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On behalf of the CompactLight Partnership

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Abstract

This document, prepared jointly by the beneficiaries and submitted by the Lead Partner on behalf of the CompactLight Consortium, has the purpose to inform the Commission about the performed work, achieved progress, and possible deviations in the XLS project during the first reporting period. As set out in detail and broken down by partner in the first section of the report, the activities are proceeding with success according to the planned time schedule in all workpackages. A short update on Dissemination & Exploitation is given in the second section, while the third section summarises the status of the Data Management Plan. Only minor deviations from Annexes 1 & 2 are observed and briefly described in section 4.

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1 Work carried out & Overview of the progress

Synchrotron Radiation is a fundamental tool for the study of materials in a wide spectrum of scientific and technological fields. The latest generation of light sources, Free Electron Lasers (FELs) driven by linacs, are delivering photon beams with unprecedented performance in terms of brightness, pulse duration and coherence and open substantially novel ways to probe matter. These light sources provide a very high, largely unexplored potential for innovation in science and technology and the demand for such facilities is worldwide continuously increasing, spurring plans for new dedicated machines. However, their high costs and complexity impede their wide diffusion and at present, only major accelerator laboratories in economically strong countries have enough resources to construct and operate them.

In view of this situation, CompactLight (XLS) is reconsidering now costs and spatial issues particularly for the hard X-ray facilities driven by long and expensive multi-GeV normal conducting linacs. The H2020 design study, which started in January 2018 with a duration of 3 years, has the main objective of facilitating a widespread development of X-ray FEL facilities across Europe and beyond, by making them more affordable to construct and operate, through an optimum combination of emerging and innovative accelerator technologies.

1.1 General Project Objectives

The project intends to design an hard X-ray FEL facility beyond today's state of the art, using the latest concepts for bright electron photo injectors, very high-gradient X-band structures operating at 12 GHz, and innovative compact short-period undulators. Compared with existing facilities, the proposed facility will

i. benefit from a lower electron beam energy, due to the enhanced undulator performance,

ii. be significantly more compact, as a consequence of the lower beam energy and the high gradient of the X-band structures,

iii. be more efficient with less power consumption, as a consequence of the lower energy and the use of higher frequency structures.

Compared with existing facilities, the CompactLight design will also have a smaller footprint with lower construction and operation costs, making X-ray FELs more affordable. In this spirit the project will provide the design of an ideal X-band driven hard X-rays FEL based on user-driven scientific requirements, including also options for soft X-ray operation.

In the following, the sections for the technical workpackages (WPs), WP2 - WP6, will explain in more detail the objectives resulting from this challenge for the technology and the performance of different technical components of the machine, present the work conducted in the first reporting period for their achievement, and discuss the obtained results. Also for the non-technical workpackages WP1 and WP7, the objectives, performed activities, and achieved major results will be illustrated.

1.2 Work carried out per WP

In this section we will provide, workpackage by workpackage (WP), information about the activities carried out by the project partners in the reporting period (M1-M18), indicating the contributions of the different partners, discuss potential results already achieved, and comment on encountered problems (if any).

1.2.1 Workpackage 1: Project Management and Technical Coordination.

Description. WP1 (M1-M36) deals with the overall management and technical coordination of the CompactLight Design Study to ensure a coordinated and timely implementation of the project activities according to the plannings and the achievement of the expected results. It is led by the Project Coordinator (LP). The activities carried out during the reporting period in the 4 tasks of WP1 by the involved project partners are described in the sections of the single tasks below.

Partners. The involved partners are ST (LP, leading also WP7), CERN (P1, leading WP4), STFC (P2, leading WP2), IASA (P5), UoM (P7), ANSTO (P8), UA-IAT (P9, leading WP6), INFN (P13, leading WP3), ENEA (P16, leading WP5), and ALBA-CELLS (P17), however also P22-UH/HIP has contributed considerably to some of the activities.

Deliverables. There are three deliverables in WP1: D1.1 - Creation of CompactLight public Website containing all the information relating to the project, including objectives and achievements (DEC, PU, M3), D1.2 - Data Management Plan (ORDP, PU, M6), and D1.3 - Production of a short monograph summarizing the Conceptual Design Report. (R, PU, M36).

Task 1.1 - General governance and scientific management. The aim of the task is to oversee and coordinate the project, facilitate the collaboration through appropriate collaboration instruments, support the implementation of the workpackages and tasks, communicate with the EC, monitor and support the timely achievement of the milestones, and ensure the duly submission of deliverables and reports to the EC. This includes also the risk management through the identification and communication of potential problems by the WP leaders and the joint decision-making on and implementation of corrective actions. All WP1 partners are involved in this task.

Activities carried out in Task 1.1. All partners have filled out the relevant information in the XLS Grant Management Platform of the Participant Portal, signed the Declaration of Honour as well as the Grant Agreement, and assigned the required roles in the participant portal. The partners have jointly prepared and agreed on a Consortium Agreement defining the rules for their collaboration in CompactLight. The Consortium Agreement has been signed by all XLS Beneficiaries and an original copy on paper has been distributed to each Partner. The partner P14-Kyma has requested an Amendment to the Grant Agreement in order to add KyTe as a Linked Third Party to the project. Coordinated by the LP, the request has been discussed within the Consortium and agreed unanimously by all partners. The formal request and the required changes of the contractual documents have been prepared, with support from the EC project officers and submitted to the EC on 24/05/2018. The Amendment has been signed by the EC on 26/06/2018. A collaboration platform for CompactLight, hosted on

the website of CERN, has been established in order to facilitate the exchange of documents and information and the execution of collaborative video meetings in the WPs. It consists of the CompactLight Indico space on https://indico.cern.ch/category/9776/ and the XLS Collaborative Workspace on https://espace.cern.ch/compactlight/_layouts/15/start.aspx#/default.aspx, as well as the EDMS Data Repository of CompactLight on https://edms.cern.ch/ui/#!master/navigator/project?P:100167595:100167595:structure and the XLS-GIT workspace on https://gitlab.cern.ch/XLS-Git. XLS Collaborative Workspace and EDMS are currently only accessible by project collaborators. On suggestion of P22-HIP and agreed with all partners, the Overleaf Latex Online Editor integrated with the Mendeley Reference Management Software has been adopted as a collaborative writing tool for CompactLight. Overleaf templates for different purposes as well as help in using Overleaf and Mendeley are provided to the partners if required, and P22-UH/HIP has held a couple of tutorials for interested partners. The Project has decided to use the Vidyo platform offered by CERN and linked to the CERN Indico space for video meetings. The progress in all WPs has been monitored and discussed continuously in regular WP leader / PCO meetings held in WP1.
Progress achieved in task 1.1. As reported in the Continuous Reporting Section of the Grant Management Platform, which is updated regularly by the LP-ST, all milestones (MS1-MS14) have been achieved timely. Deliverables D1.1, D1.2, D2.1, D3.1, D3.2, D4.1, D5.1, and D6.1 have been prepared by the involved partners and submitted by the responsible WP leaders in due time. More information on the single deliverables will be given in the sections of the concerned WPs.

Task 1.2 - Coordination among the participants, communication, meeting organization, project monitoring and reporting. The task is in charge of implementing and maintaining the project's management structures and procedures for decision making. This includes to install and manage the official bodies foreseen and described in Annex 1 of the Grant Agreement for the governance of the project: (Collaboration Board (CB), Project Coordination Office (PCO), Scientific Advisory Committee (SAC)), organise the project meetings and reviews, ensure a timely internal reporting, and assure the communication and flux of information within the WPs and the whole project. Involved in this task are all the partners leading a WP.
Activities carried out in Task 1.2. During the project's Kick-off Meeting, the project roles have been nominated and XLS governing bodies have been constituted. The partners have been informed that Gerardo D'Auria (ST) is the Project Coordinator (PC), Regina Rochow (ST) the Administrative Coordinator (AC) of CompactLight on behalf of the LP. Andrea Latina (P1-CERN) has been appointed as Deputy Project Coordinator (DPC) by the partners. The workpackage leaders are G. D'Auria (LP-ST, WP1), J. Clarke (P3-STFC, WP2), M. Ferrario (P13-INFN, WP3), W. Wuensch (P2-CERN, WP4), F. Nguyen (P16-ENEA, WP5), A. Aksoy (P9-UA-IAT, WP6), R. Rochow (LP-ST, WP7). It has been agreed that the PCO of CompactLight is composed of the Project Coordinator, the Deputy Project Coordinator, the Administrative Coordinator, and all the WP Leaders. Each Partner has nominated their representative in the XLS CB. All decisions requiring an agreement among the Partners have been taken unanimously.
Regarding the nomination of the project's SAC, the CB has fixed the number of SAC Members to three internationally recognized experts in the fields 'FEL Theory', 'FEL User Community', and 'Linac and Machine Physics'. The SAC members have then been selected by the CB from a list of names proposed by the partners and the selected experts have been contacted by

the PC. The three XLS SAC Members are Dr. Marie Emmanuelle Couprie, Prof. Dr. Dr. hc. Wolfgang Eberhardt, and Prof. Dr. Sverker Werin. A Non-Disclosure Agreement (NDA) has been prepared, agreed and signed between the Project Consortium and each SAC member.

To ensure an efficient communication and information exchange between all actors in the project, regular Vidyo meetings have been held in all WPs and, where needed, also in single tasks. Except for special cases, WP meetings have been announced by emails and on the freely accessible Indico website (https://indico.cern.ch/category/9776/) of the project, where also the meeting agendas can be found and the presentations may be downloaded. Minutes of the meetings are available for all beneficiaries on the XLS Collaborative Workspace (access restricted to partners, on: https://espace.cern.ch/compactlight/_layouts/15/start.aspx#/default.aspx). In each WP meeting at least one representative of the LP-ST has been present.

In WP1, 18 Vidyo meetings have been held in the reporting period (see https://indico.cern.ch/category/9778/), organised by the LP-ST and announced in Indico and by email. According to their particular objective, these meetings have been attained by the PCO / WP leaders, all WP1 partners, the communication team (see below), or the organisation committees for the project meetings composed of LP-ST, P1-CERN, and the local host institutions (Kick-off Meeting: P2-CERN, Barcelona meeting: P17-ALBA-CELLS, Helsinki meeting: P22-UH/HIP).

A **face-to-face meeting of the XLS WP leaders** and other key actors, organised by the LP-ST, has been carried out in Frascati on 5th March 2019. The purpose has been to inform and discuss about the status of the project and the work in the different WPs, including the upcoming deliverables and the progress report, take a number of decision, and plan the next activities. Representatives of all partners leading WPs have been present at the meeting.

Three face-to-face meetings of the whole project with large participation from the partners have taken place during the reporting period:

The project's **Kick-off Meeting** has been held on 25th January 2018 at CERN in Geneva as a special session of the CLIC Meeting. The meeting has been organised jointly by the LP (ST) and the local host P1 (CERN) and has been attended by most partner institutions. The morning session, open to the public and in particular to the participants of the CLIC Meeting, has been dedicated to a general presentation of the project and its technical workpackages. In the afternoon session, restricted to the project partners, project roles have been nominated and governing bodies constituted as explained above, organisational aspects have been discussed, decisions about collaboration rules and platform have been taken, the obligations of the WP leaders have been defined, and the LP-ST has provided information about the Grant Agreement and the Consortium Agreement to be stipulated between the partners.

The **1st Midterm Review Meeting** has taken place on 19th-20th June 2018 in Triest. The Meeting has been dedicated to a review of the work conducted during the first six months of the project and the planning of activities for the second semester 2018. After a general survey of the project status by the LP-ST, WP overviews and activity reports have been given for all WPs by the competent partners, major aspects discussed, decisions taken, and the next activities planned. Joint meetings have been held for WP2 & WP5 as well as WP3, WP4 & WP6 in order to discuss in more details the aspects and required decisions of mutual concern. The meeting provided also the first opportunity to meet the two SAC members (Marie Emmanuelle Couprie, Sverker Werin) who accepted the invitation to participate and to receive their feedback and suggestions, provided in a joint XLS-SAC Session and also in a brief SAC Report.

The **1st Annual Meeting** has been carried out on 10th-12th December 2018 in Barcelona, Spain. The meeting aimed at reviewing and discussing the work performed and the progress

achieved in the period M07-M12 of the project and at planning the work for the first semester of 2019. The event has also been the first possibility for the partners to meet and discuss with all three members of the project's Scientific Advisory Board SAC. The meeting structure has been largely similar to that of the Midterm Meeting in Trieste, with presentations, discussions, and planning in and across workpackages, more time has however been given for presentations and discussions, and in particular for discussions and decision-making on technical aspects concerning different workpackages as well as the whole project. The meeting revealed however that even more time should be available for technical face-to-face discussions within and among workpackages.
The **2nd Midterm Review Meeting** of the project, which took place in Helsinki on 1st-4th July 2019, has been prepared during the reporting period. This preparatory activities involved the LP-ST and the local host P22-UH/HIP for the overall organisation of the event, P1-CERN for the meeting website and subscription platform, and all WP leaders to establish the agenda and select the speakers for the presentations.

Task 1.3 - Administrative and financial coordination, handling and distribution of funds. In this task the LP-ST is in charge of the general administrative and financial project management, including advice and support to partners, coordination of financial reports and cost claims, and distribution of the received EU funding to the partners.
Activities carried out in Task 1.3. The pre-payment from the European Commission has been distributed to the project partners according to the rules established in the Consortium Agreement. All Partners have set up their internal accounting and financial reporting systems for the project according to their usual practice and the relevant European regulations.

Task 1.4 - Dissemination of information. This task has the objective to ensure an efficient communication and spreading of information to external stakeholders. To disseminate information and attract the interest of researchers, scientific laboratories and industry, meetings and thematic workshops will be promoted and organised, the partners will participate and present the CompactLight results in international conferences, and scientific publications will be prepared. Information and achieved results will also be collected and made available on the project public website.
Activities carried out in Task 1.4. An XLS communication team involving Gerardo D'Auria and Regina Rochow (LP-ST), Andrea Latina (P1-CERN), Evangelos Gazis (P5-IASA), and Markus Aicheler (P22-UH/HIP) has been created to promote the communication activities of CompactLight towards the external world. The team, with Andrea Latina as leader and Evangelos Gazis as deputy leader, is open for engagement by all partners. The team is also in charge of the data management for CompactLight. In the reporting period, the following activities have been carried out:
Website & Templates. The XLS website (https://www.compactlight.eu/Main/HomePage) has been designed and created in a timely manner (deliverable D1.1, due in M3). It consists of the pages 'Home' with a project abstract and the latest news about upcoming events, 'Collaboration' with the presentation of the Partners, 'Objectives', 'Concepts & Approach', 'News & Events', 'Publications' with the possibility to download the public documents, 'Workspaces', and 'Contacts'. The website is regularly updated by the team members. Project templates for letters, power point presentations, reports, and posters have been created and can be downloaded from the Collaborative Workspace by the Partners. Overleaf deliverable and reporting

templates as well as support to the partners are provided by the communication team. A standard presentation and a generic project poster have also been developed and are at the disposal of the Partners.

Activities for a General Audience. The project has participated with a poster (CompactLight - A hard X-ray Free Electron Laser at 12 GHz) to the Researchers Night in Athens in September 2018. An article about the CompactLight project has been prepared in the reporting period and published in Italian and English in the Section 'Research & Innovation' of the July edition of the journal 'Platinum' (www.platinum-online.com), which is dedicated to the dissemination of large national and European science projects. The print version is distributed in Italy with the Newspaper 'Il Sole 24ore' and directly to all Italian Universities and major Research Institutions. The online version is available in Italian and English languages in "Open Access" on the Platinum website and promoted also through major social networks.

Institutional Representation Events. The project has been presented at the following events of the League of European Accelerator-based Photon Sources LEAPS and FELs of Europe, two organisations representing relevant European facilities: 2. LEAPS General Assembly, 12th-13th March 2018, Triest, Italy (LP-ST); FELs of Europe Steering Committee Meeting, 13th-14th March 2018, Triest, Italy (LP-ST); LEAPS 1st Plenary Meeting, 12th-13th November 2018, DESY, Hamburg, Germany (P17-ALBA-CELLS).

Relations with other major Scientific Projects. The CompactLight Kick-off Meeting has been held as a special session of the CLIC Project Meeting 2018 on 25 January 2018 in Geneva, Switzerland (most partners present). Project activities and results have also been presented at the 12th Meeting of the TIARA Collaboration Council on 20th February 2019 (LP-ST) and at the CLIC Project Meeting 2019 on 07 May 2019, both in Geneva, Switzerland (P2-CERN). Close contacts, through some XLS partners, exist also with the H2020 Design Study EuPRAXIA (European Plasma Research Accelerator with eXcellence In Applications) and the CLARA project (FEL test facility currently under construction at Daresbury Laboratory).

