INMARSAT-5 GLOBAL XPRESS®:

SECURE, GLOBAL MOBILE, BROADBAND

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There is a move in the Unmanned Aerial Vehicle (UAV) community to Ka-band satellite communications (SATCOM) for Beyond Line of Site (BLOS) high rate mission data connectivity. This move is driven by a need for higher speed connectivity as well as a desire to be compatible with national systems like Wideband Global SATCOM (WGS) and Athena-Fidus. In the Inmarsat-5 Global Xpress (GX) program, Inmarsat is implementing a wideband global, mobile Ka-band network to be available as this UAV capability is deployed and demand develops. This paper shares an architectural overview of GX. Details regarding GX space segment and ground segment components are highlighted to provide insight into the various communications services supported by GX. In particular, insight is provided regarding how the GX program differentiates itself by establishing a network core that satisfies U.S. Government and International Information Assurance requirements. As a whole, GX features provide government customers with turnkey commercial SATCOM and terrestrial network services that are reliable and trustworthy to carry mission critical data.

INTRODUCTION

Inmarsat has been at the forefront of mobile satellite services (MSS) for over 30 years. As the leader in MSS, Inmarsat continues to introduce new technologies that define and elevate the industry standard. This paper provides a brief summary of the current Inmarsat global network followed by an overview of Inmarsat's next-generation wideband global, mobile, broadband Ka-band MSS offering enabled by the GX program. In addition to its robust SATCOM capabilities, this paper highlights how the GX program will differentiate itself by providing a network core that meets critical Information Assurance requirements - to include Department of Defense Instruction (DoDI) 8500.2, National Institute of Standards and Technology (NIST) Special Publication (SP) 800-53, and the International Organization for Standardization / International Electrotechnical Commission (ISO/IEC) 27000 Information Security Management Systems (ISMS) standards. To provide even greater levels of assurance, GX Satellite Access Stations (SASs) are located in NATO and "Five Eyes" countries. As a whole, these features will provide Government customers end-to-end commercial SATCOM services that are reliable and trustworthy to carry mission critical data.

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CURRENT INMARSAT GLOBAL NETWORK INFRASTRUCTURE

Presently, Inmarsat operates a fleet of 9 GEO satellites, multiple ground SASs, and a related terrestrial network to provide global coverage for MSS. These GEO satellites operate in L-band and provide seamless and reliable mobile voice and data communications around the world. The resulting services enable users to connect - whenever and wherever they need - on land, at sea or in the air. The most recent additions to the Inmarsat fleet are the Inmarsat-4 satellites. The Inmarsat-4 constellation represents a $1.5B investment by Inmarsat to achieve the world's first global, fully Internet Protocol (IP) satellite-based 3G network. The Inmarsat-4 constellation was designed to support operations into the mid-2020s. The coverage provided by this constellation is shown in Figure 1.

