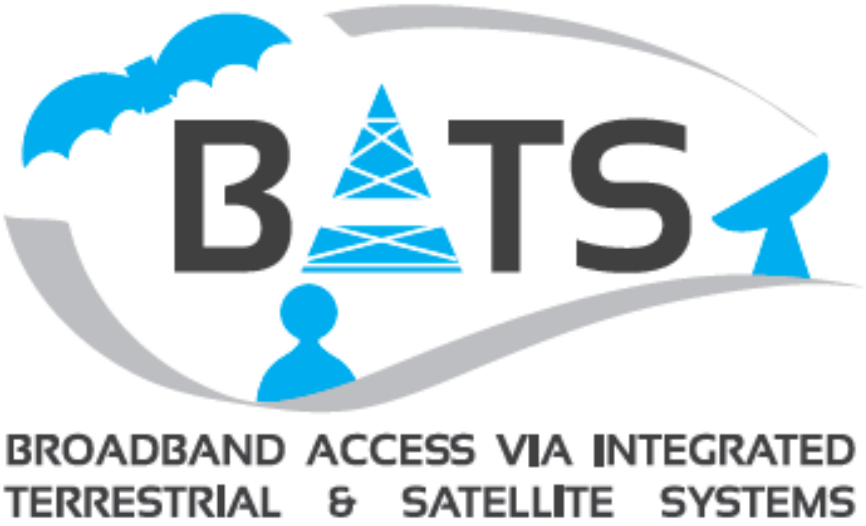

D8.4.1
Exploitation Plan - Final

Instrument	Collaborative Project
Topic	ICT-2011.1.1
Project Title	Broadband Access via Integrated Terrestrial & Satellite Systems
Project Number	317533
Project Acronym	BATS
Contractual Delivery Date	M39
Actual Delivery Date	M39
Contributing WP	WP8
Project Start Date	01/10/2012
Project Duration	36 months
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Editor	AVA
Contributors	DLR, AST, TAS-F, TAS-S, MAV, UoS, FH-FK, FH-HHI, GRA, TT, R, OPT,STM,MUL, CAL and OAF

Document History			
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1.9	6/01/16	Ready for QA	AVA
2.0	12/01/16	Document upissed	AVA

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List of Acronyms

ACM	Adaptive Coding and Modulation
ACS	Auto Configuration Server
AST	EADS Astrium (now Airbus Defence & Space)
AVA	Avanti Communications Plc.
BATS	Broadband Access via Integrated Terrestrial & Satellite Systems
BB	Broadband
BSS	Business Support System
CAL	Climate Associated Ltd.
CDN	Content Delivery Network
CPU	Central Processing Unit
DLR	German Aerospace Agency
DSL	Digital Subscriber Line
DVB	Digital Video Broadcasting
EC	European Commission
ETSI	European Telecommunications Standards Institute
FBMC	Filter Bank Multi-Carrier
FH-Fk	Fraunhofer - Fokus
FH-HHI	Fraunhofer - HHI
FPGA	Field Programmable Gate Array
FWD	Forward (Link)
GRA	Galician Research and Development Centre in Advanced Telecommunications (Gradiant)
GPU	Graphics Processing Unit
GSE	Generic Stream Encapsulation
GW	Gateway (Earth Station)
HTS	High Throughput Satellite
HW	Hardware
IETF	Internet Engineering Task Force
ING	Intelligent Network Gateway
ISP	Internet Service Provider

ITU	International Telecommunications Union
IUG	Intelligent User Gateway
LTE	Long Term Evolution
MAV	Mavigex s.r.l
MIMO	Multiple Input Multiple Output
MPTCP	Multi-Path Transport Control Protocol
MUL	MulSys Limited
(M)VNO	(Mobile) Virtual Network Operator
OAF	OneAccess France
OBO	Output Back-Off
OFDMA	Orthogonal Frequency Division Multiple Access
OGS	Optical Ground Station
OPT	Optare Solutions
OSS	Operation Support System
QoE	Quality of Experience
QoS	Quality of Service
R	R Cable y Telecomunicaciones de Galicia S.A
RTN	Return (Link)
SC-FDMA	Single Carrier – Frequency Division Multiple Access
SDR	Software Defined Radio
SW	Software
TAS-F	Thales Alenia Space - France
TAS-S	Thales Alenia Space - Spain
TDMA	Time Division Multiple Access
TT	Turk Telekom
UoS	University of Surrey
WP	Work-package

Executive Summary

This deliverable describes the exploitation plans with regard to the identified exploitable knowledge in a per-partner basis. Note that each partner has independently developed its own exploitation plan based on its business strategies; however some of the exploitable opportunities may be developed in conjunction by a subset of the project partners towards and after the completion of the project. Every partner has provided the identification of the exploitable knowledge they have developed so far in the project and what are the opportunities for exploitation coming out from such knowledge. In addition, we summarize and evaluate in the document the outcomes from the project activities on the business plan definition for the integrated satellite/terrestrial broadband delivery, identifying which are the main barriers for a commercial exploitation of such a concept and which are the recommendations in order to motivate its service take-up.

This document states the exploitation plans of each partner at the end of the BATS project.

1 Introduction

The purpose of this document is to provide a plan for the exploitation of the outcomes of the BATS project.

As expected the exploitation plans from different partners are different due to the nature of their business. Nevertheless there are also areas where these plans align. Each partner has independently developed its own exploitation plan based on its business strategies. This deliverable summarises the contributions of each partner of the consortium.

This document is now final so it states the intended exploitation plans of each partner at the end of the project. This document is structured as follows:

- **Chapter 1** provides a brief introduction to the project scope and the stakeholders of the BATS satellite/terrestrial network integration concept. It also summarizes and analyses the main outcomes from the business plan definition activities in WP5.
- **Chapter 2** provides a general overview on the BATS exploitation plans based on the specific plans from the different partners.
- **Chapter 3** details the specific exploitation plans for all project partners.
- **Chapter 4** develops the conclusions to the document.

1.1 Scope of BATS

The BATS project, funded under the European Union 7th Framework Programme, addresses the delivery of BroadBand (BB) future services in Europe according to the EC Digital Agenda objective to reliable deliver >30Mbps to 100% of European households by 2020.
In order to accommodate the areas of Europe which are 'unserved' and 'underserved' in terms of BB availability, an Ultra High Throughput Satellite System is researched that provides order of magnitude cost/bit reductions and solutions to existing market barriers of bandwidth and latency limitations. BATS proposes a novel architecture which combines satellite and terrestrial service delivery via an Intelligent User Gateway (IUG), dynamically routing each traffic flow according to its service needs through the most appropriate delivery mechanism to optimise the Quality of Experience (QoE). The integration complies with emerging home network environment standards and provides resilience and reliability of service provision to the users by using simultaneously diverse access networks. To cope with such integrated scenario, BATS provides a unified network management framework. The partners in the BATS consortium are detailed in Table 1-1.

Table 1-1: The BATS Consortium

Type of partner	Partner	Country
Enabling Research	DLR	Germany
	University of Surrey	United Kingdom
	Mavigex	Italy
	Gradiant	Spain
	Fraunhofer	Germany
	Mulsys	United Kingdom
	Climate Associates	United Kingdom

Type of partner	Partner	Country
Network Infrastructure	Airbus Defence and Space	France
	Thales Alenia Space France	France
	Thales Alenia Space Spain	Spain
	Optare Solutions	Spain
Network Operation & Service Provisioning	Avanti	United Kingdom
	R Cable y Telecomunicaciones de Galicia	Spain
	Turk Telekom	Turkey
User Equipment	STM	Norway
	OneAccess Networks	France

1.2 Stakeholders interest in BATS

Various stakeholders may be interested in the BATS satellite/terrestrial network integration concept. The stakeholder analysis carried out in WP5 identified the stakeholders and their interests for three different implementation scenarios:

- The first focuses on a major satellite service provider offering the BATS service, and also considers a similar offering by a major national incumbent telco which may also be able to offer satellite services;
- The second candidate scenario focuses on a regional MVNO providing BATS service. The considerations are fundamentally similar for other ISPs such as those lead by brands which buy wholesale access resources from the different network operators;
- The third candidate scenario considers where the customer buys service from independent providers.

The key difference between the scenarios is which types of organisations own the networking infrastructure supporting the BATS service (satellite network, terrestrial networks, BATS Intelligent User and Network Gateways - IUG and ING) and which sort of agreements between the stakeholders in the value chain are needed to be able to offer a BATS service.

The stakeholders have been classified in the following categories: network operators, technology manufacturers, end-users and external stakeholders. Out of these, the different scenarios primarily differ in the role and interest of the network operators involved in the BATS offer. Figure 1-1 illustrates the conclusions on the assessment of stakeholder sensitivities for the first operational scenario. The full analysis is detailed in deliverable D5.1 [1].

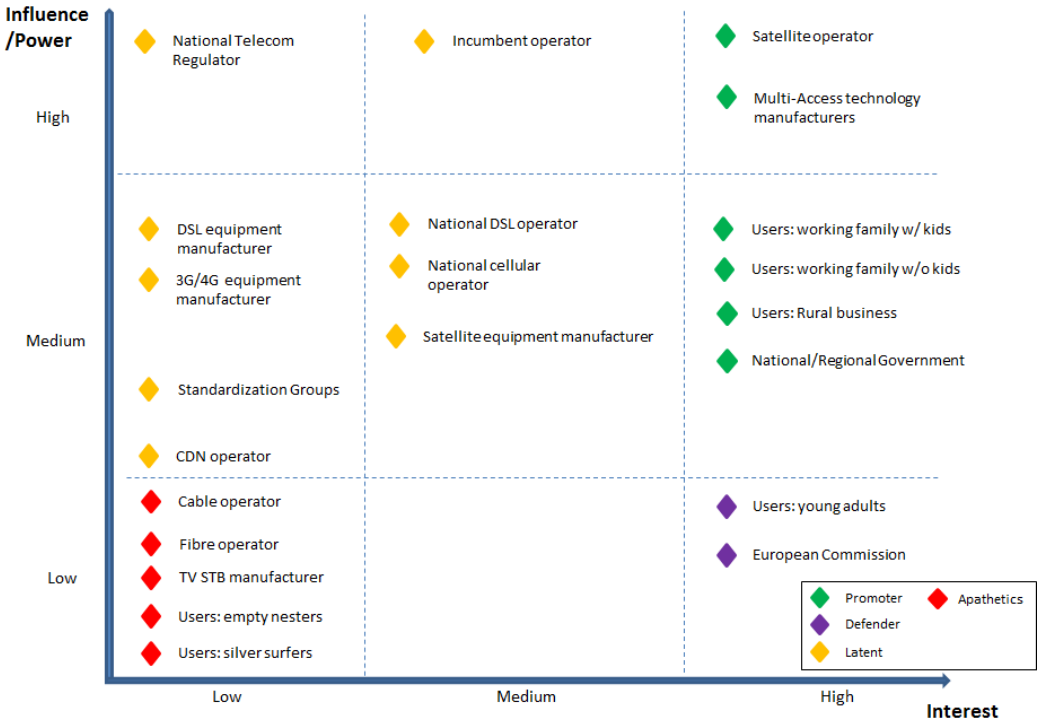

Figure 1-1: Stakeholder Sensitivity Analysis (Satcom/Incumbent led BATS)

1.3 BATS Business Case

1.3.1 Technical and Non-Technical issues influencing the deployment of a BATS system

Whilst there is clear demand for a BATS like service each country in Europe has different requirements; each country has a different mix of internet service providers and expectations. Contrary to this the economics suggest that the demand should be aggregated. This is analysed in detail in both the D5.2 and D5.4 deliverables [2][3].

It is clear from the trials that an integrated service is of interest as long it is correctly defined, communicated, implemented and tested. A stable service is an absolute requirement. The data usage levels seen in the trials suggest that some reduction in the predicted data volumes for 2020 is likely and realistic.

There are many different messages for the many different potential stakeholders identified. The common themes are that BATS;

- Offers a stable next generation broadband access service solution for underserved regions;
- Has a viable phased business plan;
- Is competitive financially and environmentally with identified alternatives.

1.3.2 Recommendations for promoting BATS service take-up

A viable plan can be foreseen by phasing the approach to focus on the target high demand countries initially and by growing the service on standard satellites. This plan is dependant on working with partners in these countries and others that already have terrestrial infrastructure that falls short of the NGA targets in some of their regions. These partnerships should be developed well before new satellites are launched to develop the systems, technologies and relationships.

There are good reasons for maintaining focus on the use of High Throughput Satellites (HTS) in geosynchronous orbit to deliver services to households in the unserved and underserved regions of Europe as Low Earth Orbit (LEO) based solutions can't provide sufficient capacity and High Altitude Platforms (HAP) based solutions focus more on access to smartphones rather than households. BATS provides a good solution to use HTS capacity with a good terrestriallatency for latency critical applications.

There are a number of ways to make a profitable business case in Galicia despite the basic model showing a shortfall. These include the following:

- **Reduce satellite costs:** The field trial data suggests this is viable;
- **Eliminate the cellular link:** These costs are not regulated. The product works well enough with a single terrestrial path;
- **Lobby for DSL regulated cost reduction in BATS areas:** As these underserved areas are those where no realistic alternatives are available this may be something the regulators would look favourably at;
- **Obtain grants to offset the capital expenditure:** Along the lines of the Voucher+ scheme providing support both for the initial one-time costs and the ongoing service.

The Galician example is felt to be representative of many other regions.

To be ready for a full service in 2020 with new next generation HTS at least one in country operator in one of the key BATS demand countries and satellite operator need to work together to develop an initial service. It is likely that a simplified service will be implemented initially for the consumer along with a further developed IUG for business.

