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Foreword

This Technical Report (TR) has been produced by ETSI Technical Committee Satellite Earth Stations and Systems (SES).

Modal verbs terminology

In the present document "**should**", "**should not**", "**may**", "**need not**", "**will**", "**will not**", "**can**" and "**cannot**" are to be interpreted as described in clause 3.2 of the ETSI Drafting Rules (Verbal forms for the expression of provisions).

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Introduction

The Energy efficiency of a satellite broadband network is addressed by ETSI TR 103 352 [i.4] "Energy Efficiency of Satellite Broadband Network". The present document carries out a full Life Cycle Analysis (LCA) of a satellite broadband network considering all stages of the life cycle.

1 Scope

Satellite Broadband Networks allow broadband services to be delivered to approaching 100 % of the population, even in remote areas, and can therefore be used to fill gaps in the coverage of other broadband technologies. Satellite Broadband services can be offered to residential or business customers in a cost effective manner compared to other methods of services provision.

The present document reviews the assessment of GHG emissions over the lifecycle of satellite broadband networks, and identifies whether additions are required to the full life cycle assessment methodology developed in ETSI TS 103 199 [i.3].

2 References

2.1 Normative references

As informative publications shall not contain normative references this clause shall remain empty.

2.2 Informative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

NOTE: While any hyperlinks included in this clause were valid at the time of publication, ETSI cannot guarantee their long term validity.

The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

[i.1] Greenhouse Gas Protocol (GHG Protocol).

NOTE: Available at http://www.ghgprotocol.org/.

[i.2] Recommendation ITU-T L.1420: "Methodology for energy consumption and greenhouse gas emissions impact assessment of information and communication technologies in organizations".

[i.3] ETSI TS 103 199: "Environmental Engineering (EE); Life Cycle Assessment (LCA) of ICT equipment, networks and services".

[i.4] ETSI TR 103 352: "Satellite Earth Stations and Systems (SES); Energy Efficiency of Satellite broadband network".

[i.5] Guidelines to DEFRA/DECC's GHG Conversion Factors for Company Reporting.

NOTE: Available at https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/224437/pb13988-emission-factor-methodology-130719.pdf.

[i.6] ISO 14044:2006: "Environmental Management-Life Cycle Assessment - Requirements and Guidelines".

[i.7] "Energy Efficiency", EC FP7 Project BATS Broadband Access via Integrated Terrestrial and Satellite Systems Deliverable D5.3.

NOTE: Available at http://www.batsproject.eu.

[i.8] "Cost Benefit Analysis", EC FP7 Project BATS Broadband Access via Integrated Terrestrial and Satellite Systems Deliverable D5.2.

[i.9] Ariane 5 ECA technical data.

NOTE: Available at http://www.spacelaunchreport.com/ariane5.html.

[i.10] Number of private households in Europe.

NOTE: Available at http://www.pordata.pt/en/Europe/Private+households+total+and+by+number+of+children-1615.

[i.11] Number of households in Croatia.

NOTE: Available at http://www.dzs.hr/default_e.htm.

[i.12] Number of households in Turkey.

NOTE: See http://www.turkstat.gov.tr/PreHaberBultenleri.do?id=15843.

[i.13] "EU Energy Trends to 2030".

NOTE: Available at https://ec.europa.eu/energy/sites/ener/files/documents/trends_to_2030_update_2009.pdf.

[i.14] "Tracking Industrial Energy Efficiency and CO2 Emissions", details of the manufacture of liquid oxygen, IEA.

NOTE: Available at http://www.iea.org/publications/freepublications/publication/tracking_emissions.pdf.

[i.15] Liquid hydrogen manufacturing conversion factor, US EPA, "Technical Support Document for Hydrogen Production: Proposed Rule for Mandatory Reporting of Greenhouse Gases", page 2.

NOTE: Available at https://www.epa.gov/sites/production/files/2015-02/documents/subpartp-tsd_hydrogenproduction.pdf.

[i.16] Chemistry of the solid rocket booster propellant.

NOTE: Available at https://chlorine.americanchemistry.com/Chlorine_Site_Content/Science_Center/Chlorine_Compounds/Ammonium_Perchlorate__Helping_to_Launch_the_Space_Shuttle_Discovery.aspx.

[i.17] "Forecast emission factors for vehicles, Chapter 5: Reducing emissions from transport".

NOTE: Available at http://www.theccc.org.uk/wp-content/uploads/2013/12/1785b-CCC_TechRep_Singles_Chap5_1.pdf.