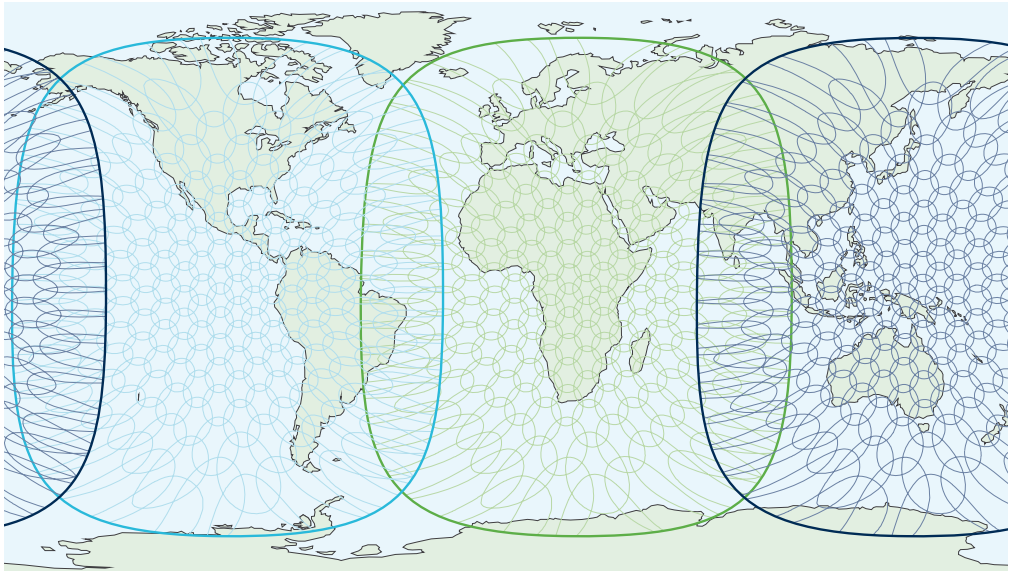

Figure 1: Current Inmarsat-4 Global Spot Beam Coverage.

IN-WORK NETWORK INFRASTRUCTURE IMPROVEMENTS

Inmarsat continues the expansion of available global, mobile satellite communications infrastructure through investments in enhanced L-band capabilities (Alphasat I-XL) and multi-beam, wideband global, mobile Ka-band capabilities (Global Xpress).

Alphasat I-XL

Alphasat I-XL provides an advanced L-band geomobile communications payload that will augment Inmarsat's Broadband Global Area Network (BGAN) services provided by the Inmarsat 4 satellites. Expanding into the extended L-band spectrum, Alphasat I-XL will provide additional capacity, resiliency, and coverage across Europe, the Middle East, Asia, and Africa. It features a new-generation digital signal processor for the payload and a 12m antenna for user access. Inmarsat's leadership in hosted payloads continues with Alphasat I-XL, which hosts technology demonstration LASERCOM and Q/V-band payloads for the European Space Agency. Representing a significant additional investment to further extend Inmarsat-4 generation L-band capabilities, and weighing more than 6,000kg, Alphasat I-XL is scheduled for delivery and launch by an Ariane 5 in July 2013. The Alphasat I-XL satellite is depicted in Figure 2.

Figure 2: Alphasat I-XL Satellite.

Global Xpress (GX)

The Inmarsat-5 GX constellation will provide the world's first multi-beam, wideband global, mobile commercial services in the Ka-band. The capabilities offered serve as an extension and complement to Inmarsat's established L-band services – emphasizing the same Inmarsat commitments to global coverage, mobility and reliability. The constellation is being realized through a $1.2B investment in three unique Ka-band satellites and associated secure ground infrastructure. GX will support mobile broadband up to 50Mbps to a 60cm stabilized antenna using Ka-band fixed spot beam services. Higher throughputs can be achieved through different terminal and antenna configurations. Additional capacity, supporting hundreds of Mbps ideal for AISR and multi-Gbps point-to-point links, is available using the steerable spot beam services. Regional GX services are planned for commencement in early 2014 with global service expected in early 2015. The Inmarsat-5 GX satellite is depicted in Figure 3.

Figure 3: Inmarsat-5 Global Xpress Satellite.

GLOBAL XPRESS OVERVIEW

The GX system has been designed to support global coverage and enable global mobility. The system includes the space segment and ground segment to provide complete GEO-visible earth connectivity. The space segment provides two primary communications payloads for servicing users - the Global Service Beam (GSB) Payload and the High Capacity Payload (HCP). The ground segment provides SASs and a multiprotocol label switching (MPLS) infrastructure that interconnects all Inmarsat L-band and Ka-band resources. The ground segment also provides secure enclaves for supporting Customer-specific equipment and services. Management and status of all interfaces is accomplished through available Web-Based User Interface (WebUI) and machine-to-machine (M2M) interfaces. An overview of the GX Architecture is depicted in Figure 4.