1.3.3 Budget for 2020

This is analysed in detail in both the D5.2 and D5.4 deliverables [2][3]. A staged and phased investment plan is proposed. In summary, the following graph (Figure 1-2) shows the scale of investment required for a satco to deliver the BATS phase 1(baseline) satellites, gateways, backbone and IxG development to provide the core BATS service. This core service would then be used by in country partners to boost the performance of their terrestrial broadband in under-served locations in their region.

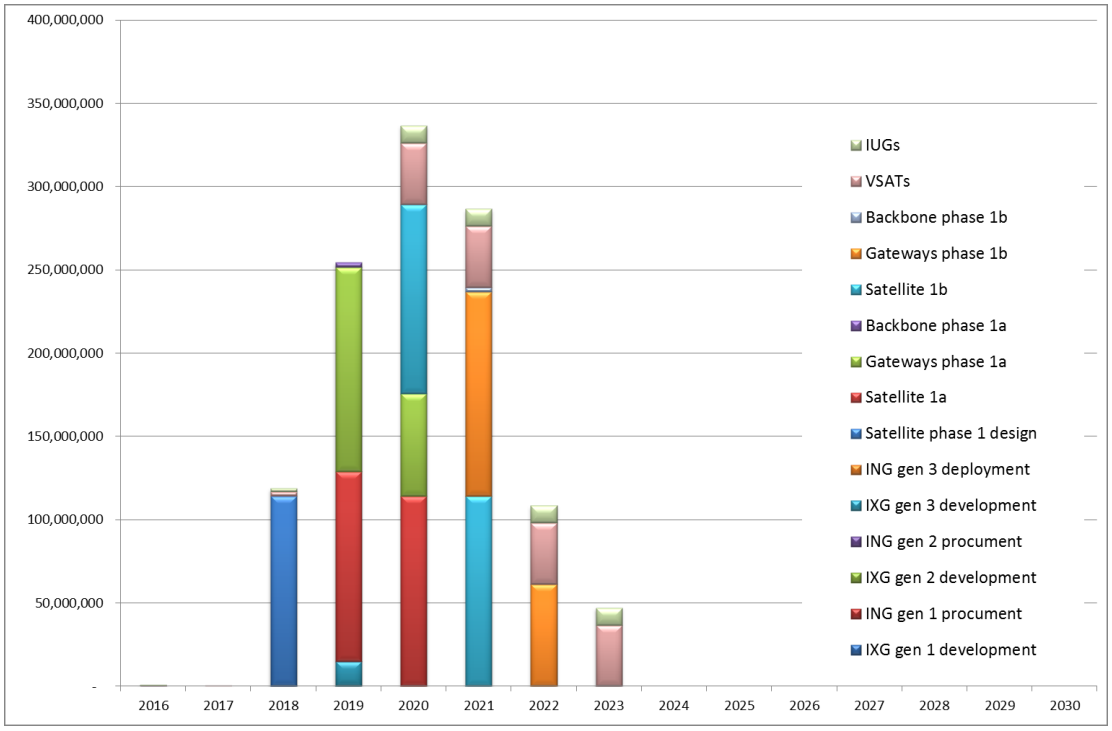

Figure 1-2 : Indicative capital investments (€).

1.3.4 Key messages

In deliverable D5.4 [3] key messages were identified for the following stakeholders:

- End users;
- Content delivery network owners;
- Incumbent and Challenger operators;
- Supply side organisations;
- Investment community.

In summary, the following key messages can be noted:

- There is demand for next generation access broadband at an affordable price;
- This service is required for both social inclusion and local wealth generation;
- BATS can deliver such a service in underserved regions at affordable prices whilst offering adequate margins for satellite and terrestrial partners;
- BATS requires a pan European commitment with local partners who offer terrestrial service;
- BATS benefits from both infrastructure investment support and local inclusion programmes;
- HTS satellites are needed to provide the density of data traffic calculated as LEO satellites cannot provide this.

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2 Overview of BATS Exploitation Plan

Within the BATS project there are several opportunities for exploitation throughout the consortium members. These opportunities can be addressed by the entire consortium, by groups or partners that are focussed on a particular theme or by project partners individually. The following sections provide an indication of the type of opportunities that exist and that are being considered within the exploitation of the BATS project outcomes.

2.1 Product Exploitation

2.1.1 Intelligent User and Network Gateways (IxGs)

In the frame of the project, partners in WP3 have been working on the design of the overall architecture and specification of the functionality of the different building modules for the Intelligent User and Network Gateways able to intelligently route the different traffic flows to the most appropriate access network taking into consideration the traffic characteristics and the status of each link in real time. Partners such as OAF and FH-FK plan to take those concepts further and incorporate some of the findings of the BATS research into their commercial platforms.

Terrestrial operator, R, also plans to work with their router manufacturers to incorporate some BATS concepts in their future products. Avanti will look to work with R and other operators possibly along with OAF to develop the satellite service needed to support a hybrid satellite terrestrial service which will require at least some IxG functionality.

2.1.2 Next Generation of High Throughput Satellites (HTS)

In WP4, the team is designing two satellite systems based on different feeder link configurations, one in Q/V-band and another in optical frequencies. These tasks are being led by TAS-F and AST respectively, which are European leaders in satellite systems manufacturing. Both companies have manifested their plans to consider the lessons learnt in BATS for future satellite payloads and to consolidate their technology development roadmap for the future HTS.

In addition, other institutions have been doing research in different techniques and technologies aimed to optimise future HTS. The involved BATS partners have communicated their work to the satellite community via publications and presentations in conferences and this has allowed them to increase their reputation across the industry and create synergies for future research activities and collaborations.

The work being done in WP4 is being reviewed by the space procurement team at AVA in order to assess what novel techniques and technologies should be included in the future HYLAS satellites.

2.1.3 Next Generation of satellite terminals

STM (now ESTN), satellite equipment manufacturer, has developed different optimisation techniques for the SatCom access (i.e., remote OBO supervision, slicing and segmenting with GSE, QoS control) which will be considered for their future platforms.

2.1.4 OSS Integration

In the frame of WP3, OPT has been leading the work on the definition of a northbound interface for the satellite network management systems that would allow their integration with the terrestrial network management systems. This will allow terrestrial operators to see satellite as not being different from the other subnets in terms of management and control and facilitate the integration. The functionality of this interface will be demonstrated in a proof of concept during the last year of the project. OPT has the intention to continue with this specification and bring it to market after the finalization of the project.

This is of great interest also for Avanti, as it will allow them to work with more and larger VNOs thanks of having to an industry standard driven interface rather than offering a partially Avanti driven interface to third parties.

2.1.5 Future role of project partners

Some examples of partners working together have been mentioned in sections 2.1.1 to 2.1.4. In addition a number of the partners are working with each other in current and planned research and innovation projects.

2.2 Service Exploitation

In terms of services, AVA strongly believes in the concept being developed in BATS on the integrated broadband delivery using satellite for bandwidth intensive applications and terrestrial connections for latency sensitive traffic. Subject to the feedback from the pilot activities, it is AVA's intention to take this concept forward once the project is completed and work with the different stakeholders in order to develop a commercial service. The field trials in Spain are a great test to such service, which AVA and R may decide to develop further and take it into commercial agreements between the two operators.

2.2.1 Future role of project partners

This section will be completed in the final version of the document by the end of the project.

2.3 Standards

A key objective of the project at the outset identified the need to develop a set of technical reports in ETSI to publish the architectures for hybrid satellite and terrestrial access system. However, the project also reviewed the need for other standards and additional objectives were defined for activity with the IETF and ITU-T SG5. The current status of the different activities follows:

2.3.1 European Telecommunications Standards institute (ETSI)

2.3.1.1 Work item DTR/SES-00347 Hybrid FSS satellite/terrestrial network architecture for high speed broadband access (TAS-F rapporteur):

Scope

Propose and analyse hybrid satellite/terrestrial network architecture for fixed high speed broadband access. Will also identify existing standards that have to be created or changed to enable these kinds of architectures

Status

Document was reviewed during SCN#9 (2-4th June 2014). It was sent to edithelp for cleaning

Next steps

Before final submission, the team needs to incorporate WP3 final network architecture.

2.3.1.2 Work item DTR/SES-00344 “Energy Efficiency of Satellite Broadband Network” (CAL rapporteur)

Scope

This technical report addresses the energy efficiency of satellite broadband networks and includes energy consumption during the Use stage only. It specifies how to assess the energy consumption of a satellite network and its subsystems during the operational lifetime of a satellite network, and identifies additions to the general assessment methodology developed in TS 103 199. It also reviews the energy efficiency related metrics developed for terrestrial wireless and mobile networks in TR 103 117 and identifies any necessary adaptations to enable the methodologies to be applied to satellite networks.

Status

ETSI Technical report TR 103 352 has reached a stable draft status and is ready for approval by WG-SCN in January 2016 and by TC-SES later in 2016.

DTR/SES-00344 was created in December 2012 by CAL on behalf of BATS. CAL based the work item on a contribution from Thales prepared prior to BATS and built on this with the Energy Efficiency analysis carried out in BATS SWP5.3 to successively update the document.

Next Steps:

It should be published in early 2016.

2.3.1.3 .Work item DTR/SES-00375 “Environmental impact of Satellite broadband network; Full LCA (Life Cycle Assessment)”: (CAL rapporteur)

Scope

This technical report specifies how to carry out a full Life Cycle Assessment (LCA) of a satellite broadband network including the raw material acquisition, production, use and end-of-life stages. This version only covers energy consumption and GHG emissions and does not address other environmental impacts such as water quality or ozone depletion. It also does not cover other scarce resources such as spectrum utilisation or satellite orbital positions.

Status

ETSI Technical report TR 103 353 has reached a stable draft status and is ready for approval by WG-SCN in January 2016 and by TC-SES later in 2016.

DTR/SES-00375 was created in 2014 when the original DTR/SES-00344 was split into two parts, one to cover energy efficiency issues and the other to cover emissions over the full life cycle. CAL used the analysis of the energy consumption of the BATS hybrid broadband satellite system carried out in BATS SWP5.3 to prepare successive contributions to this document.

Next Steps

It should be published 2016.

2.3.2 IETF standardisation activities

An Internet Draft is being published at IETF on the Initial Spreading technique developed in SWP3.2 by TAS-F. Tests with Google and Avanti are being considered.

2.3.3 ITU-T SG5 Environment and Climate Change

CAL, on behalf of BATS, is responsible for 3 work items which should lead to Supplements to ITU-T SG5 Recommendations which extend these to cover satellite networks:

2.3.3.1 Q18/5 “L.1410 Supplement - Case Study: the assessment of greenhouse gas emission of a hybrid satellite broadband system over its life cycle"

Scope

This supplement describes the greenhouse gas emissions modelling work and results from BATS SWP5.3 in 2014/15.

Status

The draft Supplement to Recommendation L.1410 has been completed by CAL and was reviewed by Q18/5 in October 2015. However, a revised version of Recommendation L.1410 has been approved by ITU-T SG5 since the BATS SWP5.3 GHG modelling work was completed. Therefore, CAL has agreed to align the draft Supplement with the revised version of Recommendation L.1410.

Next Steps

CAL will revise the Supplement to comply as far as possible with the revised version of Recommendation L.1410. Final approval is expected at the next meeting of ITU-T SG5 in 2016 (after the closure of the BATS project. Once approved, the Supplement will be available to download free of charge as an example of best practice for assessing the GHG emissions from a satellite network. As a result of the work, the methodology used for the BATS modelling work will have been verified and approved by world-class GHG emissions modelling specialists.

2.3.3.2 Q14/5 Supplement on Hybrid Satellite-based Communications Systems to Recommendation L.rfrc “Requirements and framework for low-cost sustainable telecommunications infrastructure for rural communications in developing countries”.

Scope

The text of the Supplement will show how the attributes of a hybrid satellite based systems are assessed against the requirements as set out in the draft Recommendation L.rfrc.

Status

At the meeting of Q14/5 in October 2015, the contribution drafted by CAL on behalf of BATS was reviewed with interest. However it was considered that this Supplement was too heavily biased towards future terabit/hybrid satellites without considering best practice for current satellite-based systems. Contributions on other satellite systems were requested (so far only CAL has provided information for this Supplement and this relates specifically to BATS).

Next Steps

A revised text covering other satellite-based systems will need to be provided before the Supplement can be approved by Q14/5. It is proposed to complete the drafting before BATS ends in December 2015 with final approval at the April 2016 meeting of SG5.. It is likely that there will still be gaps relating to the use of stand-alone satellite systems – information that needs to be provided by others as it is outside the scope of BATS. Alternative sources of funding are being sought in order that CAL can continue to work on this Question after the closure of the BATS project.

2.3.3.3 Q15/5 Supplement on satellite communications to Recommendation L.1502 "Adapting information and communication technology infrastructure to the effects of climate change".

Scope

This Supplement identifies the potential benefits of using satellite communications, and especially hybrid satellite & terrestrial communications if conventional communication systems are destroyed or damaged by natural disasters such as flooding which may result from climate change.

Status

Recommendation L.1502 was consented by SG5 in October 2015 and will be approved in 2016 following review. The current draft of the Supplement on satellite communications was reviewed by Q15/5 in October 2015 but further work is required before it can be consented.

Next Steps

A Supplement on best practices, such as hybrid satellite / terrestrial communications will be covered in this Supplement as identified in TD 1258 Rev.1. A further contribution by CAL on behalf of BATS this be presented at the next Q15/5 meeting on 17 December 2015.

2.3.4 Future role of project partners

CAL intends to continue to be involved in standardisation work in ETSI and ITU. There is an opportunity to extend the work on sustainability, subject to the availability of funding. CAL has secured funding in H2020 to continue to work in ETSI where our focus will move towards smart cities and the internet of things, where sustainability will be an important consideration. However, CAL has not yet secured funding for ITU-T work, and we continue to bid for funding to work in this area.

