

## **Aktivity v element 1 programu ARTES 1 na rok 2010 – aktualizace červenec 2010**

### **Study of a strategy for introducing innovation in satcom commercial scenarios and experimental payloads definition**

ESA has used different Public Private Partnerships (PPP) approaches as is evident from the latest experience with the commercial Satcom operators (Eutelsat: Skyplex, Hispasat: Amheris, Inmarsat: Alphasat and TDPs, Avanti: Hylas, Hispasat: Small Geo mission and the newly envisaged EDRS). This ESA experience has clearly demonstrated that it is possible for commercial satellite operators to preserve their commercial priorities and still manage to achieve flight heritage for newly developed technology that might eventually increase the competitiveness of European industry.

The idea behind this study is essentially to systematize the approach of partnerships procurements and piggy back payloads so as to enable flight heritage opportunities for newly developed system/technology or newly envisaged services (high market risks) through the exploitation of several launch opportunities that exist yearly from the launch of commercial Satcom operators.

Building upon the Agency's last PPP experiences, the proposed study shall aim to analyze in particular:

- PPP schemes in cases where national agencies are willing to host within their own national satellite programmes ESA payloads or vice versa,
- the case of large scale PPP schemes involving a large number of private (commercial) partners e.g. similar to Alphasat,
- the case of PPPs for the development of new dedicated satellite(s) where specific SLA agreements are needed to be defined for future ground user segment and services development,
- How to encompass the results of the working Group on PPPs with launchers.

The approach is deemed to reflect the operators' commercial constraints and their assessment of risk retirement with respect to innovation. Specific topics to be tackled include:

- low cost piggy-back opportunity on their commercial satellites –with very limited incremental cost for operators but high saving for ESA;
- cheaper operation of ESA developed payloads and related services.
- the overall framework for the above scenario considering in particular the liability aspects and the overall mechanism of implementation.

As a special use case of the above approach, the activity shall define, analyse and preliminary design two (small and medium scale) experimental technological payloads for in orbit demonstration of advanced technologies on communication satellites. Possible flight opportunity options will be proposed and analyzed, and relevant constraints and design guidelines will be derived. Candidate technologies will be short-listed based on cost/risk/benefit analyses and required development actions will be defined. In this respect the present activity will tackle the following aspects:

- Analysis of viable options for satellite communication technology in-orbit-demonstration
- Definition of two possible scenarios and relevant requirements and constraints for two classes of experimental technological payloads
  - small scale (single by-passable transponder option). This payload can be used to demonstrate new technologies (e.g. new TWTAs, filters,

converters, LNAs...)

- medium scale (self contained payload fulfilling a scaled down mission). As possible examples, scaled down versions of payloads using active/semi-active antennas, broadband digital BFNs using advanced digital technologies, optical frequency conversions...)

- Definition of key technological elements and cost/risk/benefit analysis at element/subsystem/ payload level.

**Funding required: 500 k€**

**Duration: 15 months**

**ITT expected to be issued: 2Q10 Qtr 2010**

## **Introduction of Multi-beam networks in the developing countries**

The United Nations (UN) included the development of the Information and Communication Technologies (ICT) sector as one of the key objectives of the Millennium Development Goals. It is generally admitted that this sector contributes directly (through its own activity) and indirectly (by contributing to the creation of knowledge) to the economic development of a country and to the improvement of the standard living indicators. This is the case for instance for medicine and education, as well as for the private sector. GSM services are currently being developed at a fast pace in the lesser favoured countries.

While the modern economies have seen the recent introduction of multiple spot beam satellite technologies (Wildblue & Spaceway in the US, KaSat in Europe, IPStar in Asia), it is felt necessary to identify for which purpose and under which conditions such approaches can be extended to the lesser developed countries.

The proposed activity aims to implement:

- **1st step:** the current situation of the development of the ICT sector will be analysed for the developing countries (Central and South America, Sub Saharian Africa, Central Asia, and some countries of Far East). The underlying breaks and favourable factors to the development of this sector will be analysed. The situation in the development of terrestrial networks will be analysed (most of the time mobile networks are by far more developed than fixed wired ones);
- **2nd step:** the positioning of the satellite infrastructures will be analysed with respect to the results obtained in the previous phase: what are the benefits that a satellite infrastructure could bring (in a multiple spot beam like configuration, cost of bandwidth is expected to drop significantly), what are its inherent limitations, what are the conditions for a successful implementation?
- **3rd step:** the architecture of references that are recommended for implementation (taking into account the nature and existence of terrestrial networks) and what are the corresponding developments to be implemented (other frequencies than Ka band, such a C or Ku band shall be addressed).
- **4th step:** the benefits in engaging such an R&D effort for the European industry shall be evaluated.
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**Funding required: 250 k€**

**Duration: 12 months**

**ITT expected to be issued: 2nd Q2010**

## **Evaluation of the satellite solution for the development of a broadband service for the Union for the Mediterranean**

There has been a rapid deployment of terrestrial broad band (BB) services in the European Union (and also worldwide) supported by substantial funds in the frame of EU and national broadband initiatives. The contribution of satellite broadband networks has been up to now limited.

Nevertheless, new EU member states and the non-EU countries of the Union for the Mediterranean (UfM) present an important window of opportunity for European Satellite Broadband. The European satellite industry (from manufacturers to operators and service providers) has engaged efforts to penetrate these markets and establish o relationships with local partners.

Broadband has also been identified as a key factor for development by the UfM Ministers and a decision was taken to act in solving the existing digital divide among UfM countries. During the UfM ministerial conference in Marseille in November 2008, the Minister of Transport and Communications of Greece made a proposal for the development of a Broad Band Satellite Internet Service for the Union for the Mediterranean : the BB-MED. Based on a Private Public Partnership (PPP) scheme, the proposal assumes that, following an aggregation by the UfM of broadband demand in the UfM, a consortium will be selected by UfM, following a competitive tender, and contracted for deploying the satellite internet service.