Scientific Conferences, Workshops, and Seminaries. CompactLight has further been presented through posters and presentations at different scientific events, namely Future Light Sources FLS 2018 on 5th-9th March 2018 in Shanghai (China, LP-ST, P2-CERN), 11th International Workshop on High Gradient Acceleration HG 2018 on 4th-8th June 2018 in Shanghai (China, LP-ST), Physics and Applications of High Brightness Beams HBB on 8th-12th April 2019 in Rethimno/Crete (Greece, P13-INFN, LP-ST), 10th International Particle Accelerator Conference IPAC 2019 on 19th-24th May 2019 in Melbourne (Australia, P3-STFC, P17-ALBA-CELLS), and 12th International Workshop on High Gradient Acceleration HG2019 on 10th-14th June 2019 in Chamonix (Switzerland, LP-ST, P2-CERN, P22-UH/HIP). The Project Coordinator Gerardo D'Auria (LP-ST) has participated on invitation, presenting the project, in the workshop 'Towards An Ultra-Compact X-Ray Free-Electron Laser' at UCLA (USA), 2019. Simone Di Mitri (LP-ST) has held an invited talk about project-related arguments at ENEA in Frascati (Italy). The Project Coordinator, Gerardo D'Auria (LP-ST), has been invited to talk about CompactLight at the workshop EUV Sources for Lithography on 4th-6th November 2019 in Amsterdam, Netherlands.

Abstracts Submitted. The project has submitted abstracts for presentations and will participate in the 39th Free Electron Laser Conference FEL 2019 on 26th-30th August 2019 in Hamburg (Germany; LP-ST, P2-CERN, P3-STFC), the 4th European Advanced Accelerator Concepts Workshop EAAC 2019 on 15th-20th September 2019 in ELBA (Italy; P13-INFN), and the XIII Iberian Meeting on Computational Electromagnetics EIEC 2019 on 15th-18th Oc-

tober 2019 in Potes Cantabria (Spain; P21-CSIC).
Scientific Articles. Two general articles about the CompactLight project have been published in the open journals Accelerating News and CERN Courier already in Autumn 2017 (all partners involved) and deliverable D2.1 on the CompactLight science requirements and performance specification has been published as FREIA Report 2019/01 (P3-STFC, P6-UU). One scientific articles has been published in the proceedings of FLS 2018 (all partners), six in those of IPAC 2019 (all partners), one has been submitted for the proceedings of HBB 2019 (LP-ST, on behalf of all partners), and another one to 'Physical Review Accelerators and Beams'(APS; LP-ST, P3-STFC). Further publications are in preparation by different Partners.
Data Management. Since CompactLight has opted to participate in the Open Research Data Pilot, the Communication Team has compiled a 1st edition of the project's Data Management Plan and submitted it timely to the Commission (deliverable D1.2, due in M06). This document is intended as a 'living document' and has consequently been updated as part of this report (for further information see Section 3).
In summary, all management activities in WP1 have been carried out as planned and important issues in the implementation of the project, the accomplishment of intermediate results, the submission of deliverables, the achievement of milestones, the relationship among partners or with external stakeholders that might challenge the success of the project have neither been encountered in the first 18 months nor are they foreseeable for the second project period.

LP - ST, WP Leader. Before the project start, ST has, supported by the EU officers of the project, provided to the partners support for resolving problems with the EC participant portal and assigning institutional as well as project roles.
In task 1.1, ST has coordinated the preparation and signature of the Consortium Agreement and distributed an original copy to all partners. Supported by the EU officers, the team of ST has agreed with the partners, prepared and submitted the amendment for including KyTe as a linked third party of Kyma in the project. LP-ST has also contributed to the development of the collaborative platform of the project and is supporting the partners in its application, in particular for using the Overleaf Latex platform by providing templates and Latex support. In order to monitor and discuss the progress in the different WPs, LP-ST staff have participated in all Vidyo Meetings of the different WPs and have held regular Vidyo meetings of the Project Coordination Office PCO, which involves all the WP leaders, in order to monitor and discuss activities and progress in all WPs. Including those for the preparation of events, in total 18 Vidyo meetings have been organised and conducted by LP-ST in WP1, as well as one face-to-face meeting of the project's PCO in Frascati.
In task 1.2, ST has coordinated the nomination of the major project roles (PC, AC, DPC, WP leaders) during the kick-off meeting as well as the selection of the SAC members by the partners and the preparation and signature of the NDA with the SAC members. ST staff have also organised and conducted, in collaboration with the local host institution, the four face-to-face project meetings (CERN/Geneva, Elettra ST/Trieste, ALBA-CELLS/Barcelona, UH/HIP/Helsinki). This included the selection of the venue, the preparation and agreement of the agenda, the creation of the event website, the organisation of accommodation, catering, social event, and subscriptions, the invitation of SAC members and external experts, etc. as well as the coordination of the preparation of a meeting report after the event.
In task 1.3 ST has collected the bank account information from all beneficiaries receiving funding, distributed the pre-financing from the EC to all these partners according to the table

and rules established in the Consortium Agreement, and is also keeping records about the partner budgets and money transfers to the partners. Furthermore, they have informed the partners about the upcoming financial reporting to be prepared for the first progress report.
ST is participating with two staff members in all activities of the communication team in task 7.4. They have in particular developed and created, together with P2-CERN, the project website and are actively involved in continuous updates. The team has contributed to the development of the project's DMP (D1.2) and to the update of the document. ST staffs have generated the project's templates (letterhead, powerpoint, poster, ...) as well as standard posters and presentation, have prepared and are preparing the Overleaf templates for reports and deliverables, and are supporting the partners in case of problems with Overleaf. ST has presented XLS with posters and oral contributions in different institutional and scientific events: LEAPS, FELs of Europe, TIARA Council Meeting, CLIC Meeting 2018, FLS 2018, HG2018, HBB2019, HG2019, IPAC 2019, the workshop 'Towards An Ultra-Compact X-Ray Free-Electron Laser' at UCLA, and with an invited talks at ENEA. The LP-ST team has also prepared the article for 'Platinum' and coordinated the preparation of all general scientific articles about CompactLight, as well as several articles for conference proceedings and a number of abstracts for upcoming events.

P2 - CERN. CERN has primarily contributed to WP1 in the areas of coordination among the participants, communication, meeting organisation, project monitoring and reporting, namely tasks 1.1, 1.2, and 1.4. CERN provided vital infrastructure to the project: tools such as Indico, Vidyo, SharePoint, Gitlab, EDMS (the CERN Engineering and Equipment Data Management Service) have become the backbone for the communication, remote connection, storage of data and presentations of the CompactLight collaboration. The CERN-provided license to Overleaf enabled all participants to write cooperatively the deliverables. Regarding communication articles about CompactLight were published on the on-line Newsletter "Accelerating News" and on the world-distributed magazine "CERN Courier". CERN staff members are involved in the roles of Deputy Project Coordinator and WP4 leader in XLS and have thus been involved in all activities of the PCO for scientific management and monitoring, contributing to the presentations and discussions in all WP1 Vidyo meetings and XLS project meetings, as well as the face-to-face Meeting in Frascati, supporting the creation of consensus on technical arguments, has coordinated all types of reporting by the WP4 partners, and has supported the LP in the reporting on WP1 activities. CERN has hosted the CompactLight Kick-off Meeting in January 2018 and the XLS User Meeting in September 2018, providing logistical and organisational support. CERN staff is leading the CompactLight communication team in the role of the XLS Communication Manager, has been involved in the planning and implementation of the project's communication activities, has contributed in the development of the DMP (D1.2) and has coordinated the update of the document. Together with ST, CERN has developed and implemented the CompactLight website and is involved in the regular updates. The team of CERN is also supporting the partners in using the Overleaf platform by providing templates and help for problems with Latex. CERN has presented the project in different workshops and conferences (CLIC Meeting 2018, FLS2018, CLIC Meeting 2019, HG2019, IPAC 2019) and has contributed to the writing of various articles and abstracts.

P3 - STFC. As WP2 leader and member of the project's PCO, STFC staff has contributed in WP1 to all activities of the PCO for scientific management and monitoring, including coordination among the participants, communication, meeting organisation, project monitoring and reporting of tasks 1.1, 1.2, and 1.4. STFC has contributed to the presentations and discussions in the WP1 Vidyo meetings, XLS project meetings, and to the face-to-face meeting in Frascati, has supported the creation of consensus on technical arguments, and has coordinated all types of reporting by the WP2 partners. The partner has published, together with P6-UU, deliverable D2.1 as an open-access Freya Report. STFC has presented CompactLight with a poster at the IPAC2019 Conference in Australia.

P5 - IASA. The team of IASA has contributed to tasks 1.1, 1.2 and 1.3 of the project by participating in the WP1 Vidyo meetings, XLS project meetings, and internal administrative activities. IASA staff is involved in the planning and implementation of the XLS communication activities in the role of Deputy Communication Manager and has coordinated the development of the project's DMP by writing-up the first draft version, submitted on 30/06/2018 as "D1.2: XLS Data Management Plan v1.0". IASA has also contributed to the development of the project repository. The partner has presented the project to a non-scientific audience during the Researchers Night in Athens in September 2018, an event dedicated to a general public.

P7 - UoM. A member of the UoM team has been involved in WP1 as a component of the project's PCO in the general scientific management activities of the project.

P8 - ANSTO-AS. A member of the ANSTO-AS team has been involved in WP1 as a component of the project's PCO in the general scientific management activities of the project.

P9 - UA-IAT. As WP6 leader and member of the project's PCO, UA-IAT staff has contributed in WP1 to all activities of the PCO for scientific management and monitoring, including coordination among the participants, communication, meeting organisation, project monitoring and reporting of tasks 1.1, 1.2, and 1.4. UA-IAT has contributed to the presentations and discussions in the WP1 Vidyo meetings, XLS project meetings, and to the face-to-face meeting in Frascati, has supported the creation of consensus on technical arguments, and has coordinated all types of reporting by the WP6 partners. The partner has been involved in the preparation of a poster for IPAC 2019 and two articles for the proceeedings of this conference.

P13 - INFN. As WP3 leader and member of the project's PCO, INFN staff has contributed in WP1 to all activities of the PCO for scientific management and monitoring, including coordination among the participants, communication, meeting organisation, project monitoring and reporting of tasks 1.1, 1.2, and 1.4. INFN has contributed to the presentations and discussions in the WP1 Vidyo meetings, XLS project meetings, and to the face-to-face meeting in Frascati, has supported the creation of consensus on technical arguments, and has coordinated all types of reporting by the WP3 partners. INFN has hosted the XLS face-to-face PCO Meeting in March 2019, providing logistic and organisational support. INFN has presented CompactLight at the HBB2019 Conference in Crete and the work performed within WP3 with a number of posters and articles during IPAC 2019.

P16 - ENEA. As WP5 leader and member of the project's PCO, ENEA staff has contributed in WP1 to all activities of the PCO for scientific management and monitoring, including coordination among the participants, communication, meeting organisation, project monitoring and reporting of tasks 1.1, 1.2, and 1.4. ENEA has contributed in particular to the presentations and discussions in the WP1 Vidyo meetings, XLS project meetings, and to the face-to-face meeting in Frascati, has supported the creation of consensus on technical arguments, and has coordinated all types of reporting by the WP5 partners. ENEA has been involved in the preparation of two posters and articles for IPAC 2019.

P17 - ALBA-CELLS. In the framework of the WP1, ALBA has participated and contributed to all the project coordination meetings. ALBA has also co-organized as the local host partner the 1st Annual Meeting of CompactLight. In addition, with respect to task 1.4, the following activities have been done: poster presentation in the 'Facility & linked EU-Initiatives Poster Session' of the 1st Plenary Meeting of LEAPs, preparation of the website for the 1st Annual Meeting of CompactLight, preparation of a dissemination article on the 1st Annual Meeting of XLS in Barcelona on the ALBA website, informative article about XLS on Lightsources.org, communication about the project in ALBA newsletters (Juli 2018, September 2018, October 2018, November 2018 - agenda, January 2019), and website news about the 1st Midterm Review Meeting. ALBA has contributed to the presentation of CompactLight at IPAC 2019 with a poster and and article for the proceedings of the event. The costs claimed for ALBA's activities in WP1 are mostly personnel costs (29h) and 52,17 Euros for printing a XLS poster for the LEAPS meeting.

P22 - UH/HIP. UH/HIP has initiated and coordinated the development of the collaborative platform of Compactlight, has contributed to its development, and is supporting the partners in its application, in particular in using the Overleaf and Mendeley platform by providing support for Latex and the integration of Mendeley bibliographies in Overleaf documents. UH/HIP is also developing and managing the LS Data Storage Platform in EDMS. Furthermore, they have held a couple of tutorials on different components of the platform for the project partners.

P24 - USTR. In the framework of the WP1, USTR has participated and contributed to all the project coordination meetings. In addition, with respect to task 1.4, the following activities have been carried out: oral presentations at the 11th UK-Europe-China Workshop on MM-waves and THz Technologies on "Design of a Ka-band microwave undulator", Hangzhou, China Sept 2018 and the International Workshop on Breakdown Science and High Gradient Technology (HG2018), Shanghai, China, June 2018 on the "Development of MW-level Ka-band Gyro-klystrons". Travel and subsistence funds have been used to support Strathclyde staff participate in project meetings (XLS Kick-off Meeting and CLIC Workshop Jan 2018 in Geneva, Switzerland; CompactLight first 6 month progress meeting in Frascati, Italy, June 2018; the Annual Meeting, December 2019 in Barcelona, Spain; and mid-term meeting in Helsinki, Finland in July 2019).

1.2.2 Workpackage 2: FEL Science Requirements and Facility Design.

Description. WP2 is responsible for establishing the user-driven science requirements of the CompactLight facility and from these developing the accelerator and FEL parameters that will achieve this specification. In addition, WP2 coordinates the technical studies of the relevant workpackages (WP3 to WP6) to ensure that the different aspects of the full design are compatible and consistent with each other and the overall aims of the project. WP2 is also responsible for coordinating the writing of the Conceptual Design Report.

Deliverables. The deliverables of WP2 are: D2.1 - A report summarising the requests from the users and defining the performance specifications for the FEL, (R, PU, M12), D2.2 - A report summarising the FEL design, with the accelerator and undulator requirements to achieve the specification, i.e. electron energy, bunch charge, peak current, emittance, energy spread, undulator parameters, etc., (R, PU, M24), and D2.3 - The conceptual design report for a Hard X-ray FEL facility, including cost estimates, with options for Soft X-ray FEL and Compton Source, (R, PU, M36).

Tasks. To achieve these deliverables three tasks have been established: Task 2.1 (Task Leader UU) - FEL user scientists and potential users will provide specification for the Hard X-ray FEL output parameters (in terms of wavelength range, pulse energy, polarisation, beam structure, pulse duration, synchronisation to external laser, etc.). Task 2.2 (Task Leader ST) - The outcome of the previous task will be used by FEL experts (working closely with WP3, 4, & 5) to define the FEL system, with the accelerator and undulator requirements that are needed to achieve the specification (electron energy, bunch charge, peak current, emittance, energy spread, period, field strength, etc.). Then the task will identify and choose the most appropriate technical solutions considering cost, technical risk and performance. Task 2.3 (Task Leader STFC) - Engineers, accelerator physicists, undulator and RF experts will receive machine specification from FEL experts and will then design a user facility capable of achieving these requirements.

Status of WP2. WP2 has so far completed Task 2.1 and Deliverable 2.1 and is on track with all of the remaining tasks and deliverables. For the completion of Task 2.1 considerable efforts were made by the team to consult the potential users of CompactLight to ensure that the FEL output parameters were specified according to their future needs. Consultation with these users was carried out in a number of locations and formats to provide many opportunities to gather input. Two meetings were held between representatives of WP2 and experienced XFEL users based in the UK at specific UK events which were discussing the future exploitation of XFELs by UK users. Further discussions were then held with the wider XFEL user community across Europe at two conferences during 2018. The first was at the Science@FELs Conference in Stockholm in June and the second was at the Attosecond and FEL Science Conference in London in July. All of these discussions were very fruitful and we received strong support and encouragement from all the XFEL users for our project. One of the outcomes of our discussions was a deeper understanding of the various science areas that are enabled by access to XFELs and the names of the leading researchers within Europe in each of these areas. A dedicated CompactLight User Meeting was organised by the project team at CERN in November 2018 to which the leading researchers from across Europe

were invited (https://indico.cern.ch/event/750792/). For those researchers who were unable to attend the user meeting a questionnaire was sent to them asking them to provide detailed information about their future photon output requirements. The culmination of this process of consultation was the production of D2.1 in December 2018.
Whilst the performance specification of the FEL facility was being discussed with potential users the team started to assess how the photon output would be translated into an electron beam and undulator specification (task 2.2) and how this might in turn be physically laid out as a user facility (task 2.3). Options were started to be assessed for various combinations of electron parameters (energy, bunch charge, emittance, and so on) and the consequences of such choices. For example, lower electron energy is likely to be more cost effective but will not generate such high photon pulse energies as higher electron energies. Similarly higher bunch charge will lead to higher peak currents, which is beneficial for the FEL process, but also larger emittance, which is detrimental to the FEL process. Prior to the photon parameters being finalised, generic studies of this nature were carried out under task 2.2. For task 2.3 the overall layout has started to be assessed in the light of the user requirements. This has included the proposal to install two independent FELs fed by the same linac so that the user requirement for two independent XFEL photon pulses of quite different wavelength and arrival time can be achieved. The contributions of all of the involved partners in WP2 are given below:

P3 - STFC, WP Leader. As the WP Leader STFC has organised all of the efforts within WP2 towards achieving the agreed deliverables. Task leaders have been appointed for all three tasks and D2.1 has been completed on time and is available open access at http://urn.kb.se/resolve?urn=urn:nbn:se:uu:diva-374175. STFC has chaired several WP2 video meetings and sessions at our projects face to face meetings. In addition, STFC worked very closely with UU on Task 2.1 in terms of interactions with FEL users in order to establish a clear and compelling facility parameter list for CompactLight. These activities included holding a dedicated user meeting at CERN and attending a number of FEL workshops to discuss the project and potential parameters as widely as possible. STFC also helped to draft the user questionnaire and create the list of users to whom it was sent.

