Addendum No. 17

to the

Memorandum of Understanding
for Collaboration in the Construction of the
ATLAS Detector

Common Items for the Phase-II Upgrade of the ATLAS Detector

Considering that:

The construction of the ATLAS Detector is governed by a Memorandum of Understanding, along with its Amendments and Addenda, setting out the responsibilities of the different participating Institutes and Funding Agencies for the construction of the ATLAS Detector (Construction MoU)[1].

Maintenance and Operation of the ATLAS Detector is governed by a Memorandum of Understanding for Maintenance and Operation (M&O MoU)[2].

In order to be able to fully exploit the planned High-Luminosity LHC Upgrade[3], the ATLAS Collaboration (the Collaboration) has proposed an Upgrade Program of the ATLAS Detector[4] consisting of modifications and replacements of existing Sub-Systems as well as new additions to the Detector. This Upgrade Program is divided into two phases: Phase-I for items to be installed in or before the second Long Shutdown (LS2) in 2019-2020, and Phase-II for items to be installed in the third Long Shutdown (LS3) in 2024-2026. The present document concerns Phase-II only.

Proposals for upgrades are reviewed by the LHCC on the basis of Technical Design Reports (TDR), while the estimated costs are reviewed by the Upgrade Cost Group (UCG), which includes members from the LHCC and from the Resources Review Board (RRB) scrutiny group.

Following approval[5] of the specific upgrades by the CERN Director General, the sharing of responsibilities will be the subject of addenda to the Construction MoU, signed between the Funding Agencies contributing to these upgrades and CERN as host laboratory.

For the Phase-II, the Collaboration has identified a number of items that it has agreed to bear at its common expense. These items are hereinafter referred to as Common Items.

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1 Memorandum of Understanding for Collaboration in the Construction of the ATLAS Detector (RRB-D 98-44 rev)

2 Memorandum of Understanding for Maintenance and Operation of the ATLAS Detector (CERN-RRB-2002-035)

3 High-Luminosity Large Hadron Collider (HL-LHC). Technical Design Report V0.1 (CERN Yellow Reports: Monographs Volume 4/2017)

4 ATLAS Phase-II Upgrade Scoping Document (CERN-LHCC-2015-020)

5 The first Phase-II TDR "ATLAS Inner Tracker Strip Detector" (ATLAS-TDR-25, CERN-LHCC-2017-005) has already been approved in June 2017. Several additional TDRs are in preparation or under review by the LHCC and UCG at present (September 2017).

It is agreed as follows

Article 1: Purpose

1.1 The purpose of this Addendum and its Annexes is to lay down the rules governing contributions to the Phase-II Common Items, in conformity with the Construction MoU, its amendments and addenda.

1.2 All the Annexes are an integral part of this Addendum.

Article 2: Parties

2.1 The Parties to this Addendum shall be all the Institutes that are members of the Collaboration (the Institutes) and their Funding Agencies, and CERN as the host laboratory. The current list of the Institutes is given in Annex 1 and the current list of Funding Agencies is given in Annex 2.

Article 3: Duration

3.1 This Addendum takes effect from the date of its signing and shall remain valid until the start-up of the LHC following LS3.

3.2 Any Institute that joins the Collaboration subsequent to the signing of this Addendum shall accept the agreements in force.

Article 4: Sharing of Phase-II Common Items

4.1 Annex 3 provides a breakdown and cost estimates of the Phase-II Common Items. They cover general activities and deliverables necessary to accommodate and integrate the planned Phase-II Upgrade projects into an enhanced ATLAS detector capable of exploiting the full physics potential of the High-Luminosity LHC (HL-LHC). The costs have been evaluated in considerable detail and sum up to a total of 24.4 MCHF as can be seen in Annex 3.

4.2 As for 'Maintenance and Operation Category A', the sharing of Phase-II Common Items shall be based on the principle of equity, as defined by the proportion of scientific authors holding a PhD, or equivalent qualification, of each Funding Agency.