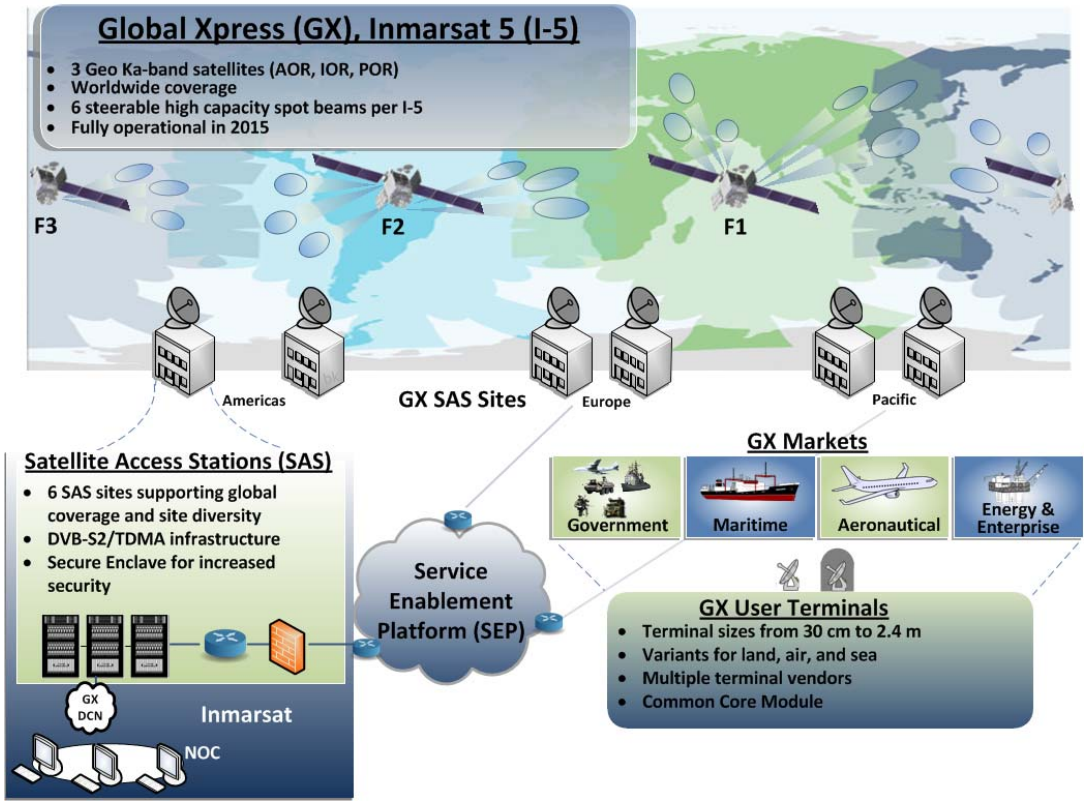

Figure 4: Inmarsat 5 Global Xpress System Overview.

Space Segment

Global Service Beam Payload - The GSB payload forms a spot beam map across the satellite visible field of view that consists of multiple fixed beams per satellite. Service in these GSBs is implemented using a channel pool. Each global service beam spot beam channel can nominally support around 100Mbps, divided between forward and return links. These links benefit from Adaptive Coding and Modulation (ACM) to maintain high link availability. The channels all terminate or originate in a gateway feeder link. A depiction of the Global Xpress GSB coverage is shown in Figure 5.