OneAccess continues its effort at the Broadband Forum and IETF to make MP-TCP a standard for WAN Hybrid Access. OneAccess continues its research effort by participating to the European project VITAL to virtualize terrestrial and satellite services. Finally, OneAccess is developing an SDN/VNF product solution.

2.4 Regulatory

By the time of writing this report, the team in SWP8.3 is working on the development of a regulatory roadmap for the exploitation of the space component of the BATS system. A questionnaire has been sent to the regulatory bodies of 34 countries in Europe and Turkey on the use of the shared Ka-bands. 25 administrations have answered the questionnaire, 22 of which are EU members. The answers to the questionnaire are being reviewed and recommendations on the exploitation of the shared bands will be published by the end of the activity on M36.

2.5 Scorecard

This section summarises some key outputs of BATs in a series of three tables. The first table lists the patents directly resulting at least in part from the work undertaken in the BATS project.

Table 2-1: Patents arising from the BATS project

Patent number	Description	BATS Partner(s)	Status
PCT/EP2015/066489	Method for receiving a digital signal in a digital communication system	DLR	Under review
INPI 1454645	Procèdé de distribution pour une liaison à liens multiples et hétérogenes	OneAccess	May 2014

The next table is a list of facilities created by the project that may be used in future.

Table 2-2: Facilities created by the BATS project

Description	BATS Partner(s)	Status
An Excel-based Greenhouse Gas Lifecycle Assessment Model has been developed for broadband access technologies. This is accompanied inventories which identify the values used in the model and the sources or derivation of these values. The model was developed entirely by CAL, so we are able to adapt this model to other purposes	CAL	validated by review by international experts in ITU-T SG5
An implementation of a MTOSI interfaces and the integration with the Avanti OSS (REST) interface that may be used in future co-operations.	OPT	Tested against Avanti OSS sandbox
A BATS evaluation system for Communications Service Providers to test and measure different use cases, including modifying the links' bandwidth and latency and using diverse applications. The system includes also a set of specifically developed test/measurement tools	OAF	Developed, deployed and actively promoted towards Communication Service Providers
A flexible test bed consisting of a satellite emulated link using OPENSANDS plus DSL and LTE emulated links using NETEM. Control software provides setting of conditions on all three links.	UOS	Test bed operational and validated by extensive measurements in BATS.

The following table identifies the project names, funding body and BATS team involved in work arising directly from the experience and knowledge gained in BATS.

Table 2-3: Projects building from BATS work

Project Name	Description	BATS Partner(s)	Funding body
RIFE [4]	RIFE addresses the major societal challenge of providing affordable Internet access to those who cannot afford it by solving the technological challenge to increase the efficiency of the underlying transport networks and the involved architectures and protocols.	AVA, TAS	H2020
SANSA [5]	Seamless inclusion of the satellite component in the terrestrial wireless network. TASE-E will develop a hybrid network manager that will be able to plan the best configuration topology, using efficiently the network resources in order to make the most suitable load distribution amongst the terrestrial mesh and satellite.	AVA, TAS	H2020
SONATA [6]	Virtualisation and software networks are a major disruptive technology for communications networks, enabling services to be deployed as software functions running directly in the network on commodity hardware.	OPT	H2020
VITAL [7]	VIrtualized hybrid satellite-TerrestriAl systems for resilient and fLexible future networks) is addressing the combination of Terrestrial and Satellite networks by bringing Network Functions Virtualization (NFV) into the satellite domain and by enabling Software-Defined-Networking (SDN)-based, federated resources management in hybrid SatCom-terrestrial networks.	OAF	H2020

Project Name	Description	BATS Partner(s)	Funding body
VICINITY [8]	Developing standards for information exchange between IoT ecosystems. CAL will apply learning on design for sustainability. Website nya. Project starts 2016.	CAL	H2020
FANTASTIC 5G [9]	FANTASTIC-5G will develop a new multi-service Air Interface (AI) for below 6 GHz through a modular design.	FH	H2020
5G ENSURE [10]	Aims to be the 5G-PPP security European reference project. TAS-E contributes in the scenarios definition, risk management and enablers for AAA and security monitoring.	TAS-E	H2020
ETSACO	Analysis of the impacts of implementing emerging terrestrial standards in satellite components TAS-E uses heritage from BATS in the development of Satcom Integration with Terrestrial 3GPP/5G Networks scenario.	TAS-E	ESA ARTES1

2.6 SWOT analysis of BATS project

2.6.1 Satellite component

The following table summarises a SWOT analysis for the satellite designs within the BATS project

Table 2-4: SWOT analysis for the satellite design

Strengths	**Weaknesses**
• Achievable • Beyond state of the art • Design optimised with ground segment • Q/V and optical variants	• Original requirements for all beams having same / similar capacity found not be optimal • May need further optimisation to include all aspects of DVB S2X
Opportunities	**Threats**
• BATS like service • Other HTS applications	• LEO constellations (real threat or funding threat)

2.6.2 IxGs

The following table summarises a SWOT analysis for the IxG designs within the BATS project.

Table 2-5: SWOT analysis for the IxG design

Strengths	**Weaknesses**
• Efficient solution • Standard-based solution (NNF and IETF) • Innovations bringing specific values to hybrid solutions: user experience AND bandwidth improvements	• Lack of standard tools to measure the user experience improvements • MP-TCP Hardware implementation • Processing power required to be reduced
Opportunities	**Threats**
• Communication Service Providers looking at increasing bandwidth based on existing infrastructure: any combination of xDSL, 4G, satellite such as a BATS like service • Offload market: fill a link until congestion, then use Psbol to intelligently distribute traffic • Hybrid MPLS market • 5G hybrid access to be explored	• Violent market shift towards SDN/VNF that shakes the industry and the business models requiring major redesign of IxG concept

2.6.3 Summary of SWOT findings

Both the satellite and IxG designs are seen to be a good step in the right direction to enable a BATS like service. The experience gained in the BATS project will allow the next iteration of the design to build on the strengths and address the weaknesses to create solutions optimised for the delivery of hybrid satellite and terrestrial broadband access services.

3 Exploitable Knowledge and Plans

3.1 Avanti (AVA)

3.1.1 Mission and Vision

Avanti Communications sells satellite data communications services to telecoms companies which use them to supply enterprise, institutional and consumer users. Avanti's first satellite, called HYLAS 1, launched in November 2010 and was the first superfast Ka-band satellite launched in Europe. Avanti's second satellite, called HYLAS 2, was launched in August 2012 and extends Avanti's coverage to Africa, the Caucasus and the Middle East. HYLAS 3 will also serve Africa in 2015 and Hylas 4 is being procured to cover the rest of Africa. Hylas 5 is being considered.

Avanti sells its services through distribution partners in the countries served by its fleet of satellites. Avanti is focused on enabling Service Providers to deliver their customers a reliable and efficient service, wherever they are. Looking at the future, Avanti strongly believes that satellite communications will play a key role in the fulfilment of the European Digital Agenda targets in the most difficult to serve locations. Complementing terrestrial broadband with satellite communications will enable the deployment of new integrated services that will improve the end-user Quality of Experience in areas where terrestrial connectivity falls to provide the Next Generation Access (NGA) experience.

3.1.2 Exploitable knowledge

The exploitable knowledge developed by AVA in the framework of the BATS project is summarized in Table 3-1.

Table 3-1: Exploitable knowledge for partner AVA

#	Exploitable knowledge and products	Sector(s) of Application	Timetable	Patents or other IPR protection
1	BATS overall network architecture	Broadband services in underserved areas Integration of satellite in to 5g	2017-2020	Publications
2	High Throughput Satellite System design with Q/V-band feeders and involved technologies/techniques	Satellite Broadband Systems New possibilities for satellite and ground segment	2020	Publications
3	High Throughput Satellite System design with Optical feeders and involved technologies/techniques	Satellite Broadband Systems Further studies to optimise designs	2020 or beyond	Publications
4	Modelling of addressable market and service take-up for satellite broadband and BATS by 2020	Business Development	2014	None
5	Lessons learnt from BATS field trials	Broadband services in underserved areas Future field trial processes	2015	None

#	Exploitable knowledge and products	Sector(s) of Application	Timetable	Patents or other IPR protection
6	OSS integration using MTOSI standard	Operation Support Systems roadmap	2015	None
7	Cost benefits, business plan messages and investment options	Future investments Early service launch	>=2016	None
8	Standardisation activities and regulatory report	Satellite Broadband Systems New spacecraft and ground segment specs	>=2016	None

3.1.3 Opportunities for Exploitation

The following are opportunities that have been identified from the exploitable knowledge acquired in the BATS project.

Integrated Satellite and Terrestrial Broadband Service

The integrated and hybrid broadband service analysed in BATS has the potential to increase Avanti's market share by including users in underserved regions that can benefit from complementing their existing terrestrial broadband with a satellite connection. Avanti will develop during the course of the project the business case for the BATS service and evaluate its commercial feasibility. In addition, the field trials will help Avanti to understand the potential benefits that an integrated satellite and terrestrial broadband service can bring to the end-users in terms of improved Quality of Experience. After the project, and in case of a successful outcome of the business plan and field trials, Avanti will work with the different stakeholders of the BATS concept in order to develop and deploy a go-to-market solution for the near/mid future, transforming BATS from a R&D concept to a real service and business opportunity. As a first approach, Avanti would like the BATS partner R to become an official distributor of Avanti's satellite broadband services and work on a plan to provide an integrated terrestrial and satellite service. Initial discussions on this topic have been held.

The knowledge gained in the role of intelligent routing in heterogeneous networks will aid in future projects such as looking at the role of satcoms in 5G networks.

The experience of providing a hybrid service will benefit in future deployments in Spain and beyond.

Next Generation Satellite Broadband System architectures

The knowledge acquired from the HTS systems design carried out in the frame of WP4 together with the advanced techniques developed during the project on interference and radio resource management will allow feed into Avanti's satellite procurement team allowing it to design its future constellation with highly innovative architectures and techniques contributing to strengthen Avanti's position as a leading satellite broadband operator. Avanti satellite procurement team are reviewing the outcomes of WP4 to identify the most promising architectures and techniques developed in the frame of the research activities in the project and to include them in Avanti's roadmap.

OSS Integration

The OSS is fundamental to successful and scalable service delivery. Avanti's service model is to create and sell different VNO models. As the scale grows the interface between Avanti's OSS and the VNOs' needs to be API based. To allow Avanti to readily work with more VNOs and larger VNOs there may be benefits in moving to an industry standard driven interface rather than a partially Avanti driven interface.

In SWP3.5 the MTOSI interface was identified and Avanti will investigate the benefits for implementing this. Avanti operations team has been informed about the benefits of adopting such standardised interfaces and discussion will be held in order to assess whether include such activity into Avanti's future implementation plans.

Avanti is considering adding an MTOSI interface to its OSS to aid future deployments.

Relationships

In addition, the experience as Project Coordinator in BATS and the relationships established with the different partners of the projects, will allow Avanti to cooperate in future research and innovation projects and lead on occasions; bringing its experience on delivering innovative satellite services in areas such as the 5G PPP. Further contacts have been made whilst disseminating the project findings. These new relationships in turn will lead to a deeper understanding of new areas allowing Avanti to grow its service portfolio and customer base. As a particular case, Avanti expects to be able to develop further the BATS integrated service concept with the terrestrial operators involved in the project, R and TT, which operate in areas under the Hylas constellation coverage.

Avanti will look to work with many of the BATS partners in future projects such as those funded under the EC's H2020 program and other funding schemes as well as more commercial opportunities.

3.1.4 Progress and Outcomes

Most of the exploitation opportunities for Avanti lie in the future.

The relationships developed in BATS have already led to a number of successful applications for Research and Innovation projects. For example, Avanti will be contributing together with TAS-S in the H2020 ICT project SANSA, and with TAS-F in the H2020 ICT project RIFE.

Avanti will look to launch a precursor BATS like service and if possible develop an early launch proposition, perhaps:

- Enterprise using an upgraded IxG to develop this concept;
- Consumer using basic routing to develop demand and basic service.

This will create a BATS like service in at least one of the major market, with the aim to ensure stability through service and product definition followed by extensive testing to ensure the end users have a stable and affordable service.

3.2 DLR

3.2.1 Mission and Vision

Satellite communication plays a key role in content distribution, primarily television. Satellites are also receiving increasing attention in ensuring broadband internet access as specified in the EU's digital agenda. Beyond the mass market, satellite communication is crucial in areas where infrastructure is hard to deploy: in the air, at sea, in disaster areas or in military operations. Finally, the associated technologies are essential for communication with earth-observing satellites and deep space probes.

In this context, the Institute of Communications and Navigation at DLR has defined technical missions relevant to industry and society to which it wishes to contribute. They are:

- High-rate data transfer from deep-space missions, earth-bound satellites and aeronautical platforms to the ground
- Radio access outside terrestrial network coverage: on the ground, in the air, at sea, and after disasters

The BATS project addressed the above missions as it developed a geostationary satellite communications system for broadband access over the coverage of EU27 and Turkey. The contributions range from basic research to proof of concept in demonstrations. The latter ensure proper consideration of real world conditions, increase external visibility, and support the transfer to industry.

3.2.2 Exploitable Knowledge

The exploitable knowledge developed by DLR in the framework of the BATS project is summarized in Table 3-2.