4.3 Contributions to the Common Items may be made in two ways:

4.3.1 By cash payments to a dedicated Phase-II Upgrade Common Fund, to be established for the Common Items, through a dedicated account at CERN. This Phase-II Upgrade Common Fund will be managed and operated by the ATLAS Resources Coordinator, in consultation and agreement with the ATLAS Management;

4.3.2 By taking the responsibility for a Common Item or parts of it, in agreement with the ATLAS Management and Collaboration Board and endorsed by the RRB. This option is termed as an "in-kind contribution".

4.4 It is agreed to adopt a flat funding profile for the Phase-II Upgrade Common Fund by dividing the total Common Items cost into 9 equal annual budgets for the years 2018 to 2026. Given the estimated total cost of the Common Items, as detailed in Annex 3, each of the 9 annual budgets amount to 2.713 MCHF.

4.5 As stipulated in Article 4.2 above, each Funding agency's share of the annual budget will be calculated in the same way as for M&O Category A, i.e. the sharing among Funding Agencies for a given year is in proportion to the number of scientific authors holding a PhD or equivalent qualification on the census day, September 9, of the preceding year.

Each year, the RRB will be invited in its October meeting to approve the sharing of the Phase-II Upgrade Common Fund annual budget for the following year. The sharing for the first year 2018 has been calculated based on the M&O author counts taken on 9 September 2017 and is shown in Annex 4.

ANNEXES

Annex 1: List of Institutes and Contact Persons

Annex 2: List of Funding Agencies and Representatives

Annex 3: Breakdown and cost estimates of Phase-II Upgrade Common Items

Annex 4: Sharing of the 2018 Phase-II Upgrade Common Fund budget by Funding Agency

Annex 5: Summary of the main cost drivers

The European Organization for Nuclear Research (CERN)

and

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declare that they agree on the Present Addendum to the Memorandum of Understanding for Collaboration in the Construction of the ATLAS Detector

Done in Geneva	Done in ....
....	....
for CERN	for ....
....	....
Eckhard Elsen Director for Research and Computing	....