The proposal presents particular characteristics and interest for the satcoms as it will lead to the largest call for satellite services in Europe and UfM (aggregated demand for about 130.000 connections in the example provided in the proposal), and satcoms are officially proposed by a member state as an efficient solution for fast deployment Also, BB-MED is a first step for further satellite applications and related technology developments in UfM.

ESA has been suggested in the proposal as a facilitator for the initiative, being a neutral, international public entity with expertise in satcoms. Major satellite operators and space industries expressed interest for the BB-MED proposal.

In this context, the European Investment Bank (EIB)is interested in supporting the UfM, and in particular to cooperate with ESA for the development of satellite broadband in the UfM and BB-MED. EIB intends to initiate a study to analyse the overall broadband market, the technological options available, and evaluate broadband deployment scenarios and also assess the socio-economic impact of broadband deployment in UfM countries covered by the Facility for Mediterranean European Investment and Partnership (FEMIP - Algeria, Egypt, Gaza/West Bank, Israel, Jordan, Lebanon, Morocco, Syria and Tunisia).

The proposed ARTES 1 study will be fully complementary and coordinated with the study of EIB for BB-MED. It will focus on the satellite broadband market and will complement the broadband market analysis for states not covered of the UfM states not covered by the EIB study ( Eastern EU countries Poland Czech Republic, Hungary, Romania, Bulgaria are such a sample).

The procurement action from EIB and ESA will be closely coordinated.

The proposed activity aims to implement:

- **1st step:**

Assessment of the broadband addressable market in the selected UfM states sample, including identifying state of existing infrastructure, market and regulatory conditions, key actions and authorities, forecast of broadband demand and utilisation scenarios.

- **2nd step:**

Evaluation scenarios for the most efficient – cost and schedule wise – broadband deployment, considering satellite and terrestrial technologies ;mix (with emphasis on the satellite component) for deploying in UfM a broadband infrastructure comparable to the European Community one (using data from Step 1 and from relevant past ARTES 1 studies and also data from the EIB study).

- **3rd step:**

Based on the findings from the previous steps, develop draft specifications and draft business/deployment plans for a satellite broadband service over the whole UfM, including the definition of Service Level Agreements (SLA's) adapted to the various UfM countries, taking into account users and type of use, cost for installation, maintenance, support, regulatory, legal, etc.

- **4th step:**

Dissemination of the results and awareness campaign in support of the satellite broadband initiative to the relevant target entities in UfM (authorities, policy makers, financial institution, users) and identification of ESA activities in support of the satellite broadband initiative and of the European telecommunication satellite stakeholders in the UfM markets.

**Funding required: 250 k€**

**Duration: 9 months**

**ITT expected to be issued: 2nd Q2010**

## **Approaching the Terabit/s Satellite: A system study**

The 2nd generation Ka-band satellites (Wildblue-II, Viasat-I, Ka-sat) is achieving the economy of scale thanks to small satellite beams with high freq. reuse and ACM (100 Gbps around 2010). But the challenge remains as IP traffic will nearly double every two years (according to Cisco forecast). In order to keep and expand satellite market share in the interactive broadband arena, satellite capacity shall be drastically enhanced in the coming years (Terabit/s satellites). The next generation Terabit broadband satellite systems (2017-2020 timeframe) will have to cope with the following challenges: users will require higher data rates and volumes for the same price, traffic will continue to develop in a very non uniform way, need to support both interactive and broadcast services (multi-mission satellites), and not all regions of the world can commercially exploit very high frequency bands because of too heavy fading (need for broadband solutions for rainy regions).

The aim of the present activity is to investigate how to provide at system and payload level near Terabit/s capacity with future multi-spot beam satellites. This represents a major enhancement with respect to current broadband satellite systems under development or under study. The study shall address the next generation broadband satellites timeframe (2017-2020). Different system solutions covering system, space, ground and user segments shall be derived. The trade-off between different options shall consider technological readiness and costs. The expected outcomes are:

- Service demands for next generation broadband satellite systems; *f*
- Identification of satellite system architectures together with main system performances and budgets;
- *f* Identification of technology gaps and technological roadmaps;
- *f* System and service cost analysis;
- *f* Preliminary design of a future flexible multibeam Ka-band payload.

**Funding required: 500 k€**

**Duration: 15 months**

**ITT expected to be issued: 2nd Qtr 2010**

## **Study of innovative global Satcom architectures**

In response to the institutional demand in support of European programmes and policies, including transport, energy and security, as asked by the 6th Space Council in its Resolution issued on May 29th, 2009, the proposed study activity aims at defining a roadmap for the provision of global satellite communications services .(In what concerns BB development in EU, the 6th Space Council on 29 May 2009 HIGHLIGHTS the potential of satellite communications technologies to bring broadband to European citizens and enterprises, ensuring a better access to modern ICT particularly in rural and remote areas<sup>6</sup>, in the context of the European broadband strategy called for by the European Council of 19-20 March; CALLS on the Commission, ESA and the EU and ESA Member States to consider integrating satellite technologies in future broadband projects with a view to support the implementation of the European Economic Recovery Plan (EERP), while respecting the principles of open competition, technology neutrality, and open and neutral internet architecture; and further RECOGNISES the need to explore innovative approaches and architectures for the provision of global satellite communications services in response to institutional demand in support of European programmes and policies, including transport, energy<sup>7</sup> and security.)

