DEFENCE AND SPACE
SECURE COMMUNICATIONS

Proteus™ Unity

Whitepaper

AIRBUS

Contents

Data Rich Helicopter Satcom

This Whitepaper describes the current challenges facing helicopter communications and how technology has evolved to answer the need for more data to and from helicopter platforms.

Helicopter users have an increasing need to send large amounts of data to and from the rotor platform over a wide geographic area; a capability which has been a reality for fixed wing aircraft for many years. Sharing and receiving high data rate intelligence and media has become a norm in day-to-day activities thanks to advancements in connectivity, and as such, users expect good connectivity regardless of what platform they are on. This expectation is no different for airborne users. Rotorcraft need the higher throughput with greater efficiency to keep satcom bandwidth usage and costs low. Furthermore, there is a need for resilient communication to adapt to changing environments whilst maintaining mission services, such as the sharing of High Definition (HD) video and media, in order to increase mission safety and reduce time.

Airbus have been working with industry partners to produce a state-of-the-art modem system that addresses the needs of military and civilian rotorcraft users and provides a unique solution to the challenges currently facing the rotorcraft industry. Proteus™ Unity is a dual use modem system designed to address the needs for resilience and security in the satellite communications world. Utilising wideband communications and designed for military and civilian use, Proteus™ Unity increases mission capabilities without compromising on quality or cost. Whether on the ground, at sea or in air, fixed wing or rotor, Proteus™ Unity adapts and maintains the most efficient communications in the given environment, ensuring multi-platform network users are connected in all environments, however fast they are moving.

Rotor Blades - Communications Today

In the world of airborne Beyond Line Of Sight (BLOS) satellite communications, helicopter rotor blades have long diminished link effectiveness. These essential components effectively disrupt and block the communications path; to the transmission, acting like a periodic interferer.

Helicopter communication has historically relied upon L-band (narrowband) providers, such as Inmarsat and Iridium, to fulfil their needs. While the majority of narrowband satcom methods like these are largely unaffected when passing through rotor blades, they endure throughput limitations. Delivering only a few hundred kbps, narrowband satcom, whilst equipped to provide voice communications, is insufficient in reaching the data demands for HD video and Intelligence, Surveillance and Reconnaissance (ISR). Although possible to extend throughput to upwards of 1Mbps with the incorporation of bonded communications channels, to do so, comes at a high operational cost.

Wideband satellite communications offer high throughput of multiple Mbps, enabling the rich data content required by today's users to be exchanged. Providing network users with a minute by minute operational picture, this high data throughput enables HD video to be shared and received whilst on the move, holding the potential to change mission conduct for the better.

In the past, rotor platforms fitted with wideband satcom have suffered from interference; the rotor blades passing over the RF path would cause interaction with the satcom high frequencies, resulting in intermittent blocking of the signal. Subsequently, this resulted in signal backscatter, causing periodic interference, and stability and safety concerns to the RF link. However, the difficulties faced when transmitting wideband satcom through rotor blades was only part of the problem.

Real estate for antenna systems on helicopters is a premium. Weight constraints and the need to balance the aircraft's centre of gravity requires antenna system to be placed close to the rotor centre. In order to do so, low profile, light weight antennas are needed and only recently have they become more prevalent with the maturity of flat panel and phase array systems appearing on the market.