ANNEX 1: List of Institutes and Contact Persons

Funding Agency	Institution	Institute	Contact person
Argentina	Buenos Aires	University of Buenos Aires, Buenos Aires	R. Piegaia
	La Plata	National University of La Plata, La Plata	M.T. Dova
Armenia	Yerevan	Yerevan Physics Institute, Yerevan	L. Sargsyan
Australia	Adelaide	The University of Adelaide, Adelaide	P. Jackson
	Melbourne	Research Centre for High Energy Physics, Melbourne University, Melbourne	G. Taylor
	Sydney	University of Sydney, Sydney	K. Varvell
Austria	Innsbruck	Institut für Experimentalphysik der Leopold-Franzens-Universität Innsbruck, Innsbruck	D. Kuhn
	FHWN	Fachhochschule Wiener Neustadt (FHWN), Wiener Neustadt	H. Frais-Koelbl
Azerbaijan Republic	Baku	Institute of Physics, Azerbaijan Academy of Science, Baku	F. Khalilzade
Republic of Belarus	Minsk AC	Institute of Physics, National Academy of Science, Minsk	Y. Kulchitsky
	Minsk NC	Research Institute for Nuclear Problems of Byelorussian State University	P. Starovoitov
Brazil	Brazilian Cluster	Universidade Federal do Rio de Janeiro, COPPE/EE/IF, Rio de Janeiro (UFRJ), Universidade de São Paulo (USP), Universidade Federal de Juiz de Fora (UFJF) and Universidade Federal de São João del Rei (UFSJ)	F. Marroquim
Canada	Alberta	University of Alberta, Edmonton	D. Gingrich
	Carleton	Carleton University, Ottawa	M. Vincter
	Montreal	Group of Particle Physics, University of Montreal, Montreal	J.-F. Arguin
	McGill	Department of Physics, McGill University, Montreal	F. Corriveau
	Simon Fraser Burnaby	Simon Fraser University, Burnaby, BC	M. Vetterli
	Toronto	Department of Physics, University of Toronto, Toronto	P. Krieger
	TRIUMF	TRIUMF, Vancouver and York University, Toronto	O. Stelzer-Chilton
	Vancouver UBC	Department of Physics, University of British Columbia, Vancouver	C. Gay
	Victoria	University of Victoria, Victoria	M. Lefebvre
CERN	CERN	European Laboratory for Particle Physics (CERN), Geneva	C. Rembser
Chile	Chilean Cluster	Joint team from Pontificia Universidad Católica de Chile, Santiago and Universidad Técnica Federico Santa María, Valparaíso	M.A. Diaz
China	China IHEP-NJU-THU Cluster	Joint Cluster formed by Beijing IHEP, Nanjing University, and Tsinghua University	S. Jin
	China USTC-SDU-SJTU Cluster	Joint Cluster formed by Hefei USTC, Shandong University, Shanghai Jiao Tong University	Y. Liu
Colombia	Bogotá UAN	Universidad Antonio Nariño (UAN), Bogotá	M. Losada
Czech Republic	Olomouc	Palacký University, Olomouc	M. Hrabovský
	Prague AS	Institute of Physics of the Czech Academy of Sciences	A. Kupco
	Prague CU	Charles University in Prague, Faculty of Mathematics and Physics, Prague	R. Leitner
	Prague CTU	Czech Technical University in Prague, Faculty of Nuclear Sciences and Physical Engineering, Faculty of Mechanical Engineering, Prague	Z. Hubáček
Denmark	Copenhagen NBI	Niels Bohr Institute, University of Copenhagen, Copenhagen	P.H. Hansen
France IN2P3	Annecy LAPP	Laboratoire d'Annecy de Physique des Particules (LAPP), IN2P3-CNRS, Annecy-le-Vieux	E. Sauvan
	Clermont-Ferrand	Laboratoire de Physique Corpusculaire, Université Blaise Pascal, IN2P3-CNRS, Clermont-Ferrand	D. Calvet
	Grenoble LPSC	Laboratoire de Physique Subatomique et de Cosmologie de Grenoble (LPSC), IN2P3-CNRS-Université Joseph Fourier, Grenoble	F. Ledroit-Guillon
	Marseille CPPM	Centre de Physique des Particules de Marseille, IN2P3-CNRS, Marseille	L. Vacavant
	Orsay LAL	Laboratoire de l'Accélérateur Linéaire, IN2P3-CNRS, Orsay	L. Iconomidou-Fayard
	LPNHE-Paris	LPNHE, Universités de Paris VI et VII, IN2P3-CNRS, Paris	D. Lacour
France CEA	Saclay CEA	Commissariat à l'Energie Atomique (CEA), DSM/DAPNIA, Centre d'Etudes de Saclay, Gif-sur-Yvette	C. Guyot
Georgia	Georgian Cluster	Institute of Physics of the Georgian Academy of Sciences and Tbilisi State University, Tbilisi	I.Minashvili
Germany BMBF	Bonn	Physikalisches Institut, Universität Bonn, Bonn	N. Wermes
	Dortmund	Institut für Physik, Universität Dortmund, Dortmund	K. Kroeninger
	Dresden	Institut für Kern- und Teilchenphysik, Technische Universität Dresden, Dresden	A.Straessner
	Freiburg	Physikalisches Institut, Albert-Ludwigs-Universität Freiburg, Freiburg	G. Herten
	Giessen	Justus-Liebig-University Giessen, Giessen	H. Stenzel
	Göttingen	Fakultät für Physik, II. Physikalisches Institut, Georg-August-Universität, Göttingen	A. Quadt
	Heidelberg	Kirchhoff-Institut für Physik, Heidelberg University and Physikalisches Institut, Heidelberg University	H.-C. Schultz-Coulon
	Berlin HU	Humboldt Universität Berlin, Institut für Physik, Berlin	H. Lacker
	Mainz	Institut für Physik, Universität Mainz, Mainz	S. Tapprogge
	Munich LMU	Sektion Physik, Ludwig-Maximilian-Universität München, Munich	D. Schaile
	Siegen	Fachbereich Physik, Universität Siegen, Siegen	P. Buchholz
	Wuppertal	Fachbereich Physik, Bergische Universität, Wuppertal	W. Wagner

