Expert Advice: The Strategic Significance of Compass

By: Scott Pace

On November 1, 2010, China’s state news agency reported that the sixth Compass satellite was launched from the Xichang Satellite Launch Center. This was the fourth Compass satellite put into orbit this year, following launches in January, June, and August. Joining the United States, Russia, and the European Union, China is deploying its own global navigation satellite system of five geosynchronous satellites, 27 in medium Earth orbit (MEO) and three in highly inclined geosynchronous orbits (IGSO).

Sometimes referred to as Beidou-2, Compass is a global RNSS (radio-navigation satellite system) that broadcasts one-way precision time signals to enable receivers to calculate their position. An earlier Chinese satellite navigation system, Beidou-1, was an RDSS (radio-determination satellite system) that provided regional coverage and required two satellites to get a position fix using two-way communications with a centralized ground station.

Like the U.S. GPS and the European Galileo system, signals from Compass use the CDMA (code-division multiple access) channel access method as distinct from the FDMA (frequency-division multiple access) method used by GLONASS. CDMA enables more precise positioning as compared to FDMA, and GLONASS is planning to shift to CDMA for its future satellites.

Compass is designed to operate on three primary L-band frequencies:

- 1559.052–1591.788 MHz,
- 1166.22–1217.37 MHz,
- 1250.618–1286.423 MHz

while offering both an open service and an authorized service. The latter is expected to require cryptographic keys for access and will be reserved for military and public safety-related uses. Compass is intended to provide service to the Asia-Pacific region sometime in 2012 and to attain global-service levels around 2020.

Reasons for Compass

The Russian GLONASS was developed to support the Soviet Navy, and the U.S. GPS arose from the merger of previously separate Air Force and Navy satellite navigation efforts. China began researching satellite navigation and positioning technologies in the 1960s, but it was not until 1983 that a plan for satellite navigation and positioning system was developed. The “Double Star Rapid Positioning System” was the basis for the Beidou-1 two-satellite RDSS system that was formally approved for development in 1994. The impetus for the Compass systems is not fully known, but press reports attribute it to military requirements for more accurate missile targeting.

The Chinese were close observers of the role of GPS in the first Gulf War. Chinese writings on military doctrine began to talk of “war under informationalized conditions” and how information from space-based systems such as GPS was changing the nature of modern warfare. Exploiting these new information sources required not just space capabilities but changes in how military forces were organized, trained, and equipped.

Chinese security interests encompass not only China itself and nearby areas, but also the sea lanes that enable the import of raw materials and export of finished goods. In recent years, China has shown an increasing interest in “maritime domain awareness,” in which satellite navigation is used for monitoring the transit of ships in the Indian Ocean (for example, oil from the Middle East) and the South China Sea (minerals from Australia, fishing zones). Satellite navigation is a dual-use, commercial and military, interest for China, and this may have prompted support for the more advanced, independent GNSS that would become Beidou-2 or Compass.

Regardless of the cause, People’s Liberation Army officials have said that China needs its own satellite positioning system to ensure its ability to conduct independent military actions. The later 1990s saw continued Beidou-1 satellite deployments while design of the newer Beidou-2/Compass satellites began. China joined the Galileo consortium in 2003 but abandoned it in 2006 in dissatisfaction over access to technology and work share arrangements. Efforts on Compass accelerated, and the first experimental satellite of the new system was launched in 2007.

In a September 2010 interview with Chinese press, Duan Zhaoyu, vice president of BDStar Navigation, said that there are currently more than 20,000 civilian users of the Beidou-1 navigation system, 60 percent of whom use products from his company. More than 10,000 of these users are fishermen in the South China Sea. Not surprisingly, the Chinese government and military constituted the majority of users as it was also reported that as of August 2009, there were only 60,000 Beidou users in total. The number of registered terminal users amounted to only 1 percent of the system’s capacity, leaving the satellite resource seriously under-used.