[i.18] EU Code of Conduct on Energy Consumption of Broadband Equipment Version 5.

NOTE: Available at http://iet.jrc.ec.europa.eu/energyefficiency/sites/energyefficiency/files/files/documents/ICT_CoC/cocv5-broadband_final.pdf.

[i.19] European Parliament COM(2009) 7604 2009/2228(INI): "Mobilising Information and Communication Technologies to facilitate the transition to an energy-efficient, low-carbon economy".

[i.20] Directive 2005/32/EC of the European Pariliament and of the Council of 6 July 2005 establishing a framework for the setting of ecodesign requirements for energy-using products and amending Council Directive 92/42/EEC and Directives 96/57/EC and 2000/55/EC of the European Parliament and of the Council.

[i.21] Directive 2009/125/EC of the European Parliament and of the Council of 21 October 2009 establishing a framework for the setting of ecodesign requirements for energy-related products (Text with EEA relevance).

[i.22] Directive 2010/30/EU of the European Parliament and of the Council of 19 May 2010 on the indication by labelling and standard product information of the consumption of energy and other resources by energy-related products (Text with EEA relevance).

3 Definitions and abbreviations

3.1 Definitions

For the purposes of the present document, the following terms and definitions apply:

baseline scenario: hypothetical reference case that best represents the conditions most likely to occur in the absence of any environmental impact reduction measures

cut-off: threshold below which part of a product, service or system can be considered insignificant and need not be considered by a LCA

Emission Factor (EF): mass of a specified pollutant (e.g. GHG or CO_2e) emitted divided by a unit mass, volume, distance, or duration of the activity emitting the pollutant

EXAMPLE: Number of kilograms of GHG emitted per kW of power generated or number of kilograms of CO_2e emitted per km travelled.

greenhouse gas: gaseous constituent of the atmosphere, both natural and anthropogenic, that absorbs and emits radiation at specific wavelengths within the spectrum of infrared radiation emitted by the Earth's surface, the atmosphere and clouds

greenhouse gas emission: total mass of a GHG released to the atmosphere over a specified period of time

3.2 Abbreviations

For the purposes of the present document, the following abbreviations apply:

ADSL	Astmmetric Digital Subscriber Line
BATS	Broadband Access via Integrated Terrestrial and Satellite Systems
CO2	Carbon Dioxide
CO2e	CO2 equivalent (warming potential of other GHGs)
CPI	Communications and Power Industries
DEFRA	(UK) Department for Environment, Food & Rural Affairs
EF	Emission Factor
EoLT	End of Life Treatment
FP7	EU 7th R&D Framework Programme
GD Satcom	General Dynamics SATCOM Technologies
GHG	GreenHouse Gas
GTO	Gross Take Off
HPA	High Power Amplifier
HVAC	Heating, Ventilation and Air Conditioning
ICT	Information and Communication Technology
ING	Intelligent Network Gateway
IPCC	Intergovernmental Panel on Climate Change
ISO	International Standards Organisations
IUG	Intelligent User Gateway
LAN	Local Area Network
LCA	Life Cycle Assessment
MW	Megawatt
PUE	Power Usage Effectiveness
QTY	Quantity
RF	Radio Frequency
UPS	Uninterruptible Power Supply
VDSL	Very-high-bit-rate Digital Subscriber Line
WAN	Wide Area Network
WBCSD	World Business Council on Sustainable Development
WEEE	Waste Electronic and Electrical Equipment
WRI	World Resources Institute

4 Requirements arising from relevant policies/legislation

European Member States have committed themselves to reducing greenhouse gas emissions (GHG) by 20 %, increasing the share of renewable in the EU's energy mix to 20 %, and achieving a 20 % energy efficiency target by 2020.

In COM(2009) 7604 [i.19] "*Mobilising Information and Communication Technologies to facilitate the transition to an energy-efficient, low-carbon economy"*, the EC notes that "The use of ICT equipment in the delivery of services represents about 1,75 % of carbon emissions in Europe; a further 0,25 % of carbon emissions come from the production of ICT and consumer electronic equipment. As the range and penetration of ICTs increase, their overall energy use is growing". The Communication went on to recommend the ICT sector set itself an energy reduction target.