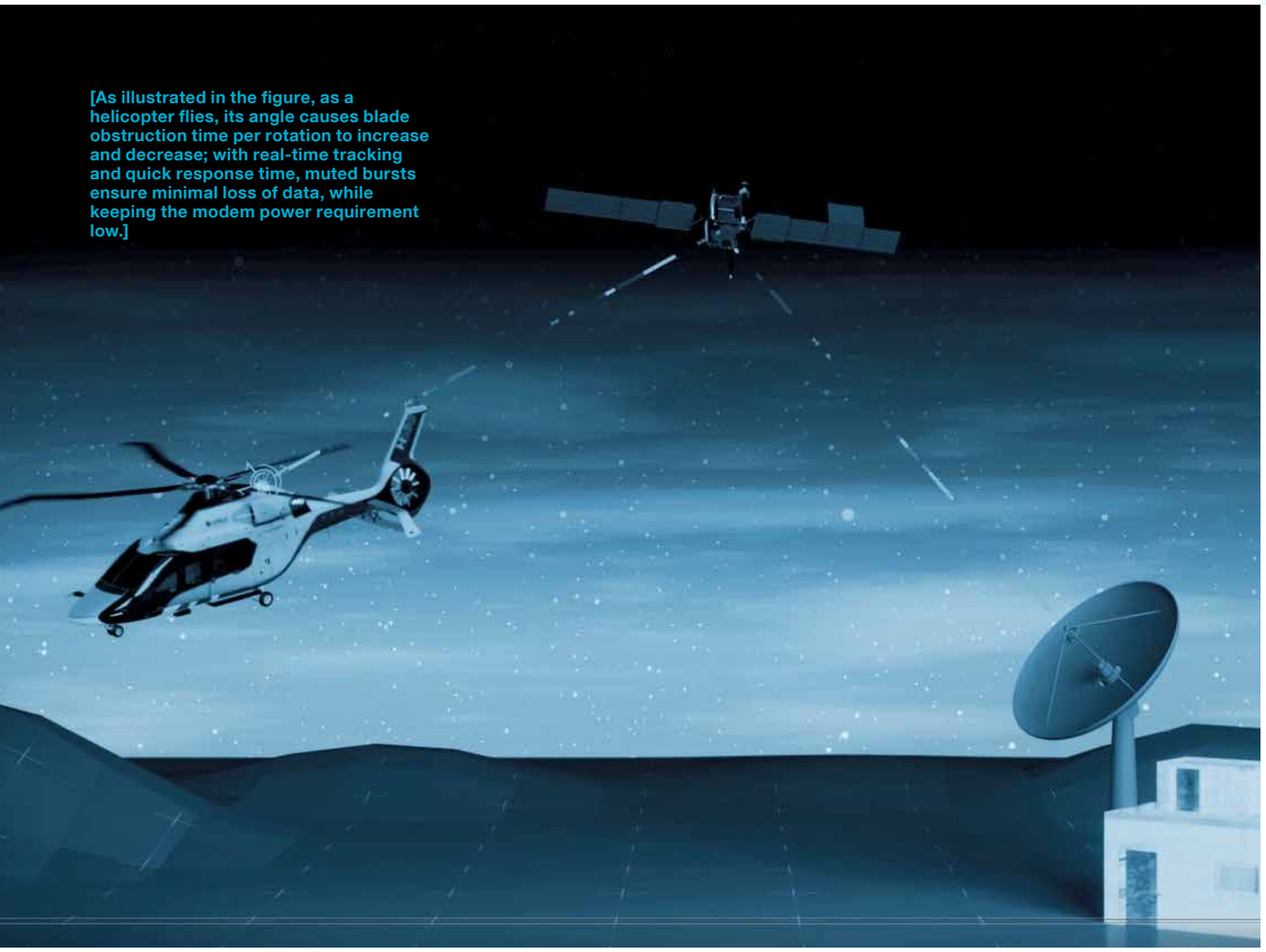
When addressing through rotor transmission challenges, many modem vendors on the market today have relied on what is termed as "the brute force approach", where more power is directed to the link. High levels of error correction are then applied to counter effect the rotors. Whilst this can be effective, it uses more satellite resource which in turn reduces its efficiency, resulting in a low bps/Hz communications link, high bandwidth for any given throughput and increased operational costs.