LP - ST. ST has contributed to the definition of the electron beam and FEL parameters for the SXR and HXR options. ST has identified two alternative 2-pulse, 2-color schemes for either alternated or simultaneous operation of the SXR and HXR FELs. ST is also the task leader for 2.2, and as such, works closely with the other technical workpackages to establish a clear set of electron and undulator parameters that will meet the agreed facility output specification. As the LP of the project, ST has participated in all WP2 Vidyo meetings to keep track, remain informed, and discuss about activities, progress, and open questions.

P2 - CERN. CERN has primarily contributed to WP2 in the area of facility design. Extensive experience has been gained by CERN in X-band linacs during CLIC design studies, as well as in other related X-band project studies, and during the construction and operation of the high-gradient X-band test stands at CERN. This experience was extensively used during the complex process of determining the FEL science requirements of CompactLight and the high-level parameters and performances of the facility. Fast feedback on the impact of a particular parameter for example was regularly provided to the discussions and studies of WP2.

CERN has also set up a Project Breakdown Structure (PBS) which is implemented in the Electronic Document Management System (EDMS). This is now being populated with appropriate technical data.

P4 - SINAP. SINAP have been present at all the Midterm Review Meetings and Annual Meetings of the project, participating in the technical discussions on WP2 arguments.Their main contribution to WP2 is however expected for the second reporting period.

P6 - UU. Within WP2, the Uppsala University (UU) group has been responsible for Task 2.1, which was to identify science requirements for the CompactLight project. The task was completed in December 2018 and the corresponding open access report was published as part of the FREIA Report Series by the UU library: A. Mak et. al. "Science Requirements and Performance Specification for the CompactLight X-Ray Free-Electron Laser", FREIA Report 2019/01. The report was also submitted as a deliverable to the H2020 project office. A number of actions were performed to accomplish the task:

- UU group participated in two conferences (Science@FELs Conference in Stockholm, Sweden in June 2018 and the Attosecond and FEL Science Conference in London, UK in July 2018) to hear about the latest scientific achievements using FEL facilities and to informally interact with leading researchers to gather their views on the parameters and performance of future FELs.
- Together with other partner institutes, UU group prepared a dedicated questionnaire that was sent to over 50 FEL experts within Europe. The raw data of the survey as well as the summarized findings are available in the mentioned report.
- UU group took part in the preparation of a dedicated CompactLight User Meeting that was held on the 27th - 28th of November 2018 at the European Organisation for Nuclear Research (CERN) in Geneva, Switzerland, where they presented also the results of the user survey.

P7 - UoM. UoM have taken part in specific WP2 video meetings as well as general discussions during the project face to face events. They have provided input on potential XFEL users to contact as part of the user consultation process.

P9 - UA-IAT. The UA-IAT which is leading the Work Package 6 - Beam dynamics and start to end modeling- contributed in clarifying the beam parameter set and possible CompactLight layout based on beam parameter options. To provide the key parameters and performance estimates of a facility which meets the user requirements, UA-IAT carried out possible injector options, beam transport with main accelerator, and bunch compression schemes as well as the beam transport in lasing sections of both Hard and Soft X-Ray beamline. The team focused on lattice layout and the beam stability issues based on the defined machine parameters presently.

P13 - INFN. The INFN contribution to WP2 activities has been focused on the definition of the reference beam parameters list required to properly drive the FEL (Task 2.2). This contribution includes the specifications of the injector performances that have been obtained after an investigation of the possible injector configurations and a number of beam dynamics simulations. The injector beam parameters have been frozen during a WP2/WP3/WP6 meeting organized at LNF on March 5, 2019. INFN has also performed an extensive investigation of the possible X-band linac configurations, with particular reference to the RF power source and distribution systems, resulting in the definition of the preliminary baseline X-band module for the CompactLight FEL linac (Task 2.3). Beam dynamics simulations including wake field effects and tolerance studies have been also performed. INFN has also contributed to identify the possible users requirements based on the experience developed during the recent design study performed at INFN for the EuSPARC project (Task 2.1).

P17 - ALBA-CELLS. In the framework of the WP2, the main activities developed by ALBA have been associated to the Task 2.1, to define, together with the FEL and potential users, the required specifications for the FEL output parameters. ALBA has participated in most of the meetings and actions dedicated to this goal.
In this aspect, specifically, ALBA has reviewed the Spanish community of dynamic science, users of pulsed lasers, users of synchrotron radiation and FELs, in order to provide a short list of invited scientist for the CompactLight Users Meeting held at CERN, 27-28 November 2018, mainly in the scientific field of Atomic and Molecular Physics and Photochemistry. Francis Perez, from ALBA, attended the users meeting and contributed to the definition of the required specifications.
In addition, since ALBA is also participating in work packages that have to work closely with WP2 (i.e. WP3, WP5 and WP6), internal meetings have been held regularly to coordinate the different tasks.

P18 - CNRS. The CNRS contribution to WP2 has focussed on the layout options of the injector and linac sections of the facility design, especially on the implications of the S-band RF photoinjector option. CNRS have joined the video meetings and taken part in discussions at the major face to face project meetings.

1.2.3 Workpackage 3: Gun and Injector.

Description. The objective of WP3 (M1-M36) is to provide a design of the injector system from the electron source up to the energy of 300 MeV. At about 300 MeV in fact the electron beam experiences a transition form the “space charge” dominated regime to the “emittance dominated” regime and the emittance compensation process, performed by the injector itself, can be considered accomplished. The target injector parameters have been discussed during the WP3 meetings together with the WP2 and WP6 colleagues, and have been fixed as reported in the following table.
To achieve these parameters the injector design should consider integrating various components. From the electron source gun (including cathode material definition and laser system specifications) to the capture section needed to boost the beam energy up to 300 MeV, including the possibility to operate in the Velocity Bunching configuration or alternatively with a

Parameters	Units	After VB and/or BC1
Charge (Q)	pC	75
Beam energy	MeV	300
rms bunch length (σ_t)	fs	350
Peak current ($Q/\sqrt{12}\,\sigma_t$)	A	60
rms Energy Spread	%	0.5
Projected rms norm. emittance	µm	0.2
Repetition rate	Hz	100 -1000

Figure 1: Target injector parameters

magnetic compressor system. Additional components are required to provide the proper parameter optimization like the higher harmonics RF structure for the longitudinal phase space linearization, the energy spread de-chirper and the X-band RF deflector system to provide the adequate longitudinal diagnostics. Downstream the injector the beam is properly matched to the X-band linac and boosted to the final energy.

Partners. The WP3 involved partners have been INFN (P13, WP3 leader), ST (P1), CERN (P2), IASA (P5), UA-IAT (P9), ULANC (P10), TU/e (P12), Sapienza (P15), ALBA-CELLS (P17), CNRS (P18), CSIC-IFIC (P21). With respect to the original XLS proposal the participant USTR (P24) has moved its activity and person/months from WP3 to WP4. Conversely the CSIC-IFIC (P21) has moved its activity and person/months from WP4 to WP3, in both cases in fully agreement with the Project Leader and the WP3 and WP4 leaders.

Deliverables. The expected WP3 deliverable are:

D3.1 Preliminary assessments and evaluations of the optimum e-gun and injector solution for the CompactLight design, (R, PU, M18).

D3.2 A review report on the bunch compression techniques and phase space linearization, (R, PU, M18).

D3.3 Design of the injector diagnostics/beam manipulations based on a X-band cavities, (R, PU, M36).

D3.4 Design of the CompactLight e-gun and injector, with phase space linearizer (R, PU, M36).

Reports D3.1 and D3.2, both due by Month 18, have been successfully delivered in due time.

Tasks and Sub-Tasks. The activities of the WP3 have been organized with some modifications with respect to the original proposal in order to clarify the goals and the partners responsibilities, keeping anyway the original Milestones and Deliverable unchanged. The new Tasks and Sub-Tasks have been organized with distributed responsibilities (in brackets the reference institute) as follows:

Task 3.1 - Gun Design

a) S-Band Gun RF Design (CNRS)
b) C-Band Gun RF Design (INFN)
c) X-Band Gun RF Design (CSIC)
d) DC Gun Design (TU/e)
e) Laser/Photocathode (IASA)

Task 3.2 - Compressor Design

a) S-Band Velocity Bunching (TU/e)
b) C-Band Velocity Bunching (INFN)
c) X-Band Velocity Bunching (Sapienza)
d) Magnetic Compressor (ST)

Task 3.3 - X-Band Transverse RF Deflector (Sapienza)

Task 3.4 - RF Linearizer Design

a) X-Band RF Linearizer Design (Sapienza)
b) K-Band RF Linearizer Design (ULANC)
c) Passive linearizer (CNRS)

The activities carried out during the reporting period in the 4 tasks of WP3 are described in the sections of the single tasks below.

Task 3.1 Gun Design. The goal of this task is to investigate the possible electron source and gun options suitable to match the CompacLight X-band high brightness injector requirements. Different schemes are under investigation including RF gun injectors at different operating frequency (S-, C- and X-band) and a DC gun based design.
Activity carried out in Task 3.1. The electromagnetic and RF designs for all cases have been investigated, including a preliminary evaluation of the laser/cathode system requirements. Matching with the downstream linac has been also investigated with beam dynamics simulations in collaboration with WP6. The preliminary results of Task 3.1 have been included in the Deliverable D3.1, where a “Preliminary assessments and evaluations of the optimum e-gun and injector solution for the CompactLight design” has been reported. As discussed in D3.1, it results that the state-of-the-art S-band injector looks appropriate to achieve the required parameters at low repetition rate (≈ 100 Hz). On the other end, a compact C-band (or X-band) RF gun design is expected to have even better performances at low repetition rates and moreover, due to the lower thermal load, could allow higher repetition rates operation, in principle up to 1 kHz, with acceptable performances degradation. DC guns are also very promising solutions for kHz range operation despite less compact. High repetition rate operation is now under active investigation being one of the main innovations expected by Task 3.1. Concerning the photocathodes the investigation performed suggests the metallic photocathode Cu for high gradient and the semiconducting photocathode Te_2Cs for low gradient gun

operation. The case of Yttrium cathode is under study. A significant progress with respect to state of the art RF guns has been achieved in this Task concerning the design of the C-band injector system. The proposed design is based on a gun with a mode launcher coupler powered with extremely short pulses of less than 200 ns. The gun is followed by two TW accelerating structures operating at 40 MV/m and solenoids to maintain under control the beam emittance increase due to space charge effects. Calculations on the possibility to operate the gun at a repetition rate of 1 kHz have been also performed. Preliminary beam dynamics simulations have been done demonstrating that the beam requirements at the end of the injector can be achieved.
Participants. the involved partners in this task have been INFN (P13), CERN (P2), IASA (P5), UA-IAT (P9), TU/e (P12), ALBA-CELLS (P17), CNRS (P18), CSIC-IFIC (P21).

Task 3.2 - Compressor Design. The goal of this task is to investigate the proper compression system for the CompactLight injector. Different schemes are under investigation: RF Velocity Bunching (VB) at different operating frequency (S- and C-band), different geometries of the magnetic compressor (C-type and S-type chicane, arcs, doglegs) and different RF frequency of the higher harmonic cavity for linearization of the compression process (X and K-band).
Activity carried out in Task 3.2. A detailed investigation of the VB capability versus Magnetic Compressor system has been carried out in collaboration with WP6. In particular the convenience of velocity bunching in the injector, in combination with a downstream magnetic compression has also been investigated and emphasized with particle tracing runs. Options of linearization through either passive dielectric or metallic structures, or sextupole magnets have been also investigated. The preliminary results of Task 3.2 have been included in the Deliverable D3.2 where “A review report on the bunch compression techniques and phase space linearization” has been reported. The report is completed by particle tracking runs identifying one of the most suitable compression schemes in combination with optimized beam parameters at the exit of the injector, in consistency with Deliverable D3.1. By the end of October 2019 the WP3 partners are committed to provide a preliminary injector design chosen among the 4 options (S, C, X, DC) under investigation, and to start the integration process with the downstream X-band linac and compressor system. This goal will mainly involve Task 3.1 and Task 3.2.
Participants. the involved partners in this Task have been ST (P1), CERN (P2), IASA (P5), UA-IAT (P9), INFN (P13), TU/e (P12), Sapienza (P15), ALBA-CELLS (P17), CNRS (P18), CSIC-IFIC (P21).

Task 3.3 X-Band Transverse RF Deflector. The goal of this task is to provide a design study of a fundamental injector diagnostics that is the high-resolution (< 100 fs) bunch length measurement. The X-band RF deflector system is expected to be the ideal tool to provide the required performances and compactness characteristics.
Activity carried out in Task 3.3. An overview of the existing S-band RF deflector systems has been done in order to evaluate a possible scaling approach to X-band frequency. Preliminary electromagnetic design is also started. The output of this task is expected to be included in the Deliverable D3.3 “Design of the injector diagnostics/beam manipulations based on a X-band cavities”.
Participants. The involved partners have been Sapienza (P15) and INFN (P13).

Task 3.4 - RF Linearizer Design. The goal of this task is to provide a design study of the longitudinal phase space linearization system based on X- or K-band RF structure to be integrated in the compression system design foreseen by Task. 3.2.
Activity carried out in Task 3.4. a higher harmonic RF accelerating structure has been designed in order to linearize the longitudinal space phase. Based on a compact TW accelerating structure operating on the third harmonic with respect to the linac frequency (11.994 GHz) with a 100-125 MV/m accelerating gradient by using conservative main RF parameters. The structure design as well as the engineering of the RF power source that will be able to produce up to a 40-50 MW input power by using a SLED system will be completed in the next months. In case of the single bunch operation, also a numerical and analytical study of the longitudinal and transverse wakefields on the beam dynamic effects has been carried out and discussed. It results that the estimated longitudinal and transverse wakefields on the beam dynamic gave no specific trouble. Numerical electromagnetic simulations were carried out by using the numerical codes HFSS and CST. The output of this task is expected to be included in the Deliverable D3.4 "Design of the CompactLight e-gun and injector, with phase space linearizer".
Participants. The involved partners have been ULANC (P10), INFN (P13), Sapienza (P15), CNRS (P18).

All the participants have contributed to WP3 activities according to the following summary:

P13 - INFN, WP Leader. INFN has been the leading partner of the WP3 activities including the organization of 4 remote and 1 face-to-face meetings and the organization of the WP3 discussion time during the XLS general meetings. INFN has also coordinated the preparation of Deliverable D3.1. The INFN research activity in Task 3.1 has been oriented to a preliminary design of the S-band and C-band injectors by using simulations codes like T-STEP, ASTRA and GPT. In particular for the C-band option a new RF gun has been also designed. This study has been focused to achieve a cathode peak field larger than 200 MV/m maintaining under control all the main quantities that drive the breakdown phenomena in normal conducting structures, such as the peak electric and magnetic fields and the modified Poynting vector. Another contribution concerns the development of Yttrium cathodes promising to minimize the thermal emittance and simplify the cathode driving laser system. INFN has been also working on the bunch compression study in the framework of Task 3.2 (see deliverable D3.2) in particular on the CSR effect and its mitigation. INFN has also designed a higher harmonic RF accelerating structure (Task 3.4) in order to linearize the longitudinal space phase based on a compact TW accelerating structure operating on the third harmonic with respect to the linac frequency (11.994 GHz) with a 100-125 MV/m accelerating gradient. Numerical electromagnetic simulations were carried out by using the numerical codes HFSS and CST.

LP - ST. In the framework of the WP3, ST has coordinated the preparation of the deliverable D3.2, (Task 3.2) i.e., a review report on magnetic compression schemes and linearization process in state-of-the-art free electron lasers (FELs) driven by high brightness electron linacs. In the D3.2, ST has specifically contributed to the definition of the report contents, to the illustration of the theoretical background of magnetic compression, to the analytical and numerical design of the compression scheme for CompactLight based on S-band injector and X-band linearizer. The validity of the analytical design of the compression scheme for CompactLight has been evaluated through 1-D tracking code LiTrack, in the presence of linac geometric wakefields. This process has launched a 3-D simulation study to be completed by the end of 2019. As the LP of the project, ST has participated in all WP3 Vidyo meetings to keep track, remain informed, and discuss about activities, progress, and open questions.