The underutilization of Beidou-1 is both a challenge and an opportunity for the Compass system in both domestic and international applications. The designer of the first Chinese satellites and current Beidou chief designer, Sun Jiadong has stressed the importance of actual utilization in arguing that “satellites in the sky should be coordinated with ground applications” and “pushing China’s Beidou satellite navigation system to bring as much economic and social benefit as early and as quickly as possible.” In order to do this, “…the state should promulgate corresponding policies, regulations, and systems as soon as possible to support development of the new satellite navigation application industry. It should guide, encourage, and attract even more Chinese enterprises and public institutions to actively participate in the construction of an industrial chain for ground applications.”

Internationally, China has stressed cooperation with other GNSS systems. At the June 2010 meeting of the Asia-Pacific Economic Cooperation (APEC) organization, the Chinese presentation said that Beidou-2 (Compass) would “provide high-quality open services free of charge from direct users, and worldwide use of Beidou is encouraged,” and that Beidou-2 will pursue solutions to realize compatibility and interoperability with other satellite navigation systems.”
In addition to the Resolution 609 multilateral meetings, the United States and China have also engaged in five operator-to-operator coordination meetings under ITU auspices from 2007–2010.

While satellite deployments have been accelerating, there continue to be delays in the public release of interface control documents (ICD) for incorporating Compass signals into GNSS receivers. The technical preparation of Beidou-2 Signal-in-Space ICD (version 1.0) has reportedly been finished but has not yet been posted on the Chinese government website for the program [www.beidou.gov.cn]. In October 2009, Cao Chong, the director of the consulting center at the China Technical Application Association for Global Positioning System, gave a speech at Stanford University where he said that English and Chinese versions of the ICD have already been completed. But their release had been postponed due to pressure from domestic companies in China.

A primary concern of all GNSS users and operators is compatibility, that is, the ability of multiple satellite navigation systems to co-exist in the same international spectrum allocations without causing harmful interference to any individual service or signal. The signals may or may not be interoperable but they should not harm each other. In the case of Compass, its signals do overlap some Galileo frequencies, particularly with respect to the Galileo Publicly Regulated Service (PRS) and to a lesser extent the edges of the GPS M-Code that is used exclusively for defense purposes. In general, however, Compass signals do not overlap the GPS or GLONASS frequencies. Informal Chinese comments suggest that they consider GPS and GLONASS to be well-established “legacy” systems that new arrivals should seek to avoid overlapping. On the other hand, Galileo and Compass are seen as having equal standing as new RNSS systems within the terms of the International Telecommunications Union (ITU).

Chinese presentations have identified several Compass signals that would overlap those of other GNSS providers. These include the Compass B1 at 1576.42 MHz with the GPS L1 signal, B2a at 1176.45 MHz with the GPS L5 signal, and B2b at 1207.14 MHz with the Galileo E5b signal. The Chinese believe that “the frequency spectrum overlap of open signals is beneficial for the realization of interoperability for many applications” and makes it easier to develop and manufacture interoperable receivers. While these claims are true to a point, GNSS providers experiencing the overlap may not agree.

Even if signals do not experience harmful interference from an overlap, the signal provider may suffer constraints on its ability to control the service it provides to specific users, as in public safety or military applications. The long negotiations between the United States and the European Union over Galileo proposals to overlay major portions of the GPS M-Code eventually resulted in the 2004 US-EU Agreement on GPS-Galileo Cooperation. More recently, the European Union has raised its concerns with China’s plans to overlay Compass signals on the Galileo signals used for the PRS service.

Within the ITU, RNSS operators (which includes the GNSS system providers) engage in direct coordination under what is known as a Resolution 609 process. This process was adopted at the 1999 World Radiocommunication Conference in Geneva, Switzerland and calls for “Consultation Meetings between administrations operating or planning to operate systems in the aeronautical radionavigation service (ARNSS) and systems in the radionavigation satellite service (RNSS) in the 1164–1215 MHz frequency band.” It should be noted that the resolution does not encompass all GNSS signals, but does focuses on those at the GPS L5, Galileo E5, and Compass B2. The most recent meeting was the 7th Consultation Meeting of Resolution 609, June 23–25, 2010 in Toulouse, France.

