer imaging technologies and the conflicting roles of national governments in developing remote sensing platforms and products while limiting access and use of data.

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Introduction

Phase V of the ASPRS Ten-Year Remote Sensing Industry Forecast seeks to extend the results of the first four phases in order to determine whether or not the trends noted in the first phases are continuing. The Phase V survey was extended explicitly to the larger international community. We hope that the results of this survey will inform and stimulate discussion about the industry. Given the limited nature of the survey, the results cannot be used to make explicit predictions, but do provide important information and indicate trends of interest.

In particular, ASPRS carried out the Phase V survey in order to obtain current statistical information and future expectations from a representative sample of the international remote sensing/geospatial community regarding:

- Use of and needs for specific requirements in geospatial information
- Workforce hiring needs and requirements
- The international marketplace of the industry
- The role of government policy in the geospatial industry.

These objectives formed the basis of a questionnaire that extended information gained from similar topics and questions in Phases I-IV and questions designed to elicit new information regarding the international creation and use of geospatial information.

Description of Sample and Internet Survey

The survey was implemented in late 2007 to members of ASPRS and the ISPRS. The initial roll out of the survey was announced at the ISPRS conference in Kuala Lumpur, Malaysia in November, 2007. The members with email addresses of both ASPRS and ISPRS were requested by email to complete the internet survey. ASPRS has approximately 6000 members, with nearly equal representation from the government, private sector and academia. ISPRS's email roster of members is approximately 5,000 individuals. Potential respondents were notified by email two times throughout this period with a request to complete the on-line survey. Five hundred and twelve (512) individuals responded to the internet survey, which amounts to slightly less that 5% of the target population.

Limitations on Interpretation

This report summarizes responses to the questionnaire and thus presents general trends occurring in the industry, not specific statistical information with confidence sufficient for prediction. The sufficiency of the sample size issue is confounded by the inability to control properly for assumptions of sampling theory (random, unbiased samples) that would allow rigorous statistical procedures. The internet delivery of the survey does not allow rigorous sampling protocols as it depended on voluntary response of the sample population. Unlike Phases I-III, Phase V relies solely on an internet survey for data. Also, this survey primarily represents the views of respondents from the civilian sector (non-military) of the geospatial-remote sensing industry. Interpretations should be viewed with the survey limitations in mind. Although there was no means to randomize sampling for various sectors or geographic regions, the results provide a useful stratification according to variations in responses between these sectors and regions.

Respondents were asked to indicate the nation in which they lived. These responses were aggregated into regions for presentation of responses to various questions in this study. The task of regionalization is never easy, and certainly the schema used in this study has its peculiarities. For example, Mexico is included with North America as there was only one response from Mexico and the nations of Central America were combined into South America. The 13 responses from Turkey were included in Europe as Turkey is an associate member of the EU and fits better into the Europe region scientifically and economically than in other adjacent regions.

The world maps of the survey results require some qualification as well. For example, Greenland is included in the European region on the global maps. However, the level of place of work activity, for instance, is at a level far below the rest of Europe.

Profile of Respondents

The sample had a total of 512 individual respondents from 58 nations. Of those individual respondents, 295 (58%) identified themselves as end users of remote sensing data/information. Two hundred and seventeen (42%) specified that their primary job was managing productivity in their remote sensing/geospatial organization.

The respondents were asked to indicate the primary sector in which they were employed. The leading categories were General Mapping (20%), and Environmental (19%). Civil government and Other were the next largest employment areas, of which 6% of the total listed education/academic within the Other category.

The majority of respondents had advanced degrees with the largest category having master's degrees (38%), followed by 35% of the respondents having Ph.D. degrees. Six percent had postgraduate certificates.

The largest group of respondents (119 or

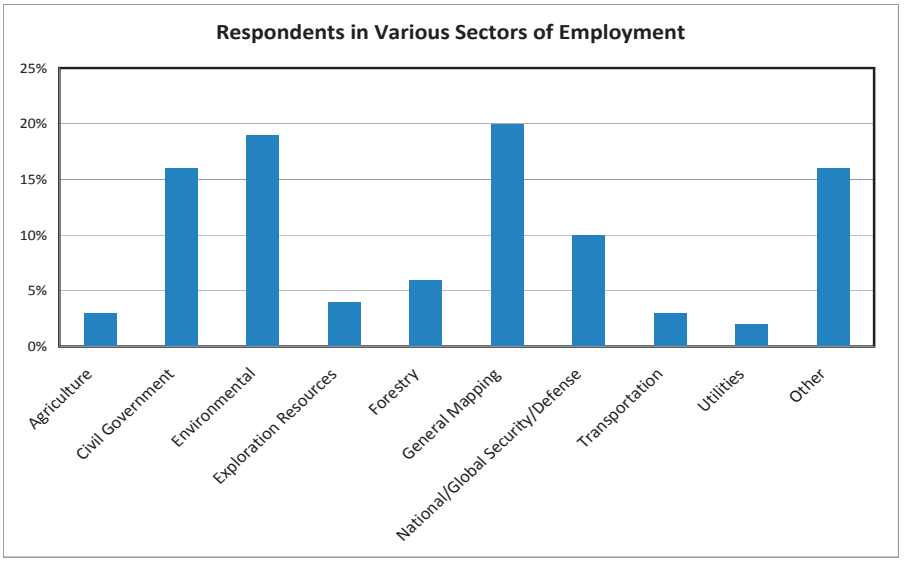

Figure 1. Question 3: In which of the following Sectors and Sub-Sectors do you work? Select one (primary)
Also important other: Academia/Education – 6%