:

- Define use cases derived from the orientation as given in the Space Council orientation;
- Derive mission requirements for a European infrastructure (information assurance and associated security issues, coverage, connectivity, constraints on user terminals, integration with existing or future networks such as Future IP ...);
- Define applicable satellite telecommunication satellite networks integration scenarios with other terrestrial, maritime, aeronautical and satellite infrastructures (Earth observation, Navigation);
- Study and select detailed network architectures (user and infrastructure segments – space and ground -, interfaces between segments, performances budgeting, ...)
- Identify regulatory constraints and propose a plan for a guaranteed access to spectrum for the corresponding applications and services;
- Derive technological and deployment roadmaps (from full fledge to deployment to stepped approaches based on existing or segments under development – e.g. data relay services)

**Funding required: 200 k€**

**Duration: 12 months**

**ITT expected to be issued: 3rd Q2010**

## **Methods for Assessing the Public Value of Satcom in a Spectrum Trading Environment**

Satellite systems could compete more fairly in a spectrum trading environment if there was equality and transparency in the methods used to determine the relative public value of different communications technologies. This study seeks to identify such methods.

The Cave report in 2000 highlighted the value of spectrum as a national asset. The subsequent auction of 3G spectrum in the UK was designed to maximise its financial value, an approach that was broadly followed across Europe. This led to a frequent requirement for the satcom industry to defend its spectrum. Yet it is becoming clear that future spectrum trading schemes may not be based simply on maximising financial value. The FCC appears to be moving to a method for trading or allocating spectrum which includes a broader assessment of public value and there will be long term pressure for the EU to adopt a similar approach.

For example, carbon trading may work in favour of satellite systems. (The UK report "Case for Space" demonstrated the advantages of satellite broadcasting in this respect.) In addition, a review by the UK regulator Ofcom demonstrates conflicting ambitions for use of released UHF spectrum by the mobile communications industry (which could make a high financial offer for the spectrum) and the HDTV market (which could bring to bear public demand and political influence). Technically, satellite DTH broadcasting could be deployed quite efficiently at UHF, with the extra advantage of delivering global access. The question of what such access is worth is being addressed by a new BNSC study into the public value of the digital dividend, quantifying the value of the social benefits in Europe and also the benefits for education in less developed parts of the world.

Similar issues arise with the development of mobile TV across Europe, where considerations of carbon footprint and ubiquity of access may favour a satellite component in any emergent system. Future large aperture satellite antennas may make city or county sized spot beams a reality, enabling true regional content provision. There are many other examples where satellite solutions or components to a solution provide clear technical advantages. Yet questions remain on how to define the value of those advantages and how to ensure that they are considered fairly in a spectrum trading environment, where auction processes may be used to maximise public value.

Rather than adopt a defensive position that demands special treatment for satellite systems, this study will identify an evaluation methodology that can be applied generally, using UHF TV broadcasting as a case study. The methodology will then be refined to identify other applications where satellite solutions appear to have clear public value advantages. The study will also identify the particular aspects of technology that would be needed to enable such satellite solutions to be deployed with low commercial risks.

**Funding required: 200 k€**

**Duration: 12 months**

**ITT already issued.**

## **Benefit analysis of integration of Mobile Satellite Systems in terrestrial mobile networks**

The success of mobile telephony in the last two decades has proved that mobility is a valuable asset. The current trend is to converge terrestrial networks to all IP based technology where data is the currency to exchange. It is projected that the amount of IP data exchange in mobility will increase seven fold in the next three years, and that is just the start (Cisco white paper: Global IP Traffic Forecast and Methodology, 2006–2011). Terrestrial mobile operators are aware of this and together with manufacturers are defining the future of the mobile networks through initiatives such as GSM Association (GSMA) and Next Generation Mobile Network (NGMN) in a longer term.

Nowadays up to 80% of the terrestrial mobile network costs are driven solely from the site costs. Consequently the technology is moving towards deployment of wider cells - up to 200km - to reduce the cost of ownership of High Speed Packet Access (HSPA) cells. Satellite technology has the potential to play an important role in improving the business case by reducing CAPEX and OPEX of mobile networks. Additionally implementation of satellite technology can bring in other essential functions for NGMN such as broadcast and multicast services, optimised backhauling and meshed networks (for base stations).

The development of future advanced terrestrial mobile systems is a very challenging task. Satellites will play a significant role in this future system and hence this will need to be reviewed. An approach that will mutually benefit both the terrestrial and satellite industry would consist of:

- Raising awareness amongst the Mobile operators, manufacturers and the associated fora – GSMA, NGMN, UMTS Forum, etc. – of the strategic role that satellite can play in the evolution of the future mobile systems; by doing so ESA will be helping to create interest towards integrated mobile satellite systems (MSS) among the terrestrial mobile networks' community;
- Satellite actors learning from the wide range of experience of terrestrial operators and manufacturers in the development of technology, standards and business practices.

Recognising this synergy, a study is proposed that will aim to:

- establish the cost benefit of integrating satcom in NGMN;
- determine the approach for enhancement of offered services through integrated satellite/terrestrial systems; i.e. considering hybrid satellite/terrestrial systems topologies and architectures;
- determine the approach for integrating terrestrial mobile technology with satcom, for both radio access and core network technologies.
- The study will also specifically focus on the following issues:
  - Cost-benefit analysis of integrated MSS with terrestrial mobile operator with a view to CAPEX, OPEX reduction. Savings may come from reduced number of base station site acquisition and construction, regulation taxes, power supply, site rent, optimisation, OAM (operation and maintenance), fast early deployment of coverage, etc.;
  - Analysis of business opportunities for new-comers into the space industry such as network manufacturers, mobile manufacturers, etc.;
  - Analysis of successes and failures in the technology evolution of terrestrial mobile networks and its applicability to future integrated MSS;
  - Integration of terrestrial network nodes and technology in the satcom space/ground segment infrastructure (i.e. through complementary ground components with OAM and Radio Network controller functionalities) and technology re-use;
  - Study of the role of satellite in the core network (back-bone), possible use scenarios, technical requirements, pros and cons;

- Proposal of roadmap and requirements for future developments.