P2 - CERN. CERN has primarily contributed to WP3 in the areas of the 'Full X-band' option of CompactLight, and of a compact S+X injector scheme (Task 3.1). Using a realistic beam distribution for an X-band gun, the main parameters of the Full X-band layout were defined using the code 'Track1D'. This code implements 1D tracking in presence of wakefields. The parameters of the Ka-band lineariser (Task 3.4) were defined, considering the impact of the short range wake fields in the longitudinal plane. Also, different compression schemes for bunch compressors were compared (Task 3.2): magnetic chicanes, arc compressors, and dogleg compressors. A 1D linac design was elaborated, and preliminary stability and tolerance studies were performed. CERN proposed also a compact injector consisting of an S-band gun followed directly by X-band bunching and acceleration. This seems an attractive scheme because it combines proven and easy to use S-band technology for the gun with the compact high-gradient X-band for acceleration, potentially using a standard linac module.

P5 - IASA. In the framework of WP3 IASA has contributed to Task 3.1 to the investigation the best photocathode/laser selection, proper to the high/low accelerating voltage. ASTRA beam dynamics simulation studies have been also performed comparing the transverse emittance, plus other beam parameters, for the two photocathodes Te2Cs vs Cu, under the S-/C-band specifications of the e-gun, taking into account an after cathode solenoid. DYNAC simulations were performed on a DC gun. ASTRA simulations were obtained, with 1.6, 2.5 and 5.6 cavity cells, for the beam parameters with various cavity voltage values and solenoid distances from the photocathode. Further optimization was performed with the GIOTTO code. Concerning Task 3.2 IASA has performed a preliminary design of the Solenoid and RF-cavity with the MATLAB/OCTAVE and SUPERFISH codes. The study for the gun and TW solenoids is under continued progress. First 3D design results of the e-gun have been obtained via the CATIA code. Calculations for the e-gun vibrations; taking into account the weight load to the e-gun girder will be started.

P9 - UA-IAT. The UA-IAT has carried out the beam dynamics simulations for X-Band photo cathode RF gun which is one of the injector option proposal for CompactLight design. The team has provided first preliminary designs for the RF gun structure and the solenoid coil for the same injector layout. In addition, the team contributed bench marking studies between codes for the injector. Since UA-IAT is leading the Work Package 6 - Beam dynamics and start to end modeling- UA-IAT has also contributed the efforts for clarifying the beam parameter sets convenient for CompactLight Injector Design.

P10 - ULANC. the University has hired a postdoctoral research assistant for 10 months dedicated to the electromagnetic design and feasibility studies for the Ka-band linearizer system. So far 2 months have been spent on the preliminary parameter study and we are now awaiting specifications from the beam dynamics work package. We have produced plots of cavity parameters to work out the required power as a function of cavity length for each aperture, and performed some preliminary wakefields studies. Initial studies of pulse compressor parameters have also been undertaken. In the next few months we will be ramping up activities to investigate Ka band klystrons before finalizing the overall system design. This work has been carried out in close collaboration with the WP4 and other WP3 partners, to take into consideration the powering requirements, as well as the impact of the use of such structure on the beam dynamics. As a result, a summary of this study was presented as a proceeding paper in the 10th International Particle Accelerator Conference in Melbourne, Australia.

P12 - TU/e. For its contribution to WP3, TU/e has been investigating the feasibility of a DC-gun injection scheme. To perform the tasks, TU/e has been working with ARCNL and has assigned a postdoctoral position (T.G. Lucas) to the design and commissioning of the injector. On top of this are four academics (O.J. Luiten, P.H.A Mutsaers, R.A. Hoekstra and X.F.D. Stragier) with a vast knowledge of low energy injectors. The basis of this design is a DC photogun which has been commercialized and demonstrated a high reliability and robustness. In order to inject into an X-band main linac, an X-band booster linear accelerator has been designed in HFSS which boosts the 100 keV electrons to 20 MeV. In combination with an L-band bunch compressor and focusing solenoids, the injector's beam dynamics have been modelled in GPT demonstrating the feasibility of using the DC gun. The future prospects of this work will include expanding the simulations to the desired beam parameters, including an investigation into the two colour injection, and the building and commissioning of the injector.

P15 - Sapienza. Sapienza group designed a RF X-band structure to be used for RF linearizer and for velocity bunching (Task 3.2 and 3.4). The design started from the specifications given by beam dynamics (e.g. the minimum iris radius and accelerating voltage needed) and the maxim allowed space to fix the necessary electric field. Sapienza group produced a first design with a constant impedance device and 4mm iris radius. Because of beam dynamics issues, after some iterations with the simulation group, the design has been modified proposing also a 5mm iris radius and investigating the use of constant impedance as well as constant gradient structure (with SLED). The 4mm iris design included the single cell design, the coupler design, the breakdown analysis and the full structure simulation. The 5mm iris design is limited to all the single cell issues, including the breakdown analysis (with modified Poynting vector) as well. All the previous studies have been performed with CST simulation code. Concerning design of RF deflecting structures (Task 3.3), the survey of existing solution has been done and preliminary design of a TW solution has been started.

P17 - ALBA-CELLS. ALBA has participated mainly in the Task 3.2 of WP3, in the evaluation of the S-Band Injector. To perform the task ALBA has hired a PostDoc researcher, Edu Marin, and dedicated part of the time of a staff of the Linac group of ALBA, Raquel Munoz. ALBA has participated in all the videoconference meetings of the work package, in the three mid review meetings (Trieste-June 2018, Barcelona-December 2018, Helsinki-July 1019), and Edu Marin presented ALBA results in the last two meetings. Specifically, ALBA has participated in the cross-checking of the S-band injector simulations. In detail, the simulations carried out by INFN using T-STEP and ASTRA codes have been contrasted by using our code, the GPT. The results between the code have shown an excellent agreement, indeed the differences in most of the relevant beam parameters is found to be within few per cent.

P18 - CNRS. The CNRS has contributed to Task 3.1, Task 3.2 and Task 3.4 of WP3, in particular for Task 3.1 has provided a comparative study of the different S-band RF guns that could be a proper choice for an S-band injector option, the results are reported in the deliverable D3.1. For Task 3.2 the CNRS team has studied the options of linearization through either passive dielectric or metallic structures, or sextupole magnets, which can be used to eliminate the non-linear effects generated from the RF linacs and the magnetic chicanes. The results of that are reported in the deliverable D3.2. Finally the CNRS has contributed to the passive linearizer design in the Task 3.4. The theoretical investigation for the passive linearizer has been finished and the Monte-Carlo simulation is on-going. The simulation includes the design of the passive structures, the wakefield calculation and beam tracking. The comparison between the RF high order mode linearizer and the passive linearizer with realistic parameters will also be performed. CNRS has participated and reported about this work in the video conference meetings and in the Compact Light's meeting reviews.

P21 - CSIC. the tasks carried out by the IFIC (CSIC-UV) in the framework of WP3 has been focused on the design of an X-band RF electron gun. The RF photoinjector design investigated is based on a 5.6 cells standing wave structure operating with the π-TM010 mode of the cylindrical cavity. The way to couple the RF power from the generator to the RF photogun is by means of a coaxial waveguide coupler, which preserves the circular symmetry of the entire device. First, the RF design of the structure is optimized to fulfill the desired specifications (RF electric field profile in cells to ensure proper electron acceleration, operating frequency, coupling factor, etc.). This task was performed using the SUPERFISH, which is a 2D software very efficient for solving RF electromagnetic problems with circular symmetry. After this, an exhaustive analysis of the RF electromagnetic performance of the RF photoinjector was carried out, taking into consideration the RF pulse heating, the RF breakdown risk due to the presence of high intensity RF electromagnetic fields, the multipactor discharge risk at the coaxial coupler, and undesired neighbour modes effects.

1.2.4 Workpackage 4: Linac and rf system

Description and summary. The focus of WP4 is the design of the linac, and corresponding rf system, of CompactLight which represents a major part of the overall facility cost. The linac begins at the output of the injector where the beam is fully relativistic, with an energy of 300 MeV, and ends when the beam has achieved its final energy of 5.5 GeV. The linac is composed of repeated modules, each with an identical layout and composition - specifying the modules is a key overall objective of the WP4. The main components of the module rf system are the modulator, klystron, pulse compressor, waveguide network and accelerating structure. The module also includes diagnostics, magnetic elements such as focusing quadrupoles and correcting dipoles as well as sub-systems such as vacuum and cooling.
Significant progress has been made in defining the layout and dimensions of the linac modules, as well as the detailed specifications designs of the components which make up the modules. This has been carried out through numerous exchanges inside of WP4 as well as extensive exchanges with other work packages especially WPs 2,3 and 6.
During the WP4 design process, the possibility to operate the linac with different combinations of final energy and repetition rate - specifically high energy/normal repetition rate and low

energy/high repetition rate modes - has emerged and been defined. This adds an important new capability to the CompactLight design.
Partners. The WP4 involved partners have been CERN (P2, WP4 leader), ST (P1), SINAP (P4), UU (P6), UA-IAT (P9), VDL ETG (P11), INFN (P13), UH/HIP (P22) and USTR (P24).
Deliverables. The first deliverable was prepared and completed on time during this reporting period: Deliverable D4.1: Report on the computer code and simulation tools which will be used for rf power unit design and cost optimization.
Tasks. The work package is organized with the following task structure:
Task 4.1 Layout and optimzation of the linac rf system
Task 4.2 Industrialization
Task 4.3 Klystron and Modulator Technology
Task 4.4 Power sources for higher-harmoic systems
Task 4.5 Integration

Progress in the individual tasks are outlined below, followed by progress elaborated by partner.

Task 4.1 Layout and optimzation of the linac rf system. The goal of this task is to develop the overall RF powering schemes and the relevant RF structure designs including accelerating structures, linearizers and pulse compressors.
Activity carried out in Task 4.1 The work done so far has been mainly devoted to the design optimization of the X-band accelerating structure and of X-band accelerating module which are the baselines of the linac design. The accelerating structure design is mainly constrained by the minimum acceptable average radius of the iris aperture of the cells, that has been set to 3.5 mm in WP6 according to transverse beam dynamics considerations. On the base of this data and taking into consideration the shape of the compressed RF pulses powering the linac, an optimal accelerating structure has been designed, which resulted to be 90 cm long with a proper linear tapered profile of the cell irises. The baseline RF module will consist in 4 RF structures powered by one klystron through a pulse compressor system. The pulse compressor consists of a spherical X-band pulse compressor, and was preliminary tested in the high power test setup in BVERI, finally the multiplying factor of peak power is about 6 similar to design. By using a commercial 50 MW peak klystron, the module average accelerating gradient will exceed 65 MV/m, with an expected breakdown rate well below the acceptable limits. Efforts are undertaken in order to increase the overall repetition rate of the machine and linac from 100 Hz to 1 kHz. Preliminary schemes of possible RF modules suitable for high rep rate operation have been also elaborated.
Participants. The involved partners have been CERN (P2), SINAP (P4), UU (P6), UoM (P7), ANSTO (P8) and INFN (P13).

Task 4.2 Industrialization. The goal of this task is to report on the optimized for series industrial production of the designed accelerating structure (in other WP4 task), which is an important cost driver for the facility.
Activity carried out in Task 4.2 An approach for the breakdown of the design into mono-parts and assembly steps for particle accelerator hardware has been defined. In discussion with work package partners (WP4) the scope has been confined to the accelerator structure itself, because this is the most critical subassembly in the RF structure with respect to machining and assembly. During the Midterm meetings in Trieste and Helsinki and WP-telecon meetings the

approach was discussed such that the industrialization can be started based on the outcome of the design work. The approach is to make a breakdown that includes all steps between (preliminary) design and final realization including e.g. design for manufacturability, NRE-costs, machining- , assembly- and test-approach and -costs. In order to meet the deliverable date (end of project) it was decided that, if the RF design is not available by September 2019, the breakdown will be based on the “brazed PSI X-band”. In case base-line will be “brazed PSI X-band” structure, new input from the RF-design yielded by WP4, will be incorporated if reasonably possible.
Participants. The involved partners have been CERN (P2), VDL ETG (P11), INFN (P13), UH/HIP (P22).

Task 4.3 Klystron and Modulator Technology. The goal of this task is to choose a power source suitable for XLS RF unit based on X-band technology.
Activity carried out in Task 4.3 The investigation done by the WP2 among the FEL users showed strong preference towards high repetition rate operation of the XLS linac. In view of these results a survey of the existing Xband klystrons and modulators was done. This showed that currently there are very limited options. This led to the series of discussions with experts and industrial partners to identify the current limitations of the systems and on possibilities for modifications and new development of the existing products to increase the repetition rate.
Two possible solution were identified. First one based on a high power klystron, where the repetition rate could be increase by factor 2 to 2.5 at the expense of RF power and pulse duration. In this case the RF tube shifts from optimal working point and the total efficiency decreases but the repetition rate of 200 to 300 Hz could be achieved.
The second option could increase the repetition rate even further by combining the power from two (or more) low power, high repetition rate units that are also available on the market. This increases the complexity of the system but maintains the nominal efficiency of the RF klystrons. With this option we should able to run the linac with 1kHz repetition rate. Three preliminary options for the linac design based on these two solutions have been proposed during midterm meeting and discussed among members of XLS. In the future we will evaluate the performance of all three designs. It is important to add that thanks to our discussion with the companies two manufacturers are already preparing prototypes of the high repetition rate units that could be even more suitable for XLS project.
Participants. The involved partners have been CERN (P2), UU (P6), INFN (P13).

Task 4.4 Power sources for higher-harmoic systems. The goal of this task is to investigate the RF power sources to drive the higher-harmonic systems. The RF power source is required to deliver 3 MW output power at 36 GHz with a repetition rate of 1 kHz.
Activity carried out in Task 4.4 Different types of high power microwave sources were reviewed. The gyroklystron was chosen because it can achieve high power 3 MW amplification at a high frequency of 36 GHz and has the potential to operate at a high pulse repetition frequency of 1 kHz. Gyroklystrons with different cavity numbers were investigated and a three-cavity configuration was chosen as the optimum balance between gain, efficiency and complexity. Linear and non-linear codes were developed to evaluate the performance. The design was further verified by using 2D Particle-in-Cell simulations. A gyro-klystron designed to achieve 2 MW

output power was published in a refereed journal paper [2] with the design upgraded to achieve 3 MW output power.
Participants. The involved partners have been USTR (P24).

Task 4.5 Integration. The goal of this task is providing a framework for condensing/bringing together mechanical designs and related systems designs and ensuring proper interfacing with adjacent injector and undulator as well as establishing lists of components for costing exercises.
Activity carried out in Task 4.5 Multiple iterations of the potential RF module layout have been developed and various schemes for the module layout of the different configurations for different linac options have been established. A coherent design is now achieved with minimum longitudinal dimension, further enhancing the compactness of the machine . Additionally, a list on component dimensions and overall resulting module lengths as a general guideline for the other work packages (e.g. WP6) has been established. Lastly, a list of individual components which are not attributed to any other partner within the WP (such as magnets, vacuum systems, etc.) has been completed and will be worked on in the next phase of the project.
Participants. The involved partners have been UH/HIP (P22) and CERN (P2).

All the participants have contributed to WP3 activities according to the following summary:

P2 - CERN, WP Leader. CERN has provided the leadership of WP4. This has included co-ordination of scientific and technical work in the various tasks, regular vidyo meetings https://indico.cern.ch/category/9781/, organization of WP4 contributions to CompactLight-wide events and organization, collation and editing of reports including the first WP deliverable D4.1. CERN has given extensive technical guidance for the work carried out in WP4 based on experience gained in the CLIC project, the XBox test program and other high-gradient and X-band projects. A preliminary design of the full rf system for the harmonic linearizer system, including waveguides and pulse compressor based on the Strathclyde designed gyroklystron. CERN has also set up a Project Breakdown Structure (PBS) which is implemented in the Electronic Document Management System (EDMS). This was initially implemented for WP4 but is now being adopted over the project as a whole.

LP - ST. As the LP of the project, ST has participated in all WP4 Vidyo meetings to keep track, remain informed, and discuss about activities, progress, and open questions.