	Würzburg	Julius-Maximilians-Universität, Würzburg	T. Trefzger
Germany DESY	DESY	DESY, Hamburg und Zeuthen	K. Mönig
Germany MPI	Munich MPI	Max-Planck-Institut für Physik, Munich	S. Bethke
Greece	Athens NTU	Athens National Technical University, Athens	E. Gazis
	Athens	Athens University, Athens	C. Kourkoumelis
	Thessaloniki	University of Thessaloniki, High Energy Physics Dept. and Dept. of Mechanical Engineering, Thessaloniki	C. Petridou
Hong Kong	Hong Kong Cluster	Chinese University of Hong Kong (CUHK), University of Hong Kong (HKU) and Hong Kong University of Science and Technology (HKUST)	M.-C. Chu
Israel	Technion Haifa	Department of Physics, Technion, Haifa	S. Tarem
	Tel-Aviv	School of Physics, Tel-Aviv University, Tel-Aviv	E. Etzion
	Weizmann Rehovot	Department of Particle Physics, The Weizmann Institute of Science, Rehovot	E. Duchovni
Italy INFN	Bologna	Dipartimento di Fisica dell'Università di Bologna and I.N.F.N., Bologna	A.Bruni
	Cosenza	Dipartimento di Fisica dell'Università della Calabria e I.N.F.N., Cosenza	E. Tassi
	Frascati	Laboratori Nazionali di Frascati dell'I.N.F.N., Frascati	M. Antonelli
	Genova	Dipartimento di Fisica dell'Università di Genova and I.N.F.N., Genova	C. Gemme
	Lecce	Dipartimento di Fisica dell'Università di Lecce e I.N.F.N., Lecce	E. Gorini
	Milano	Dipartimento di Fisica dell'Università di Milano e I.N.F.N., Milan	G.F. Tartarelli
	Napoli	Dipartimento di Scienze Fisiche, Università di Napoli 'Federico II' et I.N.F.N., Naples	G. Carlino
	Pavia	Dipartimento di Fisica Nucleare e Teorica dell'Università di Pavia e I.N.F.N., Pavia	G. Gaudio
	Pisa	Dipartimento di Fisica dell'Università di Pisa e I.N.F.N., Pisa	C. Roda
	Roma I	Dipartimento di Fisica dell'Università di Roma I 'La Sapienza' and I.N.F.N., Roma	P. Bagnaia
	Roma II	Dipartimento di Fisica dell'Università di Roma II 'Tor Vergata' and I.N.F.N., Roma	A. Di Ciaccio
	Roma Tre	Dipartimento di Fisica dell'Università di Roma III 'Roma Tre' and I.N.F.N., Roma	D. Orestano
	Trento	Università degli Studi di Trento (UniTN) and Trento Institute for Fundamental Physics and Applications (TIFPA INFN)	G.-F. Dalla Betta
	Udine	Dipartimento di Fisica dell'Università di Udine e I.N.F.N., Udine	M. Cobal
Japan	Hiroshima IT	Hiroshima Institute of Technology, Hiroshima	Y. Nagasaka
	KEK	KEK, High Energy Accelerator Research Organisation, Tsukuba	K. Hanagaki, K. Tokushuku
	Kobe	Kobe University, Kobe	H. Kurashige
	Kyoto	Department of Physics, Kyoto University, Kyoto	T. Sumida