An alternative to this solution is for the modem system to be preloaded with

rotor platform templates. This approach requires the modem to be fixed to a platform with known rotor profile which is then used to inform of the blade rotation pattern; given the correct parameters, this can be highly effective and perform reasonably well. However, as the helicopter manoeuvres and the geometry and dynamics of the link to the satellite change, a template solution can result in sub optimum link efficiencies. To overcome these limitations, what is required is a modem system that is able to sense and adapt the communications path. As the airborne platform manoeuvres and the look angle varies, the amount of blade blocking will vary from zero, looking beyond the rotor disk edge, to a high blocking ratio when looking towards the centre of the rotor disk. Airbus has developed enhanced software within Proteus™ Unity that automatically uses dynamic blade tracking to sense the clear sky between the rotating blades and mute transmissions when blades are present. It is designed to utilise the available bursts of data transmission, from the helicopter to the satellite, when no blade is present. This in turn, minimises any outages, avoids RF transmission to the helicopter blades and removes potential safety issues with reflected RF into the helicopter cabin. The automatic sensing of blade position data can then be used to assist the forward link error correction, leading to a highly efficient duplex wideband satellite communications system and a cost-effective means of communication.

In September 2021, Airbus successfully demonstrated BLOS, through rotor blade communications using the Proteus™ Unity Satellite Modem System. During the flight test, which took place in the US, blade detection and avoidance were demonstrated, providing a stable communication and a throughout efficiency of between 70% and 85% to and from the Blackhawk helicopter[1].

[1] Throughput efficiency is dependent on the position of the antenna on the platform and the resulting look angle to the satellite. It will vary as the re beam interception point moves between the blade edge and the rotor hub centre throughout the flight. Beyond the blade (clear sky) would be 100%.



[As illustrated in the figure, as a helicopter flies, its angle causes blade obstruction time per rotation to increase and decrease; with real-time tracking and quick response time, muted bursts ensure minimal loss of data, while keeping the modem power requirement low.]

Resilience

A key issue for all communications is resilience; whether it be to changing environmental conditions or to interference, deliberate or accidental, resilience causes degradation to the communications link.

In the past, mitigating interference to give a highly resilient link has been expensive and complex. Normally reserved for military users, mitigation has varied from dual satellites paths to alternative bearers. The majority of commercial modems rely on link margins to provide some element of resilience and to maintain communications. However, this additional link margin results in higher transmit powers for a given data rate and increased demand on satellite resources. When interference is encountered, the majority of modems will experience errors causing the link to drop completely and communications to be lost potentially delaying, endangering or impacting the mission and its safety.

Intentional interference, or jamming, has long been a threat to military users and more frequently, commercial operators, who often have to operate from foreign territories, have also experienced interference with the intent of denying transmission.

The Airbus Proteus™ Unity Modem System makes use of an adaptive hybrid waveform that as well as adapting to helicopter rotor blades, is highly resilient due to its frequency hopping and spreading, a capability normally reserved for specialist military users.

Built on many years of experience, this highly capable dual use modem addresses the challenges facing wideband interference and maintains satellite links.

Operating Cost

Today, satellite communication operators are most likely to use L-Band satellite services as they are optimised for voice or low data rate exchange and provide a good quality of experience at a reasonable cost for the rotary winged user. However, when considering richer data content, such as HD video, the transmission rates and volume of exchanged data increases dramatically and narrowband becomes less of an obvious choice.

For helicopter missions, the ability to send and receive HD videos is a game-changer for governmental, military and commercial domains and will help to redefine mission strategy for years to come. The ability to stream HD videos in near real-time will vastly increase the chance of success in missions ranging from search and rescue, surveillance, reconnaissance and medivac.

With HD video data rates generally beyond the limit of Narrowband satcom, wideband satcom, such as X, Ku or Ka–Band, becomes necessary. Advancements in modem technology to support wideband satcom have enhanced the use of helicopter satcom, enabling communications, HD video and richer data content to become a reality, anywhere and anytime.

The incorporation of wideband satcom into helicopter platforms also provides access to High Throughput Satellites (HTS). The latest generation HTS with spot beams, allows for frequency reuse, making power and bandwidth leasing cheaper. The HTS enables helicopter terminals to be smaller, and therefore consume less electrical power. For example, 10 Mbps throughput can be achieved on Intelsat Epic (weighing less than 10kg) using a 30 cm terminal, a 15.5 W HPA (High Power Amplifier) and 9.5 MHz of allocated bandwidth.