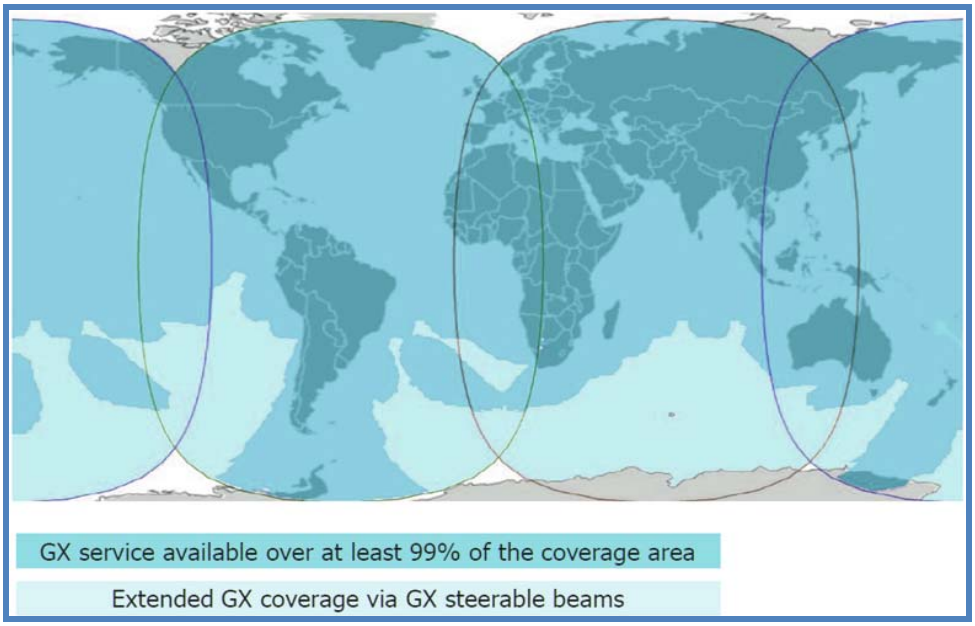

Figure 5: Global Service Payload Spot Beam Coverage.

Using the next generation of iDirect-based waveforms, the GSB service provides seamless handover between individual satellite spot beams and low-latency handover between satellites. Sophisticated global bandwidth management is built into the system in order to ensure the most efficient use of available satellite capacity. The mobility feature that results from this design allows customers, particularly in the mobile military market, to adopt a more affordable and efficient approach to buying commercial satellite services. That is, the user will no longer have to lease prepositioned capacity by guessing where the next conflict will be, or compete on the spot market with other commercial users. The same high-quality connection used for training will be available both en route and upon arrival in theater.

High Capacity Payload – HCP - Each Global Xpress satellite is configured with a total of 8 steerable spot beam antennas on the nadir face of the spacecraft. Two of these antennas are dedicated to supporting gateway connectivity (primary and redundant SAS). The remaining six antennas support High Capacity Military (HCM) and/or High Capacity Commercial (HCC) operations. Each steerable spot beam antenna is securely and independently pointed and can accommodate channels assigned to HCM and HCC applications simultaneously. GX steerable spot beams can serve locations anywhere on the GEO-visible earth. A summary of the steerable spot beam capabilities is shown in Figure 6.

HCM channels are in the 30-31/20.2-21.2GHz range and are designed to augment and enhance national MILSATCOM systems such as WGS and Athena-Fidus with various combinations of 40, 125, 270, 400 and 730MHz bandwidths available in two polarizations at comparable Effective Isotropic Radiated Power (EIRP) and Gain to Noise Temperature (G/T). As such, the HCM capability serves as an excellent MILSATCOM complement, offering military users additional capacity for training, en route communications, and in-theater mission support using existing WGS-certified terminals. Paired with the global coverage GSBs and existing national MILSATCOM, the combination makes it possible for users with small single-band Ka terminals to support dy-

namic and unplanned missions with en route connectivity everywhere and robust, extremely high capacity in operational areas.

HCC channel allocations are in the 29-29.5/19.2-19.7GHz range and are designed to augment GSBs in high demand areas such as aero routes, energy markets, and disaster response. Up to two 100MHz HCC channels can be allocated to a single steerable spot beam antenna and each HCC steerable beam can support up to 600Mbps.