	Kyoto UE	Kyoto University of Education, Kyoto	R. Takashima
	Kyushu	Kyushu University, Kyushu	K. Kawagoe
	Nagasaki	Nagasaki Institute of Applied Science, Nagasaki	M. Shimojima
	Nagoya	Nagoya University, Nagoya	M. Tomoto
	Okayama	Faculty of Science, Okayama University, Okayama	R. Tanaka
	Osaka	Osaka University, Osaka	K. Hanagaki
	Shinshu	Faculty of Science, Shinshu University, Matsumoto	T. Takeshita
	Tokyo ICEPP	International Center for Elementary Particle Physics and Department of Physics, the University of Tokyo, Tokyo	H. Sakamoto
	Tokyo Tech	Tokyo Institute of Technology, Tokyo	O. Jinnouchi
	Tokyo MU	Physics Department, Tokyo Metropolitan University, Tokyo	C. Fukunaga
	Tsukuba	Institute of Physics, University of Tsukuba, Tsukuba	F. Ukegawa
	Waseda	Waseda University, Tokyo	K. Yorita
Morocco	RUPHE Morocco	Réseau Universitaire de Physique des Hautes Energies (RUPHE) : Université Hassan II, Casablanca ; Université Mohamed V, Rabat ; Université Cadi Ayad, Marrakech ; Université Mohamed Premier, Oujda ; Centre National de l'Energie des Sciences Techniques Nucléaires (CNESTEN), Rabat	A. Hoummada
Netherlands	NIKHEF	FOM - Institute SAF NIKHEF and University of Amsterdam/NIKHEF	W. Verkerke
	Nijmegen	Radboud University Nijmegen and NIKHEF, Nijmegen	N. de Groot
Norway	Bergen	University of Bergen, Bergen	A. Lipniacka
	Oslo	University of Oslo, Oslo	F. Ould-Saada
Poland	Cracow IFJ PAN	Institute of Nuclear Physics (IFJ PAN), Polish Academy of Sciences, Cracow	B. Wosiek
	Cracow AGH/UJ	Faculty of Physics and Applied Computer Science, University of Science and Technology, Cracow	W. Dabrowski
Portugal	Portugal Cluster	Laboratório de Instrumentação e Física Experimental de Partículas (LIP), Lisbon, in collaboration with: Universidade de Lisboa, Universidade de Coimbra, Universidade do Minho, Universidade Nova de Lisboa and Universidad de Granada	P. Conde Muíño
Romania	Bucharest Cluster	Horia Hulubei National Institute of Physics and Nuclear Engineering (IFIN-HH), Institute of Atomic Physics, Bucharest; West University, Timisoara; University Politehnica Bucharest; National Institute for R&D of Isotopic and Molecular Technologies (ITIM) Cluj Napoca; Transylvania University of Brasov; Alexandru Ioan Cuza University (UAIC) Iasi	C. Alexa
Russia	Moscow ITEP	Institute for Theoretical and Experimental Physics, Moscow, NRC KI, Russia	I. Tsukerman
	Moscow FIAN	P.N. Lebedev Institute of Physics, Moscow	K. Zhukov
	Moscow MEPhI	Moscow Engineering and Physics Institute (MEPhI), Moscow	A.Romaniouk