P4 - SINAP. In the past 18 months, SINAP has worked on development of X-band high gradient accelerating structure, spherical X-band pulse compressor, C-band photoinjector. SINAP designed one new X-band accelerating structure dedicated for FEL linac. The X-band accelerating structure is about one meter, and it is designed with large beam aperture to improve beam quality, meanwhile round shape cell is used to increase shunt impedance which could induced 80MV/m accelerating gradient by 80 MW. SINAP has made one spherical X-band pulse compressor, and was preliminarily tested in the high power test setup in BVERI, finally the

[2] L. Wang, K. Dong, W. He, J. Wang, Y. Luo, A. W. Cross. K. Ronald et. al, Design of a Ka-band MW-level high efficiency gyroklystron for accelerators, IET Microwaves, Antennas & Propagation, vol. 12, no. 11, p. 1752-1757, 23 May 2018, DOI: 10.1049/iet-map.2018.0103

multiplying factor of peak power is about 6 similar to design, however since X-band klystron met with problem, it was tested only by 2 MW input power. Based on the accelerating structure and pulse compressor, one brief layout including one pulse compressor and two accelerating structures is design for the RF units. SINAP is developing the C-band photoinjector composed of 3.6-cell C-band gun and two C-band accelerating structures. The C-band photocathode gun runs on 150 MV/m on cathode, and the C-band accelerating structures run on 30 MV/m and 40 MV/n respectively. The 95 percent projected normalized emittance on 250 pC could be lower as 0.23 mmÂ·mrad which slice emittance is 0.19 mmÂ·mrad. The total length of C-band photoinjector is about 5 meters.

P6 - UU. The main activities of the University of Uppsala within WP4 were focused on investigating possible options for running the XLS linac with high repetition rate in view of the clear preference of the users towards such operation. We performed a survey of the existing Xband klystrons and modulators and discussed the possibilities for modifications and/or new development of the existing products to increase the repetition rate. We studied the possibility to base the RF unit on klystrons with smaller power and higher repetition rate that are available on the market. The RF system layout in this case would be more complicated, requiring high level of combination and compression of the RF power. The estimation of the footprint and cost will be crucial. Discussion on twin-modulator as a possible cost- and space reduction was started.

P7 - UoM. UoM have taken part in specific WP4 video meetings. They have contributed to the definition of the RF plants participating in the general discussions, also via "Vidyo", during some face-to-face project meetings.

P8 - ANSTO. ANSTO have contributed to the Task 4.1 for the layout of the RF plants, participating remotely in the general discussions.

P9 - UA-IAT. The UA-IAT contributed the studies about structure optimization particularly to the efforts on design of structure geometry in order to meet the requirements for transverse stability during the transport of beam. The team also contributes to module optimization in line with the beam dynamics point of view. Since UA-IAT is leading the WP6 - Beam dynamics and start to end modeling- UA-IAT has also contributed the efforts for clarifying the beam parameter sets convenient for CompactLight Design.

P11 - VDL ETG. Given the goal “optimize for industrialization / manufacturability” we have defined an approach for the breakdown of the design into mono-parts and assembly steps for particle accelerator hardware. In discussion with work package partners (WP4.2) the scope has been limited to the accelerator structure itself, because this is the most critical subassembly in the RF structure with respect to machining and assembly. We have attended the Midterm meetings in Trieste and Helsinki and WP-telecon meetings at which we had discussions with other WP members to align the approach. The approach is to make a breakdown that includes all steps between (preliminary) design and final realization including e.g. design for manufacturability, NRE-costs, machining- , assembly- and test-approach and -costs. If the

RF design is not available by September 2019, we have decided that we will start the breakdown based on the “brazed PSI X-band” design in order to be able to meet our deliverable by the end of the project. Note; new input from the RF-design will be incorporated if reasonably possible.

P13 - INFN. In the framework of the WP4 the INFN has been responsible of Task 4.1 “Layout and optimzation of the linac rf system”. The work done so far has been mainly devoted to the design optimization of the X-band accelerating structure and of X-band accelerating module which are the baselines of the Linac design. The accelerating structure design is mainly constrained by the minimum acceptable average radius of the iris aperture of the cells, that has been set to 3.5 mm in WP6 according to transverse beam dynamics considerations. On the base of this data and taking into consideration the shape of the compressed RF pulses powering the linac, an optimal accelerating structure has been designed, which resulted to be 90 cm long with a proper linear tapered profile of the cell irises. The baseline RF module will consist in 4 RF structures powered by one klystron through a pulse compressor system. By using a commercial 50 MW peak klystron, the module average accelerating gradient will exceed 65 MV/m, with an expected breakdown rate well below the acceptable limits. Preliminary calculations on the possibility to increase the linac operational rep rate from 100 Hz toward 1 kHz has been performed, pointing out that a reduction of the baseline gradient is unavoidable to sustain the rep rate increase. Preliminary schemes of possible RF modules suitable for high rep rate operation have been also elaborated.

P18 - CNRS. The CNRS contribution has focussed on the linac layout for the facility design, especially for the integration of the S-band RF photoinjector option into the machine layout. CNRS has also joined the periodic video meetings of the WP4 and participated in discussions at the major face-to-face project meetings.

P22 - UH/HIP. The University of Helsinki/Helsinki Institute of Physics is task leader for the task 5 “Integration” within the WP4. To this end, we have worked on the potential RF module layout and have provided various schemes for the layout of the different configurations for different linac options. Additionally, we have created a list on component dimensions and overall resulting module lengths as a general guideline for the other work packages. We have started to look into the individual components which are not attributed to any other partner within the WP (such as magnets, vacuum systems, etc.). The aim of this effort is to compile rudimentary specifications, compare to similar CLIC components and ultimately report on theses existing designs back to CompactLight. Additionally, we are contributing to the effort of making a coherent and complete list of components necessary for the WP and implement these into our data storage system of choice (EDMS).

P24 - USTR. Post-doctoral researcher Dr. Wenlong He was employed part time (45 percent) for 8 months (March 2018 to October 2018) to supervise University of Strathclyde, Engineering Physical Science Research Council, UK, PhD student Laurence Nix to design of a three-cavity, 3MW, Ka-band (35.8GHz), gyroklystron operated at the fundamental TE02 mode while the input and buncher cavity were operating with the TE01 mode. Working in collaboration with Dr. Li Wang of the University of Electronic Science and Technology of China the optimised design of the magnetron injection gun (MIG) and interaction circuit were completed using the PIC (particle-in-cell) simulation code Magic and analytically using a MATLAB code. The simulations show the gyroklystron can deliver an output power of 3 MW with a gain of 39 dB at 35.8 GHz. The achieved efficiency was 40 percent when driven by a 150 kV, 50 A electron beam.

1.2.5 Workpackage 5: Undulators and Light Production.

Description. The main request to WP5 is to perform the survey of undulator technologies. This scope has been pursued trying to describe the widest range of technologies – either already exploited at fully operating free-electron laser facilities or going to be available within the forthcoming five years – with the most comprehensive technical details. In addition to the technological solutions, WP5 also covered aspects related to the magnetic measurements framework, the beam dynamics inside the undulator line, the FEL schemes requested to provide polarised radiation. Finally WP5 evaluated the FEL performance operating with the electron beams under study within this project, and performed the cost estimate of the undulator system. Each institution participating to the WP5 activities expressed specific interest

Particip.	P. M. Undulators	S.C. Undulators	Beam Dynamics (Opt. & Match.)	Exotic Undulators (RF, Laser, Plasma)	Magn. Measurem. & Cost+Risk	Advanced FEL schemes (Multicolour, Polar.)
ENEA						
KYMA	R. Geometrante					
CERN						
USTR						
STFC						H.M.C. Cortes
KIT		A. Bernhard				
PSI					T. Schmidt	
ANSTO				D. Zhu		
Au-IAT			Z. Nergiz			
ALBA						

Figure 2: List of WP5 task activities shared by the specified involved institutions.

to some of the proposed subject fields, subsequently arranged in tasks to be addressed and run by a dedicated institution representative person. Figure 2 shows how the WP5 activities have been subdivided. In particular, this structure is designed to have the available expertise covering the specific tasks, in synergy with other working packages: undulator system cost estimate with WP7, beam dynamics inside the undulator line with WP5 and FEL schemes and performance with WP2.

Partners. The partners involved in WP5 are the following: LP (ST), P2 (CERN), P3 (STFC), P8 (ANSTO), P9 (UA-IAT), P14 (KYMA), P16 (ENEA, WP Leader), P17 (ALBA-CELLS), P19 (KIT), P20 (PSI), P24 (University of Strathclyde).

Deliverables. The deliverables of WP5 are D5.1 Technologies for the CompactLight undulator and D5.2 Conceptual Design Report of the undulator.

Tasks. For convenience, we report here below the list of WP5 Tasks declared and agreed within the XLS-CompactLight Grant Agreement:
Task 5.1. Review the technology trends for undulators R&D worldwide, and compare the

potential for innovation and performance. In particular: superconducting undulators enabling field amplitude adjustment along the undulator (equivalent to the tapering of permanent magnet undulators), enhanced-bandwidth FEL radiation or super-radiant light sources at short wavelengths.
Task 5.2. Select a few outstanding options to be considered for CompactLight.
Task 5.3. For the options selected in T5.2, perform a systematic optimization of the electron beam parameters at the linac-to-undulator interface to maximise the photon production, in close contact with WP2 and WP6.
Task 5.4. Report the conceptual design of the selected options as resulting from T5.3.

Status of the WP5 Tasks with explicit reference to what declared in the Grant Agreement. The work carried on after the first 18 months is reported on:

- the `INDICO` web-page, https://indico.cern.ch/category/9782/, listing the 11 ”Vidyo” meetings, with access to agendas and slides, held in WP5 between December 2017 and June 2019;
- the deliverable document D5.1: Technologies for the CompactLight undulator.

In particular, the D5.1 document is the result of the activities performed during the first half of the project. The main sections of this report review the current and near future undulator technologies that could be adopted in a compact FEL source that meets the specification given by WP2.

Task 5.1. Review the technology trends for undulators R&D worldwide, and compare the potential for innovation and performance. In particular: superconducting undulators enabling field amplitude adjustment along the undulator (equivalent to the tapering of permanent magnet undulators), enhanced-bandwidth FEL radiation or super-radiant light sources at short wavelengths.
Activity carried out in Task 5.1. As previously mentioned, this has been the core activity of WP5 during the first 18 months, *completed* and *reported* in the deliverable document D5.1, with title “Technologies for the CompactLight undulator”.
In this document, each undulator technology is scrutinised in terms of status and perspectives. Main emphasis is clearly given to devices based on permanent magnets and on superconducting technologies, studied assessing their strengths, weaknesses, and opportunities to advance. Furthermore, the guideline request for a compact FEL facility has stimulated an analysis of also novel concepts such as microwave undulators. As a result, a systematic technology comparison in terms of undulator period and strength is performed, driven by potential XLS-CompactLight users' requests on the peak brilliance and on the target resonant wavelength, and constrained by the current studies on electron beam energy and quality.
As a further guideline, the D5.1 document also presents a preliminary estimate of the undulator system cost. This effort will be complemented by also drawing an appropriate risk model associated to the undulator technologies selected for the final design.
Participants. The partners involved in this Task are the following: LP (ST), P2 (CERN), P3 (STFC), P8 (ANSTO), P9 (UA-IAT), P14 (KYMA), P16 (ENEA), P17 (ALBA-CELLS), P19 (KIT), P20 (PSI), P24 (University of Strathclyde).

Task 5.2. Select a few outstanding options to be considered for CompactLight.
Activity carried out in Task 5.2. The process of down-selecting options will be addressed and completed during Autumn 2019, in close connection with the studies to be performed for the WP2 deliverable document D2.2, with title “FEL design with accelerator and undulator requirements”.

Task 5.3. For the options selected in T5.2, perform a systematic optimization of the electron beam parameters at the linac-to-undulator interface to maximise the photon production, in close contact with WP2 and WP6.
Activity carried out in Task 5.3. As stated and agreed in the XLS-CompactLight Grant Agreement, activities within this Task will start upon completion of Task 5.2.

Task 5.4. Report the conceptual design of the selected options as resulting from T5.3.
Activity carried out in Task 5.4. As stated and agreed in the XLS-CompactLight Grant Agreement, activities within this Task will start upon completion of Task 5.3.

P16 - ENEA, WP Leader. The ENEA team pioneered the development of Free Electron Lasers since from the beginning. Within the XLS-CompactLight, ENEA coordinated the activities of the working package under discussion, namely on *Undulators and Light Production*. In view of this commitment, during the first 18 months, ENEA organized and run 11 videoconference meetings via dedicated [3] `INDICO` and `E-Groups` web-pages, where up-to-date progress in each WP5 task has been reported and minutes related to every meeting have been posted. Meetings have been run with the `Vidyo`® conference system. The subject fields identified by ENEA as working tasks in Figure 1 have been coordinated to converge in alike sections of the deliverable D5.1 document, where past experience with permanent magnet Delta undulators and with design of laser wave undulator concepts has been sketched. Finally, jointly with WP2 and WP6, ENEA initiated [4] the discussion towards specifying the electron beam and undulator parameters making use of the G. Dattoli’s semi-analytical formulae.

LP - ST. As the LP of the project, ST has participated in all WP5 Vidyo meetings to keep track, remain informed, and discuss about activities, progress, and open questions.

P2 - CERN. First, the current status of HTS magnet technology was reviewed with respect to undulator technology, taking the development of solenoidal and dipole magnets into account. Parameter space investigations, by means of 2D and 3D simulations, were performed for three HTS REBCO tape undulator configurations (horizontal racetrack, vertical racetrack and helical): Magnetic peak field at beam position, magnetic field at conductor, undulator parameter, gap and undulator period length. HTS REBCO tape performance from the year 2016 and 2019 was compared to each other as well as to the sate-of-the-art LTS undulator technology Nb-Ti, showing the significant development and the advantages of HTS technology. Additionally, supplementary technologies (HTS joint connections, quench detection and protection, mechanical

[3] https://indico.cern.ch/category/9782/
[4] https://indico.cern.ch/event/742620/contributions/3067152/attachments/1683674/2707648/WP2Meeting_July9th_FN.pdf

and geometric properties) were reviewed. Finally, the challenges and developments for HTS to become a mature undulator technology were emphasized.

P3 - STFC. Here is a summary of STFC contributions to WP5: assessment of SCU technology as a feasible possibility for the XLS facility layout; assessment of multipulse FEL options and implications for layout and undulator technology; literature survey of possible FEL schemes which can be applied in order to generate pulses with the characteristics suggested by the users; studies of polarisation control and multi-colour schemes using the option of afterburner undulators; quantitative assessment of a subset of undulator technologies considered by WP5 to inform choice of XLS beam energy; detailed assessment of all undulator technologies considered by WP5 using different merit functions to compare performance and confirm choice of beam energy. All these efforts culminated in an active collaboration in the writing and compilation of the deliverable D5.1 document.

P8 - ANSTO. The ANSTO team joined the CompactLight Project WP5 as the coordinator of the team for exotic undulators, and did research on microwave undulator electron beam dynamics and photon beam radiation simulations. The team wrote the draft of the section of microwave undulator in the WP5 deliverable D5.1 report, and presented a poster with title *The conceptual design of a 36 GHz RF Undulator*, at the IPAC 2019 conference.

P9 - UA-IAT. The UA-IAT team is responsible for the FEL Beam Dynamics task within WP5 for normal conducting planar type of undulators. The effect of the wakefields in the undulator region is investigated by UA-IAT. This effect would be so critical for the decision of undulator technologies. For this purpose, GENESIS and SIMPLEX simulation codes are used. Some preliminary studies were done for several energy and beam parameters. Detailed study will continue for dedicated beam parameters. This task includes matching in undulator region and specifying optimum Twiss parameters.

P14 - KYMA. Kyma Srl worked together with its third party, Kyma Tehnologija d.o.o., on WP5 "Undulators and light production". In particular, Kyma main contributions were dedicated to Permanent Magnet Undulator task. Considering Kyma expertise, specific efforts were done to address all the issues related the magnetic and mechanical designs and simulations, finalized to the definition of the state-of-the-art technologies applicable to CompactLight project and design. Once the applicable options were well set and specified, an analysis of strength and weakness, opportunities and threats has been performed for each of the technologies studied. On top of that, Kyma contributed to the cost analysis of any single technology comparing its cost and its availability applying both the laboratory and the industrial approach. The result of that is collected in the almost 100 pages D5.1 report delivered.

P17 - ALBA-CELLS. ALBA (J. Marcos and F. Perez) has joined WP5-"Undulators and light production" of CompactLight project to provide its experience in connection with the following subtasks: (i) permanent magnet undulators, (ii) optics and matching in undulators, and (iii) magnetic measurement facilities. During the first 18 months of the project, ALBA has participated in all the remotely held meetings specific for WP5 (11 of them so far) and has attended the three general half-year meetings (Trieste-June 2018, Barcelona-December 2018, Helsinki-July

1019). In addition, in two of these general meetings (Barcelona and Helsinki) a representative from ALBA, Jordi Marcos, has delivered the talks presenting the status of the permanent magnet undulators subtask. On top of this, ALBA has coordinated the section devoted to permanent magnet undulators of deliverable D5.1, consisting of a review of technology trends for undulators R&D worldwide. In order to complete this task it has been necessary to carry out an extensive survey of the existing literature, and to present it in a coherent and well-structured way.