**Funding required: 300 k€**

**Duration: 15 months**

**ITT ready to be issued.**

## **Technologies and Techniques for High Throughput & Flexible Backbone Networks**

Satellite can play an important role in the continuous expansion of Internet backbones taking place all over the world. In order to be competitive with respect to fiber optic based solutions, the satellite service needs to provide an elevated throughput with very high link availability and flexible connectivity at affordable cost.

The necessity of providing, for certain locations, throughput in the order of several Gbit/s calls for the adoption of frequency bands in which adequate bandwidth is available. Ka band, with 2.5 GHz of available bandwidth is a distinct possibility but the use of Q/V band also needs to be investigated.

The use of high frequency bands, on the other hand, makes more challenging the fulfillment of the link availability requirements, that for this scenario are higher than 99.9%. A possible approach for coping with this constraint is to envisage very high system margins, with resulting heavy impact on the cost of both space and ground segment. A more effective solution is to employ advanced Interference and Fading Mitigation Techniques (IFMT), such as Adaptive Coding and Modulation, originally devised for satellite interactive networks. In this regard ad-hoc IFMTs can be envisaged that exploit the peculiarities of this scenario. In this scenario the satellite can provide a number of advantages with respect to the use of terrestrial links. In particular the use of a flexible payload would enable adjustment of the link capacity based on the actual capacity demand, thus enabling: (i) a very efficient reuse of the on board and radio resources; (ii) reconfiguring of the payload and antennas for serving different locations in case of development of new market opportunities.

Based on the above rationale the key aim of the study is to carry out an analysis of technology and architectural aspects with associated cost/benefit analysis for satellite networks that can provide for high throughput (up to several Gbit/s) and flexible connectivity between Internet backbones. The study will focus on the optimization of the space and ground segment with a particular emphasis on the following:

- identification of relevant scenarios for satellite applicability to Internet backbone connectivity;
- identification and analysis of technologies and techniques that enable fulfilment of the system requirements, with emphasis on space/ground equipment, payload flexibility and advanced IFMTs;
- high level system design and optimization to reduce the overall cost and improve the system remunerability;
- Cost/benefit analysis;
- identification of required technology roadmaps.

**Funding required: 300 k€**

**Duration: 12 months**

**ITT ready to be issued:**

## **Designing & analysing system level reliability for low cost telecom missions**

The standard industry methods of assessing satellite system reliability uses a bottom up approach and are largely based around MIL-HBK-217. Such approaches provide numerical measurements of reliability for subsystems or systems via mathematical descriptions of the relationships between electronic components of known failure rates. The failure rates used are based on statistical life data and adjusted according to effects of factors such as procurement level and environment. These quantitative reliability measurements are used by both operators and insurance underwriters when assessing spacecraft and ground equipment in overall business case analysis.

The requirement to quantify system reliability in a bottom up fashion can significantly influence satellite design in terms of module redundancy, margins and component selection resulting in significant manpower use that can drive up the satellite cost. Also basing assessments of system reliability purely on component data is not always the most appropriate engineering approach as other factors including mission complexity can also affect overall system reliability.

The aim of this study is to:

- survey different approaches to reliability assessment;
- assess the relevance of bottom up reliability assessment methods with new and emerging technologies;
- assess whether different reliability analysis approaches are appropriate for systems using spacecraft of different sizes and complexities;
- assess the extent to which different reliability analysis approaches can adversely impact on low cost approach to spacecraft designs.

The study will be conducted in two stages with the initial task focusing on :

- surveying different approaches that can be taken to assess the reliability of a communications satellite from the bottom up MIL-HBK-217 approach, via basic considerations of Mean Time Between Failure (MTBF) data for particular systems to a top down systems approach considering the known reliability of units based on heritage data and focusing only on key areas of concern;
- providing an engineering interpretation of the reliability measurements provided by an assessment compliant with MIL-HBK-217 and other reliability analysis approaches in view of all technical factors affecting spacecraft reliability. A valuable addition to this task would be to actually examine historical satellite failures and determine whether the most likely failure mechanisms proposed for the observed failures could have been prevented by the reliability analysis performed;
- identifying certain case studies to be performed in a subsequent task to support the rationale outlined above.

The case studies identified above shall cover:

- an analysis of the outputs provided by different reliability analysis methods for telecommunications missions of varying size and complexity to determine if there are breakpoints at which it makes sense to employ different approaches;
- an engineering case study examining the evolution of a simple engineering design employing a minimum of two different approaches to reliability to assess the variation in design complexity and associated cost that can arise when employing such different approaches.

The outcome of this study shall result in both a report summarizing the work undertaken and a set of recommendations for the implementation of reliability analysis approaches for low cost design approaches on telecommunications missions of varying size and complexity.

**Funding required: 250 k€**

**Duration: 12 months**

**ITT issued.**

## **Applicability of Cognitive Radio (CR) to satellite systems**

EC DG Information Society and RSPG recognizes that the total volume of services that depend on radio spectrum availability is estimated to be worth at least €200 billion annually in Europe. The efficient use of spectrum is therefore an item of growing importance.

CR technologies are frequently used in terrestrial communications systems on the basis of the offered efficient and dynamic use of frequency spectrum for both civilian and military applications.

Software Radio (SDR) and Cognitive Radio (CR) are the subject of two AIs (AI.1.19 and A.I. 1.2) for the upcoming WRC-012 conference. SMAG experts recommend to investigate the applicability of CR to satellite systems. This is the scope of the proposed feasibility study. Two situations deserving special attention are identified: (a) techniques that allow sharing the spectrum among systems without causing interference; (b) dynamic use of the spectrum when it is free. The study should cover channel identification techniques.

