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Galileo and GPS – Competitors or Complements

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Dr. Nardon – thank-you for the introduction and overview.

First, I am delighted at the opportunity to address this group; April in Paris is the best of travel opportunities. I can see a number of colleagues in the audience with whom I have a long-term association, so it is good to be among friends and aerospace experts. I expect to learn a lot from you this morning.

Second, let me congratulate you on your success in reaching a decision on Galileo at the Barcelona Summit and among the Transport Ministers. The entire global navigation satellite system community has watched you closely and now wants to see how you will implement your decision.

It is clear to me there is opportunity for synergy among satellite navigation systems. The right recipe will delight our users with ever increasing levels of performance and set the stage for the development of new space based navigation applications and markets.

Since our governments are our major investors at this point, I think it is incumbent on both GPS and Galileo to prove better performance will grow these markets. We must demonstrate for our governments that their investments are sound business decisions that meet our collective and individual national objectives. I believe we can construct agreements and technical architectures to do this, whether these national objectives are free trade in space based navigation goods and services or autonomy of systems to avoid single points of failure. In particular, the U.S. has both policy and public law that provides GPS signals free. The U.S. business case is that the government investment is offset by a combination of tax revenues from private sales of GPS user equipment, applications, and augmentation services, improved efficiencies in national infrastructures and services, and a technical edge in national defense.

From a systems engineering viewpoint, it is clear we can maintain separate systems while providing users with better position and timing information with the proper synergies among the systems. If we embrace proven standards and execute good technical solutions, I am sure that together, we will provide global navigation satellite services for our combined user base that are more accurate and more reliable, anyplace, any time.

I fully understand Europe's needs for autonomy and independence for Galileo, but hope those requirements are confined to the architectural approaches for the system and not the standards essential for synergy among the systems. It would be a tragedy for world users if the U.S. and Europe each went their separate ways and users did not get significant boosts in performance by using both systems synergistically. I would hope

as well that our mutual standards would allow user equipment to be supplied inexpensively and not be more complex because it must compensate for lack of good systems integration among the available navigation signals. It would be my hope, for example, that user equipment could use the best combination of satellites in view without regard for continent of origin and use these signals to calculate a more accurate time or position determination than available from either constellation in isolation.

So what can you expect from the GPS part of these complementary systems? I think many of you are very familiar with U.S. GPS modernization efforts but let me innumerate them briefly.

Modernization of the space segment of GPS will begin with the launch of a modernized GPS IIR satellite. This satellite is a Lockheed Martin product we are very proud of. There are six IIR satellites on orbit and they are performing very well. For example, the navigation signal range deviation, an important measure of accuracy from these satellites, is typically about 80 centimeters. Of course this is just the accuracy of the signal in space, but it is a reflection the satellites are performing excellently. The IIR satellites are consistently the top performers in the constellation in terms of accuracy.

In 2003, we will launch the first of Lockheed Martin's modernized replenishment satellites. The satellite's outward appearance is exactly like the satellites we are launching today.

The modernized IIR satellite will have two new signals: a new civil signal centered on the L2 frequency at 1227 MHz, and a new military signal. The availability of a second civil signal will have significant implications for public and private sector users. Civil users will have the advantages of an open access signal on a different frequency, and the new code performs much better than the original course acquisition code on L1. While the existing open access signal doesn't change so that we can assure our many users their existing investment in user equipment is preserved, the second signal is a very modern code that will allow much faster entry into the GPS constellation by more quickly delivering the satellite almanac. My guess is that commonly available user equipment will provide accuracies in the 4 meter range, that's at least a three fold improvement over today's performance. It is nearly equal to today's GPS with ground based differential augmentation. Lockheed Martin will provide up to 12 of these modernized IIR satellites. By the end of 2005, the complement of new civil signals will be complete with the launch of the first Boeing IIF satellite equipped with the L5 signal. L5 has ten times the bandwidth of the other two open access signals with all the advantages the additional bandwidth will bring to users. It is also four times more powerful than the other civil codes so it is less susceptible to local interference. With three open access signals at 1176 MHz, 1227 MHz, and 1575 MHz, public and private sector users will have a good selection of signals to base position and time measurements on and to compensate for naturally occurring errors in the navigation signals as they travel from the satellite to the user equipment. With two of the signals in the internationally recognized aeronautical radio navigation service, users will also have

the spectrum protection they are seeking for dual frequency navigation in safety of life applications. By 2008, we can reasonably expect to have about 18 of these modernized satellites in orbit with a very high probability of having four satellites in view with two civil frequencies each available for user equipment use and perhaps six or so with the new L5 signal.

We have recently completed a study to develop technical requirements for the next phase of our modernization program – GPS III. Our GPS III studies predict that increases in accuracy of the signal from space to the 20-50 cm range are likely through a combination of atomic frequency standard improvements and a more accurate navigation message. We also see availability of the GPS signal improving to 99.9% probability that four satellites are in view. More important perhaps, those satellites in view will have better geometries in the future so that total system accuracy to an avionics grade receiver will be on the order of 1.5 meters. Lockheed Martin has recommended a requirement to provide an integrity signal that will faithfully provide an immediate indication of transmission of hazardously misleading information. We believe as users depend more on the GPS signals they are receiving, they must be assured the signal is authentic and accurate. We believe we can meet current accuracy, availability, and integrity performance necessary to execute category one precision landing approaches with future GPS alone. GPS III could exceed the performance of today's space-based augmentation concepts.