The Airbus's Proteus™ Unity Modem System will give operators more efficiency in their operating costs by having an improved data throughput for a given bandwidth. Previously, operators have been apprehensive to implement satcom on helicopter platforms. Even with the additional benefits and possible mission improvements factored, operating cost has previously been a negative factor. Proteus™ Unity gives mission enhancements for a low cost of ownership.

Wideband satcom provides a number of advantages over Narrowband, these include:

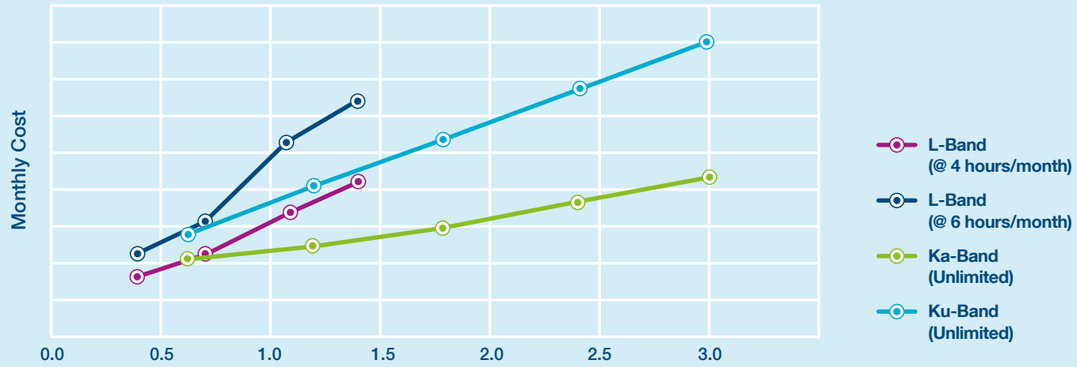
- Higher data rates at a lower costs
- Unrestricted usage and data services
- Shareable bandwidth

An L-Band Narrowband link offering a highly compressed video stream at around 1 Mbps would typically cost around $15k to $25k per month for a consumption of 4 to 6 hours/month. A comparable like for like on wideband could easily be achieved in 2-4 MHz of bandwidth, costing around $6k to $13k per month on Ka or Ku Bands, for the same duration. Assuming no

other advantage of the capabilities of wideband satcom is consumed this would lead to a saving of almost $500k over 4 years. Even when considering that L-Band terminals are cheaper than Ka or Ku terminals (~ factor 3 price ratio), after 4 years we can still achieve around 25% of savings (~$250k) on data transmission capabilities.

Keeping in mind the problem areas discussed above for helicopter users, sending and receiving HD video whilst in transit would require a higher bandwidth than that offered for L-Band. With this, missions can be enriched with live mission updates, sending rich-data content, such as ultrasound scans, and duplex persistent ISR. It is estimated that a throughput of around 5Mbps to a platform would be sufficient for this jump in capability, a rate not achievable with L-Band alone. Coupled with the ability to share bandwidth between a fleet of platforms and offer a maximum and minimum data rate, significant capability improvements can be achieved for a competitive cost.

Satellite bandwidth monthly cost including terminal HW price (amortized over 4 years)

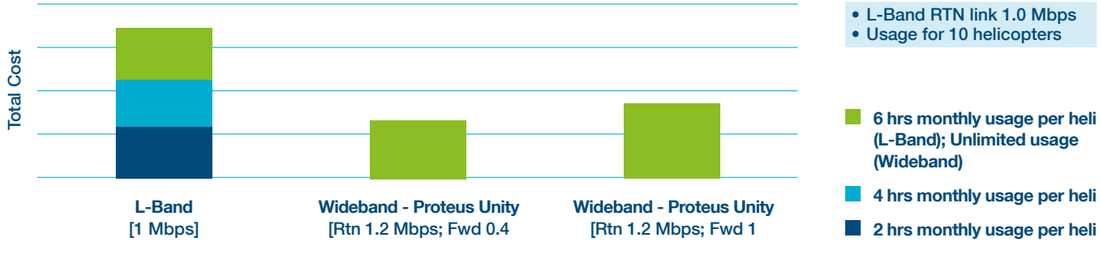


The Proteus™ Unity Modem System allows bandwidth to be shared in required proportions for the return and forward links.