Starting from the identification of potential system use cases, the study shall use both analytical and simulation methods to assess the CR technology. Propositions of technology roadmaps shall be provided.

It is proposed to implement a restricted competition between Finnish Industry because of the established expertise in the domain; of both Industrial actors and Academic Institutions.

**Funding required: 100 k€**

**Duration: 6 months**

**ITT expected to be issued: 2nd Qtr 2010**

## **Interworking in the Aeronautical Telecommunication Network (ATN) for future aeronautical data communication system**

The International Civil Aviation Organisation (ICAO) has defined a data communications architecture and accompanying standards for air-ground mobile communication, known as the Aeronautical Telecommunication Network (ATN). ICAO recognises two versions of ATN, ATN/OSI, which uses OSI, and ATN/IPS (Internet Protocol Suite), which uses IP protocols. While the ATN/OSI version is mature and extensive validation trials have been performed, particularly by

Eurocontrol, the ATN/IPS has been recently specified and is envisaged to be the future basis for data communications in the 2020+ timeframe. Validation trials are being prepared in various centres, mainly in Europe. SESAR has adopted ATN/IPS as the basis for data communications in the 2020+ time frame, and several SESAR projects are planning to develop infrastructure to support this. Since ATN/OSI will be already implemented while ATN/IPS will start its development, the interworking or co-existence in the same system of the two protocol stacks shall be evaluated. This activity proposes to define the validation concept of such interworking and the development of the key software element(s) that will enable the interfacing within an overall validation process.

The activity aims to implement:

- **1st step:** Definition of a validation concept suitable for aviation safety purposes and of the testbed(s) set-up necessary to fulfill the overall validation. This includes lessons learnt from previous verification and validation campaigns for aviation, the review of the E-OCVM (European Operational Concept Validation Methodology) concept from Eurocontrol, the definition of a validation concept and plan for all steps until certification, the definition of the hardware and software set-ups. Adaptations for the peculiar case of a satellite link shall be proposed if needed.
- **2nd step:** Definition of the interface concept between the satcom system foreseen by SESAR and the terrestrial network for the future air traffic management concept. This task shall detail the interworking mechanisms at network layer for both ATN/OSI and ATN/IPS protocol stacks and propose implementations of those techniques for a ground implementation and an airborne implementation. This work shall take into account the impact of the multiple transport layer 4 techniques used (TP4, TCP and UDP) within the overall air traffic management system. ICAO technical specification of ATN/OSI and ATN/IPS as well as the ATN SARPs (Standards and Recommended Practices) are the key standards of reference to be considered for starting the work.
- **3rd step:** Verification by means of simulations of the interworking functions including the dialogue service specified by ATN/IPS specification.

**Funding required: 100 k€**

**Duration: 6 months**

**ITT expected to be issued: 2nd Q2010**

## **Low cost anti-interference techniques for Satcom Commercial Satellites**

Commercial satcom systems are increasingly being utilised by the military to enhance global connectivity for the provision of milsatcom services. A recent Euroconsult report has identified this as a major growth area as indicated by the following extract from the report:

- i) transponder demand for milsatcom services reached 222 units in 2007 with growth forecasted at 8% Compound Annual Growth Rate (CAGR) over the next ten years with the US expected to account for the major share (88%) of this market by 2017;
- ii) DoD's demand for satellite bandwidth has multiplied by a factor of 3 in 5 years, driving use of commercial capacity.

Hitherto, this demand has been met by satellite operators through conventional business approach such as transponder leasing, but other novel approaches are also emerging such as PPP/PFI based business models involving risk sharing between Government and the private sectors. An example of this approach is the complex milsatcom services provided by Paradigm Secure Communications to the UK MOD through a contract that involves build, launch, operation and maintenance of Skynet 5 satellite.

A key feature of this market will require commercial satellite operators to address network security aspects that will protect the satellite network from jamming and radio interference. Recent experiences suggest that concerns of jamming and interference is not only confined to the military domain as it is evident from cases that have affected the following commercial satellites: Indonesia-1990, Iran-2006, Eutelsat-2007, Thuraya-2007. As interference/jamming vulnerability is a common problem for the commercial and institutional customers alike they would both benefit from low cost anti-interference/jamming solutions that would maintain a robust and reliable quality of service. Prediction is that more satellite operators will demand increased resilience to interference/jamming for their newly ordered satellites. This prediction is underpinned by the following developments:

- as around 60 to 80 per cent of the US DOD military satellite communications is being carried by commercial satellite operators such as Intelsat, they have been under pressure from the Pentagon to include enhanced encryption capability to their newly ordered satellites;
- military satellites use methods like encryption and frequency hopping to prevent jamming. Due to cost manufacturing implications commercial satcom satellite lack such safeguard measures. US manufacturers are already considering to transfer some of their knowledge from their milsatcom (i.e. jam-resistant antennas) into their commercial offer strongly relying on their robust DoD R&D programme back up;
- the sensitive nature of this technology and its ITAR implications has been recognised by the European satellite manufacturers which have developed anti-jamming expertise in X band under their national milsatcom programmes but the cost implications of this technology is still a concern for its acceptance by commercial operators.

Commercial satellite operators are therefore willing to support anti-jamming measures and other protective measure for their satellite to better guarantee their operational services. In support of this logic the objective of this study activity is to assess anti-interference/jamming techniques applicable to telecommunications commercial satellites end-to-end system taking into account market demand evolution and the need to develop low cost techniques in line with the operators' commercial requirements.