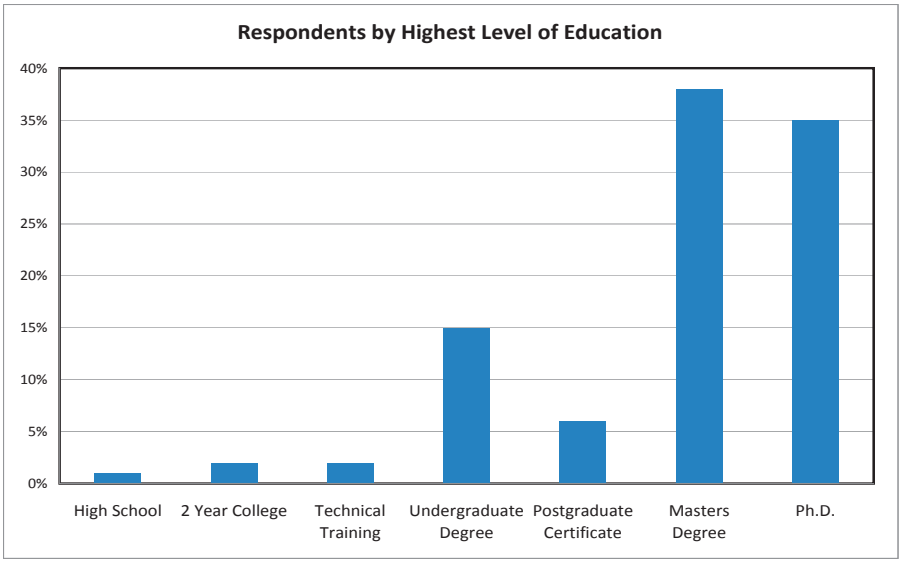

Figure 2. Question 6: What is your highest level of education?
n = 486

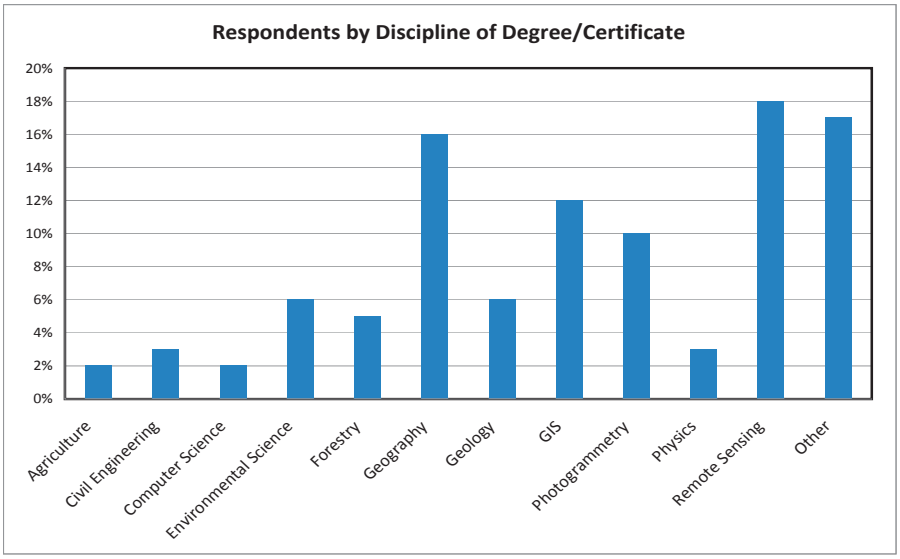

Figure 3. Question 7: In what discipline is your degree/certificate?
n = 677 (more than one category chosen)

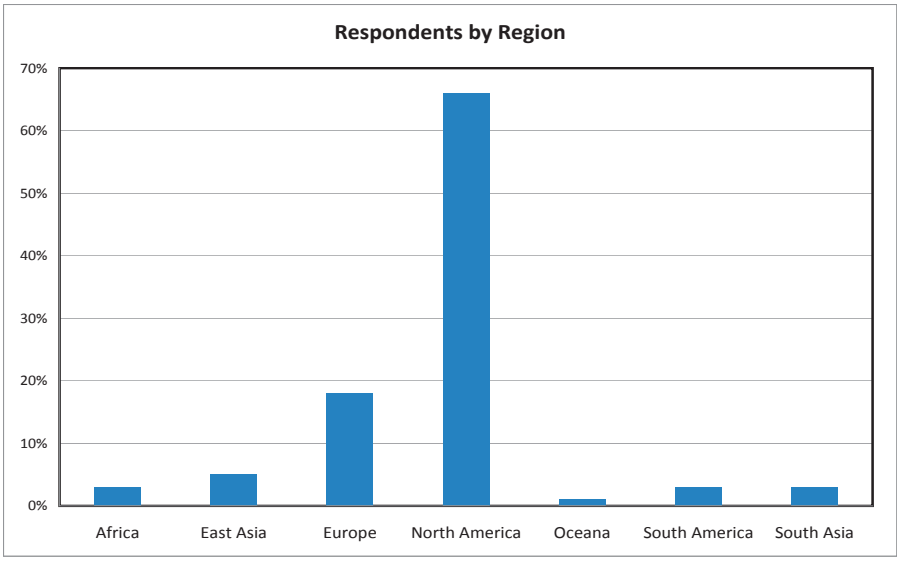

Figure 4. Question 4: In what country do you live?
n = 492

18%) to this question listed Remote Sensing as their primary discipline. This was followed by Other at 17% (113), which included numerous other disciplines from atmospheric science to urban planning. Geography was listed as the third largest disciplinary category at 16% (106). This result indicates the greater international prevalence of specific degrees in remote sensing. This is opposed to a North American prevalence of comprehensive academic programs in remote sensing and geospatial information being centered in university geography departments. Unlike some industries, persons of diverse disciplinary backgrounds are successful in the multidisciplinary geospatial business.

Most of the respondents (66%) lived in North America, with 18% from Europe, five percent from East Asia, and three percent from Africa, South Asia and South America.

The map of the where the respondents worked indicates the global nature of the industry. One can see that many of the current industry projects, as evidenced by where respondents are working, are in the regions of the developing world. North America and Europe are magnified as places where respondents are working, since the majority of respondents live in these regions and, therefore, specified these regions as where they work. Future analysis will focus on diminishing the bias to identify those regions outside of North America and Europe that have most project activity.

One interesting derivative question from the survey is how many North Americans and Europeans are working in regions of the world. If one examines the regions that respondents are working excluding their resident region, a different map of project activity results. Since the size of the group being examined is different, one should focus the relative percentages between the two maps, as well as absolute numbers. East Asia increases from 7% (135) to 14% (112) of the total indicating that when East Asians are not counted for the region, a large number of non-residents respondents have projects in East Asia. The same is true for the other regions. The greatest decline in respondents eliminating residents between the two maps is in North America. Specific conclusions are difficult, but the trend appears to be that a large number of North Americans are working in other regions of the world.

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WorkForce Issues

Response to Question 21 regarding the level of education most desired by organizations for their remote sensing workforce revealed a slight difference between our more international response in Phase V and the previous solely North American response in Phase IV. The Phase V respondents cited the need for more undergraduate degrees for students followed by the need for a workforce educated to the master's degree level. Phase IV had the master's degree as the preferred level of education for the workforce and the educational community is not meeting the industry need for master's and Ph.D. level graduates, and for graduates with technical training and geospatial certificates.