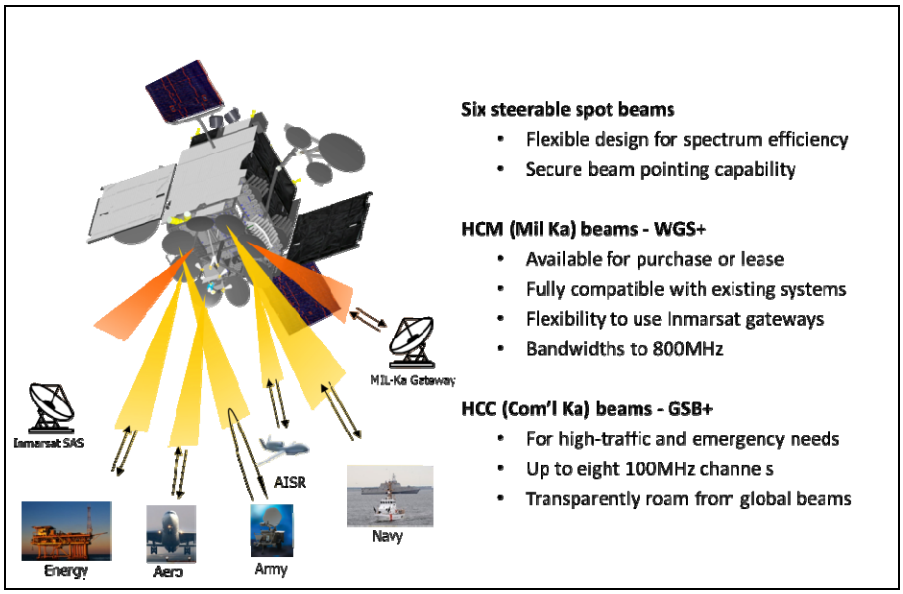

Figure 6: HCP Steerable Spot Beam Antennas

Ground Segment

Satellite Access Stations - The GX satellites interconnect with the ground infrastructure principally through the SASs. There are 6 SASs that support this connectivity. Fully redundant pairs of SASs, selected to ensure access diversity, work together to ensure highly reliable gateway links are maintained. SASs are allocated to ocean regions with pairs designated for IOR, AOR, and POR. All SASs and interconnects are located in either NATO or "5-Eyes" countries. When utilizing the secure enclave facilities in these locations, information assurance services can be provided to meet up to DoD 8500.2 MAC I government requirements.

An iDirect-based DVB-S2, multicarrier MF-TDMA system is installed at each SAS to deliver a range of GSB managed services. These managed services support a wide range of Customer needs with priority for government users and include an ability to provide Federal Information Processing Standards (FIPS) 140-2 compliant AES-256 encryption where required. A secure enclave is available at each SAS. The secure enclave is a controlled space within the SAS that is US-citizen controlled and is provided to accommodate a broad range of Customer-furnished equipment, allowing new applications to leverage the global reach and capabilities of GX.

The first SAS locations, serving the IOR satellite, are located in Fucino, Italy and Nemea, Greece. These sites are completing construction presently and will be on line in 2013 to support regional initial operating capability with the launch of the first GX satellite. The AOR and POR SASs are under development and will follow shortly.

Terrestrial Network - The Inmarsat IP backbone is built using an IPV6-capable MPLS core and delivers customer traffic to any of three Meet Me Points (MMPs) in Europe, Asia-Pacific and the U.S. The Global Xpress terrestrial network provides a multi-service, multi-protocol network to connect the six SASs to the Inmarsat IP backbone. Each interconnection is implemented via separate and diverse MPLS routes. As a result, the network is designed to achieve extraordinarily high uptime. Border gateway routers at each SAS connect to the existing IP backbone and will function as MPLS P/PE devices.

GX - A Trusted Communications Platform

Information Assurance Requirements - The cybersecurity of government communication systems is of paramount importance to Inmarsat and GX is being designed from the ground-up to incorporate the highest security possible for a commercial SATCOM capability. In 2009, the Defense Information Systems Agency (DISA) and General Services Administration (GSA) partnered to create the Future Commercial Satellite Communications Services Acquisition (FCSA) program to be the vehicle for future satellite service contracts. In recognition of the importance of cybersecurity, FCSA commercial SATCOM (COMSATCOM) providers are required to address a broad range of Federal information assurance and protection requirements to include the "National Information Assurance Policy for Space Systems used to Support National Security Missions" (also known as CNSSP 12); the "Information Assurance (IA) Policy for Space Systems Used by the Department of Defense" (DoDD 8581.1); and the "Minimum Security Requirements for Federal Information and Information Systems" (FIPS 200). The Department of Defense (DoD) and National Institute of Standards and Technology (NIST) have issued complementary security control requirements described in "Information Assurance Implementation" (DoDI 8500.2) and "Recommended Security Controls for Federal Information Systems and Organizations" (SP 800-53). FCSA COMSATCOM providers must satisfy a checklist of 121 security control items that include the satellites, their telemetry & control links, the satellite control facilities and operations staff, the commercial teleports and operations staff, the data communications network and Internet connectivity gateway, and the associated network management staff. Inmarsat is designing the GX system to support customer systems requiring the highest levels of DoD, NIST, and international security standards.