P19 - KIT. The KIT team is leading the task on superconducting undulators within WP5 of the XLS-CompactLight project. We hired one doctoral student (0.5 years) and one scientist (1.5 years), did parametric studies on the magnetic performance of state-of-the-art and beyond-state-of-the-art superconducting undulators, mainly based on own finite element calculations, but partly also on simulation and experimental data collected from the other XLS partners. The results of these studies entered into the deliverable report D5.1, to which, besides that, we contributed a general introduction to superconducting undulators as well as the section on low-temperature superconducting undulators.

P20 - PSI. The PSI team (T. Schmidt, M. Calvi) is involved in the development of superconducting undulators for a compact Hard X-ray beamline. The electromagnetic modelling of the involved process of HTS bulks magnetisation using field cooling techniques is well advanced, the optimisation of the undulation geometry is completed and the preliminary design has been sketched. On the experimental side, three samples with identical geometry (10 mm period, 4 mm gap and 10 cm long) and different technologies are ready to be extensively tested during the second half of 2019 at the university of Cambridge (a collaboration contract has been established by PSI). The preliminary results will be discussed in August-September (2019) during PASREG and EUCAS conferences where the applied superconducting community meets to exchange ideas and methods. Kai Zhang has been hired as a post-doc with a 2 years contract.

P24 - University of Strathclyde. Microwave undulators (MU) can be an alternative to the permanent magnet undulators in a free electron laser (FEL). The Cockcroft Institute, post-doctoral researcher Dr. L. Zhang was employed full time for 2 months (June and July 2019) to design and simulate two Ka-band microwave undulators. The first was a corrugated cavity-type MU that supports a standing wave to boost the electromagnetic field strength. When operating with an HE_{11} mode at 36 GHz the corrugated cavity type MU was predicted to realise a field strength of 1.27 T at a period of 4.34 mm when driven by a 50 MW microwave source resulting in an undulator parameter K value of 0.52. The second was a waveguide-type MU based on a helically corrugated waveguide (HCW) that supports a traveling wave. The use of the HCW allows partial conversion of a traveling wave mode into a backward traveling wave mode, hence increasing the effective interaction length. When operating with a TE_{11} mode at 30.3 GHz, the HCW-MU was predicted to realize a field strength of ~ 0.3 T and an undulator period of 4.95 mm when driven by 1 GW of microwave power resulting in an undulator parameter K value of 0.14.

1.2.6 Workpackage 6: Beam dynamics and start to end modelling.

Description. The scope of WP6 (M2-36) is to perform the start-to-end simulations of the whole facility, with the beam transport from the cathode to the undulator exit, in order to optimize the key parameters of the FEL, while meeting the user requirements. Clearly each section of the machine has many subsystems and the start-to-end optimization will comprise a large number of parameters. Therefore, WP6 is strongly linked to WP2, WP3, WP4 and WP5.

Partners. The involved partners are ST (P1), CERN (P2), STFC (P3), IASA (P5), UoM (P7), ANSTO (P8), UA-IAT (P9, leading WP6), INFN (P13), ENEA (P16), ALBA-CELLS (P17) and VU (P23).

Deliverables. There are two deliverables in WP6, namely D6.1: Computer codes for the facility design - A report providing a global analysis of the most advanced computer codes available for the facility design and performance evaluations (R, PU, M18) and D6.2: Start-to-end facility simulations - Final report of the accelerator lattice, FEL design and performance (R, PU, M36).

Tasks. In accordance with the deliverables, the WP6 has been divided into two tasks:

- Task 6.1: Study of the existing design and simulation tools for the evaluation of the facility performance. Analyse and improve their capabilities if necessary.
- Task 6.2: Using the above mentioned tools, design and evaluate the lattice performance from the e-gun up to the undulator exit, including space-charge effects, Coherent Synchrotron Radiation in magnetic compressors, wake field effects and FEL performance. Simulations will include the study of key tolerances and mitigation strategies to deal with imperfections.

Due to its valuable capabilities in terms of efficiency and gradient, normal conducting X-band technology has been proposed for the main linac, while different injector schemes are being investigated. These schemes include DC and RF guns at different operating frequencies (S-, C- and X-band), followed by a pre-injection linac at the same frequencies. It is obvious that in this context each injector will require different harmonic linearizers and different bunch compressor schemes to meet the requested beam parameters at the end of the linac. In addition to that, due to different initial conditions, such as initial bunch distribution at the cathode surface, different focusing configurations at the gun stage etc., for each of the different gun injector schemes, a different linac layout has to be evaluated independently. To this end, in order to find the "optimum" configuration, we have created new layouts and new 'technical' tasks within Task 6.2 of WP6 after the project's kick-off meeting, which fulfil all requirements of the Task 6.2 given in the proposal. The new technical tasks, further divided in sub-tasks, are summarized as follows:

- Task 6.2.1 - Injector
  - (A) S-band gun + S-band pre-injection linac
  - (B) C-band gun + C-band pre-injection linac

(C) X-band gun + X-band pre-injection linac
(D) DC gun + X-band pre-injection linac

- Task 6.2.2 - Linac
  (A) S-band rf + X-Band linearizer + BC1 + X-Band rf + BC2 + X-Band rf+ Beam Delivery
  (B) C-band rf + K-Band linearizer + BC1 + X-Band rf + BC2 + X-Band rf+ Beam Delivery
  (C) X-Band rf + K-Band linearizer + BC1 + X-Band rf + BC2 + X-Band rf+ Beam Delivery
  (D) X-Band rf + Optic Linearizer + X-Band rf + BC2 + X-Band rf+ Beam Delivery
- Task 6.2.3 - FEL
  (A) Soft X-Ray
  (B) Hard X-Ray
- Task 6.2.4 - Start-to-End Integration
  (A) Beam based alignment for the final layout
  (B) Start-to-end integration for the final layout

Each technical task and sub-task given above is led by a task leader (TL), who receives the contributions from the members of the Collaboration involved in the task (see Table 1). The task leader ensures the effective cooperation among all the participants and monitors the work progress towards the milestones.

Table 1: Matrix of WP6 activities shared by institutions. (TL: Task Leader, M: Member)

Institute	Injector				Linac				FEL		S2E	
	1A	1B	1C	1D	2A	2B	2C	2D	3A	3B	4A	4B
AU-IAT	M	M	**TL**		M	M	M	**TL**	M	M	M	**TL**
ST					**TL**	**TL**	M				M	M
CERN	M	M	M		M	M	**TL**				M	M
STFC									M	M		M
IASA	M											
UU									**TL**	M		
UoM											M	
ANSTO											**TL**	
INFN	**TL**	**TL**		M								
ENEA									M	**TL**		
ALBA					M	M		M				
VU				**TL**								
CNRS	M	M	M		M	M						
CSIC			M									

The activities carried out during the reporting period in the four tasks of WP6 are described in the sections below.

Task 6.2.1 Injector. The goal of this task is to investigate the possible injector option matching the CompactLight requirements. This section covers the simulation from the cathode to the end of the pre-injection linac up to 250 MeV beam energy, where the space charge forces are restraining the brightness of the electron beam. Different schemes are under investigation including RF gun injectors at different operating frequency (S-, C- and X-band) and a DC gun based design. The task also includes combined simulations with the first magnetic compressor system and the liberalization scheme. The possibility to operate with a velocity bunching configuration or alternatively with a magnetic compressor system is also taken into account.
Activities in Task 6.2.1. Beam dynamics simulations have been investigated using various space charge simulation tools in collaboration with WP3. The preliminary results of the injector simulations as well as the performance comparison of the simulation tools have been reported in the deliverable D6.1. Since the scope of the first deliverable of WP6 has been to analyze and evaluate existing simulation tools, a clear compromise between injector options has not been discussed. An overview of the compression performance of the injector can be found in Section 1.2.3.

Task 6.2.2 Linac. The task is responsible to investigate the optimum linac configuration that provides high brightness and low emittance electron beams suitable to generate intense, ultra-short, coherent soft and hard X-ray pulses. The linac is supposed to provide high quality electron beams in a wide range of energy (i.e. from 1.0 GeV up to 5.5 GeV), while operating at both 100 Hz and 1000 Hz repetition rates. The operational aspects of an X-band linac, where the instabilities are mainly dominated by wakefields, are quite demanding and challenging, bringing along some concerns. In addition to that, the suggested machine layout with two bunches per pulse makes the system more complex. To this end and to be more effective, Task 6.2 is strongly linked to other tasks in different WPs such as RF-design, magnet design, module configuration as well as the design of the harmonic linearizer.
Activities in Task 6.2.2. Preliminary beam dynamics simulations for 100 Hz and single bunch operation have been carried out using well known simulation tools in collaboration with WP3. In order to make a fast optimization of the energy spread modulation and the compression factors in magnetic bunch compressors, 1D simulation tools have also been used and compared with the previous tools. The preliminary results of the linac simulations as well as the performance comparison of the simulation tools have been reported in the deliverable D6.1. The team involved in Task 6.2 has also focused on exploring the RF module configuration in order to meet the requirements for transverse beam stability during the beam transport.

Task 6.2.3 FEL. Concerning the FEL beamlines, a preliminary design, consisting of a chain of undulators with identical period and length to cover photon energy between 0.25 - 16 keV, has been proposed. The suggested schemes include a seeding option and the possibility to have different polarizations in the final design. In collaboration with WP5, Task 6.3 is also responsible for investigating the key parameters and performance of the FEL. Therefore, the team is involved in the undulator design and the lattice design for other WPs as well.
Activities in Task 6.2.3. Simulation tools as well as semi analytical approximations have been evaluated in line with the deliverable D6.1. A case study for 0.7 Å wavelength has been taken into account for a comparison among the simulation tools and analytical approximations. Preliminary results of this case study have been reported in the deliverable D6.1. The team

has currently focused on the technology choice for the undulators, including their costs and optimizations, in order to meet the user requirements for the facility.

Task 6.2.4 S2E Integration. Task 6.4 is responsible for providing the performance prediction of the facility, including the key tolerances and mitigation strategies to deal with imperfections. The team will integrate all the subsection options performing S2E simulations for a better comparison and matching of the sections. If necessary, an adaptor and a consistent tool for modelling the machine will be developed.
Activities in T 6.2.4. Since a clear selection among the different options for the sub-sections has not been made yet, no activity has been performed for task 6.2.4.

The WP6 members have contributed to the planned activities according to the following summary:

P9 - UA-IAT, WP Leader. UA-IAT has been the leading partner of the WP6 activities, in charge of the preparation of deliverable D6.1. The research activities carried out by UA-IAT have been mainly focused on the simulations for the X-band based injector option (leading Task 6.2.1 C), using simulation codes like ASTRA, GPT and Rf-Track. In addition to that, a preliminary lattice configuration has been proposed by UA-IAT. Furthermore, the partner has contributed the RF-Module optimization as well as structure design efforts in line with the beam dynamics perspectives. Since the WP6 is closely linked to WP3, WP4 and WP5, UA-IAT has carried out simulations for different injector options, beam transport in the main accelerator, bunch compression schemes, as well as the beam transport in the lasing sections of both Hard and Soft X-Ray beamline.

P1 - ST. ST has taken the responsibility for the coordination of the layout designs in the Task 6.2.2 A and Task 6.2.2 B. For the Task 6.2.2 A configuration, the team has carried out preliminary 1-D injector-to-undulator e-beam dynamics simulations for the SX and HX FEL options. ST has contributed to deliverable D6.1 with a short report on Li-Track, a 1-D tracking code. As the LP of the project, ST has participated in all WP6 Vidyo meetings to keep track, remain informed, and discuss about activities, progress, and open questions.

P2 - CERN. CERN has primarily contributed to WP6 in the areas of code development and 1D optimisation of the "Full X-band" option. During the CLIC design studies, extensive experience has been gained by CERN in beam dynamics performance evaluation for X-band linacs and wakefield-dominated regimes. A code called 'Track1D' has been developed for the fast optimisation of the machine parameters under the effects of acceleration, wakefields, and magnetic compression. Solutions for the 'Full X-band' layout, based on X-band injector gun with Ka-band lineariser have been found. The option of a compact 'S+X' has been considered, too. The 6D tracking code 'RF-Track' has been extended and improved to make injector simulations easier and faster, also in presence of imperfections.

P3 - STFC. Given the goals by WP6 and the different tasks assigned to fulfil those goals, STFC has taken ownership in studies which are related to FEL simulation and assessment of FEL properties and efficiency. One of the earlier tasks STFC played an important role was the assessment of transverse offsets due to wakefields and their impact on FEL performance (comparing against pulse energy at saturation). In order to address the start-to-end (S2E) simulation environment (one of the main goals of the WP6), STFC reviewed the 1D and 3D FEL theory and the available semi-analytical approximations and existent FEL simulation codes to perform different design studies and assess FEL performance. Study cases to benchmark the FEL simulation codes and the semi-analytical approximations were carried out and scenarios in which the FEL codes can be used within a S2E framework (interfacing with beam dynamics simulation codes) were proposed. STFC has had active participation in the different meetings which had taken place since the beginning of activities within WP6, including presenting results and providing input to the different tasks performed in accordance to the main objectives proposed by WP6.

P5 - IASA. IASA team has carried out ASTRA simulations taking the beam profile from the e-gun to the TWS, optimizing the beamline parameters with the GIOTTO code. They have also started a 3D design of a 5.6 cell X-band Gun.

P6 - UU. Within WP6, the Uppsala University (UU) group contributed to the Task 6.2.1. The group developed a simulation tool in Matlab for comparing the performance of different undulators in terms of saturation length, saturation peak power, coherence time and peak brilliance. The tool turned out to be useful and was adopted for undulator studies within the WP5.

P7 - UoM. Since the final layout configuration for the entire facility has not been fixed yet, UoM has not started any activity in WP6.

P8 - ANSTO. ANSTO is leading the technical task 6.2.4A. The team is responsible to carry out the beam based alignment simulations and find out the optimum technique for meeting the beam parameters at the entrance of the lasing section (CompactLight requirements). However, since the final layout configuration for the entire facility has not been fixed yet, ANSTO has not started any activity in WP6.

P13 - INFN. INFN is leading most of the activities in the injector section, particularly for the S- and C-band injector schemes. Preliminary design of the S-band and C-band injectors heve been performed using simulation codes like T-STEP, ASTRA and GPT. In particular for the C-band option, a new RF gun has been designed and proposed in the framework of the CompactLight Collaboration. The team has also the responsibility to design the first bunch compressor taking into account the higher harmonic phase space linearizer.

P16 - ENEA. ENEA is leading the activity Task 6.3 B and has contributed to the WP6 activities along two different research subjects. First, A. Giribono has worked on the design study of the S-band photo-injector option and the beam dynamics optimisation. As sub-task leader, she has performed the comparison of several codes for simulating the beam dynamics in the photo-injector and has been in charge of reporting on this argument in the deliverable D6.1. Second, after estimating a table of parameter values for operating a FEL at Hard X-rays using the G. Dattoli semi- analytical formulae, F. Nguyen has worked in close contact with the WP6 FEL sub-task leader, providing steady-state results for the FEL operations evaluated with G.

Dattoli semi-analytical formulae and time-dependent results evaluated with the PERSEO code, featuring longitudinal dynamics effects. The two techniques have also been described in detail in the deliverable D6.1.

P17 - ALBA-CELLS. ALBA-CELLS has carried out the start-to-end simulations using the GPT code for the S- and X-band injection options. They have also performed the design of the linac lattice, using the PLACET code in order to validate a preliminary design made by ST with the 1-D code Li-Track.

P23 - VU. Feasibility of a DC photogun injection scheme has been studied by a VU team in collaboration with TU/e. Preliminary simulations of the injector have been done in GPT. In addition, activities i) finalizing the injector design, ii) testing the alignment requirements of each component, and iii) testing the peak current for injection have been carried out. The beam parameters achieved from DC photo cathode gun have been a 10 pC, 20 MeV, 350 fs electron bunch with a normalized emittance of 400 nm rad. A new Post Doc, (Dr. Tom Lucas) has joined to the team by Feb. 2019. The high power RF components for the injector test will arrive in the second half of 2019.

1.2.7 Workpackage 7: Global Integration with New Research Infrastructure.

Description. WP7 (M7-M36) addresses strategic issues related to the objectives of CompactLight, namely the scientific and technical impact/benefits for the XFEL communities. The work package aims at preparing documents that support applicants, funding agencies and policy makers in decision-making on the construction of new, or upgrades of existing, research infrastructures based on CompactLight technologies. WP7 includes four tasks. The activities carried out in each of them during the first reporting period are described below.

Partners. The WP7 partnership is composed of 12 partners and includes all WP leader institutions as well as the two companies involved in the project: ST (LP, leading WP1 and WP7), CERN (P1, leading WP4), STFC (P2, leading WP2), IASA (P5), UoM (P7), ANSTO (P8), UA-IAT (P9, leading WP6), VDL-ETG (P11), INFN (P13, leading WP3), Kyma (P14), ENEA (P16, leading WP5), ALBA-CELLS (P17), and VU (P23).