Table 3-2: Exploitable knowledge for partner DLR

#	Exploitable knowledge and products	Sector(s) of Application	Timetable	Patents or other IPR protection
1	Analytical framework for link selection optimization	TV and broadband Internet access, services and applications	Initial study	Publications
2	Digital optical feeder link architecture and evaluation of performance	TV and broadband Internet access, services and applications	Proposed for inclusion in BATS mission 2025	Publications
3	Pre-distortion adaptive optics and transmitter design	TV and broadband Internet access, services and applications	Initial study	Publications
4	Network coding – bipartite index coding	TV and broadband Internet access, services and applications	Initial study	Publications
5	Reliable multicast through fountain coding	TV and broadband Internet access, services and applications	Initial study	Publications
6	Optimization of power and spectral efficiencies of OFDMA, SC-FDMA and TDMA and receiver design	TV and broadband Internet access, services and applications	Proposed for inclusion in BATS mission 2025	Patent
7	Intermodulation interference management through channel-adaptive output back-off setting	TV and broadband Internet access, services and applications	Proposed for inclusion in BATS mission 2020	Publications
8	Scheduling algorithms for full frequency reuse with interference cancellation	TV and broadband Internet access, services and applications	Proposed for inclusion in BATS mission 2025	Publications

#	Exploitable knowledge and products	Sector(s) of Application	Timetable	Patents or other IPR protection
9	Network Coding in DVB-S2/RCS2	TV and broadband Internet access, services and applications	Validation	-

WP3

The exploitable knowledge in WP3 is the possibility to carry out a preliminary evaluation of those scenarios in which the satellite can provide a significant contribution, together with the main terrestrial communications technologies, towards the satisfaction of the QoS constraints of different kinds of traffic in an economical and energy efficient way, and at the same time to give hints on how to tune some important system parameters.

WP4

In WP4, the following research areas have been identified and several contributions have been presented: optical feeder link design, techniques for high aggregate throughput, advanced waveforms and receiver design, interference management, radio resource management. These contributions address technical challenges and propose solutions for the design of the satellite communication system. The exploitable knowledge developed in WP4 addresses the satellite system design, in particular the feeder and user links architectures, air interface design and optimization, interference management, radio resource management and system performance evaluation. The activities carried out by DLR included the invention of novel solutions to the design challenges, as well as the evaluation, benchmarking and adaptation of existing techniques for application in the BATS system. The description of the exploitable knowledge for each of the explored research areas is presented hereafter.

A novel digital optical feeder link architecture has been developed which relies on packet level coding to protect the data transmission from the fades in the turbulent atmospheric optical channel. This solution enables the transmission of the entire traffic through a single feeder link, reducing the number of required gateways. Furthermore, it enables the application of interference management solutions for the user link to maximize the system throughput. The developed architecture has been extensively tested in link level simulations under modelled channel conditions. In addition, current pre-distortion adaptive optics techniques have been evaluated for application at the uplink transmitter, and their performance benefits have been studied.

In order to increase the aggregate throughput and reliability of the user link, two solutions have been developed and studied: network coding in the form of bipartite index coding for unicast sessions and reliable multicast through fountain coding. Both techniques show very promising results and potential. Next studies include the evaluation of these techniques over practical satellite channels.

The air interface of the user link is a challenging and hot topic. In BATS, DLR evaluated the suitability of LTE-based waveforms for application over the non-linear satellite channel. For this purpose, the power and spectral efficiencies of OFDMA and SC-FDMA have been optimized and compared with state-of-the-art TDMA. In addition, a novel interference cancelling receiver has been developed and patented. The results show a significant room for improvement of the state-of-the-art air interface. Demonstration of the selected SC-FDMA waveform is considered within the framework of BATS.

In addition, to manage the intermodulation interference in the multi-carrier return link signal at the satellite, a channel-adaptive output back-off setting has been evaluated for application in

the BATS system. The concept shows potential to optimize the end-to-end link budget, increasing the system throughput and availability.

Finally, scheduling algorithms for full frequency reuse with interference cancellation have been evaluated for application in the BATS system. The results show that the radio resource management can almost double the system throughput by enabling the use of full frequency reuse while mitigating the resulting interference.

WP6

The work done in WP6 is focussed on implementation and proof-of-concept. DLR has extended its DVB-S2/RCS2 testbed with network coding in the forward link for terminal-to-terminal communication and validated the technique in a validation campaign. The results show that almost half of the transmission resources can be saved. The newly developed network coding protocol can contribute to new standards.

3.2.3 Opportunities for Exploitation

WP3

The focus of DLR in WP3 has been the theoretical modelling and analytical study and optimization of the link selection algorithm at the IUG and ING, which constitutes a fundamental element in the integration between satellite and terrestrial networks. The research carried out contributed to increase the knowledge and expertise related to advanced queueing system mechanisms and link selection. Such elements are being exploited, and are planned to be further developed, in order for DLR to increase its visibility within the international research community and to strengthen its academic knowledge and reputation in order to contribute actively towards the integration of satellite and terrestrial networks in Europe. To this aim, of great help is the contact with other academic partners within BATS that are very active in the sector of satellite communications, such as the University of Surrey, as well as the discussions related to the accuracy of the adopted model in describing real systems and scenarios gathered though discussions with industrial partners such as TAS and Avanti. The study performed has a TRL of 2. The results produced using the derived framework constitute a valuable indicator of the fact that the satellite technology can indeed play a major role in the communication arena in conjunction with the main terrestrial technologies. The analytical tools developed will be exploited to define scenarios in which the potential of the satellite platform can be fully exploited. They also allow making a preliminary tuning of relevant system parameters and estimate both the technical and the economic performance of the specific systems under study.

WP4

In WP4 of BATS, DLR focused on the development of solutions for the feeder and user links of the high throughput satellite communications system. Thanks to the research carried out to define the optical feeder link architecture and to study unicast and multicast techniques for high aggregate throughput, LTE-based waveforms for application over the non-linear satellite channel and receiver design, channel-adaptive output back-off setting for interference management and scheduling algorithms for full frequency reuse with interference cancellation, DLR's expertise and research portfolio have been enriched in the area of high throughput satellite communications, consolidating DLR's strategic position as the major technology center for Satellite Communications in Germany. Through the gained contacts to the leading manufacturers of satellite systems and networking solutions in Europe such as Airbus DS, TAS, STM and OAF, major research institutions such as UoS, MAV, FhG-HHI and GRA, and network operators such as AVA, Turk Telecom and R, the visibility of DLR in this strategic area of high throughput satellite communications has significantly improved.

The research carried out in BATS has offered great insight in the potential of disruptive solutions to significantly increase the capacity of satellite systems. The studies show conclusive results from the simulation test campaigns, and future research activities will focus on the implementation aspects on prototype platforms. In particular, the developed

digital modulation and coding scheme for the optical feeder link will be integrated in a free space optical communication test bed and potentially also tested over an existing satellite link. In addition, the promising results from the interference management and radio resource management studies promote the study and incorporation of further advanced techniques and algorithms from terrestrial communications into satellite systems.

The gained expertise contributed to new scientific publications. In addition, contributions to standardisation are envisioned. DLR has been an active member of the DVB standardisation group, and as such DLR aims at producing technical reports and possible technical specifications that describe the technical solutions developed within the BATS project.

DLR also plans to exploit the results by licensing of knowledge and of early proof-of-concept implementations to manufacturers for prototyping and certification purposes. Furthermore, due to compatibility with state-of-the-art TDMA-based receivers, DLR is investigating opportunities to position the developed interference cancelling receiver in the market by contacting manufacturers for implementation in gateways and user terminals.

The close cooperation within the consortium has enabled the future collaboration for the implementation of key solutions for the system architecture, such as the optical feeder link and the channel adaptive output back-off setting together with Airbus DS and TAS-F, and return link scheduling algorithms for full frequency reuse with interference cancellation together with STM. In addition, demonstration activities on the benefits of SC-FDMA for the satellite return link have already been initiated with MAV and UoS. The close collaboration with MAV, GRA, UoS, FhG-HHI and TAS-S has created opportunities for joint acquisition of projects on interference and radio resource management in satellite systems within the ESA ARTES Programme or the Calls of the Horizon 2020 framework of the European Commission.

WP6

The main focus of DLR in WP6 is the proof-of-concept implementation of network coding in the DVB-S2/RCS2 satellite standard. The gained expertise enables DLR to provide inputs to further DVB standards and to create technical specifications that specify the requirements and methods of the implemented protocol.

3.2.4 Progress and Outcomes

WP3

The progress in the exploitation of the work carried out within WP3 by DLR is to be found both in the know-how that was built during the work package development and in the preparation of publications aiming at both increasing DLR visibility in the academic/industrial scenario and contributing to a topic that is gathering more and more attention in the international research community such as the study of Network Coding/packet-level codes in MP-TCP systems as well as the joint-optimisation of network selection and network coding schemes, as instrumental to meet the QoS levels demanded by users.

In this respect, a conference paper has been presented in the IEEE International Conference on Communications (ICC'15) and a journal is under preparation. Such publications contain the main results that have been developed within WP3 such as a new queuing model and priority mechanism analysis for QoS provisioning and a theoretical framework for link selection optimization. Additional theoretical investigations are being carried out for possible inclusion in the planned journal paper.

Furthermore, the simulation results obtained so far using the developed analytical framework helped to define scenarios in which the satellite may play a main role in the integration with other terrestrial technologies. This will be used to steer future research directions.

WP4

The exploitation of the knowledge developed in the WP4 of the BATS project aims to increase of the visibility of DLR in the area of high throughput satellite communications. For this purpose, in total 13 publications have been presented at relevant conferences such as ICSOS 2015, Ka Conference 2015, WiSATS 2015, EuCNC 2015, Ka Conference 2014, ASMS 2014 and EuCNC 2014. These include several publications on the optical feeder link architecture, the air interface waveforms, interference and radio resource management. Furthermore, 2 journal publications have been accepted in the highly renown IEEE Transactions on Communications and International Journal of Satellite Communications and Networking. The DLR work on a non-linear noise cancelling receiver has been protected by a patent.

In addition, DLR contributed to the setup of the SC-FDMA demonstrator for the satellite return link, developed together with MAV and UoS. The aim is to validate the achievable benefits of this waveform obtained in the simulation studies.

The promising results from the simulation campaigns have been introduced to the ETSI standardization body in the form of a technical report: ETSI TR 103 297 SC-FDMA based radio waveform technology for Ku/Ka band satellite service.

DLR is currently in the process of project acquisition for subsequent studies, in order to expand and verify the study results in further proof-of-concept demonstrations in practical system setups.

WP6

The enhanced DVB-S2/RCS2 testbed serves as a proof-of-concept implementation for network coding in a recent satellite standard. It will be used as a demonstration platform to show the benefits of network coding in a realistic setup.

The implemented protocol for network coding in DVB-S2/RCS2 will be specified as two Internet Drafts, one for the protocol in general and one for the integration into the DVB standard.

3.3 Airbus Defence & Space (AST)

3.3.1 Mission and Vision

Airbus Defence and Space is a division of Airbus Group formed by combining the business activities of Cassidian, Astrium and Airbus Military. The new division is Europe's number one defence and space enterprise, the second largest space business worldwide and among the top ten global defence enterprises.

Airbus Defence & Space perceives the Broadband application as the main market evolution of the coming years. To keep its leading position as a manufacturer of multibeam Broadband satellite systems, Airbus Defence & Space builds on its R&D activities carried out in the frame of studies from ESA, EC and national space agencies. The BATS project is contributing to this effort by enabling Airbus Defence & Space to consolidate its technology and product development roadmap and contribute to open up / enlarge the potential market for high throughput multibeam satellites.

3.3.2 Exploitable knowledge

The exploitable knowledge developed by AST in the framework of the BATS project is summarized in Table 3-3.

Table 3-3: Exploitable knowledge for partner AST

#	Exploitable knowledge and products	Sector(s) of Application	Timetable	Patents or other IPR protection
1	Advanced SAT Network architecture and dimensioning – Definition and design of next generation HTS architecture	R&D – Broadband	2016	None
2	Optical feeder approach - Optical ground segment design (optimization OGS localization + backbone design - done)	R&D – Broadband	2020	None
3	Optical Feeder approach –Optical / RF interface at satellite level – preliminary)	R&D – Broadband	2020	None
4	Optical Feeder approach – optical link design trade-off (digital / analog –on going)	R&D – Broadband	2020	None
5	Regulatory roadmap – Identification of regulations/standardization/recom. relevant on the BATS concept	R&D – Regulatory	2015	None
6	Regulatory roadmap – Risk assessment of the use of BATS shared satellite/terrestrial bands (on-going)	R&D – Regulatory	2015	None
7	Regulatory roadmap – Questionnaire at EC level on the use of shared satellite/terrestrial bands	R&D – Regulatory	2015	None

3.3.3 Opportunities for Exploitation

The following are opportunities that have been identified from the exploitable knowledge acquired in the BATS project.

Optical ground segment design (Optimization OGS localization + backbone design)

One important aspect of the innovative Optical feeder link approach is the ground segment dimensioning. As a result of BATS, the optimization of the Optical Ground Stations (OGS) localization and the backbone design to support and guarantee the diversity mechanisms to ensure the required feeder link availability, have been studied in detail. The use of meteorological models to optimally locate OGSs combined with the backbone design to minimize ground segment costs provide a powerful methodology that will be used for the future development of Optical feeder links design for our next generation HTS systems.

Optical Feeder approach – Optical / RF interface at satellite level – preliminary

In the frame of BATS we have assessed the optical to RF interface in the case of analogue optical modulation, selecting the intermediate frequency as a compromise between the optical spectrum occupancy and the size of the frequency converters. This will allow Airbus DS to further consider the analogue option and its integration in future optical feeder payloads avoiding the implementation of complex on board processors.

Optical link design trade-off (Digital / Analog optical modulations)

The trade-off proposed in the frame of BATS between digital and analogue optical modulation, taking into account the atmospheric turbulence impairments, the telecom performances, the mass and power budgets and the TRL levels allow to set a detailed comparison framework to perform a comprehensive assessment of both modulation schemes which can be applied in free space GEO feeder links. It is a step forward for Airbus DS in order to consolidate its technology development roadmap for the future optical based HTS feeder links.