For the military user, we expect to increase the jamming resistance by a factor of 500 above where it is today. That amounts to 27 dB more power for the new military code on demand. The feature will be programmable at various power levels and over variable size areas tailored to user needs. As the military exploits the precision of GPS in its many missions, we must insure that GPS is not easily denied by a savvy adversary.

Beyond these basic features, there are a number of service excursions that will provide alternate communications paths for the information essential to using GPS. In itself, the ability to access the constellation based on external aiding could have significant performance advantages.

As far as the best signaling arrangement for Galileo, we are hopeful we can enter technical discussions in the very near term. We believe the use of existing GPS frequencies for Galileo open access services would be optimum; however, we must insure that backward compatibility for the installed user base is maintained. A decision to share the spectrum allows GPS and Galileo functionality to share the same antennae and radio frequency electronics and for digital processing to isolate the separate systems. Other spectrum identified for RNSS services could potentially be used for Galileo's value added, regulated or closed access services. Of course in overlaying the GPS open access signals; appropriate design provisions must be made for the elimination of interference between the two systems. I believe there are technical approaches that can address such issues without compromising the objectives of the separate systems. For example, it appears the new GPS L5 and L2C signals have

available signal codes that could be provided to Galileo system for a completely compatible signal structure.

Now the issue of the national security implications of any GNSS must be carefully addressed. Modern warfare is inextricably tied to precision time and location. In recognition of this, it is incumbent on any space based navigation provider to consider how the navigation service will be controlled to provide maximum advantage to peaceful and authorized users and no advantage to enemies and adversaries. Several of us in this room provided this finding to the United Nations in our recommendations to the 6th International Space Cooperation Working Group last year. It is fairly clear to me that any system precise enough to lead a blind person to an unfamiliar doorway could just as accurately steer a Galileo guided weapon through the door. So we must develop appropriate procedures and technical means to prevent enemies from taking advantage of any of our services so that our future advantages and dependencies do not become disadvantages.

I would hope as well that our cooperation could extend to the configurations of our separate constellations and the way we operate our systems so that again, users can maximize the performance of the combined systems. For example, we will want to study whether constellation designs and deployment plans can be coordinated in such a way that the combined GPS and Galileo system can together provide better satellite geometries for improved accuracy and better delivery of global navigation satellite services in mountainous terrains and cityscapes.

In another direction, we know that satellites must be removed from service for routine and periodic maintenance. Should we choose to coordinate those outages, we will be able to provide users overall better performance. That, of course, assumes a user can use both systems simultaneously to produce a highly accurate position calculation. In such a case, our separate constellations will provide back-ups for both scheduled and unscheduled outages.

In the best of all possible worlds, the operational turn over of the first few Galileo satellites will provide users with immediate performance improvements on open access services of the combined constellations. Under these conditions, European users would not have to wait for a full constellation to be deployed before they begin to reap the benefits of this major investment.

Beyond that, there is even more room for cooperation. For example, the U.S. marketplace for atomic frequency standards is depressed given the low cost and high performance of a GPS receiver as a frequency standard. Availability of space-qualified components is a particular challenge. At the same time, we need to have a stable source of supply to feed our global navigation satellite systems. There could be advantages to having both European and U.S. suppliers of compatible atomic frequency standards. Given that we will each prefer domestic suppliers, we might consider whether an overseas supplier would be a good second source. In that way, we might undertake technology upgrades within our limited clock industrial base without significant risk to

sustaining that industrial base. The clocks are just an example; I am sure there are many others.

Beyond that, there are opportunities for joint GNSS monitoring stations that would feed all the space based navigation service providers. These monitoring systems would provide both integrity monitoring and the ephemeris and time corrections necessary to maintain the systems at peak operating performance. Perhaps at some point in time the monitoring stations and local area augmentation systems inside our civil aviation administrations may be a good source for this joint information. Perhaps this is a way to save money or to increase the number of monitoring stations each system has access to.

Now I hope you share at least part of this vision. Because if you do, it provides the basis on which we can work together. We will excite global navigation satellite system users with the potential. By approaching the future of global navigation satellite system II in a coordinated and complementary fashion, we will provide better performance at the user level than either of our governments is willing to finance on its own. If we can reach into the dark corners of our city streets and into the narrow valleys of our many recreational areas and landscapes with properly coordinated constellations then we will have created a combined system that is much more capable then either system on its own. In so doing, we create value we may not otherwise bring to our customers on our own.

Last, there are clearly opportunities for collaboration between Galileo and GPS for our mutual protection of the radio frequency spectrum so that we can get the most performance out of our respective systems. We should work together to have a unified stance within the International Telecommunications Union as well as solicit support from all global navigation satellite system users to assist us in the protection of this vital resource. Once we allow incompatible users into this spectrum, we will have to redesign our systems in order to maintain performance.

Now, let me thank you once again for the opportunity to address this group. I look forward to your questions.