EPFD Levels. As the Resolution 609 process has continued, calculations of aggregate, equivalent power flux density levels (epfd) show that levels from filed RNSS systems (some operational, some planned) are nearing the allowable maximum aggregate epfd level. This level is specified in Resolution 609 itself, as revised at the last World Radiocommunications Conference (WRC-07). The United States position is that it is important to discuss methods to ensure that this limit is not in fact exceeded.

The Toulouse Consultation Meeting discussed three potential methods to achieve this important objective:

- use of actual operational characteristics (for example, maximum operational power levels, instead of filed parameters);
- use of the actual number of satellites in orbit, instead of the filed number; and
- technical revisions to the epfd calculation methodology (per ITU-R Recommendation M.1642-2).

The meeting also considered proposals in the case where calculations show the aggregate epfd level would be exceeded, to perform a second aggregate epfd calculation including only satellites that are in actual operation, or are planned to be in operation before the next Resolution 609 Consultation Meeting is scheduled to occur (that is, within the next 12 to 16 months). The point of the second calculation would determine that epfd actually being produced from RNSS satellites in the 1164–1215 MHz band will not in fact exceed the allowable epfd limit.

In addition to the Resolution 609 multilateral meetings, the United States and China have also engaged in five operator-to-operator coordination meetings under ITU auspices from 2007–2010.
The United States has also offered the possibility of direct bilateral talks with China on GNSS services and applications — as was done with Japan, Russia, and the European Union. Europe similarly has sought to have direct talks with China to coordinate their concerns over Compass-Galileo. There have been at least six meetings on frequency compatibility and interoperability during 2007–2010, alternating between Beijing and Brussels. While both sides continue to express support for compatibility and even interoperability, the European side continues to oppose Compass overlays of the Galileo PRS while China shows no indication of being willing to change its frequency plans.

Finally, with respect to Russia, a Beidou-GLONASS frequency compatibility meeting was held in Moscow in January 2007, but there seems to have been little follow-up. Given the lack of overlap between the frequencies used by the two systems, this is not surprising.

**International GNSS Coordination**

Compass is represented in broader GNSS coordination activities, not just those involving the ITU. The most important of these is the International Committee on GNSS (ICG) that was established in 2005 as an outgrowth of the United Nations Committee on the Peaceful Uses of Outer Space (COPUOS). The most recent, and fifth, meeting of the ICG was held in October 2010 in Turin, Italy.

The purpose of the ICG is to “promote the use of GNSS infrastructure on a global basis and to facilitate exchange of information.” Through meetings of the ICG, GNSS providers have adopted various principles such as transparency for open services, that is, every provider should publish documentation that describes signal and system information, policies of provision, and minimum levels of performance for its open services.

On a regional basis, China participates in the APEC GNSS Implementation Team. This team was established by the APEC Transportation Working Group in 2000 with a mission of promoting regional GNSS augmentation systems to enhance inter-modal transportation. The United States hosted the 14th APEC GT meeting this past June in Seattle, Washington; the next meeting is tentatively scheduled for Brisbane, Australia, in May 2011. The significance of the APEC meetings on GNSS is their recognition of the value of such systems to states at greatly varying levels of development, not just the providers of GNSS or major GNSS augmentations. Although the group has a transportation focus, the productivity, safety, and environmental benefits of GNSS use provide an incentive for common efforts across the Asia-Pacific region.

In addition, the group calls for cooperating with non-APEC organizations (such as the ITU) as necessary to provide for seamless implementation.

**Strategic Significance of Compass**

Unlike Galileo, Compass is not a multinational cooperative program nor did it ever consider being a public-private partnership. Like GPS and GLONASS, Compass was created as an independent strategic effort by a national government for military and economic benefits.

Unlike the history of GPS and GLONASS, however, the Chinese government from the beginning recognized the dual-use nature of Compass signals. Like GPS today, Compass plans to deploy CDMA signals at multiple frequencies to support a full range of application, from transportation to precision positioning and timing.

Like Galileo, Compass still has to demonstrate that its signals are stable, operationally reliable, and accurately represented by published interface control documents to attract manufacturers to build the capability into their products. Galileo, Compass, and GLONASS all have the challenge of meeting the expectation of the existing installed base of billions of GPS users — whether or not they know they are reliant on GPS.