Regulatory roadmap – Using Civil Ka Shared bands in user links of HTS systems

- Identification of regulations/standardization/recom. relevant on the BATS concept
- Risk assessment of the use of BATS shared satellite/terrestrial bands (on-going)
- Questionnaire at EC level on the use of shared satellite/terrestrial bands

The use of the civil Ka shared band, in addition to the exclusive Ka band allocated to FSS, enables a step-forward in terms of capacity increase for next generation HTS systems. However, coordination issues may arise, above all in satellite coverages where several countries are involved, as it is the case in BATS baseline scenarios. Indeed, each country has its own regulations and specificities concerning these shared satellite/terrestrial bands which can lead to potential road-blocks making difficult the BATS system deployment. As a result of BATS, a questionnaire at EU level on the use of the shared frequency bands has been submitted to the target administrations. The outcomes will allow a better understanding of the associated risks and will provide the necessary inputs for a feasibility analysis on the use of these bands for HTS systems covering European territory.

Finally, potential future collaborations have been identified with DLR and TAS-F in the frame of Optical systems as a result of the activities carried out in WP4 related task and its proven expertise in Free-space optical technology/design. In addition, partners such as MAV have also been identified for potential future R&D projects, combining Airbus DS expertise in satellite system architecture design with their extended experience in advanced signal processing that could be of interest for next generation HTS systems.

3.3.4 Progress and Outcomes

Regarding the optical feeder link design, the trade-off between Digital and Analogue optical modulation schemes has been concluded, leading to the definition of the most adapted air interface scheme to cope with BATS feeder link capacity and availability requirements. Concerning regulatory matters, the assessments of the questionnaires are on-going and the conclusions are expected by the end of BATS project.

3.4 Thales Alenia Space (TAS-F and TAS-S)

3.4.1 Mission and Vision

TAS-F a world leader in manufacturing satellite systems, is responsible in the project for the end to end definition of a very high throughput satellite network operating in Ka band and addressing a continent wide coverage. In particular TAS-F leads the design of a space diversity scheme to mitigate atmospheric attenuation in the Q/V band feeder link and has defined a novel network transport protocol adapted to multi-link access and supporting standard security schemes defined for the Internet.

TAS-S is the Spanish subsidiary of Thales Alenia Space, devoted to the development and supply of Space systems and equipment for civil and military programs with applications in telecommunications, navigation, Earth observation, science, exploration, space transportation and infrastructure.

TAS-S participates in BATS contributing to the integrated User Segment and Management aspects. TAS-S also contributes to the Radio Interface, Interference Management and Radio Resource Management for the next generation satellite systems.

TAS is convinced that the future of network infrastructures will integrate several network technologies forming a unified heterogeneous network at management and service level. This convergence will allow optimising the service delivery to users exploiting the best set of technologies considering cost, service availability, resilience and/or performance criteria.

TAS leverages research activities carried out in the BATS project and in CNES and ESA complementary projects to develop its end to end satellite broadband solution based on multi beam GEO stationary satellites targeting the promising high speed broadband access market.

The ability to support a flexible and a timely access to data will supersede the throughput which is currently the main performance metric of SatCom networks. This will allow breaking the current opinion of SatCom networks: costly, providing service with poor QoS and limited performance. By taking part in BATS, TAS also contributes to establish the business conditions for a sustainable satellite broadband market.

3.4.2 Exploitable Knowledge

The exploitable knowledge developed by TAS-F and TAS-S in the framework of the BATS project is summarized in Table 3-4.

Table 3-4: Exploitable knowledge for partner TAS

#	Exploitable knowledge and products	Sector(s) of Application	Timetable	Patents or other IPR protection
1	Advanced SAT Network architecture and dimensioning – Definition and design of next generation HTS architecture	R&D – Broadband	2016	None
2	Q/V band feeder approach - inter GW backbone design)	R&D – Broadband	2016	None
3	Smart Multi link routing to simultaneously exploit both satellite and terrestrial access links for a resilient and high Quality of experience broadband service delivery	R&D – Broadband	2016	None
4	Network Management systems enablers for harmonised service and performance management between satellite and terrestrial networks	R&D – Broadband	2016	None
5	Standardisation roadmap – Definition of the integration of satellite broadband access in the terrestrial networks. Definition of the network protocols	Standardisation	2016	None

3.4.3 Opportunities for Exploitation

TAS is taking part in the BATS project to work in the context of fixed broadband access on the following topics:

- Develop technical enablers for a smooth integration of Satcom network solution in the overall telecom network infrastructure;
- Upgrade the performance and flexibility of the SatCom network solutions to support the improved QoS requirements promised by future network solutions.

In particular, TAS:

- Leads the research on the definition/dimension of the appropriate inter-GW network architecture necessary to support space diversity and compensate for meteorological impairments on the feeder links operating in very high frequencies and/or optical (TAS-F);
- Contributes to the research on multi access link routing scheme (TAS-F);
- Contributes to the research on the enablers for a smooth integration of SatCom in the network management system, improve QoS/QoE performances and interfaces towards service providers (TAS-E);
- Leads research to improve the SatCom network performance with Q/V feeder links (TAS-F) integrating innovating techniques in the area of Radio Resource Management (TAS-E), Interference management (TAS-E) and Radio interfaces.

This will allow TAS to support satellite and Internet service providers and/or operators in the design of the optimum satellite systems for their integration in “terrestrial networks” to maximise the SatCom network usage and revenues.

Beyond the BATS project, collaboration with the partners will be three fold:

- Integration of products (including the enablers for the integration in the terrestrial network) developed by vendors such as OneAccess, STM, Optare, in the satellite solution;
- Deployment of the satellite solution for the service providers and operators such as R, Turk Telecom and Avanti Communications;
- Research on future upgrades of the satellite solutions with research centres and universities.

3.4.4 Progress and Outcomes

In parallel with the project, TAS is preparing its satellite broadband system offer for bids calling deployment at the Horizon 2020. This includes the space segment design, the inter GW network and the end-to-end satellite network solution based on in house Space Gate product evolution.

The Space Gate Solution constitutes the TAS solution for satellite access network system to be deployed in broadband telecommunication systems or telecommunication ground user segments.The Space Gate solution is constituted by the following components:

- The Space Gate Hub (SG-Hub acronym in this URD) and modems providing the infrastructure for building the satellite access network to be used by the service providers on one hand and by the end users on the other hand;
- The Space Gate NMS providing the facilities allowing to configure and supervise the satellite access network;
- The Space Gate security management providing all the functionalities necessary to manage the security features embedded in the satellite access network.

In addition, TAS is taking advantage of the BATS project to develop its network expertise to support satellite service providers in the integration of the solution in terrestrial network.

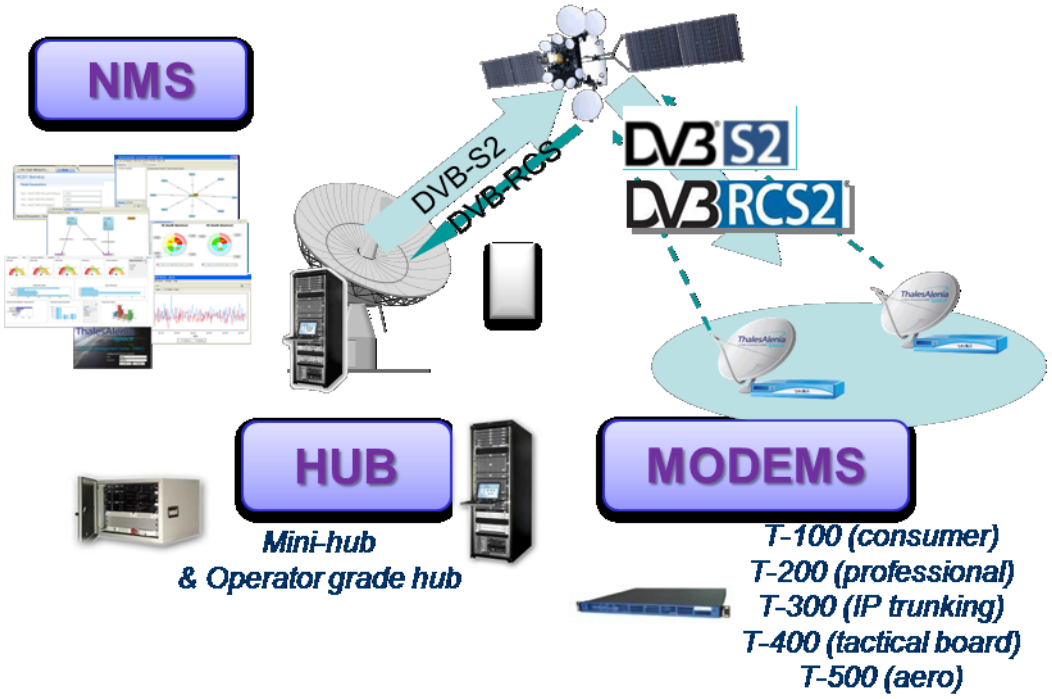

Figure 3-1: Space Gate Satellite IP Network solution from TAS.

3.5 Mavigex (MAV)

3.5.1 Mission and Vision

Mavigex (MAV) is an academic spin-off company of the University of Bologna focused on the sector of Information and Communication Technologies, with emphasis on satellite communications, mobile and wireless communications, and multimedia communications, including mobile services and applications development. Mavigex consists of two main areas: "ICT Solutions" and "Application and Services". In particular, the ICT Solutions Area of MAV, involved in BATS, works in the research and development of advanced broadband communication systems focusing mainly on PHY layer solutions including the design and the algorithm implementation on different HW/SW platforms, such as FPGA and CPU/GPU.

3.5.2 Exploitable knowledge

The exploitable knowledge developed by MAV during BATS activities comes from the achievements in WP4 and WP6. In particular, in WP4, MAV developed the know-how on the design and assessment of both evolutionary (DVB-S2/S2X based) and disruptive (SC-FDMA based) air interfaces, and interference management techniques for high-throughput satellite systems, such as precoding and interference cancellation. Moreover, in the framework of WP6, MAV implemented a test-bed including transmitter and receiver software modules integrated with a SDR front-end, acting as a proof of concept of the disruptive satellite radio interface design assessed in WP4.

Table 3-5: Exploitable knowledge for partner MAV

#	Exploitable knowledge and products	Sector(s) of Application	Timetable	Patents or other IPR protection
1	Design and assessment of precoding techniques for HTS systems	Broadcast, broadband	Proposed for inclusion in BATS 2020 and 2025 missions	Publications Know-how for future developments
2	Design and assessment of interference cancellation techniques for HTS systems	Broadband	Proposed for inclusion in BATS 2020 and 2025 missions	Publications Know-how for future developments
3	Design and assessment of predistortion and equalization techniques for HTS systems	Broadcast, broadband	Proposed for inclusion in BATS 2020 mission	Publications Know-how for future developments
4	SC-FDMA receiver architecture design and end-to-end performance evaluation	Broadband	Proposed for inclusion in BATS 2025 mission	Publications Know-how for future developments
5	SC-FDMA SDR test-bed development	Broadband	Proposed for inclusion in BATS 2025 mission	Developed SC-FDMA test-bed modules

3.5.3 Opportunities for Exploitation

In the frame of the BATS project, MAV collected a set of interesting exploitable opportunities to increase its business development activities. In particular, working with the main actors of the satellite market such as manufacturers of satellite payloads, systems, and terminals, and network operators, allowed MAV to significantly improve the company know-how and expertise in the design of satellite solutions. Such acquired expertise will be exploited to increase the competence on the implementation of real satellite systems. Moreover, the strong collaboration with the main European research institutes offers the possibility to enlarge the collaborations and the cooperation in future research projects.

Thanks to BATS, the visibility of MAV in the satellite broadband market has increased as well as the opportunities to be involved in new regional, national and international projects on these topics.

MAV is already working to exploit such gained contacts to create new opportunities of collaboration and partnership for future research and business activities after the end of the project.

The objective is to establish new business collaborations thanks to the increased competitiveness achieved through the activities performed in the BATS project.

3.5.4 Progress and Outcomes

So far, MAV has exploited the know-how gained in the framework of the project mainly by disseminating the achieved results on the disruptive radio interface design and the interference management techniques. To do this, MAV participated and presented BATS papers on these topics at EuCNC2014, ASMS2014, Ka-band2014, WiSATS2015, and EuCNC2015 conferences. This dissemination activity has led to an increased visibility for MAV in the European context and to the possibility to create new contacts for potential collaborations.

Finally, the development of the SC-FDMA test-bed allowed MAV to validate the research activity results on the feasibility of this concept for next generation HTS systems.

3.6 University of Surrey (UoS)

3.6.1 Mission and Vision

The University of Surrey is a research based organisation with a mission to extend knowledge and to exploit the knowledge in conjunction with industrial partners.

The University of Surrey has a long involvement in EU projects in the satellite communications area. The Institute of Communications systems has 150 full time academics and researchers in the area of satellite and mobile communications and is the home of the £37m 5G Innovation Centre involving 10 industrial companies. Surrey's involvement in BATS covers the future satellite design and in particular interference mitigation improvements and gateway diversity studies. It is also hosting the lab trials of the intelligent user gateway (IUG) involving subjective testing of the improved quality of experience offered by the integrated delivery system.

3.6.2 Exploitable Knowledge

The exploitable knowledge developed by UoS in the framework of the BATS project is summarized in Table 3-6.

Table 3-6: Exploitable knowledge for partner UoS

#	Exploitable knowledge and products	Sector(s) of Application	Timetable	Patents or other IPR protection
1	Multibeam satellite return link interference scheduling	Satellite system design	Algorithms are available for given system parameters	Published but know how retained.
2	Time division switched gateway links for HTS	Satellite system design	System evaluated and implementation ideas proposed	Published but know how retained
3	Flexible satellite terrestrial test bed for BB access	BB systems test beds	Test bed available	Knowhow and equipment available

3.6.3 Opportunities for Exploitation

The interference mitigation technique on the satellite return link design in the frame of WP4 can be exploited by various satellite operators who operate multi beam satellite systems in order to increase their throughput and hence revenue. We are already investigating this to the Inmarsat I4 satellite system. The technique merely involves the inclusion of software at the gateway and so can be applied to existing or new satellite systems.