Deliverables. There are two deliverables in WP7, D7.1 - Mid-term report with CompactLight global integration and cost analysis (R, PU, M24) and D7.2 - Final report with CompactLight global integration analysis, services and cost. (R, PU, M36).

Task 7.1 - Global integration of CompactLight for new Research Infrastructures in Europe and worldwide. Task 7.1 deals with the global integration of X-band technology for new accelerator-based Research Infrastructures in Europe and worldwide. The workpackage will survey the present and future requirements of the user community and show, how the specific nature of X-band technology can address these requirements. The task, lead by ST (LP), is divided into the subtasks (1) Users demands on FELs (subtask leader: LP-ST), (2) Overview of existing infrastructures (LP-ST), (3) Demands for accelerator upgrades (tbd), (4) Case study on new large facilities (tbd), (5) Integration of existing facilities (tbd) and involves also CERN (P2), STFC (P3), UA-IAT (P9), INFN (P13), ENEA (P16), VU (P23).

Activities carried out in Task 7.1. The work in this task has started with the exploration of the user needs in collaboration with WP2. CompactLight partners have participated in the Science@FELs Conference in Stockholm, 24.-27 June 2018, https://indico.maxiv.lu.se/event/476/) to get in touch with the FEL user community and have a first indication of the users' expectations concerning future developments of FEL light sources, in particular with respect to the performance of the produced light beams. This was achieved by attending the speeches and talking directly with the presenting experts about state-of-the-art experimental techniques, expected or desired future developments, and the related needs in terms of photon beam characteristics. For the same purpose, representatives of the project have also attended the Conference on Attosecond and Free Electron Laser Science 2018 that took place on 2nd-4th July 2018 at University College in London.

A survey of the user needs in the form of an online questionnaire has been developed, reviewed and sent to a mailing list of acknowledged experts jointly selected by the WP7 and WP2 partners. The replies have been analysed and results and conclusions of this analysis have been published in deliverable D2.1. Furthermore, a User Meeting has been organised together with WP2, which took place on 27.-28. November 2018 at CERN.

10 international experts representing the FEL user communities in different research fields have been invited by the project to participate in this event, together with a number of XLS Partners involved in WP2 and WP7. The meeting aimed at informing major experts in the most important application fields of FEL radiation about the CompactLight project, establish contacts with key players that may also be contacted in the further course of the project to provide input and suggestions, and to explore and discuss face-to-face in much detail the potential user needs in terms of future FEL facilities. The meeting started with presentations on CompactLight by LP-ST and P3-STFC, included a summary of the results from the Survey on User Needs by P6-UU, left large space for user presentations and discussions on useful and desired photon beam characteristics from the users' point-of-view, and yielded important insights for CompactLight that have been reported in deliverable D2.1.

Progress achieved in task 7.1. The work programme for this task envisages to intensify the study of the current landscape and future needs for large FEL light sources in the next months, in order to present first significant results in deliverable D7.1, which is due in the end of 2019. For the moment, no deviations from the work programme have occurred or are expected.

Task 7.2 - Services to be provided. Task 7.2 addresses the services that can be provided to the global community by exploiting the new technology for a wide spectrum of applications that goes beyond large-scale FEL facilities. The ability of the new technology to provide science and society also with such complementary services will be investigated and possible future upgrade paths will be explored. The subtasks (1) Photon Beams (P17-ALBA),(2) Particle Beams (P13-INFN), (3) Special Applications (LP-ST), and (4) Very high gradients (P2-CERN) reflect major possible application fields. Involved are also the partners MoU (P7), VDL-ETG (P11), and VU (P23).

Activities carried out in Task 7.2. The activities in Task 7.2 have started, coordinated by LP-ST, with the breakdown of the activities into subtasks and the assignment of the subtask leader roles (indicated in brackets above) by the involved partners. The work in the single subtasks has started with the collection and review of information and literature by the subtask leaders, but is still in an embryonic state. This is in agreement with the activity programme, where results from this task are expected to be reported only in deliverable D7.2 in the end of the project.

Task 7.3 - Preliminary estimation of construction/operation costs. Task 7.3 is covering the costs and estimated budgets required for the construction and operation of FEL facilities based on CompactLight technologies. Comparison of the construction and operation costs of CompactLight facilities and facilities based on conventional technology will be made, taking into account already committed investments (where applicable). The task is led by P5-IASA and is supported by the 3rd party AUEB, with the following subtasks: (1) Data Integration (P5-IASA, AUEB), (2) WP2 Input (P3-STFC), (3) WP3 Input (P13-INFN), (4) WP4 Input (P2-CERN), (5) WP5 Input (P16-ENEA), (6) WP6 Input (P9-UA-IAT), (7) Building, Services, Operational Costs etc. (LP-ST). Further involved partners are the companies VDL-ETG (P11) and Kyma (P14).
Activities carried out in Task 7.3. Task 7.3 has started in autumn 2018 with a number of presentations on concepts for cost analyses by the task leader P5-IASA, elaborated together with their 3rd party AUEB, and discussed intensively with different audiences within the project (WP7 partners, WP leaders, all partners). This has stimulated a first discussion on data collection needs and responsibilities and helped to structure the task into the subtasks and to appoint the subtask leaders. As a result of a presentation of the Project Breakdown Structure (PBS) of the CLIC Project and the tools used for the CLIC cost analyses by P2-CERN, which has intensified the discussion, the Partners have agreed to adopt a similar concept with a depth of three or four levels (to be decided according to the needs of each WP) for the CompactLight project. So far, a PBS down to level 4 has been developed and implemented in EDMS for WP4 (P2-CERN, with UH/HIP for EDMS implementation), and the assignment of responsibilities for each single cost item is ongoing. The development of a PBS for all other WPs, coordinated by the respective WP leaders (WP1: LP-ST, WP2: P3-STFC, WP3: P13-INFN, WP5: P16-ENEA, WP7: LP-ST), has recently started and is still in course. LP-ST is in charge of developing a PBS for all cost categories not covered by the technical workpackages (building, services, operational costs, ...). In parallel, the partners involved in this task are discussing about how to handle all other relevant aspects, such as the basis for cost estimates, uncertainties, risks, cost differences among countries, etc. in the final methodology. Discussions about test cases and the selection of case studies have also started among the partners involved in this task .
Progress achieved in task 7.3. The work in this subtask is advancing as planned, with the development of the cost analysis methodology and the PBS, as well as the assignment of responsibilities for data collection getting well ahead. Test calculations are planned for the next months and the cost analysis activities for CompactLight will start as soon as the technical definition of the facility is mature enough.

Task 7.4 - Technology Transfer. Task 7.4, which is not present in the original plannings for WP7, has been added in order to develop appropriate strategies, identify the addressees, and plan, organise and conduct suitable activities to support the transfer of CompactLight technologies, fostering their wide future utilisation. It is led by P5-IASA, involves ST (LP), CERN (P2), IASA (P5), VDL-ETG (P11), Kyma (P14), ALBA-CELLS (P17) and is split into the subtasks (1) Technology Transfer Strategy (LP-ST), (2) Internal Acquisition (P5-IASA and AUEB), (3) Documentation (P2-CERN), (4) Stakeholder Relations (LP-ST).

Activities carried out in Task 7.4. An “Action Plan” establishing suitable activities to support and facilitate the exploitation and dissemination of XLS technologies and other project results by the partner institutions as well as external applicants, is under development in subtask 7.4.1. The document aims at supporting the project partners in disseminating the CompactLight innovations in an efficient and effective way, fostering their wide application and further development, and maximising the benefits of the project for science and society. Created as a "living document", it will be updated whenever required according to the developments and progress achieved in the course of the project. User-relevant parts of the contained information will be published also in the support documents for potential applicants of the CompactLight technologies to be created by WP7 (D7.1 and D7.2). For this purpose, the ”Action Plan” will include a chapter describing the expected and achieved innovations, which are collected by subtask 7.4.2 and documented as well as archived by subtask 7.4.3. It will further identify possible applicants and define measures, resources, and responsibilities to support their dissemination and utilisation. These activities and measures will then be implemented by subtask 7.4.4.
The "Action Plan" is not intended as an "open document" but primarily as a guide for internal use that helps defining, bundling, guiding, and monitoring the project activities aimed at supporting technology transfer, in order to ensure enough attention, avoid doubling of efforts, and foster the creation of further ideas. However, as already explained above, the user-relevant information (description of achieved innovations as well as all other useful information and tools created by the task that can support potential users and have not been foreseen in the Annexes of the Grant Agreement) will be included in D7.1 (information and instruments already available at the delivery deadline) and D7.2.(all available information and instruments). The activities carried out will also be reported in the 2nd Periodic Report.
To document and archive the materials, subtask 7.4.3. will use the EDMS platform at CERN, which has been selected as the CompactLight archive for long-term data storage. The archive is broken down in a general section and single workpackage sections for the storage of generic documents. A further section, structured according to the PBS developed for the cost analyses in Task 7.3, is used for the storage of the data and documents required for the cost analyses. The access to the archive is currently restricted to the project partners. However, the system permits to attribute access rights (public or restricted), which will be provided at a later point in order to allow potential users of the CompactLight technology to access the Open Data of the project. The XLS Data Management Plan has been integrated with a description accordingly.
Concerning subtask 7.4.4 on stakeholder relations, a couple of activities that aimed at informing potential users of the new technologies about the CompactLight project and establishing contacts with them have already been carried out. In particular, the project has been presented through oral talks, face-to-face discussions and/or posters at various occasions, as listed in the WP1 section. These presentation and publication activities will help to spread the information about CompactLight to a large scientific audience, which includes also potential future applicants. More dedicated actions to raise in particular the awareness of potential users and get in touch with them have been the face-to-face discussions between project representatives and scientists participating in the events Science@FELs 2018 (25th-27th June 2018, Stockholm, Sweden) and Attosecond and Free Electron Laser Science 2018 (2nd-4th July 2018, London, UK) as well as the XLS User Survey performed in Summer 2018 and the XLS User Workshop held at CERN in Autumn 2018, both described in more detail above. Moreover, the project has invited a number of enterprises operating in the field of klystrons and rf Components to

participate in the Mid-term Review Meeting 2019 in Helsinki, get informed about the project, present their relevant activities, and discuss with the partners.

Progress achieved in task 7.4. With these activities, CompactLight has definitely created already large awareness among potential scientific and industrial users. The further intensification of the awareness-raising activities planned for the second period of the project on the basis of the achieved progress and maturity of the design will boost the level of awareness even more.

LP - ST, WP Leader. LP-ST is leading WP7 and the tasks 7.1 and 7.2. The partner has coordinated the organisation of WP7 (breakdown into tasks and subtasks, appointment of task and subtask leaders etc.), the WP7 activities, the work in the subtasks 7.1 and 7.2, and the collaboration among the different tasks and subtasks. LP-ST has also supported the coordination of tasks 7.3 and 7.4, convened and chaired the Vidyo meetings in WP7 and its tasks, organised the WP7 contributions for XLS project and PCO meetings, presented the WP and its results at these occasions, and coordinated the preparation of reports on WP7 activities. In Task 7.1 LP-ST has developed and implemented the user survey and led the creation of the mailing list of addressees, coordinated the organisation of the user workshop, invited the users selected jointly with WP2, chaired the event, and participated in the Science@FELs and Attosecond workshops in order to raise awareness about the project, get in contact with the users and explore their expectations with regard to the light characteristics of future FEL light sources. LP-ST has also started the activities in subtask 7.2.3 on special applications with the collection of information and a literature review. LP-ST staff have stimulated and coordinated the discussion on the development of a methodology for cost analyses and the adoption of the CLIC Project Breakdown Structure PBS for the project in task 7.3. Finally, LP-ST has started the preparation of a first draft of an “Action Plan” to promote the use of the CompactLight technologies in task 7.4, brainstormed on efficient activities to raise awareness and facilitate the use of CompactLight technologies by potential industrial and scientific applicants, and organised the participation of a couple of relevant enterprises in the project’s Midterm Review Meeting held recently in Helsinki.

P2 - CERN. CERN is involved in all four tasks of WP7, leading the subtasks 7.2.4 on ’Very high Gradients’, 7.3.4 on ’WP4 input" to cost analyses, and 7.4.3 on ’Documentation’. CERN staff has participated with significant contributions in all the WP7 Vidyo meetings and project face-to-face meetings. In task 7.1 CERN has contributed in the development of the user survey and the creation of the mailing list. As the local host of the User Meeting, CERN has co-organised the event, provided logistic support and conducted the visit of the invited users and participating partners to the X-boxes. In task 7.3, CERN has made their experience gained with the PBS of the CLIC project available for CompactLight and has presented and discussed the PBS structure and the related methodological issues intensively with the partners in task, WP and project meetings. CERN has also created, as a ’model’ for the other WPs, a PBS for WP4 and implemented the structure in the EDMS, where it will be used for the storage of data and documents, and in particular for the cost analyses.

P3 - STFC. STFC is involved in tasks 7.1 and 7.3, leading the subtask 7.3.2 on ‘WP2 input’ to the cost analyses. In Task 7.1 STFC staff have been actively involved in discussions with

FEL users to establish their demands from the CompactLight facility in terms of photon output performance and have then been involved in selecting appropriate electron parameters to meet these requirements. STFC staff have contributed to the development of the user survey, the creation of the mailing list of addressees, and the evaluation of the survey results lead by P6-UU (WP2). They have co-organised the user workshop, contributed to the selection of users to be invited, and supported the LP in conducting the event and presenting the project to the users. They have participated also in the Science@FELs and Attosecond workshops in order to get in touch with potential users, raise awareness about the project and explore the users' expectations. STFC staff have taken part in the WP7 videoconference meetings and discussions at all the face to face events. STFC staff have also provided input to the cost modelling activity via discussions with the task leader and feedback on the technology transfer action plan.

P5 - IASA. IASA is leading the tasks 7.3 and 7.4 as well as the subtasks 7.3.1 on 'data integration' for the cost analyses and 7.4.3 'internal acquisition' for the collection of information on exploitable project results. In task 7.3, the ISAS team has, together with their third party AUEB, studied the cost analysis for the CompactLight project in comparison with other X-FEL facilities in operation or under construction in the world. A draft breakdown of the main parts of the accelerator has been proposed, taking into account the special infrastructure cost models of the literature. A SWOT analysis for the project has been performed, investigating the strengths, weaknesses, opportunities, and threads for the project. A risk analysis strategy of the project has been presented, defining the main parts of the accelerator as the identification nodes and listing the potential failures for each of them. In collaboration with AUEB, the theoretical basis for the CompactLight cost analyses has been studied, and the PBS of WP3 and WP4 have been described analytically. This analytical procedure for the XFEL items will help to determine the cost per item and calculate the total cost. In task 7.4 possible technologies to be transferred in the cases of SX and HX FELs have been investigated, with the option that parts of the knowledge and technologies may be transferred to industries. A deep scientific analysis has then been performed for CompactLight, taking the complex features of the project into account. The obtained results are expected to be applied to the project and to provide the best practice for technology transfer to industry, research, or universities.

P9 - UA-IAT. UA-IAT is involved in tasks 7.1 and 7.3, leading the subtask 7.3.6 on 'WP6 input" to the cost analyses, where they have started to prepare the PBS for the WP6. UA-IAT has participated in the XLS user meeting and the discussions with the users there.

P13 - INFN. INFN is involved in task 7.1, and is leading the subtask 7.2.2 on 'Particle beams' as well as the subtask 7.3.3 on 'WP3 input" to the cost analyses, where they have started to prepare the PBS for the WP3. INFN has participated in the XLS user meeting, contributing to the discussions with the users.

P14 - Kyma. During the 1st half of the project, Kyma S.r.l. was involved in WP7 "Global Integration with New Research Infrastructure" and, in particular, in Task 7.3 - Preliminary estimation of construction/operation costs and in Task 7.4 - Technology Transfer, which has been added to WP7 to address strategies and plans, to foster CompactLight knowledge and technology transfer. Besides being actively involved in the different meetings organized in the framework of WP7, Kyma has been contributing to the discussion and the review of the “Action Plan”, which outlining the actions needed to reach the most efficient exploitation and dissemination of XLS technologies.

P16 - ENEA. ENEA is involved in task 7.1 and is leading in task 7.3 the subtask 7.3.5 on ’WP5 input’ to the cost analyses. In perfect synergy with WP5 activities on “Undulators and light production”, ENEA coordinated a comprehensive and detailed estimate of the undulator system cost. This study aims at covering undulator configurations operating at both Hard and Soft X-rays, also accounting for variable polarization. This cost overview is obtained with data from laboratories and industry, where emphasis is put on specifying whether a series or a single device is accounted for. The result is expressed in terms of price per unit length and the optimum solution seems to be that having many not too long modules, rather than a few very long ones. Finally, the undulator system is going to be fully documented within the XLS-CompactLight Project Breakdown Structure layout. ENEA has also participated in the XLS user meeting, contributing to the discussions with the users.