The survey asked the respondents to identify the knowledge and skills most needed by new employees in the future. The 399 respondents could list more than one type of knowledge or skill. Taking those types of knowledge and skills cited by more than 50% of the respondents, new hires should possess knowledge of application GIS tools (66%), spatial database understanding (57%), cartography/visualization (55%), verbal and communication skills (54%), and photogrammetry (50%). These results (similar to Phase I-IV) reveal that the most needed skill areas involve the development of applications, especially in the GIS realm, rather than more basic areas of a particular sensor technology or related skill set. Interestingly, cartography (visual communication of information using maps) and verbal and communication skills are two of the most needed skills surpassing all of the other technical areas associated with remote sensing. This provides valuable insight into the apparent inability of current employees to speak, write and communicate effectively. It indicates the need for a broader education that focuses on analytic and communications skills as well as technical training. Photogrammetry was listed with a 50% response, a bit more than in similar questions in Phases I-IV. This may reflect the greater emphasis on photogrammetry within the international community.

Spending Trends

In most purchasing categories, Phase IV respondents expected the level of total purchases to decline in future years. Further, they expressed increasing uncertainty about estimated future purchases with time. Phase V still shows a strong percentage unsure of

Figure 5. Question 5: In what country or countries do you work (please check all that apply)?
n = 492. Total exceeds number of respondents since many work in more than one region.

Figure 6. Regions that respondents are working, excluding their resident region
n = 492. Total exceeds number of respondents since many work in more than one region.

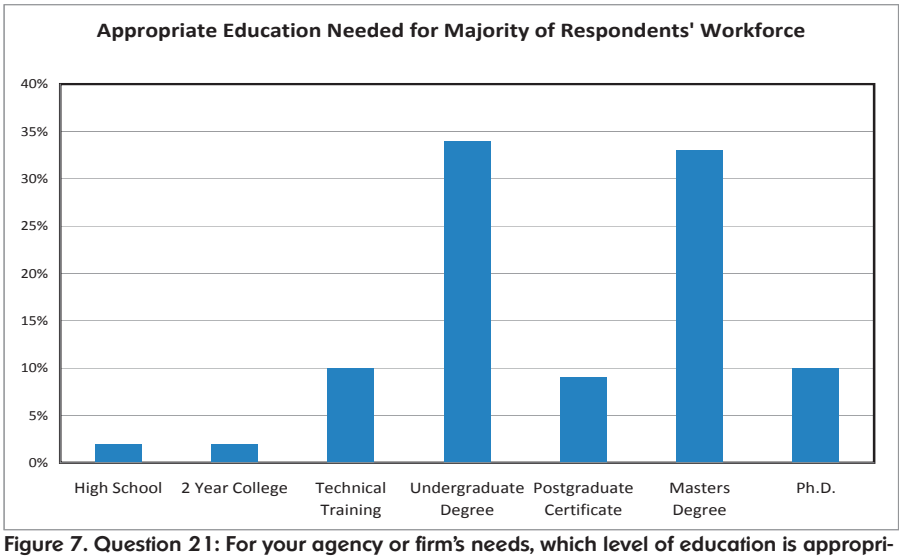

Figure 7. Question 21: For your agency or firm's needs, which level of education is appropriate for the majority of your workforce?
n = 398

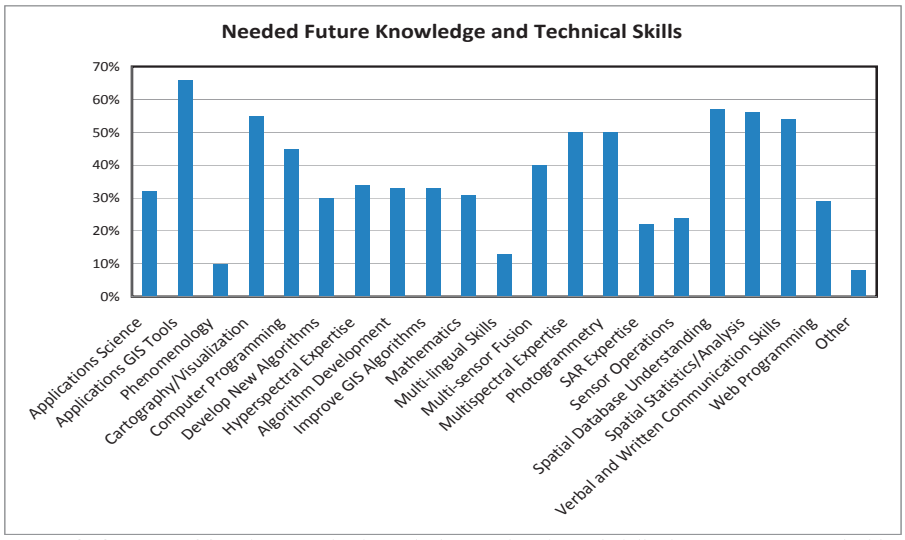

Figure 8. Question 22: What are the knowledge and technical skills that are most needed by your employees for the future? Please check all that apply.
Percentages reflect the number of respondents, where n = 399.

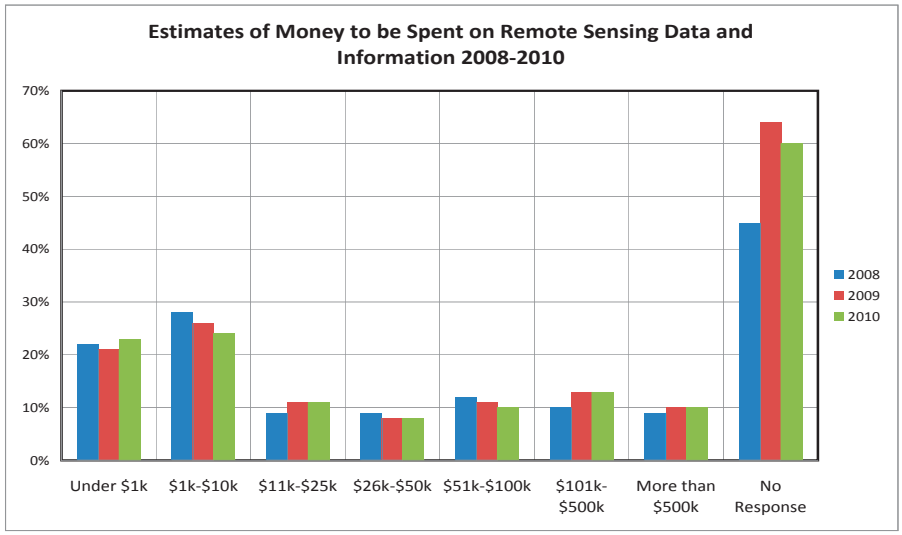

Figure 9. Questions 10-11: For the years 2008, 2009 and 2010, about how much money will you spend or authorize to acquire remotely sensed data or information, in US Dollars?