The time switched gateway for High Throughput Satellite (HTS) systems, which has also been developed in the scope of WP4, would be applied to future satellite systems and hence we see this as entry for us into other research or development projects.

The flexible laboratory test-bed with both terrestrial and satellite emulators is a unique facility which can be used in other projects and again our exploitation is seen as knowhow to allow us entry into other research projects.

3.6.4 Progress and Outcomes

So far we have used the return link interference coordination work in a bid to improve the I4 capacity. The test bed is a unique facility and we are considering using this in conjunction with other project bids. We consider that further testing needs to be performed with different applications and this is being considered for a follow on project. The time switched gateway scheme was not adopted for the BATS 2025 mission but this is now being considered for the second generation of other Ka band satellite missions.

3.7 Fraunhofer Fokus (FH-FK)

3.7.1 Mission and Vision

Fraunhofer FOKUS develops novel solutions to enhance the broadband coverage of rural or remote areas - world-wide. The BATS project addresses a key element for such efforts, namely the seamless integration of ubiquitous high-speed connectivity provided by modern satellites. The major concern regarding broadband provisioning via satellite is the often sluggish user experience due the long signal propagation times. Fraunhofer FOKUS believes that the BATS project's approach to dynamically combine terrestrial and satellite connectivity based on application requirements is a major step forward to achieving the goal of enabling broadband Internet Access in rural areas.
Exploitation plans focus mainly on knowledge & IPR accumulation to strengthen Fraunhofer’s position in the field of applied research. Newly acquired expertise will be used to support work in related areas and to support industry in the development of new products and services. FH has a strong background in successfully launching spin-off companies to bring promising ideas to the market. Multi-Technology Self-Managing Mesh networks following the principles of Autonomic Communication are of particular interest. A seamless integration of satellite communication strengthens Fraunhofer's approach (which is currently focusing on terrestrial wireless technologies).

3.7.2 Exploitable Knowledge

The exploitable knowledge developed by FH-FK in the framework of the BATS project is summarized in Table 3-7.

Table 3-7: Exploitable knowledge for partner FH-FK

#	Exploitable knowledge and products	Sector(s) of Application	Timetable	Patents or other IPR protection
1	Definition of Components to allow for adaptive QoS/content aware load balancing	Research and Development	2015	Publications
2	Extension of SENF Library to support emulation of LTE and DSL links	Prototype	2015	none

#	Exploitable knowledge and products	Sector(s) of Application	Timetable	Patents or other IPR protection
3	Refinement of Satellite representation in Heterogeneous Wireless Backhauling	Research and Development	2015	Publications
4	Research prototype Validation	Field Trials	>2015	None

3.7.3 Opportunities for Exploitation

The following are opportunities that have been identified from the exploitable knowledge acquired in the BATS project.

Definition of Components to allow for adaptive QoS/content aware load balancing.

As a result of the BATS work, the adaptive load balancing components in Fraunhofer FOKUS' back-hauling architecture have been improved to better address data pipes with highly varying latencies.

Extension of SENF Library to support emulation of LTE and DSL links

The Fraunhofer FOKUS Simple and Extensible Network Framework (SENF) library (http://senf.fokus.fraunhofer.de) provides tools to quickly proto-type network protocols and architecture. It also allows for the real-time emulation of various link types to support protocol validation or scalability evaluation. During the course of the BATS project, link models for LTE, DSL and satellite have been added and refined. This will allow for more complete or realistic protocol evaluations in the future. Further development of our flexible real-time network emulator are planned for future integrated terrestrial-satellite networks projects with consideration for 5G enabling technologies.

Refinement of Satellite representation in Heterogeneous Wireless Backhauling

Satellite integration into 5G back-haul networks is a major topic for Fraunhofer FOKUS. To exploit the specific characteristics of satellites (i.e. multicast/broadcast, ACM, multiple beams), the resource model representing the satellite connectivity for radio and capacity planning/management needs to properly reflect the properties of such satellite links. This aspect will strengthen the Fraunhofer FOKUS back-haul architecture in the 5G context.

3.7.4 Progress and Outcomes

The implementation of the SENF library enhancement is complete and has been made modular for easy adaptation for different use cases. The enhancement concerning the wireless back-haul architecture has also been integrated and results published. The results and validation have resulted in new opportunities for to integrate satellite terminals in the network architecture in providing broadband coverage in rural regions across the EU and Africa.

The synergy among the key partners, knowledge exchange and relationships built during the course of the project has provided new opportunities for collaboration in future applied research projects.

3.8 Fraunhofer HHI (FH-HHI)

3.8.1 Mission and Vision

Fraunhofer Heinrich-Hertz-Institut (HHI) located in Berlin, Germany, brings innovation to the field of communication technology since 1928; since 2002 it belongs to the Fraunhofer alliance. The core competencies of HHI are in the areas of Photonic Networks and Systems, Mobile Broadband Systems, Photonic Components and Electronic Imaging. HHI's mission is to develop communication technology intellectual property and practical solutions which have major impact to the world of information and communication.

FH-HHI has a strong background in successfully launching spin-off companies to bring promising ideas to the market. In BATS, the exploitation plans focus mainly on knowledge and IPR accumulation to strengthen FH-HHI position in the field of applied research. Newly acquired expertise will be used to support work in related areas and to support industry in the development of new products and services. Multi-Technology Self-Managing Mesh networks following the principles of Autonomic Communication are of particular interest. A seamless integration of satellite communication strengthens Fraunhofer's approach (which is currently focusing on terrestrial wireless technologies).

3.8.2 Exploitable knowledge

The exploitable knowledge developed by FH-HHI in the framework of the BATS project is summarized in Table 3-8.

Table 3-8: Exploitable knowledge for partner FH-HHI

#	Exploitable knowledge and products	Sector(s) of Application	Timetable	Patents or other IPR protection
1	FBMC based PHY – layer design for the return link in satellite communication systems	Research and Development	2015	none
2	FBMC based PHY – Prototype implementation in SDR platform	Prototype	2015	none
3	Dynamic Fractional Frequency Reuse in the FWD Link	Research and Development	2015	none
4	Dynamic fractional frequency reuse with interference-aware scheduling	Research and Development	2014	none

3.8.3 Opportunities for Exploitation

The following are opportunities that have been identified from the exploitable knowledge acquired in the BATS project.

FBMC based PHY – Prototype implementation in SDR platform

The Software Defined Radio Frontend is a flexible radio platform consisting of a stacked digital card and an analogue radio front-end. SDR is a platform able to support different communication standards with variable signal bandwidths, carrier frequencies and transmit power.

As a result of BATS, the platform is able to operate in a satellite environment. Likewise, the implementation of FBMC enhances the functionality of the system making it more attractive for customers and research partners.

Multi-Layer Cellular System Evaluation

One of the main fields of competence of the FH-HHI system-level-innovation group (SLIG) is the evaluation of heterogeneous network architectures. Our competence is often requested in research projects as well as by industry partners. As a result of BATS, the system-level simulation environment (currently consisting of cellular macro, pico, and femto-cell layers) can be enhanced with an additional fixed-satellite layer. This enables a more integrated evaluation of the convergence of such networks.

Resource-allocation strategies

Resource allocation is a major topic in highly utilized networks. Multi-spot satellite systems differ significantly from cellular mobile networks. Hence, the studies of Dynamic Fractional Frequency Reuse as well as interference-aware scheduling and the integration into existing evaluation chains offers potentials for new industry partners to test their concepts and algorithms in a simulation framework before implementation on prototype hardware and product design.

3.8.4 Progress and Outcomes

Currently, the implementation of the mentioned techniques is ongoing. The implementation of FBMC into the SDR platform will be finished in the beginning of next year (2015). Further tests in WP7 will then show the potential of this technique in satellite systems.

The final results of the Resource-allocation strategies and the System Evaluation will be ready by end of the year.

3.9 Gradiant (GRAD)

3.9.1 Mission and Vision

GRAD (Gradiant: Galician Research and Development Center in Advanced Telecommunications) is a private, non-profit foundation started on December 2007, which was born with the aim of making academic research, development and innovation meet business demands. It plays a fundamental role in the generation and transfer of ICT knowledge to companies. The area of GRAD involved in BATS is the Communication Subsystems area, whose focus is on the design, simulation and implementation of communication and information processing subsystem:

- High Frequency. Design and implementation of RF and optical prototypes, including their digital phases.
- Programmable Devices. Design, simulation and implementation of communication subsystems on FPGAs and DPSs.
- Signal Processing. High-level design and implementation. Hardware description languages for channel simulators and information processing subsystems.
- Optical, Wireless and Wired Infrastructures. Simulation and implementation of communication subsystems under different standards and over different transmission channels.

3.9.2 Exploitable knowledge

The exploitable knowledge developed by GRAD in the framework of the BATS project is summarized in Table 3-9.

Table 3-9: Exploitable knowledge for partner GRAD

#	Exploitable knowledge and products	Sector(s) of Application	Timetable	Patents or other IPR protection
1	5G Waveforms over satellite	TV and broadband Internet access, services and applications	Proposed for inclusion in BATS mission 2025	Publications and Know-how exploitation in future research and innovation projects
2	Multi-user detection techniques for multibeam satellite systems	TV and broadband Internet access, services and applications	Proposed for inclusion in BATS mission 2020 and 2025	Publications and Know-how exploitation in future research and innovation projects

The knowledge that GRAD has developed in BATS is mainly related to physical transmission technologies:

5G Waveforms: Filter Bank Multicarrier (FBMC) and other non-orthogonal multicarrier systems are being proposed as new air interfaces for future 5G terrestrial systems. In BATS, GRAD is studying the possibility to reutilize these waveforms in a satellite link. GRAD is consolidating its expertise on satellite communications and new waveforms.

Interference Management: In multibeam satellite systems, the throughput of the return link can be increased reducing the frequency reuse factor and adopting interference management techniques at the satellite gateway. In the context of BATS, GRAD is studying multi-user detection techniques previously proposed in terrestrial MIMO systems and is evaluating the performance of these techniques when implemented in a multibeam satellite scenario. In particular GRAD is acquiring expertise on satellite multibeam channels and multi user techniques together with rain impairments and non-ideal channel state information.

3.9.3 Opportunities for Exploitation

The exploitable opportunities that GRAD pursues are the following:

- According to its major objective, GRAD can act as a proactive actor in the SatCom sector, contributing to increase the competitiveness of regional and national companies through the transfer of the know-how acquired in the course of the project. GRAD is establishing and/or consolidating business relationships with companies interested in SatCom market.
- GRAD IP portfolio in the fields of SatComs and physical transmission technologies will be increased thanks to the expertise acquired in the BATS project (i.e. 5G waveforms, multibeam satellite channel and multiuser detection techniques).
- The knowledge acquired in the BATS project allowed GRAD to get involved in European Platforms, Associations, Forums or events in the field of SatComs and future terrestrial communication such as NetWorld2020 and 5G-PPP, where there is a prominent industrial presence. GRA is contributing to key white papers, providing its vision about the R&D roadmap for 5G communications.

- GRAD has established collaborations with some partners of the BATS project that will also be maintained after the end of the project to keep strengthening GRAD activities in Europe.
- Thanks to the expertise acquired in BATS project, GRAD is creating new opportunities for collaboration with other national and European entities external to the BATS project. GRAD is also increasing its capacity to get involved in consortia for national and European project proposals.
- Scientific publications produced during the project will give GRAD more visibility in terrestrial and satellite scientific communities.

3.9.4 Progress and Outcomes

- Business relations. Technical partnership with a national company in a public tender procedure for the design of a satellite link for offshore communications in maritime scenario.
- Two collaborations have started with two partners of BATS: DLR (FBMC over Nonlinear channels and multiuser detection with scheduling) and Fraunhofer HHI (FBMC).
- Participation in the European 5G infrastructure ecosystem and the European Technology Platform NetWordl2020. The know-how acquired during BATS has helped GRAD contribute to NetWorld2020's white papers on strategic research and innovation priorities for 5G.
- Publications. So far, GRA has co-authored 1 journal paper, 3 conference papers and 2 posters showcasing research results obtained within the BATS project.

3.10 R Cable y Telecomunicaciones de Galicia (R)

3.10.1 Mission and Vision

R is the Galician telecommunications operator providing telephony, television, broadband and mobile services. R's new network covers 1M units in Galicia, about 90% of urban areas and it is present in 200 out of 316 Galician councils. Out of R's network, in the rural areas of Galicia, R rents ADSL lines from Telefonica. As the performance of ADSL lines in rural areas is not comparable to its optical network, R is very interested on an integrated gateway that can combine ADSL, 4G and satellite in order to improve broadband performance and extend the network coverage into rural areas by using the designed Intelligent User Gateway (IUG) concept of BATS. R is also a MVNO and owns a 4G-20MHz license in the 2.6GHz band.

As of 2014, about 80.000 individual locations in Galicia have an ADSL speed below 2Mbps. Although many of them are covered by 3G networks, this situation is an interesting market opportunity for bonded access services integrating satellite broadband. Those individual locations are 100% rural areas and out of HFC networks, which will be difficult to serve with wired terrestrial superfast broadband technologies in the near future. In fact, the Galician government has classified them as not reachable by new wired networks.

R has a strong historical relationship with the government of Galicia. The Galician government has launched 2 initiatives to extend broadband coverage. In 2006, it launched PBLI, where R invested 160M€ with a government grant of 39M€ . In 2011, PBLII was launched, with several lines (L1= DSL speeds , L2=3G speeds, L3= satellite speeds, L4= superfast speeds and L5= support for public operator). R, as the winner of the L4 action, invested 94M€ with a government grant of 27M€. The government is now studying PBLIII, where R is suggesting to use BATS concepts it its definition. Following those plans, the government of Galicia has a detailed knowledge of the broadband situation in every corner of the territory, and has a detailed planning of the network options possible to reach every household in Galicia.