At Airbus, we understand that there is a cost of introducing new HD video services capability with Proteus™ Unity. Even if the additional mission benefits and safety improvements cannot always be recognised in financial terms, Proteus™ Unity provides real financial benefits for a capability when compared to L-Band equivalents. Some other modem vendors have solved the through rotor problem with extreme spreading of the signal and repeated transmission of the data, however this results requiring more bandwidth for transmission and hence a higher operating cost. Bandwidth efficiency as a metric is an important factor when evaluating a wideband satcom system. Proteus™ Unity has been shown to achieve a bandwidth efficiency of 0.7 bps/Hz, which means for a typical throughput of around 5 Mbps, a bandwidth of approximately 7 MHz would be required, keeping operating costs low.

[2] Note: actual throughput is dependent on satellite (coverage, beam gain, power, frequency band) and antennas in use (gain, buc power etc)

Total Cost over 3 years: L-Band vs Wideband [Proteus Unity]



Proteus™ Unity

The Proteus™ Unity Modem System has been developed to address the current communication challenges facing the helicopter user industry and generate new capabilities to redefine the strategy of future helicopter missions.

Proteus™ Unity modems are Software Defined Radios (SDR) which use blade detection to enable satcom through the rotor blades and have options for increased resilience through frequency hopping. Airbus' range of high specification Proteus™ modems are available for fixed, land mobile, airborne and maritime platforms. They deliver maximum satellite bandwidth efficiency and data throughput, while offering robust protection against interference and interception.

The Proteus™ Unity Modem System has been designed to meet the needs of security and flexibility for the modern world. Using a hybrid FHSS and DSSS waveform, the Proteus™ Unity Modem System is able to hop over large bandwidth at a high rate to counter interference to the link; the signal is then spread to improve its performance through jamming. Smaller terminals, such as those used for airborne environments, are also able to adhere to the ITU off axis limits for transmission to adjacent satellites enabling higher throughputs for these terminals from the platforms.

One of the unique features of the modem is its adaptability. Proteus™ Unity adapts to the environment it sees to ensure the most efficient, secure and resilient communications. Operated in star networks in wideband satcom, it is both frequency band (C, X, Ku, Ka-Band) and antenna agnostic.

One of its key features is it's through rotor adaptability; Proteus™ Unity uses the forward link to provide an optimised return path that adapts to the received signal and varies the throughput to ensure optimum rate. Tests have shown highly efficient links are maintained as the look angle varies, this is automatic and no profiles, pre-configuration or manual tuning is required. This means that the system can be moved between platforms, swapped out easily and installed prior to missions as a Roll On Roll Off fit. Proteus™ Unity also provides interoperability with other modem users in the network irrespective of what platform they are on enabling real-time, full motion, high-definition video, communications and intelligence to be sent and received whilst on the move.

Airbus have also made significant steps towards simplifying the planning of these normally complex modem systems. The Proteus™ Unity Modem System uses the Airbus SMPS Management system which has been specifically adapted from existing planning tools for Proteus™. This allows for a typical network plan to be achieved in under 30 minutes and the suite of tools provides a common interface for everything from spectrum planning through to key management.

Summary

Up until recently, Beyond Line of Sight, secure, helicopter communications have been limited to use of narrowband communications. Now with the advent of smaller, lighter wideband antenna systems and modems that can adapt to the rotor blades, wideband satellite communications can be realised.

The Airbus Proteus™ Unity Modem System has been tested to show minimal loss through an overhead rotor disk. The modem maintains an optimal link through use of ACSM (Adaptive Coding Spreading and Modulation) and offers helicopter operators a cost effective, secure and resilient wideband satcom solution for their missions. Up to 90% throughout efficiency and over 0.7 bps/Hz spectral efficiency, the Proteus™ Unity modem adapts to the environment and allows the helicopter user the ability to adapt a rich data content at a low cost of ownership.

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