In terms of carbon accounting, any organization (or indeed industry sector) is responsible for greenhouse gas (GHG) emissions in a number of ways, either directly by burning fuel or processing chemicals, through the purchase of energy from other sources, and indirectly through its supply chain the use of its products. The Greenhouse Gas Protocol is a collaboration between the World Resources Institute (WRI) and the World Business Council on Sustainable Development (WBCSD) [i.1]. It differentiates between these three different categories of emissions and refers to them as Scopes 1, 2 and 3 respectively. Recommendation ITU-T L.1420 [i.2] explains how ICT companies can apply this to their own operations.

In line with this policy landscape, the European Union has issued a number of directives to foster energy efficient design of products:

- Directive 2005/32/EC on 6^{th} July 2005 [i.20] establishing a framework for the setting of eco-design requirements for energy-using products
- Directive 2009/125/EC on 21^{st} October 2009 [i.21] establishing a framework for the setting of eco-design requirements for energy-related products.
- Directive 2010/30/EU on 19^{th} May 2010 [i.22] on the indication by labelling and standard product information of the consumption of energy and other resources by energy-related products

5 Life Cycle Assessment (LCA) Overview

5.1 Life Cycle Stages

ETSI TS 103 199 [i.3] specifies the following life cycle stages applying to ICT Equipment, Networks and Services:

a) Goods Raw material acquisition which is composed by:

- Raw material extraction.
- Raw material processing.

b) Production which is composed by:

- ICT Goods production.
- Support Goods production.

c) Use which is composed by:

- ICT Goods Use.
- Support Goods Use.
- Operator support activities.
- Service Provider support Activities.

d) Goods End of Life Treatment:

- Re-use.
- ICT specific EoLT.
- Other EoLT.

If all these life cycle stages are not assessed, this should be stated when reporting.

The LCA for a satellite broadband network is described in the following sections. For all stages, the design operational lifetime is considered to be 15 years.

5.2 Scope and Boundaries

Figure 1 (from ETSI TR 103 352 [i.4]) shows the main components of a 2 way service satellite network architecture suitable for providing broadband services. The boundary of the satellite system includes:

- The satellite composed of the payload and the platform.
- The satellite terminals composed of the antenna system (dish), the RF part (Power Amplifier, Low Noise Amplifier and filters) and the modem implementing the base band processing of the satellite radio interface.
- The Hub that includes both a Network Control Centre to manage the in orbit radio resources and a Gateway with its antenna system, the RF part, a set of modems.

The Network Control Centre is not shown here and the power consumption is ignored under cut-off rules.