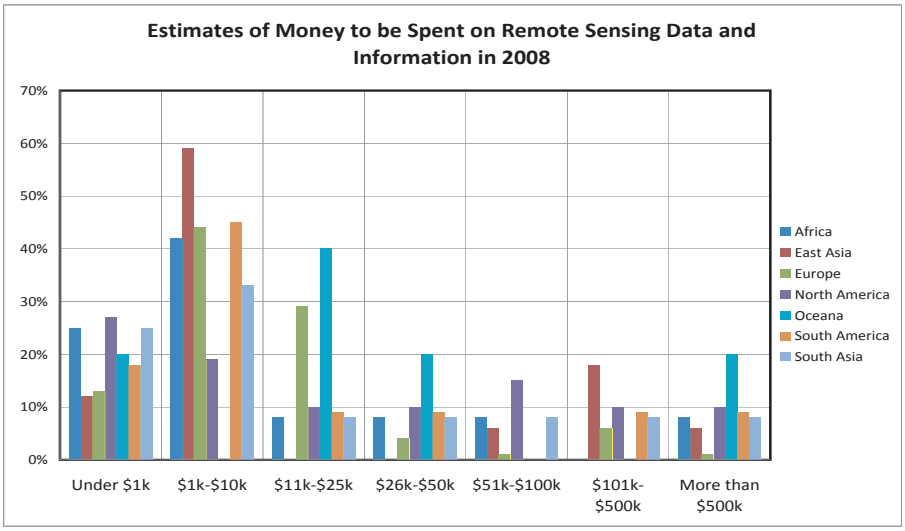

Figure 10. Question 10: For the year 2008, about how much money will you spend or authorize to acquire remotely sensed data or information, in US Dollars?

the future, however the out years no longer highlight a spending decline. These results may represent an expected modification in economic spending due to political change.

The overall spending at mid levels noted here shows a level trend. This survey has increased international participation versus previous studies and reflects the desire of many firms to perform work internationally. Commercial firms continue to outsource many core industry products and services internationally to achieve lower cost of goods sold.

In review of the data segmented by region a much stronger bias is seen in spending at the lower end of the spectrum with the largest data consumption under $10K USD, this may be highlighting data required to complete outsourcing tasks. It is also apparent that this spending trend is maintained through the near future, with some locals considering additional spending by 2010.

Technology Application Areas

Phase V of the Forecast provides a follow-up assessment of the technology areas which firms utilize to conduct business. Technology areas polled in Phase V are similar to those found in the previous phases of the Forecast. This has been done to allow the user to trend data over time. It MUST be noted however that population and regional sampling have changed. Overall trend data may still be compared.

Data Characteristics

As in previous phases key attributes in remotes sensing were sampled:

Spatial Resolution *Geospatial Accuracy*
Vertical Accuracy *Image Types*
Currency *Air versus Space*

Phase V continued this enquiry using a regional breakdown of the data. Two points stand out in the relative importance of the attributes. Data currency is clearly continuing to increase in relative importance. As global change escalates the demand for timely data continues to rise. The lack of international interest in data licensing is worthy of note. Data licensing barely registered as a point of concern in the study. While this often appears as an area of discussion, those participating in Phase V do not seem to share in this significance.

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Data Characteristics: Spatial Resolution

The question about spatial resolution "needed" versus the resolution of the data "used" reflects the continued demand for high resolution data worldwide. Past surveys highlight that demand for the highest levels of resolution was clearly not met; data users wanted higher resolution content. Phase V shows that this trend continues in the global market. Digital aerial sensors, as well as the continued operation of high-resolution satellite systems have expanded the global demand for better than half meter data. This "used" versus "needed" transition point has shifted to higher quality data from previous surveys. Provision of data lower in resolution than half meter is now the area of potential overcapacity. The industry confirms this argument in price reductions for course resolution orthophotography.

Data Characteristics: Geospatial & Vertical Accuracy

Past industry surveys indicate that high quality geospatial and vertical accuracy data as an end product is in high demand, even with the cost associate premiums. With the growth in automated aero-triangulation, lidar, and direct geo-registration, much of this demand is well served. Each of these technologies drives improvement in data overall. The new imaging sensors with superior resolution and dynamic range require timely and current positional data to complete their data georegistration processing. Ground sample distances (GSD) of 6" and better continue to offer users the ability to focus on smaller and smaller targets, each requiring better positional data for production. Phase V validates the overall shape of the trend worldwide.

Vertical accuracy source data pushes overall quality in many imaging systems that are now classified as DEM-limited in performance. The greatest error source in pixel placement for these systems is that associated with the source elevation data. Phase V of the Forecast shows that technology has closed the previous gap in elevation data supply versus demand at the half meter level. While the best levels of performance still show unmet demand, the overall match in "used" versus "needed" worldwide indicates a greater shortfall than in the US only Phase IV. The adoption of automated elevation extraction and lidar still shows strong potential globally.

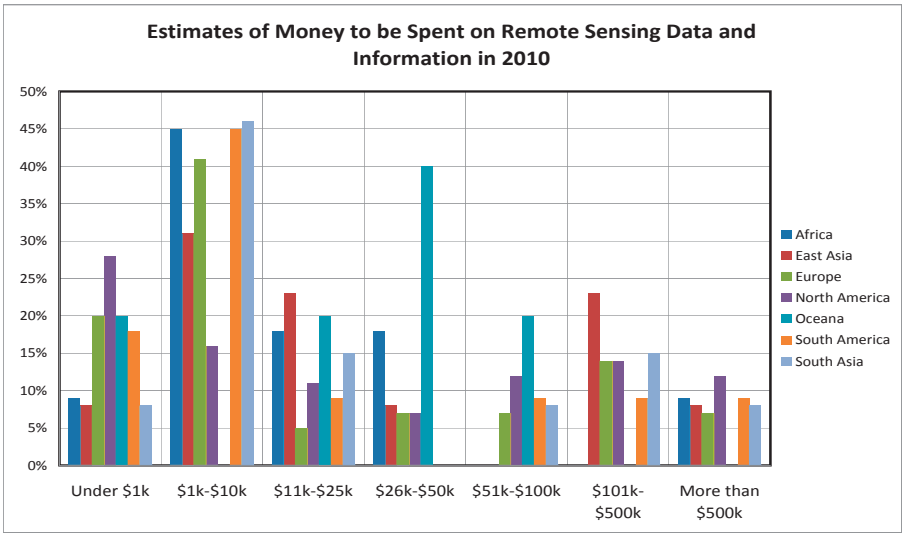

Figure 11. Question 11: For the years 2009 and 2010, about how much money will you spend or authorize to acquire remotely sensed data or information, in US Dollars?