**Funding required: 300 k€**

**Duration: 12 months**

**ITT expected to be issued: 3rd Qtr 2010**

## **The role of satellite in Future Internet Services.**

The current Internet has its origins as an experimental platform which has evolved (a) into a commercial distributed database interconnecting machines; and (b) as a content distribution network. Whilst very popular, it suffers from severe technological shortcomings. Indeed, not only the basic Internet protocols are now 30 years old and the Internet scale has increased by many orders of magnitude, but it has also accredited hundreds of additional protocols and extensions which make its management more and more complex. Unforeseen and extremely useful and popular applications, such as skype, wikipedia, facebook, youtube, have sprung up and steered the Internet use into directions which were not initially anticipated, posing demanding technological and policy challenges in different domains such as security, mobility, heterogeneity and QoS management, ad-hoc connections as well as deficiencies in social, multi-sensor, and multi-modal networking. There are workarounds to 'fix' these problems but they do not provide an optimum solution.

The features that would be desirable in a Future Internet would be Global coverage (ubiquity and pervasiveness), Networks resilience, Wireless (mobile) high data services, Media Aware Networking Devices (MANETs), Virtual worlds including 3D and personalised content rendering, Integration of physical world with digital world, huge numbers of connected persons/sensors/machines, Composed services, P2P/social and multi-sensor networking communications as well as Real-time applications.

To meet the above requirements the future Internet will, as a minimum, be expected to be :

- secure and reliable, managed through an open, dynamic, decentralised governance supporting unpredictable behaviour;
- capable of providing scaleable and flexible services with the same performance anywhere around the globe regardless of user location;
- capable of supporting emergency management and to assist society to restore situations on emergencies, crisis or natural disasters.

Satellites, due to their global coverage nature, are well placed to respond to the challenges outlined above. Early inclusion of satellites as an integral part of a future infrastructure is essential to ensure that the future Internet will interwork over satellite to exploit the wide area multicast features and provide new mobility paradigms, security frameworks, adaptive transport protocols, etc. and accommodate the effects of satellite delay.

A study activity is proposed, that will take into account US, EU and other International studies undertaken in this area, to provide a foresight into the long term perspective for the evolution of IP satellite services and applications. It shall focus on two major system use cases:

- i) internet of persons –social networking; and
- ii) internet of things –multi-sensor networking.

The study shall investigate in a bottom up approach:

- the services requirements (including horizontal services and brokerage, computing resources as services), main actors' business views (telcos and satellite operators) and ethical/social and regulatory issues; and
- identify plus quantify the critical areas in satellite future internet services provision including Security (for all type of combined services like location based related, integrated QoS / Security / inspectability...), Middleware technologies enhancements (from IPv6 enhancements to new simplified protocols design with cross-layer optimisations)

The study shall result in the following outcome:

- Detailed services requirements;
- Critical technical areas identification and quantification;
- Future services business organisation and tariffs; and

- Technological Roadmap both for ground and space segment.

**Funding required: 300 k€**

**Duration: 18 months**

**ITT expected to be issued: 3rd Qtr 2010**

## **Emerging system concepts for UAS command and control via satellite: a pre-WRC-12 system study**

The unmanned aviation community is currently preparing for WRC-12 with regards to frequencies dedicated to command and control of UAS (Unmanned Aerial Systems). It is believed that this is a key enabler for UAS integration into civilian airspace.

In the draft CEPT (European Conference of Postal and Telecommunications Administrations) proposal for WRC-12 a total of 47 MHz for satellite will be required for the UAS command and control via satellite by the year 2030 in an AMS(R)S band (at least for the satellite/UAS link). If this frequency band is allocated by national administrations after WRC-12, a new niche market for UAS command and control could well develop for safety satellite services in proposed bands. Already at the moment some commercial companies operate UAS for government customers, and this market is expected to grow significantly.

The fact that there are currently no frequencies allocated for such UAS command and control services means that they are only offered on an ad-hoc basis, ruled by a lengthy administrative process and solely for governmental/military purposes. This precludes the development of such services for civilian purposes. In case such frequencies are allocated, this would contribute considerably to the process of integration of UAS into civilian airspace and the development of corresponding civilian applications. Satellite systems would need to be designed for such UAS command and control services in the allocated frequency bands.

Such satellite systems and services would be characterised by:

- stringent safety and security requirements,
- compliance with ICAO and associated standards and civil aviation certification requirements
- support/anticipation of frequency band solution from WRC-12
- compatibility with existing services (e.g. MLS - Microwave Landing System, ANRS – Aeronautical Navigation Radio Services) in the same frequency band, e.g. using innovative spot-beam concepts,
- a limited payload size and as such perhaps allowing innovative, step-wise deployment scenarios, possibly combining this with other institutional payloads, and following the ramp up of UAS population
- a new type of user segment (omni-directional, low-gain antenna, new air interfaces) with specific integration constraints,
- a mix of civilian and institutional business case.

A study is proposed to investigate the feasibility for such a system and identify system concepts.

The objective of the activity is to define initial system concepts for a new satellite communications system providing command and control communications to UAS beyond-line-of-sight (BLOS) of their control ground stations, and thereby supporting the safe-and-seamless insertion of Unmanned Aerial Systems (UAS) in non-segregated airspace. (C2 includes Command & Control, ATC relay and Sense & Avoid communications).

This activity supports and complements ongoing developments in EDA, EASA, Eurocontrol, EUROCAE, RTCA and FAA and promotes satcom capabilities in the emerging UAS markets.

The activity shall cover all the regular ESA Phase 0 aspects, with a particular focus on the safety and security issues. It shall build upon related ESA internal activities (GSP, IRIS, IAP and ARTES 1, see below), as well as external activities (EDA studies).

The study shall take benefit of user requirements and state-of-the art inventory that will be collected by the then-ongoing feasibility studies under the EDA and ESA IAP (ARTES 20) programme (ESA ITT 6118: "Unmanned Aerial System (UAS) Mission supported by Integrated Space Systems"). In addition,

the proposed study shall be forward-looking with respect to future space infrastructure and shall take into account developments taking place now as part of WRC-12 preparations.