3.10.2 Exploitable knowledge

So far, R has not developed exploitable Intellectual Property in the course of the BATS project. However, R plans to exploit the knowledge acquired during the course of the project both in terms of concept and lessons learnt during the field trials in order to define a business plan for the exploitation of an integrated terrestrial and satellite broadband service for the rural areas of Galicia in Spain. However, the participation in the BATS project has allowed R to gain a much better technical understanding of satellite as a broadband delivery solution and to consider it as an interesting network extension for rural areas in the Galician territory.

3.10.3 Opportunities for Exploitation

The following are opportunities that have been identified from the exploitable knowledge acquired in the BATS project:

- Exploitation of the results obtained during the field trials to see whether the BATS system, though being at a very early stage, provides improvements to the existing solutions in terms of end-user Quality of Experience.
- Definition of a Business Plan for the exploitation of the subsequent BATS service.
- Working with our router partners to incorporate the BATS concepts in our multi-access routers, even if they end up being not as complete as the one designed in the frame of the BATS project.
- R is in the process of merging with another cable company, Euskaltel, which also operates in the north of Spain (Basque country). Euskaltel has a satellite service in place, and is analysing BATS results in order to study how best to incorporate BATS concepts in and improved satellite offer. Euskaltel already has 5.000 satellite and Wimax customers in place with outdated equipment which could be replaced by a 2016 BATS-like system

3.10.4 Progress and Outcomes

So far, R has contributed to most of the WPs, except to WP4, and as a telco operator has provided the point of view of services commercialisation, networks limitations and users preferences.

R had a paramount role in the field trials that will be held in Galicia in 2015.

3.11 Turk Telekom (TT)

3.11.1 Mission and Vision

Argela, an affiliate company of Turk Telekom, helps telecom operators to increase their customer satisfaction and revenue while decreasing their operating costs and churn through its agile approach and innovative products. Argela's solutions portfolio includes Network Performance Monitoring, Small Cell Solutions for public and defense (3G & LTE), Internet TV, Fixed-Mobile Convergence and Regulatory solutions.

Argela's mission is defined as:

- Becoming a preferred, sought for and profitable telco manufacturer of the world by using the international telecommunications technologies experience and know-how of its employees,
- Decreasing the dependency of Turkey to foreign sources while increasing the income of the company,
- Having its products to be used in worldwide markets.

Argela's vision is that with the continuous integration of mobile, fixed and internet infrastructures, future services will be provided to subscribers independent of these infrastructures, these services will be enriched with multimedia and various emerging opportunities and subscribers will be provided with richer and more diverse services, and that telco services should have open and scalable architectures complying to international standards.

3.11.2 Exploitable Knowledge

The exploitable knowledge developed by TT in the framework of the BATS project is summarized in Table 3-10.

Table 3-10: Exploitable knowledge for partner TT

#	Exploitable knowledge and products	Sector(s) of Application	Timetable	Patents or other IPR protection
1	Gained satellite knowledge as a terrestrial operator	eHealth, eLearning	2-3 years	N/A
2	Gained knowledge on how other partners, especially operators work in European region	eHealth, eLearning	2-3 years	N/A
3	Gained knowledge on hybrid CDN solutions	eHealth, eLearning	2-3 years	N/A

3.11.3 Opportunities for Exploitation

Turk Telekom is the largest terrestrial operator in Turkey, and has the largest coverage. However, there are still underserved areas in the country, especially in the eastern, and south eastern regions, resulting from the geographical inconvenience and thus, cost of terrestrial cabling. Enhancing the service in these underserved rural areas using the insight gained from BATS is the primary opportunity from Turk Telekom. Gaining knowledge about the satellite access has given birth to such opportunities such as satellite internet access, emphasizing flowing services in underserved rural areas such as:

- eLearning services,
- eHealth services,
- Emergency and early warning systems.

Specific knowledge on hybrid CDN systems and protocols between satellite and terrestrial networks is an opportunity for Turk Telekom to enhance the services listed below in urban areas:

- eLearning services,
- eHealth services,
- eEntertainment services.

3.11.4 Progress and Outcomes

So far, as project members, we've shared our insight with strategy, business development, and regulation departments of Turk Telekom. These departments are making plans for these opportunities.

3.12 Optare Solutions (OPT)

3.12.1 Mission and Vision

Optare Solutions is a Systems Integrator company specialised in Fulfilment and Assurance areas inside the OSS systems of the operators providing management of Telco Services and Resources. These areas allow the operators to capture and validate their customer orders, maintain service catalogues, service decomposition and orchestration, service fallout management, service and resource activation in heterogeneous networks, inventory management, service problem management with automatic diagnostics and the integration of third-party services into the catalogue of the operator.

The vision of Optare Solutions is to be a reference consulting company in OSS/BSS Systems to help the Telecom Operators to become “Lean operators” with the knowledge in processes and services.

The mission of Optare Solutions is to offer the best services and solutions to improve Client’s OSS/BSS Systems based on efficient and quality solutions, Telecommunications' Business and Market knowledge, capacity of critic situations resolution and, finally, establish a mutual confidence relationship of trust with the customers.

3.12.2 Exploitable knowledge

The exploitable knowledge developed by OPT in the framework of the BATS project is summarized in Table 3-11.

Table 3-11: Exploitable knowledge for partner OPT

#	Exploitable knowledge and products	Sector(s) of Application	Timetable	Patents or other IPR protection
1	MTOSI Interface base implementation	Support for CSP that needs provision complex multi technology composed services	2016-2018	None
2	Deployment techniques for rich interfaces	CSP with complex integrations to be performed oriented to DevOps	2017	None
3	Lessons learnt from BATS lab and field trials	Communication needs for real customer in underpopulated areas	2016	None
4	Base knowledge of service activation orchestration	Reference for 5G (NFV/SDN) orchestrator of Network Services	2018	None
5	Intense use of Hyperjaxb3 technology	Integration of TI systems	2016	None

3.12.3 Opportunities for Exploitation

The opportunities that Optare can exploit as results from this project are explained below.

Integration of complex composed services

Most of the service providers has adopted a complex catalogue of product and services mixing different nature of services. BATS it is not an exception. It depicts an integration of several technologies, satellite and terrestrial, to offer an optimum combined service in some areas were other technologies as fibber or cable cannot access. The users from that areas could then use broadband services.

The complexity for create this combined set of products is minimized using a common and standard set of interfaces that are capable to perform the service activation activities. The MTOSI framework offers this possibility and the implementation generated in the projects clarify the feasibility for their use to support real scenarios. With this interfaces a shorten time to market for this kind of products will be observed.

The reference implementation that has been built in the project uses the last version of the MTOSI interfaces (4.0), giving to Optare a competitive advantage in the integration of OSSs field. The experience acquired in the process of complete the implementation of the interfaces offers will facilitate the deployment in other use cases.

5G Orchestration

Several challenges are cited in the 5G approaches. Some of them are related with the orchestration of the new services built over technologies as Network Function Virtualization (NFV)/Software Defined Networks (SDN) trying to optimize the cloud environment for the network services offered by the service providers. The solid knowledge generated by the BATS project has facilitate to Optare the vision to understand the requirements needed in the NFV and 5G scenarios. The concepts of service lifecycle and the information structures created in the MTOSI implementation, have helped in obtain a clear understanding for extracting the requirements for the 5G service platform and the orchestration of services.

Many of the implementation made on MTOSI had to deal with a huge number of definitions of information elements and interfaces that generated the need of use a continuous integration model to manage it with *DevOps* techniques as Jenkins or generation of base interface through Hyperjaxb3 technology.

Satellite providers

The knowledge acquired in the project could open new opportunities with Satellite CSPs for Optare. The limitations, risks and needs of satellite service providers are very different from the aspects considered in the terrestrial operators and the needed interactions in the project with Avanti offer now a clear understanding on that area.

Standards and regulations

During the implementation of the project, several problems in the MTOSI standard were found and some of the proposed corrections has been sent to the TMForum staff as improvements to include in the standard. These actions could help in the recognition of Optare as an expert in the service activation area in the industry.

Relationships

The participation on this project could offer future opportunities to work together. The knowledge acquired has helped in the success for participate in a H2020 5G related project, SONATA with service management orchestration of new Network Services over NFV.

3.12.4 Progress and Outcomes

Optare Solutions has built a solid foundation in the service activation area based on a complete implementation of the interfaces of the MTOSI framework. With that foundation, Optare now is recognized as an expert in that area and can offer novel solutions for the support and orchestration of complex and composed services.

The foundation offers a complete view of all the elements needed in the service activation process and interconnects it in an agile approach facilitating the deployment of the solution and its posterior exploitation with the support to new approaches as NFV.

3.13 STM Norway (STM)

3.13.1 Mission and Vision

STM Norway AS has been acquired by Emerging Markets Communications during the course of the project and has changed name to *EMC SatCom Technologies Norway AS* (ESTN).

ESTN is responsible for R&D of the SatLink brand of baseband satellite modems, including remote modems and hub modems. SatLink implements the lower layers of the DVB-RCS2 air interface specification published by ETSI.

ESTN participates in BATS with particular focus on the SatCom solutions for next generation HTS broadband systems.

3.13.2 Exploitable Knowledge

The exploitable knowledge developed by ESTN in the BATS project is:

Table 3-12: Exploitable knowledge for partner STM

#	Exploitable knowledge and products	Sector(s) of Application	Timetable	Patents or other IPR protection
1	Method for remote supervision of OBO	R&D	2020	None
2	Potential of dynamic fading margin	R&D	2020	None
3	Potential of slicing and segmenting with GSE	R&D	2020	None
4	Methods for burst size dynamics	R&D	2020	None
5	Structured hierarchical FWD link resource management	R&D	2020	None
6	Upstream QoS control based on status of FWD link SatCom service impacted by contention and fading	R&D	2020	None
7	Upstream QoS control based on status of RTN link SatCom service impacted by contention and fading	R&D	2020	None

3.13.3 Opportunities for Exploitation

Insufficient Output Back-Off (OBO) at remote user VSATs is a potential source for excessive Adjacent Channel Interference (ACI) in the return link. The OBO at a user site is typically established by an installer. In large systems with cost-sensitive installation it is valuable to have an efficient method for remote supervision of the population of remote transmitters with respect to OBO and detect units operating with insufficient OBO. An automated system for such detection would be of great value.

Ka-band and higher band operation is subject to fading events that can be mitigated by employing sufficiently large fading margins in the Adaptive Coding and Modulation (ACM) and Adaptive Carrier Selection (ACS) control. It is seen that fading events are not evenly distributed in time and that this can allow using in average a lower fading margin if adapting the margin to the conditions that are prevailing at any given time. This includes increasing the margin when the conditions are unstable and reducing the margin at stable clear-sky conditions.

The DVB-RCS2 specification makes use of Generic Stream Encapsulation (GSE) in the FWD with segmentation of user packets at the edge of the DVB-S2 frame. A method for slicing a GSE packet between successive frames has been defined by DVB. It is seen that combined utilisation of slicing of Generic Stream Encapsulation (GSE) packets and segmenting of higher layer packets into multiple GSE packets can reduce GSE overhead compared to alone doing segmentation at the frame edge. This allows for an optimized implementation of a GSE transmitter for a DVB-S2 ACM based FWD link.

Burst size dynamics are essential to minimize jitter also with minimized extra resource consumption. Principles for dynamically selecting burst size have been established and implemented.

Structured resource management has been enhanced and implemented for the forward link. A multi-level hierarchy supports various mechanisms to control both aggregation and separation of user traffic sharing forward link resources in a statistical way. This allows implementing various service models by configuration.

Upstream QoS control with tracking of FWD service status may allow for utilizing standard QoS enforcement in combination with a service level impacted by SatCom link rate variation. For transmission in the FWD direction that is shared between many users the impact on the FWD aggregate can be cascaded down by upstream devices following the status of the aggregate.

Upstream QoS control with tracking of RTN service status may allow for utilizing standard QoS enforcement in combination with a service level impacted by link rate variation. For transmission in the RTN direction the impact of resource contention and SatCom link conditions will hit directly on the single user.

3.13.4 Progress and Outcomes

ESTN has contributed in the assessment of the SatCom access in various contexts. The outcome is:

- An understanding of the potential gain of applying dynamic fading margin.
- An understanding of the potential gain of exploiting GSE packet slicing in combination with exploiting user packet segmentation into several GSE packets.
- A burst waveform design for remote probing of OBO at user sites.
- Separation of shared FWD transmission resources into segments that are isolated from each other with respect to contention and user site fading, and that can be separately tracked with respect to the effective maximum line rate of each segment.
- Methods for exploiting DVB-RCS2 burst size dynamics.
- Methods and algorithms for close tracking of status of contention based SatCom services impacted by ACM and ACS, for use in upstream QoS control, both for FWD and RTN.

3.14 Mulsys (MUL)

3.14.1 Mission and Vision

MulSys is an R&D company specialising in media processing and communication technologies. MulSys has been active in the areas of signal processing for fixed and wireless communication systems, 2D-3D content adaptation, wireless channel modelling and security. Various wireless communication applications have been developed including 2D-3D video/audio coders, error resilient transmission, scalable content generation and security systems. MulSys has also gained expertise in Quality of Experience measurements and modelling techniques covering Audio-Visual service and applications from previous research in EU–ROMEO project and in other research conducted for commercial customers.

MulSys participates in the BATS reference scenarios definition process and mainly concentrates on the user segment of the system, such as the functionalities the users potentially can make most of in a home environment served intelligently by multiple broadband technologies. MulSys also takes role in the selection of audio-visual multimedia service and contents for the evaluation of hybrid broadband delivery to homes in the scope of BATS project's laboratory trials. The Quality of Experience (QoE) measurement is done following standard recommendations and the results will be analysed.