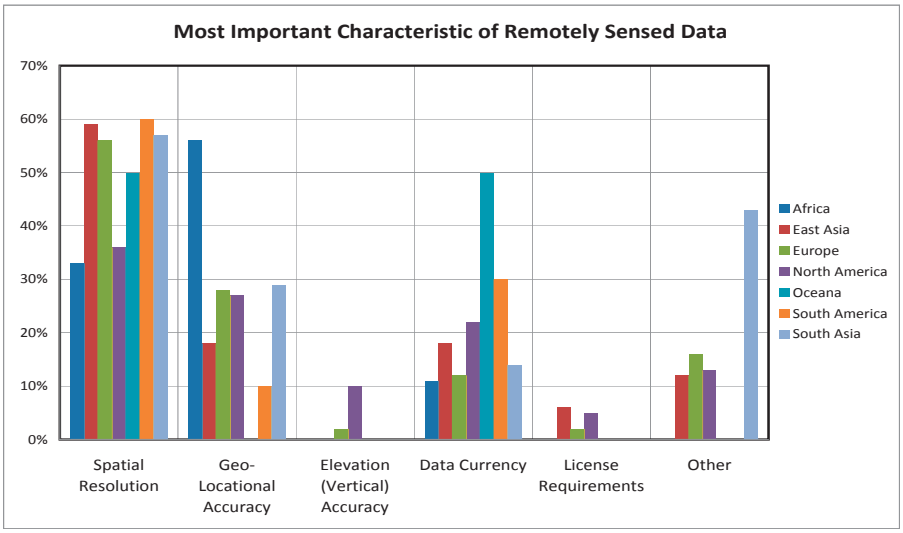

Figure 12. Question 12: For your job requirements, which is the most important characteristic of remotely sensed data or information?

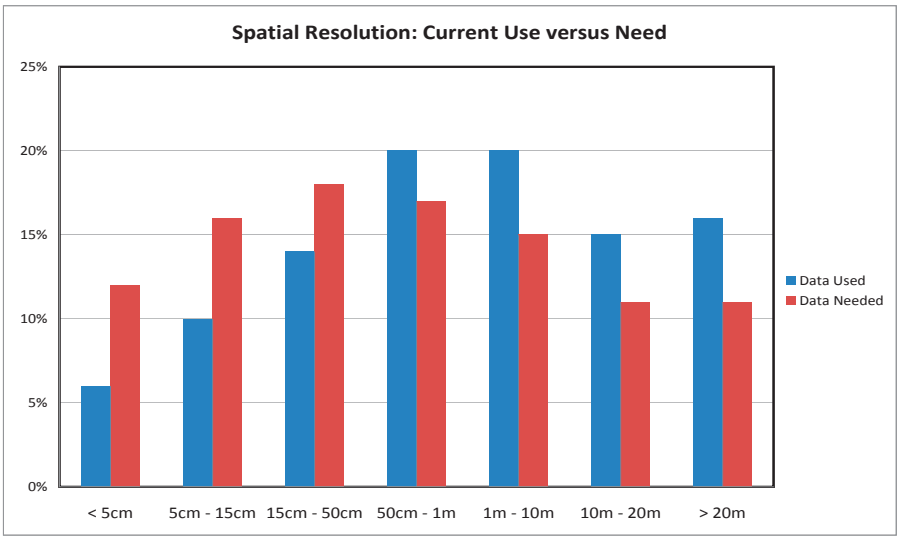

Figure 13. Question 13: What levels of Spatial Resolution do you currently WORK WITH today? What levels of Spatial Resolution do you NEED most to do your job? (Could be the same – check all that apply)

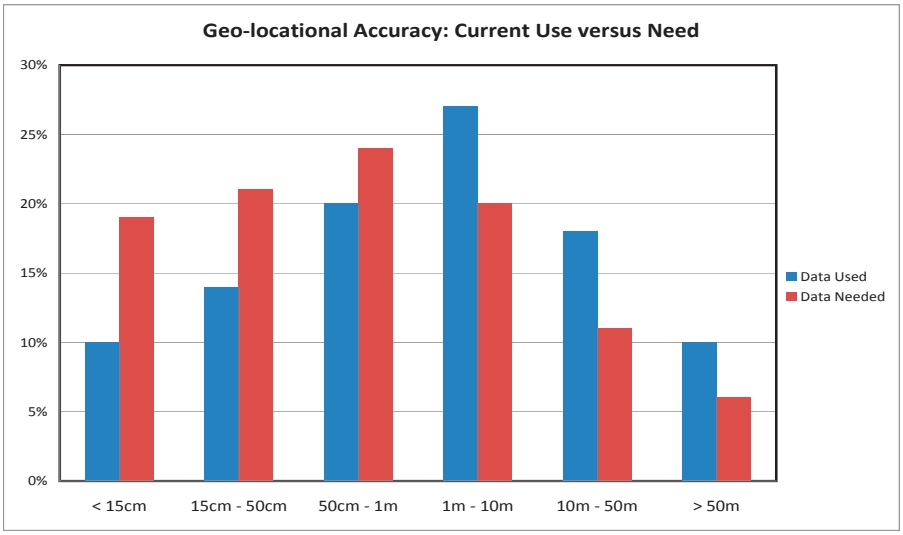

Figure 14. Question 14: What levels of geo-locational accuracy do you currently WORK WITH today? What levels of geo-locational (horizontal) accuracy do you NEED most to do your job? (Could be the same – check all that apply)