The study schedule shall be aligned with the WRC-12 preparatory cycle and shall only start when reasonable consolidated positions for new UAS C2 frequency allocations are available, which are expected around June 2010.

The activity shall:

- review the main user requirements and airspace integration requirements as found in previous ESA and external studies
- identify additional system and civil aviation requirements for UAS C2 and their insertion into non-segregated airspaces (e.g. SWAP - size, weight, power, capacity, availability)
- base itself on WRC-12 draft positions and align with ICAO, RTCA and EuroCae standard developments
- involve the major stakeholders (EUROCONTROL, EUROCAE, EASA, EDA, national air navigation service providers) to discuss viability and policy issues regarding new space segment for UAS C2 services
- present the business case and the viability, including non-economic factors such as legal and political issues,
- investigate various satellite system solutions and architectures for UAS C2, taking into account existing frequency sharing/compatibility studies performed in European studies like SIGAT
- investigate the candidate waveforms and associated security aspects
- investigate the safety, latency, security and certification issues
- investigate interaction and interoperability with line-of-sight (LOS) communications
- lay out the required technology development roadmap for space, ground and user-segment,
- develop deployment scenarios for an initial capability for C2 of UAS,
- present and promote such satellite system solutions actively to the UAS community
- suggest standardisation/certification paths.

In case this activity concludes in the beginning of 2011, European industry will be in a privileged position to react fast after WRC-12.

**Funding required: 250 k€**

**Duration: 9 months**

**ITT expected to be issued: 2nd Qtr 2010**

**Relation with ongoing and past ESA activities:**

The current GSP studies provide only a high level definition of a satellite system supporting UAV C2, not at the level of an ARTES Phase 0.

The feasibility studies that are currently in preparation with EDA and the ARTES 20 IAP programme are focussing on UAV missions and services as such based on existing space infrastructure, but do not address the business case for a dedicated space segment using new WRC-12 candidate bands. However, it is expected that the feasibility studies will identify capability gaps of existing infrastructure, which shall be used as inputs for the proposed study.

The ARTES 10 programme is specifically focussing on communication for ATM (ATS/ATC), not including any relay from an Unmanned Aerial Vehicle (UAV) to the pilot-in-command. Still, there are very relevant findings in terms of deployment scenarios, certification issues, waveform candidates, etc.

In various ARTES 1 Air Traffic Management (ATM) related studies, various business models for satellite ATM services have been detailed and various piggy-back solutions have been investigated. The results of these studies shall be taken into account as well.

## **The role of Satellite in converged mobile/fixed/broadcasting environments**

Convergence in fixed/mobile/broadcasting environments is an evolutionary development for operators because of the inheriting potentiality to transform their business models and lower their overall Capex and Opex. Operators move from simple connectivity providers to full service providers adding streaming, live media broadcast services, on demand and other value added services in their portfolios; all from a single service platform capable of delivering over several network infrastructures and employing different transport technologies. Such evolution can already be witnessed through the most advanced terrestrial networks i.e. DSL, 3G and DVB-H.

A prognosis of future telecom infrastructure is based on the user requirements first and service providers offering secondly considering the available infrastructure and the fore coming technical developments. These developments are summarised under the buzz word 'Next Generation Networks'. While ETSI TISPAN group set up their Next Generation Network (NGN) concept, other standardisation activities contribute to convergence, i.e. DVB-CBMS (Convergence of Broadcast and Mobile Services; DVB-CBMS), 3GPP (3GPP defined the IP Multimedia Service (IMS) concept for the mobile access, providing service control mechanisms ) and OMA (Open Mobile Alliance: leading industry forum for developing interoperable mobile service enablers. It drives service enabler architectures and open enabler interfaces that are independent of the underlying wireless networks and platforms.). All developed concepts are based upon complete separation between connection and service control and they permit complete service management independently from the underlying transport technology. For example DVB-CBMS phase 2 is currently developing mobility scenarios to facilitate the provision of services every where/anytime enabling roaming/handover capabilities between DVB-H/3G/WiMax...; in parallel OMA/BCAST elaborates concepts on Digital Right Management distribution in the same environments. Lately, TISPAN and DVB-IP are assessing the support IPTV within NGN. Unfortunately, the satellite component is not considered in these standardisation loops at first place.

The convergence of terrestrial networks towards all IP-NGN will have noticeable effects on satellite networks. It is urgent to not only predict the convergence paths in the terrestrial networks and services but also study convergence scenarios that include the satellite component and analyse the critical issues.

The aim of the study activity is to evaluate satellite networks convergence scenarios, for example satellite/WiMax/3G etc, and define reference model for a satellite centered service platform capable of services provision in the convergent fixed/mobile/TV2.0 broadcasting era. The technical and business analysis shall be done looking for the whole value chain, from content production to user terminals. New developments shall be identified and a set of recommendations shall be issued for standardization, i.e. to feed the new standardization cycles in DVB-CBMS phase 2, OMA/BCAST v2.0, in order to guarantee the widest access to the proposed services and technologies.

The study activities will start with the investigation of the evolution of the satellite operators' and service providers' roles in the converged world with emphasis on mobility and TV2.0. The study will proceed with the definition of services classes and the analysis of services domain and business organization. Typically location based multimedia entertainment services will be considered. Satellite links integration with IMS/TISPAN core networks will be analyzed and the use of satellite return link will be tackled.

Finally, the study will propose a model of an open 'Unified' Electronic Service Guide (UESG) to support users' handing-over/roaming between different access and delivery networks, supporting also capabilities for peer-to-peer applications. A proof of concept UESG simulator will be developed.