The technical management of Compass is clearer than its policy management. Compass and BeiDou-1 are the responsibility of the China Aerospace Science and Technology Corporation (CASC), the administrative holding company for the China Academy of Spacelflight Technology (CAST), the primary state-owned contractor for the Chinese space program. The military plays a large role in all Chinese space activities, and in recent years there has been uncertainty as to who is the government policy leader for space. In particular, the role of the Chinese National Space Agency (CNSA) appears to have diminished in recent years. CNSA leaders scheduled to speak at major international conferences, such as the International Astronautical Federation, have cancelled at the last minute, while PLA speakers have presented instead.

When U.S. President Barack Obama and China’s President Hu Jintao met in Beijing in 2009, their joint summit statement included a call for the NASA administrator to meet with an unspecified Chinese counterpart. Some of this may be coincidence due to other time demands such as launch schedules, but the Chinese decision-making hierarchy for space remains as opaque as it does in so many other areas.

The openness of Chinese political decision-making prompts speculation as to what China’s long-term strategic intent is with respect to Compass. The advent of open Compass signals would be potentially positive for the current installed base of GPS users — providing interoperable signals that improved the availability of positioning solutions. Internationally, the Chinese presence helps secure the international use of the RNSS spectrum and could be a potential ally in suppressing commercial sales of GNSS jamming devices — some of which are manufactured in China today. The view from Russia with respect to GLONASS is likely to be similar to that of GPS; Compass is largely a complementary system.

From a European perspective, however, Compass is more problematic, both technically and commercially. The signal overlay on the Galileo PRS is a potential complication for Europe being able to deny PRS access in times of emergency.

Perhaps more importantly, the rapid pace of Compass satellite deployments means that Compass may reach an initial operational capability sooner than Galileo. This is highly probable for coverage in Asia and increasingly likely on a global basis as Galileo faces criticism over cost increases and schedule delays. While Galileo has published an open service ICD and China has not, it would be a simple matter for China to time the release of an official Compass ICD one product cycle (that is, 18 months) before the 2012 completion of Asia-Pacific coverage. This would make Compass potentially very attractive to manufacturers looking to decide what would be of most benefit to the existing installed base.

In general, China pursues its space activities as part of a broad approach to what might be termed “comprehensive national power” to include military power, economic power, diplomatic influence, scientific and technological capabilities, and even political and cultural unity. This need not necessarily mean that such power will be used for aggressive purposes.

If China’s strategic intent is to ensure its own independence and a place at the global table, then it is possible that Compass will not be harmful to U.S. interests. This outcome will depend on whether China continues to work with the international community in forums such as the ITU, the ICG, APEC, and so on, maintains open markets, and does not use Compass in military efforts to force changes in the status quo regarding Taiwan, the South China Sea, or the Indian Ocean.

Since China’s strategic intentions are unclear, it makes sense for the United States to seek bilateral discussions with China on Compass and to maintain a close strategic dialog with other countries in the region, notably Japan, Australia, Korea, Russia, and India. These countries are not only militarily and economically important, but also have their own GNSS-related systems and equities to consider.

The choices for China are whether Compass will be part of its “peaceful rise” and will serve truly national interests. Those interests could be seen as harnessing the kinds of dramatic IT productivity benefits other economies have seen in GNSS applications — enhanced by open, market-driven innovation and competition.

Alternatively, it is possible to imagine China closing off its domestic market, protecting domestic state-owned enterprises, and focusing on the space and military aspects of Compass rather than market-driven civil and commercial applications.

The question for Chinese leaders is whether they should measure the success of Compass just by the success of Chinese firms at home or by the global acceptance of Compass as a reliable brand name for GNSS services and signals.

Compass is like China itself, where there are both great promise and some concerns. The signs to date for Compass are positive and will hopefully continue on the path of engagement and cooperation. The United States and the global GPS community should continue to encourage those positive signs in working with China, commercially, diplomatically, scientifically, and (perhaps especially) with more direct military-to-military contacts. All of these efforts can increase the chances that China will join the United States as another good steward of GNSS.

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