P17 - ALBA-Cells. ALBA-CELLS is involved in task 7.2, leading subtask 7.2.1 on ’Photon beams’, and in task 7.4. In the framework of the WP7, the main activities developed by the Consortium have been preparatory work in order to address the integration of the future Compact Light Facility with the other research infrastructures in the field of light science. ALBA has participated in all the meetings and actions of the Consortium dedicated to this goal. In particular, ALBA participated in the 1st WP7 team meeting on October 4th 2018, where the roles of the different members have been distributed and clarified. In that meeting, ALBA assumed the role of subtask leader of the Task 7.2 dedicate to investigate and make a review of the user’s needs in the area of Photon Beams. In this aspect, initial investigations of the landscape of the Photon Science Facilities have been performed, including Synchrotron Light Sources and Free Electron Lasers. This has been done in close relation with the LEAPS initiative (https://www.leaps-initiative.eu/) where ALBA has a leading role. ALBA presented a poster about Compact Light Project in the 1st LEAPS Plenary Meeting (https://www.leaps-initiative.eu/news/first_leaps_plenary_meeting/). Since February 2019, ALBA assumed the role of Deputy Leader of the task 7.2. ’Services to be provided’. Initial work has already started in the preparation of the Action Plan document in order to promote the use of the CompactLight technologies in other fields. A meeting was held on May 30th, 2019 and the work will continue in the 2nd Midterm Annual Review Meeting in Helsinki in July 1st - 4th, 2019. ALBA has also supported the selection of users to be invited to the XLS user meeting, participated in the meeting, and contributed to the discussions with the users.

P22 - UH/HIP. UH/HIP is not an official partner of WP7, but has participated in the user workshop, contributing to the discussion with the attendant users and has supported and is still supporting the WP leaders in implementing the PBS for their WPs into the EDMS System. They will further provide help for the storage of data and documents and the definition of access rights.

1.3 Impact

1.3.1 Description & Objectives.

The XLS design study addresses the key points that can make FELs more affordable also for smaller countries or universities:

- Cost - The total facility construction and operating costs must be compatible with in the budget available in a national laboratory or university.
- Footprint - Physical space is often limited if the facility is to be integrated with existing national and university laboratories.
- Complexity - The design and optimization requires a broad range of expertise, beyond that available in the target national and university-scale facilities. FELs are complex machines to operate but much more complex to design and optimise.
- Power consumption - The efficiency of the facility must be high to minimise the power consumption, in particular if one aims at a high repetition rate.

These points have a direct impact on the scientific, technological and industrial areas that will benefit from the design study. Moreover, CompactLight has also socio-economic and strategic impact on future science and technology development in Europe, boosting the EU position worldwide in the field of photon-science and providing recommendations to the scientific community and policy makers for new Research Infrastructures at European level.

1.3.2 Progress achieved.

Scientific impact. The XLS Collaboration has organized a User Meeting at CERN, on November 27-28, 2018, where the project potential have been highlighted. The meeting was also the occasion to collect and discuss with the User Community their future needs in terms of photon beam and FEL facilities.
Two partners, P13, INFN and P3 STFC are currently working to upgrade existing facilities making use of the CompactLight technology:

- EuPraxia@SPARC_Lab at INFN-LNF (IT) project, a proposal for a new facility based on the combination of a high gradient compact X-band linac (1 GeV) and high-power lasers for plasma acceleration tests and a FEL facility with user beam line at 3 nm wavelength.
- XARA at STFC Daresbury (UK), X-band Accelerator for Research and Applications, a 1 GeV upgrading, of the existing CLARA FEL test facility, using the CompactLight technology at X-band.

Technological Impact. In terms of technology the XLS Collaboration has started R&D activities in several emerging and high-priority areas like:

i) X-band based beam diagnostics and phase space manipulation, i.e.:

a) X-band deflecting cavities, commonly used to impart a longitudinal-position-dependent transverse velocity to electron bunches, in order to measure bunch lengths with fs accuracy.

b) X- and Ka- bands linearizer. Accelerating structures and RF power sources for correcting the RF curvature of beam phase space.

ii) S- C- and X-band photoinjectors high-performance sources able to deliver high brightness and high repetition rate electron beams.

iii) Novel short period undulator beyond the current state-of-the-art to achieve shorter saturation lengths, including permanent magnet, or super-conducting undulators.

Industrial Impact.

- *X-band RF stations and high power generators:* The main companies in the field of solid-state modulators and high power klystrons, worldwide, have showed a strong interest in the XLS design study. Contacts have already been established with Scandinova, Ampegon and JEMA Energy (solid-state modulators) as well as CPI, Canon and Thales (Klystron manufacturers). All the companies have been invited at the 2nd Midterm Review Meeting in Helsinki to present their relevant activities and discuss with the XLS partners the future needs in terms of RF power.

- *X-band components:* Besides VDL ETG, partner of the XLS consortium, several companies have showed an interest in CompactLight: DMP, an ultra-high-precision machining firm, already manufacturing CLIC structure prototypes and X-band components, COMEB Rome, a high-precision machining company that has already manufactured the C-band structures for the ELI NP project as well as X-band components for CERN. They are interested in developing their capability of manufacturing and assembling X-band components on an industrial base, following the specifications defined by CompactLight.

- *Undulators:* The impact on the market of shorter, lighter, and possibly less expensive equipment is large, not only as a key component of an X-band technology-based accelerator, but also for the compact particle accelerators in general. In the framework of the XLS Collaboration, given the participation of leading institutes for undulators R&D, such as KIT and ENEA, and an industrial partner Kyma is bringing the development of new and revolutionary concepts for new undulators with much shorter period than the traditional ones.

Socio-economic and strategic impact. The XLS collaboration is providing a complete overview of the basic science, applied science, and industrial applications, where high brightness electron guns, short period undulators, and X-band technology will have significant benefits. A project website (www.compactlight.eu) is already available and is acting as the central hub of knowledge dissemination to the scientific community, industry, and the general public.

2 Exploitation & Dissemination: Update

The plan for the exploitation and dissemination of the CompactLight results, as described in the DoA, has basically not changed. However, more concrete activities are being defined now.

To support an efficient communication of the project with the general public and a wide scientific dissemination of the results, a Communication Team has been set up, which has already been working very successfully during the first reporting period (see description of the activities for WP1), is continuously encouraging the partners to actively communicate and disseminate, and is permanently organising further dedicated activities.

The CompactLight activities will lead to the creation of a large amount of new knowledge, ideas, concepts, methods, applications, devices, and technologies that can potentially be exploited. The project's primary concern of stimulating and supporting a widespread development of FEL facilities by making them, through an optimum use of emerging and innovative technologies, more resource-efficient, sustainable and thus affordable implies directly that new knowledge, know-how, and technologies created by the project are transferred to potential users at the best and that the users get efficiently supported.

For this purpose, the project has adopted the concept of "Open Innovation", through a continuous exchange with relevant external parties, such as other projects working in relevant fields, potential scientific users or possibly benefiting industries, and their involvement in the innovation process. In this way, XLS tempts to foster mutual learning and a direct access to the newest findings, to increase the efficiency of knowledge and know-how transfer, and to promote the innovation process. The project is therefore establishing now suitable actions to be carried out in the second project period in order to support and facilitate the exploitation and dissemination of the obtained results by the partner institutions as well as external applicants, in particular research centres, universities and companies.

To focus and strengthen the corresponding activities, CompactLight has created in WP7, dedicated to the strategic activities supporting the application of CompactLight technologies, a supplementary task for technology transfer described already above. As a first step, this task is currently developing an XLS Action Plan (see also the description of activities in WP7) intended for supporting the project partners in their endeavour to disseminate the CompactLight innovations in an efficient and effective way, foster their wide application and further development, and maximise the benefits of the project for science and society. Created as a "living document", it will be updated whenever required according to developments and progress achieved in the course of the project. User-relevant parts of the contained information will be used also in the support documents for potential applicants of the CompactLight technologies to be created by WP7. The document is broken down into chapters (i) dealing with the expected XLS innovations, (ii) analysing their possible applicants, and (iii) defining measures, resources, and responsibilities to support their dissemination and utilisation. A further chapter, which will be updated regularly, is collecting user-relevant information about already achieved results. The task will also generate the planned support measures and carry out the intended activities with the different user groups.

3 Data Management Plan: Update

A first version of the Data Management Plan (DMP) has been agreed, released on-line on the CompcactLight website, and submitted to the EC as deliverable D.1.2 in M6. This document is based on the Horizon 2020 DMP template, which is designed to be applicable to any Horizon 2020 project that produces, collects or processes research data. It is envisaged as a single 'living' document for the CompactLight project that covers all aspects of data management significant for the project and future users of its results. After a first draft, the document has been updated according to the developments in terms of data, data storage and access to data in the first 18 months. In particular, the platforms offered by CERN, fruit of decades of collaborative work and pioneering experience with web and web-based application, have been chosen as backbone for the data management of CompactLight:

- For any final scientific output, technical sheets, and engineering drawings, it has been chosen the use of the EDMS, the CERN's Engineering Data Management Service. EDMS was established at CERN in the 90s with the goal of providing electronic data management capabilities in the scope of the Large Hadron Collider project. It allows to store, manage, organize and distribute large amounts of engineering information, covering a wide spectrum of fields. The lifecycles of CERN projects last between 25 and 40 years. EDMS ensures the persistence of the documents for such long time cycles (http://edms-service.web.cern.ch/edms-service/faq/EDMS/pages/).

- For data files relative to simulation scripts, simulation codes and data exchange between the partners, the CERN-based Gitlab platform has been chosen (https://gitlab.cern.ch/).

- For organising meetings and conferences, handling participants lists, timetables, and giving persistence and accessibility to presentations, the CERN platform Indico has been chosen. Indico is an advanced tool that enables to manage complex conferences, workshops and meetings (https://indico.cern.ch/). This platform and the 'Open Data' of the project stored there are openly accessible for all interested parties.

The corresponding update of the CompactLight Data Management Plan is currently under progress. The updated version will be available on the project website in Autumn.

4 Deviations from Annex 1 & Annex 2

The deviations concern a few minor changes in the assignment of activities and efforts to WP1 and WP7, which render the work more efficient, as well as the inclusion in the project of a new, linked 3rd party (KyTe, partner Kyma) approved through an amendment to the Grant Agreement.

4.1 Tasks & Objectives

In the following section we describe the deviations for tasks and objectives in each of the CompactLight workpackages.

4.1.1 Workpackage 1

In order to concentrate all activities, which are relevant for promoting the future use of CompactLight technologies in a single, dedicated workpackage, all activities concerning the dissemination to potential applicants of the novel XLS technologies as well as their exploitation in general have been transferred to WP7, which is dedicated to the development of support materials and activities. Communication activities for a broad audience and broad scientific dissemination through scientific publications and presentations or posters in conferences remain activities of Task 1.4.

4.1.2 Workpackage 2

In the reporting period no deviations for tasks and objectives of WP2 have occurred.

4.1.3 Workpackage 3

In the reporting period no significant deviations for tasks and objectives of WP3 have occurred. With respect to the original XLS proposal the participant USTR (P24) has moved its activity and person/months from WP3 to WP4. Conversely the CSIC-IFIC (P21) has moved its activity and person/months from WP4 toWP3, in both cases in fully agreement with the Project Leader and the WP3 and WP4 leaders. The activities of the WP3, have been organized with some modifications with respect to the original proposal in order to clarify the goals and the partners responsibilities, keeping anyway the original Milestones and Deliverable unchanged. The new Tasks and Sub-Tasks have been described in paragraph 1.2.3.

4.1.4 Workpackage 4

In the reporting period no deviations for tasks and objectives of WP4 have occurred.

4.1.5 Workpackage 5

In the reporting period no deviations for tasks and objectives of WP5 have occurred.

4.1.6 Workpackage 6

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4.1.7 Workpackage 7

As explained already above, to better focus the exploitation and dissemination activities that address potential users of CompactLight technologies in a single WP, considering also the suggestions of the CompactLight SAC to sharpen our ideas on technology transfer, task T7.4 named Technology Transfer has been added to WP7.
The "Action Plan" developed by task T7.4 is not intended as an "open document" but primarily as a guide for internal use that helps defining, bundling, guiding, and monitoring the project activities aimed at supporting technology transfer, in order to ensure enough attention, avoid doubling of efforts, and foster the creation of further ideas. However, as already explained above, the user-relevant information (description of achieved innovations as well as all other useful information and tools created by the task that can support potential users and have not been foreseen in the Annexes of the Grant Agreement) will be included in D7.1 (information and instruments already available at the delivery deadline) and D7.2.(all available information and instruments). The activities carried out will also be reported in the 2nd Periodic Report.

4.2 Use of resources

4.2.1 Partner P5, IASA

For technical reasons, IASA has not accounted the work efforts of their staff for CompactLight activities in this periodic report, but will do it for the whole duration of the project in the second periodic report.

4.2.2 Partner P7, UoM

Due to personnel issues, related to the fact that one of the major UoM experts in the relevant field for the project left the University, we have had to initiate a discussion with UoM to re-profile their goals, tasks, schedule etc. This re-profiling is still underway.

4.2.3 Partner P8, ANSTO

Since one of the major ANSTO experts in the relevant field for the project has suddenly passed away, we have had to initiate a discussion with ANSTO to re-profile their goals, tasks, schedule etc. This re-profiling is still underway.

4.2.4 Partner P12, TU/e

Due to some outstanding questions about the travel costs and their relation with the project, TU/e decided to report the costs that have a relationship with the project as an adjustment in period 2.

4.2.5 Partner P13, INFN

For technical reasons, INFN has not accounted the work efforts of their staff for CompactLight activities in this periodic report, but will do it for the whole duration of the project in the second periodic report.

4.2.6 Partner P15, SAPIENZA

The Sapienza staff involved in the project is Prof. Luigi Palumbo (Full Professor) and Prof. Andrea Mostacci (Associate Professor). At the time of the proposal (later become grant agreement), Andrea Mostacci was Assistant Professor, which has a hourly cost smaller than the Associate Professor; the average personnel cost in the Annexes to the GA was calculated on that basis.
The increase of the average personnel cost from the planned value (4000 Euros) to the claimed one (6395.19 Euros) is thus due to these two reasons:

i) The hourly cost of Andrea Mostacci increased due to the change of his professional level within the Sapienza organisation from Assistant to Associate Professor.

ii) In the first year, the contribution of Prof. L. Palumbo to the work done for the project was higher than expected in the proposal phase. This increased effort at the professional level of 'Full Professor' affected the average personnel cost in a relevant way.

4.2.7 Partner P17, ALBA-CELLS

In terms of outreach and communication it has been considered important by the partners to be present and present CompactLight during the 1st Plenary Meeting of LEAPS (League of European Accelerator-based Photon Sources, https://www.leaps-initiative.eu) in Hamburg. Therefore, a poster has been prepared and printed for this occasion, which has been presented by Francis Perez from P17 (ALBA-CELLS) during the event. The preparation costs of 52.17 € (category: other goods and services) have not been planned in Annex 1, since the partners did not know yet that this event would take place and they would have the possibility to present the project when they prepared Annex 1.

4.2.8 Partner P18, CNRS

Due to others commitments during the 1st 18 months of CompactLight, the CNRS personnel involved in the Project has been only 4.1 PM. The difference of 3.4 PM will be compensated and reported in the 2nd reporting period.

4.2.9 Partner P22, UH/HIP

In order to use the skills, know-how, and experience of the Partner concerning the Indico Platform, Collaborative Workspace, Data Storage System (EDMS, GIT etc.), Overleaf Latex Online Editor and Mendeley Reference Management Software in the best way for the project, UH/HIP has been added as a member of the XLS Communication Group to WP1.

4.2.10 Outlook on the 2nd Reporting Period

Some Partners have signalised already that, given their travel expenses for the project during the first reporting period, their total allocated financial resources in the category 'other direct costs' might not be sufficient to cover also the required travels to XLS events and scientific conferences in the second period of the project. For the remaining period, it might therefore be necessary to redistribute the budget of some partners between 'personnel costs' and 'other direct costs'.

4.3 Unforeseen subcontracting

No unforeseen subcontracting has taken place in the first reporting period.

4.4 Unforeseen use of in kind contribution from third party against payment or free of charges

4.4.1 Partner P14, Kyma

Kyma S.r.l. requested an Amendment of the Grant Agreement No. 777431 - XLS, to formally add Kyma Tehnologija d.o.o. as linked third party, keeping the total operative and economic points unchanged. Despite Kyma Tehnologija was originally considered since from the beginning in the proposal through the contribution of its employees, it was not formally specified as a third party due to the fact that Kyma S.r.l. (Italian company) owns 100% of Kyma Tehnologija d.o.o. (Slovenian company). Kyma Tehnologija d.o.o. was established in 2008, as Slovenian daughter company of Kyma S.r.l. to take care of magnetic assembling and characterization of insertion devices thanks to a fully equipped laboratory. The Amendment has been signed by the EC on 26/06/2018. The budget for Kyma s.r.l. in the original version of the grant agreement has been distributed on Kyma (30.100 Euros) and KyTe (61.900 Euros).