**Funding required: 400 k€**

**Duration: 12 months**

**ITT expected to be issued: 3rd quarter 2010**

## **Introduction of QC in satellite communication networks (of which 100 k€ reserved for the Austrian industry)**

The Vienna University is one of the world leaders in the field of Quantum Communication (QC), and in particular for Quantum Key Distribution (QKD) between two (or more) parties. Based on the physical principles of entanglement of photons, an absolute security is ensured by this type of system (i.e., a single photon cannot be either split or cloned, and any attempt of measurement will modify its quantum state).

QKD has been demonstrated for optical fibre networks. The potential of QKD for space systems has been assessed in several R&D activities under the ESA's General Studies Programme (contract numbers 16358/02/NL/SFe, 16441/02/NL/SFe and 17766/03/NL/PM). The feasibility of distributing entangled photons, single photons and weak laser pulses from LEO orbit to ground has been demonstrated by representative (in terms of total attenuation and atmospheric turbulence) long-distance free-space horizontal links on ground (contract number 18805/04/NL/HE).

The European technology and expertise in the field of QC has been judged as mature enough to evaluate the opportunity of its introduction into operational telecommunication networks.

It is thus proposed to engage an ARTES 1 activity to identify the applicability of Quantum Communication (including at least QKD) to space-based telecommunication services. This activity shall address the service definition and assess the corresponding market segments, the concept of operation, and the requirements on the satellite based infrastructure (including the interfaces with other networks) and for the corresponding segments (ground infrastructure, user, and space). The benefits of a satellite based service shall be assessed. The Geostationary-satellite orbit (GEO), Medium Earth Orbit (MEO) and Low Earth Orbit (LEO) shall be addressed. The programmatic elements for the operational introduction of such a network shall be developed, including the justified need for additional technological developments and validation (including in orbit experiments).

Recognising that such an activity calls for a variety of expertise (telecommunication and security market understanding, telecommunication services definition, network architecture and engineering, optical free space communication, quantum communication, space segment engineering), this activity shall be open to competition, while at the same time reserving 100 k€ for the Austrian industry.

**Total funding required : 250 k€**

**Duration of 9 months.**

**ITT is scheduled for Q3/2010.**

## **Efficient networking and MAC techniques in next generation interactive broadband satellite networks**

Interactive broadband satellite networks targeting consumer and business applications have to face many stringent requirements and constraints to be competitive wrt. terrestrial networks. The major one is to be able to deliver to end-users the same experience as terrestrial alternatives at an affordable cost. Broadband satellite networks also have to be capable of a seamless integration with the Internet and to offer to operators the possibility to be managed as any other access networks. Furthermore, for DVB-RCS NG systems, interoperability between multi-vendor sub-systems is a major requirement.

The focus of this activity is the study of efficient networking and MAC techniques in interactive broadband satellite systems (DVB-RCS NG, VSAT, mesh ...) to cope with these requirements.

Among the upper layer techniques that may greatly participate in the performance optimisation, the study will address header compression, which has been little studied by the space community. The efficient integration and use of random access techniques in systems also implementing DAMA, for the improvement of the offered QoS, will be analysed too. Regarding the integration with terrestrial infrastructures, the study will analyse e.g. techniques enabling the satellite system to seamlessly extend terrestrial Virtual Private Networks based on commonly used technologies, e.g., VLAN 802.1 Q or MPLS, as well as the required adaptations for the migration towards IPv6. Additionally, the integration of OSS solutions commonly used by ISPs/Telcos for alternative access networks will be considered. Key interoperability issues at upper layers for DVB-RCS NG systems will at last be analysed.

The activity will have to identify appropriate and efficient techniques and solutions, and to validate them through UML-like models.

The final objectives of the activity will be:

- *f* To provide contributions to the DVB-RCS NG WG, with the objective to help in the finalisation of a full end-to-end solution for DVB-RCS NG. Contributions are planned for end 2010/beginning of 2011, in order to be integrated in the second release of the standard. Their objectives are to cover technical areas not addressed or partially addressed by the standard.
- *f* To define generic recommendations on the use and implementation of optimised and efficient upper layer techniques for interactive broadband satellite networks, e.g. DVB-RCS, VSAT, mesh. These generic recommendations will be made public by ESA to the different interactive broadband satellite network stakeholders.

**Funding required: 350 k€**

**Duration: 12 months**

**ITT expected to be issued: 1st Qtr 2010**

## **Integration of satcom access networks in IMS core networks**

The general trend in telecommunications is the move away from "vertical" architectures relying on access specific networks towards converged "horizontal" architectures where core networks and service architectures are shared among several access technologies.

Telecom operators are favouring the IMS ("IP Multimedia Subsystem") as the architectural framework of choice for the next generation of telecommunications networks, where a single IP backbone will be used in conjunction of different access networks. The IMS is expected to offer substantial cost savings and enable the convergence of services in fixed and mobile networks. As satellite networks are interesting candidates for integration in next generation networks, especially as access networks, the issue of their seamless integration with IMS is a strategic one.

Currently two parallel ARTES-5 activities "IMS Satcom Integration" are being finalized. These two activities, run respectively by consortia led by Siemens (A) and TNO (NL), have addressed in detail, by means of analysis as well as simulation, the integration scenarios between satellite broadband access networks (DVR-RCS) and the IMS. They have identified a number of challenges for IMS/Satcom integration, and critical areas to be addressed by standardization in order to guarantee integration.

The activity aims to consolidate the findings of the two ARTES-5 studies, select the suggestions for areas to be standardized (e.g. billing, admission control) and map them to relevant standardization bodies. The team running the activity will then actively participate in standardization by proposing activities to these standards bodies, and according to their feedback by allocating the effort to specific working groups in those standards bodies which will be found most suitable - both from their confirmed interest as well as from a timeliness point of view (e.g. compatibility with the project timescale).

**Funding required: 150 k€**

**Duration: 12 months**

**ITT expected to be issued: 2nd Qtr 2010**