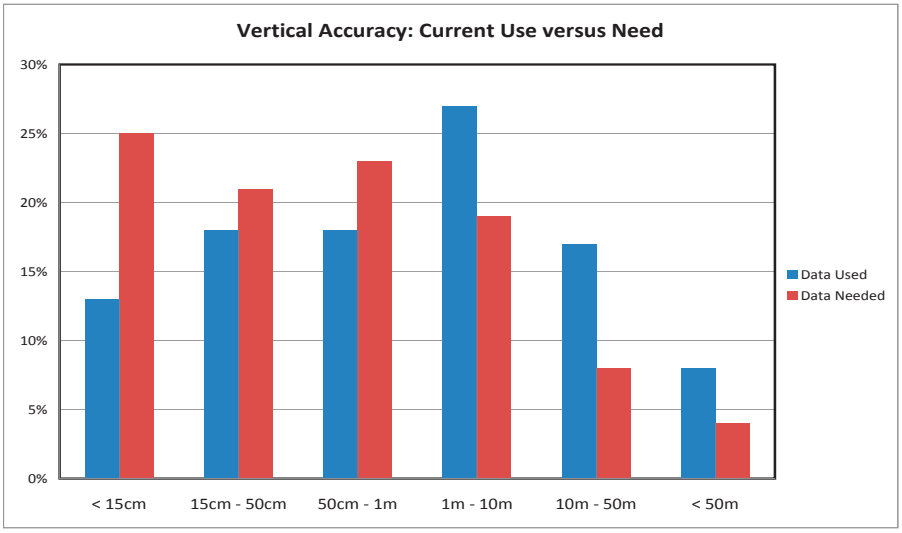

Figure 15. Question 15: What levels of elevation (vertical) accuracy do you currently WORK WITH today? What levels of elevation (vertical) accuracy do you NEED most to do your job? (Could be the same - check all that apply)

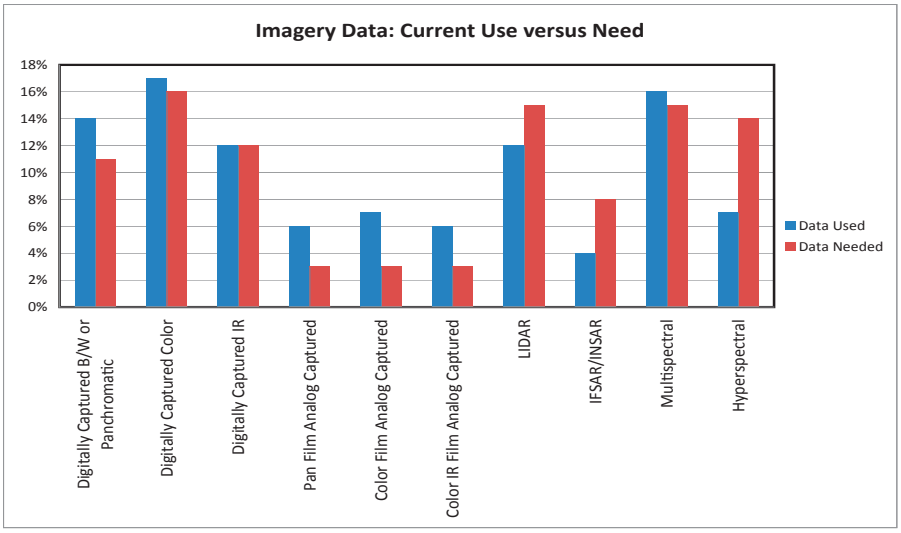

Figure 16. Question 16: What image/sensor types do you currently WORK WITH today? What image types do you NEED most to do your job? (Could be the same - check all that apply)

Data Characteristics: Image Types

The industry continues its utilization of technologies comparable to those of previous studies. Film-based image acquisition has shown a steady decline since the inception of the Forecast; Phase V confirms this but does show a slightly higher use rate worldwide than U.S. only data. Phase V continues the track of film versus digital transition in consumer and professional imaging markets. Phase V also confirms the overcapacity of digital sensors first seen in Phase IV. Only hyperspectral, IFSAR, and lidar appear to still drive industry demand.

Phase V confirmed the degree of data fusion and integration. This fusion had been qualified but not quantified. Clearly the demand for high quality resolution in concert with elevation is seen in the near 70% usage of fused data sets.

Data Characteristics: Currency

While resolution, accuracy and sensor type define the technologies employed, currency defines a critical component of the service aspect of the geospatial industry. The demand for "current" data is influenced heavily by global events. After the September 11, 2001 terrorist attacks, and again due to Hurricane Katrina, a strong increase was noted in demand for real time and near real time data. Users understood the value of near real time data in the assessment of disaster, triage, and rapid response. Commercial vendors have multiple price points for new, versus archival, data. As data pedigree ages to greater than one year its overall demand significantly decreases for many applications.

Data Characteristics: Air versus Space

If one examines the aerial-satellite question on a regional basis, the clear pattern is that satellite data is utilized more in the developing regions of the world. Only in North America does the use of aerial exceed satellite data usage. The likely reasons are the large area coverage needs in some regions, the lack of aerial coverage in many regions and the availability of lower cost aerial data in North America.

High-resolution satellites have proven themselves now in multiple generation commercial devices. Consolidation has occurred

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both in air and space based data vendors. The proportional use of satellite data has steadily increased compared to the aerial segment since the inception of the ASPRS Ten-Year Remote Sensing Industry Forecast. This study phase shows a leveling of both technologies.

Relatively few respondents indicated that restrictions were not an issue in their region. Respondents from Africa, East Asia and Oceania report the highest levels of data licensing and sharing restrictions. Forty percent of South Asian respondents indicated that government posed the greatest restrictions on access.

Landsat 7 was the most utilized by respondents (74%), followed by Landsat 5 (66%), GeoEye-Ikonos and Digital Globe-Quickbird (both at 62%) and MODIS and SPOT 5 with about 44% of the respondents citing usage. These results indicate the clear demand for both the moderate and high spatial resolution data. Other important data sources were Terra-ASTER (37%), AVHRR (30%), SPOT 4 (28%), Radarsat (25%) and Orbview and EO-1 (25 and 24%). These results indicate the clear dependency of respondents from all regions of the world on U.S. supported satellites and data.

View to the Future

Phase V of the ASPRS Ten-Year Remote Sensing Industry Forecast had a relatively high response with limited, but still useful responses from every region of the world. Phase V reinforced trends identified in Phases I-IV and recalibrated these trends based on the uncertainty of the financial situation and the increasing distribution of new technologies across the world.