For a COMSATCOM operator, the biggest challenge is this transition from being a "bent pipe" circuit provider to a trusted infrastructure service provider. To facilitate this transition, Inmarsat leadership is committing resources and facilitating organization buy-in; Corporate engineering, software development, and contracting processes will require new security provisions; Legacy systems, processes, and operations need to be reviewed and updated to accommodate compliance security controls; Inmarsat is adopting the use of multiple compliance frameworks such as ISO/IEC 27000 and U.S. NIST 800 series for developing an Information Security Management System (ISMS); and Inmarsat has included Cyber Security as an area of review when looking at risks to corporate operations.

Satellite Access Sites (SAS) Information Assurance - As discussed above, Global Xpress Satellite Access Sites are the primary link between the satellite constellation and the Inmarsat high-speed IP backbone terrestrial network. As such, these facilities are being built out to comply with up to DoD 8500.2 MAC I requirement features to include physical security controls in the secure enclave and fully redundant fail-over locations. In addition, these sites will be located in North Atlantic Treaty Organization (NATO), New Zealand, and United States Security (ANZUS) Treaty countries to further facilitate the hosting of U.S. allied government network interfaces. Each of these locations will be integrated into the overall Inmarsat managed infrastructure to provide

24x7 network monitoring and response, enabling customer data transport with guaranteed delivery.

Terrestrial Network (DCN and Meet-Me-Points) Information Assurance - Global Xpress interfaces to government and large commercial customers will be provisioned at one or more Meet-Me-Points or directly at the Satellite Access Site facility. These interconnection points will be built to U.S. DoD Gateway standards. Each will include appropriate firewalls, restrictive network ports and protocols, administrator authentication mechanisms, virtual private network separation features, and Internet interfaces. The Inmarsat Data Communications Network (DCN) backbone consists of diverse high-speed leased circuits between each of the geographically dispersed Meet-Me-Points and the Satellite Access Sites. The network infrastructure components within this environment will be configured using DISA Security Technical Implementation Guides (STIGs) when available, or commercial equivalents such as the Center for Internet Security (CIS) benchmarks, and require multi-factor authentication for operator/administrator access. Core network devices will be selected from the National Information Assurance Partnership (NIAP) Common Criteria Evaluation and Validation Scheme validated product list wherever possible.

User Terminal Network Access Information Assurance - User terminals will be equipped with a Global Xpress network-specific core module that is built to FIPS 140 Level 1 compliance standards and configured with a unique identifier to authenticate and communicate with Inmarsat's SAS equipment. This will enable Inmarsat government customers to securely manage each of these terminals and collect usage metrics.

Information Assurance Summary - This combination of security capabilities across the Global Xpress network infrastructure will provide critical and sensitive data customers with a trusted communications platform to move their data from remote air, sea, and land platforms to their enterprise network infrastructures with confidentiality and reliability.

SUMMARY

Inmarsat continues to deliver the world's most complete global mobility solutions. Inmarsat-4 satellite and network resources are widely used today to provide trusted command and control for UAVs worldwide. Building on the significant government applications of the existing L-band constellation, the next-generation Global Xpress system represents a tremendous leap forward in capabilities. Ka-Band broadband services for airborne, maritime, and land users will be available anywhere on the GEO-visible globe with a common, standard user terminal architecture. Global managed services in commercial bands and leased and managed services in MILSATCOM-interoperable military bands will provide government users a wide range of resilient and competitively priced high-rate services. As the planned launch date for GX approaches, Inmarsat is making great strides towards a new and even higher standard in global, mobile broadband connectivity. Through the Inmarsat-4 and Inmarsat-5 programs, Inmarsat will continue to provide critical resource augmentation to meet expanding AISR demand.