3.14.2 Exploitable knowledge

The exploitable knowledge developed by MUL in the framework of the BATS project is summarized in Table 3-13.

Table 3-13: Exploitable knowledge for partner MulSys

#	Exploitable knowledge and products	Sector(s) of Application	Timetable	Patents or other IPR protection
1	Home Gateway standards for current and future Internet service delivery schemes	Research & Development, Regulatory	2020	None
2	Analysis of currently used broadband services and QoS/QoE requirement and projection for future applications	Research & Development	2020	None
3	Quality of Experience measurement for novel broadband service delivery schemes in lab environment	Research & Development	2020	None

3.14.3 Opportunities for Exploitation

Various opportunities that MulSys can exploit as a direct result of BATS Project involves:

- The knowledge of multimedia quality evaluation on a novel broadband service delivery framework can lead to improved Quality of Experience modelling for such multimedia broadband services, which involves audio-visual content consumption and interaction (e.g., video conferencing, gaming), taking into consideration the delivery model. Because, most existing Quality of Experience models for 2D/3D multimedia services consider only particular transmission and compression characteristics. This knowledge will also improve the QoS/QoE based routing decision taking algorithms of IUG like devices or systems. MulSys plans to incorporate the knowledge gained and especially the analysis done on the subjective test results in a high quality and possibly joint journal publication or an equivalent conference publication within a year after the completion of the project.

- MulSys' prospective audio-visual communication related products will benefit from the advance knowledge on the trends in future broadband delivery systems combining more than one access technologies in order to improve their scalability (e.g., bit-rate, resolution) to adapt to the intelligent routing strategies delivered by products like BATS IUG.
- MulSys expects to act together with the project partners dealing with the networking technologies in future project ideas. These would aim at further advancing the knowledge gained during BATS by combining it with novel paradigms such as cloud media processing for easing the load on user devices, and even extending its usage to cover mobile users.

3.14.4 Progress and Outcomes

So far, MulSys has contributed to the definition of service and user characteristics that are currently available and within the scope of BATS development as well as the projection on types of services and added functionalities likely to be available in 2020 timeframe. Besides, several existing home gateway standards have been investigated and the suitability of BATS' main product, namely the Intelligent User Gateway, to those home gateway standards has been analysed. Currently, MulSys is preparing the broadband services and selects the content to be used in the evaluation of the BATS Intelligent User Interface prototype and sets up the subjective testing environment for the lab trials in WP7.

3.15 Climate Associates (CAL)

3.15.1 Mission and Vision

Our mission is to provide consultancy internationally to help companies and governments to minimise the environmental impact of ICT through carbon footprint reduction, recycling and to promote the use of 'Smart ICT' to make other sectors more sustainable. Through publications and contributions to international standards CAL has established a track record as thought leaders in determining carbon footprint and in designing ways to minimise carbon footprint, whilst ensuring that operational performance and costs are not compromised. CAL provides consultancy to organisations that wish to specify, design and operate systems in the most energy efficient way. CAL also acts as an independent assessor of the performance and costs of systems implemented by others. We engage activity in thought leadership, including setting international and European Standards, and by engaging with committees that are setting future directions. CAL has also run courses in developing countries so that they can understand the causes and impact of climate change and the practical steps that they can take to minimise the whole-life carbon footprint of systems and services that they deploy.

We intend to continue to hold thought leadership roles, e.g. championing energy efficiency on the Board of the European Telecommunications Standards Institute (ETSI) and acting as Vice Chair of ITU-T SG5 (Environment and Climate Change). Most of all, our aspiration is that CAL will play a significant role in reducing the planet's carbon footprint helping to slow down climate change.

CAL's Vision is to become the consultant or research project partner of choice where assessing and optimising the carbon footprint of new systems is required.

3.15.2 Exploitable Knowledge

The exploitable knowledge developed by CAL in the framework of the BATS project is summarized in Table 3-14.

Table 3-14: Exploitable knowledge for partner Climate Associates Ltd

#	Exploitable knowledge and products	Sector(s) of Application	Timetable	Patents or other IPR protection
1	Constructed a life-cycle model to compare the greenhouse gas (GHG) emissions for alternative broadband systems. Validated by the world's experts in ITU-T SG5	ICT, Smart Cities, Smart Applications, Demand Side Management and Intelligent Transport Systems. Consultancy More advanced R&D Standards Deliver Training	Seeking immediate opportunities for consultancy and also further research, particularly in H2020. 2016-on 2016-on 2016-on 2015-on	Publication
2	Understand the divergence in values used for embodied carbon in different national accounting methods. Lack of common values agreed across Europe: work needed to rationalise	Potential for a European Support Action. Consultancy and standardiation needed.	2016 onwards	Publication
3	Understanding the practicalities of using lower power modes for communications equipment, its control and impact on performance, and the potential for significant reduction in GHG emissions	ICT technology deployment	2016-on Seeking immediate opportunities for consultancy and also further research, particularly in H2020	Publication
4	Improved understanding of Hybrid Satellite Broadband systems. Identification of opportunities for export & deployment in developing countries.	Low-Cost Sustainable Telecommunication Infrastructure for Rural Communications in Developing Countries	2016 onwards	none

3.15.3 Opportunities for Exploitation

The Greenhouse Gas (GHG) emissions accounting model developed by CAL for BATS is designed to provide a complete lifecycle analysis for the lifetime of the project and makes a direct comparison with alternative technologies. We have worked with experts in ITU-T SG5 to determine best practice and have shared our methodology with that group. This has validated CALs model and the approach taken which can be applied to other studies. As a result we have also made people aware that the use of satellite communications is a sustainable choice, particularly when used as part of a BATS service.

CAL has worked with project partners to develop techniques to allow those parts of the BATS system that consume most power to be powered down to a lower state of activity when full performance is not needed, without compromising the users' quality of experience.

We have devised ideas for more aggressive power reduction in the BATS solution, but these ideas would require additional signalling to be used and will require evaluation tests that are beyond the scope of the current project. We are discussing opportunities for a follow-on project that would lead to more energy efficiency optimisation of the BATS concept.

We are ambitious to apply knowhow gained about the ICT sector to make energy savings in other sectors, such as transport and buildings, which have a much larger carbon footprint. Our modelling techniques may be applied to other systems and in preparation we have engaged in thought leadership activities to minimise the carbon footprint of Smart Cities. For example, CAL Director Keith Dickerson is a member of the European Innovation Partnership on Smart Cities and Communities. We have ensured that energy efficiency and the carbon footprint is considered in the most effective way. The work we have carried out in this area so far has not been funded: it is an investment for future work in an area of outstanding need.

3.15.4 Progress and Outcomes

The BATS project consortium's intention to use the best practice for carbon footprint assessment and optimisation for BATS requires CAL to liaise directly with the relevant standards groups in ITU-T and in ETSI. We have used CAL's ongoing relationship with these standards bodies to support the candidacy and successful appointment of Keith Dickerson as Vice-Chair of ITU-T Study Group 5 (Environment and Climate Change). There is no income from this role, but it enhances CAL's reputation as thought leaders in carbon footprint minimisation. This has helped CAL to win contracts to prepare reports for the ITU-Development Sector (ITU-D), under the sponsorship of other organisations working with the ITU. For example, Keith Dickerson and Dave Faulkner have recently completed a study on the resilience of ICT infrastructures in the face of climate change. Keith Dickerson has recently completed a study into improving the sustainability of their power generation systems in Pakistan. Dave Faulkner has developed a training course on Climate Change, its causes and effects, and practical steps and best practice to mitigate this. This has been delivered in India and in Abu Dhabi.

CAL worked with three consortia that submitted H2020-14 bids, with the intention that CAL could increase the breadth and depth of our modelling techniques and contribute to future emissions reduction. These bids were not successful. We continued with three H2020-15 bids, one of which (VICINITY) has been successful. This will take CAL into the IoT world where we shall be able to use the learning from BATS, broaden our influence, and open up further opportunities. We continue to look for opportunities to build on our specific skills in broadband access and satellite systems.

3.16 OneAccess Networks (OAF)

3.16.1 Mission and Vision

OneAccess designs, develops, and manufactures network access products (routers) and associated software and markets them towards Telecom Operators and Communication Service Providers.

These products allow the latter to offer managed communication services from OneAccess equipment installed in their end enterprise customer premises.

Integrated OneAccess Products (software and hardware) are sold to CSPs Telecom Service Providers under the form of an access platform located in the enterprise premises that connects the CSP network to the internal enterprise network.

This platform is equipped with one or several access technologies (DSL, fibber, radio, cable and others), as well as a set of hardware and software functions allowing to offer a wide range of services to the enterprise market, including in particular routing, secure and reliable transmission of data, Voice over IP, prioritization and optimization of certain critical applications.

OneAccess is present on the two major market segments of network access products, the:

- **Branch Office segment** which encompasses all the remote sites of an enterprise (branches, industrial sites, mobility access …) on one side and the main sites of the enterprise (headquarters, data center ….);
- **Mid-Range segment** - on the other side to which the remote sites are connected.

Relying on continuous success on the Branch Office Market where OneAccess already has 15,1% market share in terms of revenue in EMEA and is the second provider of Branch Office routers, OneAccess has recently added new Mid-Range routers to his portfolio of routers implementing a mix of functions similar to the Branch Office but including more performant services as well as a higher bandwidth.

In order to become a global actor on the multi services solutions market, OneAccess has defined a development model and a certain number of strategic axes to achieve his objectives, including:

- Pursue his international development
- Enlarge the customer base by addressing new Service providers like Managed Service Providers acting on vertical segments (e.g. hospitality, retail …)
- Develop new network services relying on Virtualization (SDN and NFV)

3.16.2 Exploitable Knowledge

The exploitable knowledge developed by OAF in the framework of the BATS project is summarized in Table 3-15.

Table 3-15: Exploitable knowledge for partner OAF

#	Exploitable knowledge and products	Sector(s) of Application	Timetable	Patents or other IPR protection
1	Means to improve User QoE in Multipath TCP context	Broadband access in rural areas	2015	IPR
2	Estimation of Path characteristics in an autonomous self-learning mode	Broadband access in rural areas	2015	IPR
3	Traffic Classification	Protocol and encryption agnostic applications	2015	IPR
4	Traffic Distribution	Intranet and Cloud-based SaaS applications	2015	IPR

3.16.3 Opportunities for Exploitation

The market opportunities contemplated in 2014 have been significantly broadened when promoting the BATS findings within the Communication Service Provider market. The objective of providing high speed broadband to the rural broadband areas is actually also found in the non-rural areas. Even in urban areas, and because of many reasons including local regulations or provider status, the high cost of pulling fiber FTTH or even FTTC is still seen as a major barrier to satisfy the market appetite for connectivity bandwidth. Deutsche Telekom has launched its Magenta service in September 2014, a xDSL + LTE solution promising to double the bandwidth for less than 30€ per month. This solution targeting exclusively the consumer market is enjoying sufficient success to have been deployed in the summer of 2015 across all of Germany. This success has raised the the interest of the other European, but not only, Service Providers owning their own xDSL and LTE infrastructure as bringing more bandwidth is not seen just as a Digital Agenda 2010 target but is confirmed as a significant market opportunity to increase the Average Revenue Per User. The Huaweï GRE-based technology used by Deutsche Telekom being proprietary and coming from significant limitations, has been challenged by the market.

OneAccess contributions at the Broadband Forum have gathered along 2015 the support of major Incumbent Service Providers as well as equipment suppliers, all looking for a standard-based solution to combine xDSL and LTE.

In parallel, OneAccess has identified opportunities in very rural areas where satellite is already deployed but suffers from its latency and cost. A single low-speed xDSL or 3G link transforms the existing system by making it more reactive and therefore more usable.

The MPLS market where customers are looking at cheaper alternative is also an opportunity for the BATS output. Service providers have no choice but to pass the high Operation cost of maintaining a highly stable and secured network to their customers. Cheap VPN Internet access links are taking an increasing share from the MPLS market thanks to over the top VPN / WAN Optimization solutions. The output of the BATS project allows developing an hybrid MPLS solution for the Service Provider to regain control on its customer base.

3.16.4 Progress and Outcomes

Designed, implemented and tested a new algorithm for optimization of data transfer by identifying/classifying TCP data traffic by flow size and assigning flows to the relevant links. A description of the algorithm has been provided in detail as well as the corresponding test results.

Designed and benchmarked Link Estimation based on real-time characteristics of the data links, in order to increase accuracy of Link selection algorithm and match QoE requirements. Algorithm & test results have been documented in official BATS documents.

A new algorithm for Link Selection based on packet Inter-arrival time has been studied, a prototype implementation tested and results produced. This algorithm aims to provide a universal solution to the link selection for all types of TCP transfers (http, ftp, real-time application, video streaming etc…).

The different innovations (MP-TCP profile, Link Estimation, Traffic Classification, Traffic Distribution) have been developed and integrated into the Lab Test and Field Trials IxGs successfully deployed in UK, Germany and Spain.

Significant required improvements have been identified during the tests, and developed and integrated into an Evaluation platform proposed to the Communication Service Providers lloking at exploring the technology in house. Development continues and its virtualization is part of the VITAL European project.

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4 Conclusions

This deliverable provides an assessment of the exploitation plans for each of the partners in the BATS project at the end of the project. It captures the exploitable knowledge that each partner has develop from the project activities up to this date, and it identifies which are the opportunities for exploitation that each partner is targeting. Note that each partner has independently developed its own exploitation plan based on its business strategies; however some of the exploitable opportunities may be developed in conjunction by a subset of the project partners towards and after the completion of the project.

At least one exploitation plan will look to build on the findings of the business case which suggests the best process is to develop an initial BATS service in one region in 2016 to allow the service to grow and launch its own satellites in the 2020 timeframe.

5 References

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