Several areas of investigation need to be addressed in future phases, in addition to the extension of the lines of inquiry already developed in Phases I-V. These new areas for investigation are 1) the role of information firms, such as Google and Microsoft in the dynamics and traditional business models of the remote sensing industry; 2) the nature of the relationships between military and intelligence demand for imagery data, especially in the high resolution arena and the economic situation of imagery providers and the civilian sector's ability to acquire imagery to meet increasing demand; and, 3) the increasing role of many nations in providing satellite imagery with a multitude of capabilities and restrictions.

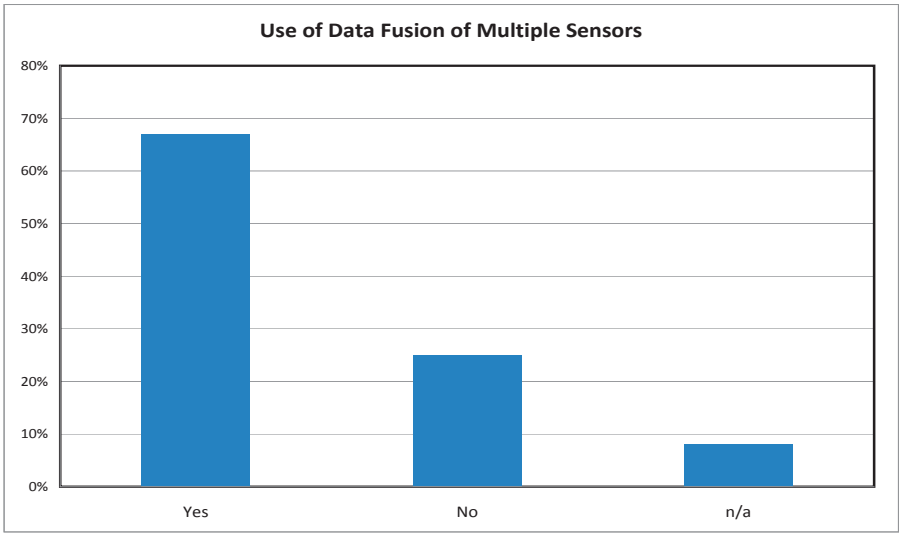

Figure 17. Question 17: Do you use data fusion of multiple sensor types you have selected above?

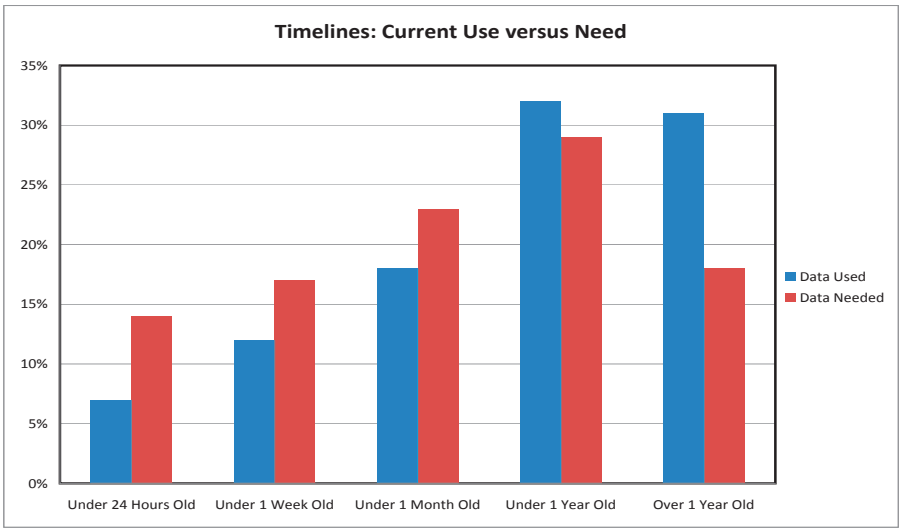

Figure 18. Question 18: How current are the data sets that you WORK WITH? How current do you NEED your data to be?

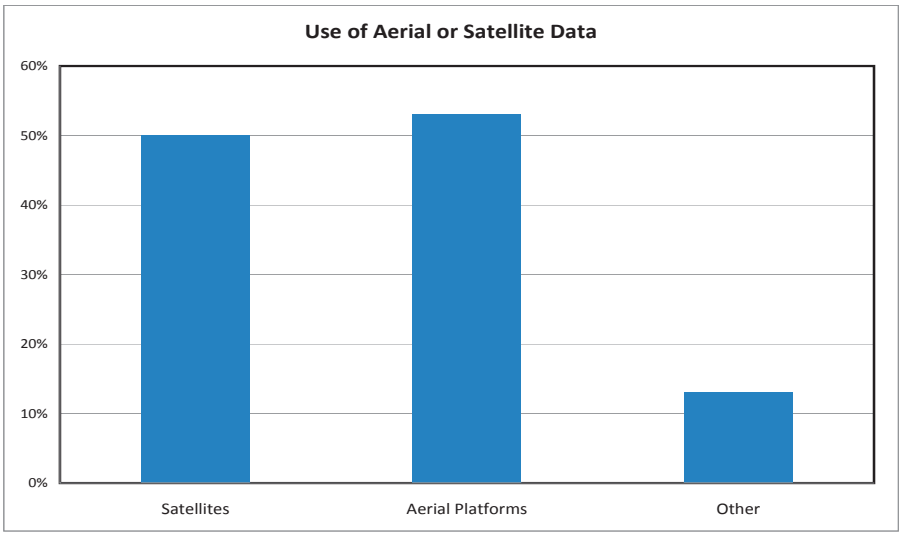

Figure 19. Question 19: What proportion of you remote sensing data/information is collected by aerial platforms vs. space-based collection? Your responses must add to 100%.