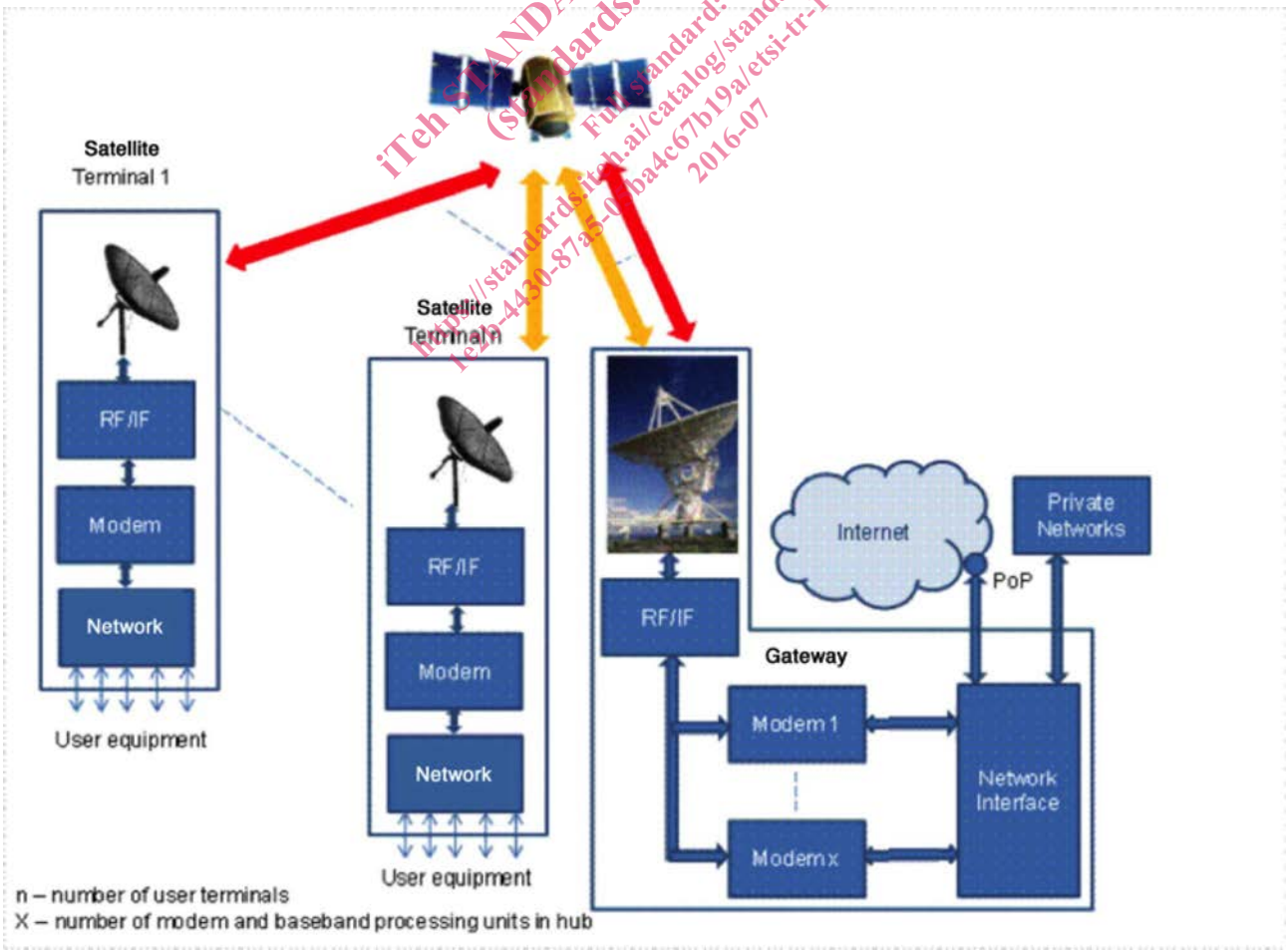

Figure 1: 2 way service satellite network architecture (e.g. Broadband)

The GHG emissions arising from a satellite network during all stages is the sum of the GHG emissions from all subsystems and equipment included within the boundary of the system under investigation. The GHG emissions per operator is the sum of the GHG emissions arising from the satellites, satellite control centres, gateways and terminals under the control of the operator that are used to provide the broadband service.

5.3 Key Input Parameters

For the purposes of the LCA, the key input parameters are:

- The total energy consumption (covered in ETSI TR 103 352 [i.4]).
- The weight of a component or subsystem.
- The lifetime of the satellite broadband system.
- The number of terminals in operation per year.
- The GHGe emission factor of the electricity supply (either for locally generated electricity if this is all that is used for the system, or the emission factor per country).
- The embodied carbon during manufacture, installation and EoLT.
- The annual change in value of the inputs over the period of the study.

5.4 Assumptions and Approximations during the LCA

The approximations made during the environmental assessment will depend on the budget available and the purpose of the assessment, and a balance should be struck between these. Often a quick provisional assessment will provide 80 % of the value from an assessment at (perhaps) 20 % of the costs. The benefits of doing this often make results available which can be acted on sooner, to improve energy efficiency of a subsystem for example, which may outweigh the value of carrying out a full LCA. A faster assessment can point to the equipment or subsystem whose environmental impact or energy efficiency should be improved without going to the expense of a full LCA, and generally a more accurate model need only be developed if there is doubt about the validity of the application of a cut off rule.

During the raw material extraction, production and EoLT stages, assumptions can be made as follows:

- The lifetime of the system in use.
  The design operational lifetime of a satellite broadband network is considered to be 15 years. This cannot be known accurately in advance but could have a significant impact on the resulting GHG emissions per annum, particularly when compared with the calculation of the embodied carbon in the other stages. If the lifetime of the system is less than predicted then the impact of the embodied carbon arising from the other stages will be higher than calculated and may therefore become more significant according to the cut-off rules.
- The use of weight or price as a predictor of the embodied carbon in a component or subsystem. In the DEFRA tables [i.5] a single figure is given to cover the raw material acquisition, proportion of recycled material and production stages. It is uncertain how accurate an assessment this provides, but does offer a way forward to what otherwise would be a very wide ranging assessment. Reference to a more detailed embodied carbon database for electronic products and recycling would be preferable if this becomes available.
- For the purposes of calculating emissions from the production stage, the satellite launch vehicle needs to be taken into account. In one example it was assumed to be the Ariane 5.
- The fuel for the delivery vehicles should be taken into account over the lifecycle. In one example it was assumed that all road transport delivery vehicles will continue to use diesel fuel rather than adopt renewable technologies such as hydrogen fuel cells.