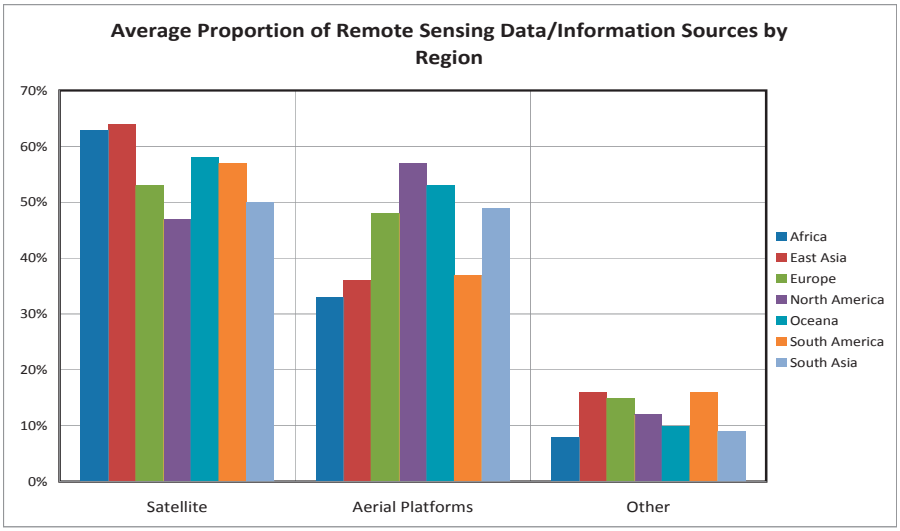

Figure 20. Question 19: What proportion of your remote sensing data/information is collected by aerial platforms vs. space-based collection? Your responses must add to 100%.

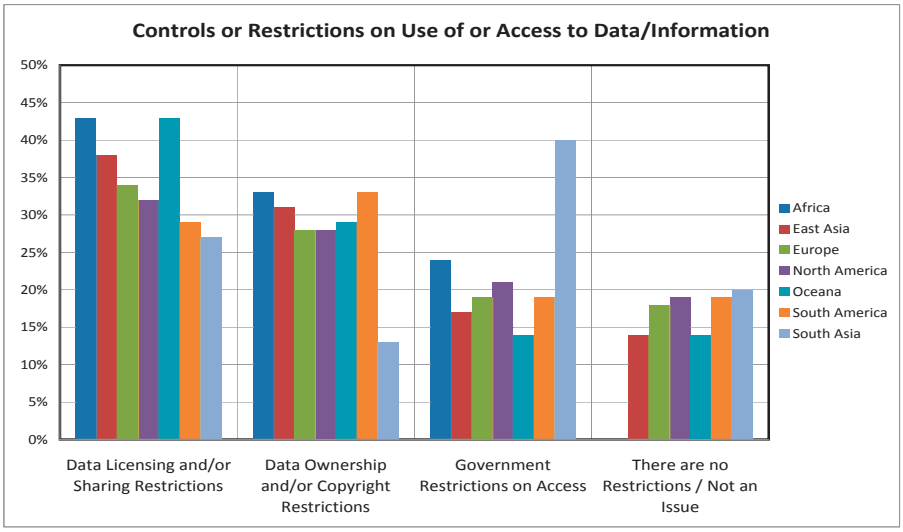

Figure 21. Question 20: What controls or restrictions on the use of, or access to, data/information most affect your work? Select all that apply.

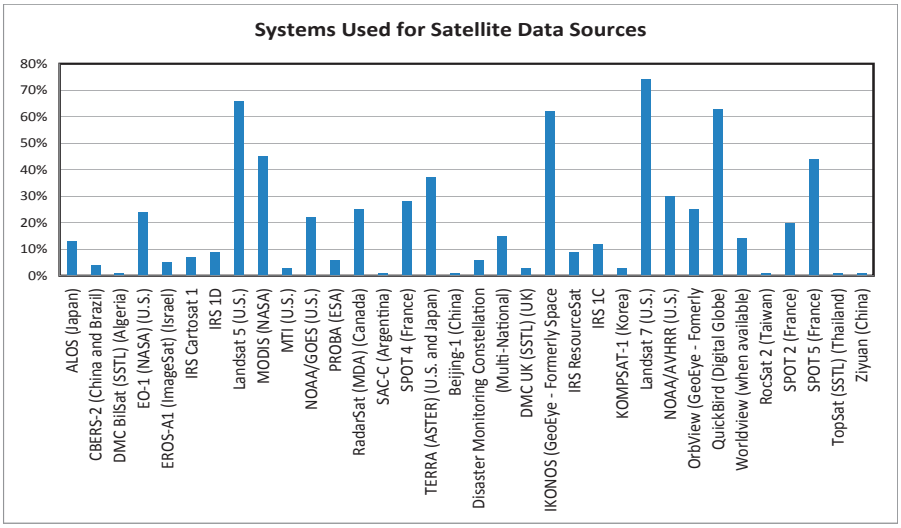

Figure 22. Question 26: Which sources provide satellite data utilized by your company/organization?
n = 2302 (More than one category chosen)

References

Charles Mondello, George Hepner, and Ray A. Williamson, "10-Year Industry Forecast: Phases I-III -- Study Documentation," *Photogrammetric Engineering and Remote Sensing*, Vol. 70, No. 1, January 2004, pp. 7-58.

Charles Mondello, George Hepner and Ray A. Williamson, "Ten Year Forecast of the U.S. Remote Sensing Industry Phase IV," *Photogrammetric Engineering and Remote Sensing*, 72-9 (September, 2006) pp. 985-1000.

Cover Caption

The NASA Applied Sciences Program within the Earth Science Division of the Science Mission Directorate has historically demonstrated practical applications of NASA Earth science observations and research. Through the NASA Scientific Purchase (Highlight Article, PE & RS, February, 2008), implemented by the NASA Commercial Remote Sensing Program (now the Applied Science and Technology Project Office) commercially available remotely sensed data was acquired and used to benefit many NASA research and application studies. Some examples from these valuable studies are represented in the images on page (x).

EarthWatch/Intermap STAR-3i DEM data over Alaska enabled essential detailed hydrologic analysis and modeling for large scale Arctic watersheds used in permafrost research studies (includes material ©EarthWatch and/or its suppliers, Longmont, CO). (upper right)

Positive Systems ADAR 5500 high-resolution aerial imagery over Wyoming was used to evaluate and monitor ecosystems, including streams and riparian areas, in Yellowstone National Park for watershed analysis studies (includes material © Positive Systems, Inc.). (upper left)

IKONOS imagery (this image acquired over Faial Island) was used to observe highly sensitive and previously inaccessible oceanic island landscapes, and to quantify the sensitivity of landscape systems to different forcings and climate change (image courtesy of Space Imaging, LLC). (lower right)

An orthorectified Landsat TM image of Mount Kilimanjaro in East Africa, used for sustainable development projects; this data has also been utilized as a significant baseline dataset for assessing global and local land cover change (Courtesy of NASA and Earth Satellite Corporation). (lower left)