	Moscow SU	Moscow State University, Moscow	L. Gladilin
	Novosibirsk BINP-NSU	Budker Institute of Nuclear Physics (BINP), Novosibirsk	Y. Tikhonov
	Protvino IHEP	State Research Center Institute for High Energy Physics (Protvino), NRC KI, Russia	A. Zaitsev
	Petersburg NPI	Petersburg Nuclear Physics Institute, St. Petersburg, NRC KI, Russia	O. Fedin
	Tomsk SU	Tomsk State University (TSU), Tomsk	A.Khodinov
JINR	JINR Dubna	Joint Institute for Nuclear Research , Dubna	V. Bednyakov
Serbia	Belgrade Cluster	Institute of Physics, University of Belgrade, Belgrade	D. Sijacki
Slovak Republic	Slovakian Cluster	Bratislava University, Bratislava, and Institute of Experimental Physics of the Slovak Academy of Sciences, Kosice	D. Bruncko
Slovenia	Ljubljana	Jozef Stefan Institute and Department of Physics, University of Ljubljana, Ljubljana	M. Mikuz
South Africa	South Africa Cluster	University of Cape Town; Department of Physics, University of Johannesburg (UJ) and School of Physics, University of the Witwatersrand (WITS), Johannesburg	B. Mellado Garcia
Spain	Barcelona	Institut de Física d'Altes Energies (IFAE), Universitat Autònoma de Barcelona, Bellaterra (Barcelona)	M. Bosman
	Madrid UA	Physics Department, Universidad Autónoma de Madrid, Madrid	F. Barreiro
	Valencia	Instituto de Física Corpuscular (IFIC), Centro Mixto Universidad de Valencia - CSIC, Valencia and Instituto de Microelectrónica de Barcelona, Bellaterra (Barcelona)	C. Garcia
Sweden	Lund	Fysiska institutionen, Lunds universitet, Lund	T. Åkesson
	Stockholm KTH	Royal Institute of Technology (KTH), Stockholm	B. Lund-Jensen
	Stockholm	Stockholm University, Stockholm	D. Milstead
	Uppsala	Uppsala University, Department of Physics and Astronomy, Uppsala	R. Brenner
Switzerland	Bern	University of Bern, Albert Einstein Center for Fundamental Physics, Laboratory for High Energy Physics, Bern	M. Weber
	Geneva	Département de Physique Nucléaire et Corpusculaire, Université de Genève, Geneva	G. Iacobucci
Taiwan	Hsinchu NTHU	National Tsing Hua University (NTHU), Hsinchu	K. Cheung
	Taipei AS	Academia Sinica, Taipei	S.-M. Wang
Turkey	Ankara	Joint Ankara University cluster formed by Ankara University, TOBB University, and Istanbul Aydin University (IAU)	O. Cakir
	Boğaziçi	Joint Boğaziçi University cluster formed by Boğaziçi University Istanbul, Bahçeşehir University, Gaziantep University and Istanbul Bilgi University	V. E. Ozcan
United Kingdom	Birmingham	School of Physics and Astronomy, The University of Birmingham, Birmingham	A.Watson
	Sussex	University of Sussex, Brighton	A. De Santo
	Cambridge	Cavendish Laboratory, Cambridge University, Cambridge	A.Parker
	Edinburgh	School of Physics and Astronomy, University of Edinburgh, Edinburgh	P. Clark
	Glasgow	Department of Physics and Astronomy, University of Glasgow, Glasgow	C. Buttar
	Lancaster	Department of Physics, Lancaster University, Lancaster	R. Jones
	Liverpool	University of Liverpool, Liverpool	M. Klein
	London QMUL	School of Physics and Astronomy, Queen Mary University of London, London	E.S. Rizvi
	London RHBNC	Department of Physics, Royal Holloway, University of London, Egham	V. Boisvert
	London UC	Department of Physics and Astronomy, University College London, London	N. Konstantinidis
	Manchester	Department of Physics and Astronomy, University of Manchester, Manchester	T. Wyatt
	Oxford	Department of Physics, Oxford University, Oxford	I.Shipsey
	RAL	Rutherford Appleton Laboratory, Chilton, Didcot	S. Haywood
	Sheffield	Department of Physics, University of Sheffield, Sheffield	D. Costanzo
	Warwick	University of Warwick, Warwick	S. Farrington
United States of America	Albany	State University of New York at Albany, New York	V. Jain
	Argonne	Argonne National Laboratory, Argonne, Illinois	J. Proudfoot
	Arizona	University of Arizona, Tucson, Arizona	P. Loch
	Arlington UT	Department of Physics, The University of Texas at Arlington, Arlington, Texas	K. De
	Austin	University of Texas at Austin, Austin	P. Onyisi
	Berkeley LBNL	Lawrence Berkeley Laboratory and University of California, Berkeley, California	I. Hinchliffe
	Boston	Physics Department of the University of Boston, Boston, Massachusetts	J. Butler
	Brandeis	Brandeis University, Department of Physics, Waltham, Massachusetts	J. R. Bensinger
	Brookhaven BNL	Brookhaven National Laboratory (BNL), Upton, New York	S. Rajagopalan
	Chicago	University of Chicago, Enrico Fermi Institute, Chicago, Illinois	J. Pilcher
	Columbia	Nevis Laboratory, Columbia University, Irvington, New York	J. Parsons
	Dallas UT	University of Texas at Dallas, Dallas	J.M. Izen
	Duke	Department of Physics, Duke University, Durham, North Carolina	M. Kruse
	Harvard	Department of Physics, Harvard University, Cambridge,	J. Huth

		Massachusetts	
	Indiana	Indiana University, Bloomington, Indiana	H. Evans
	Iowa State	Iowa State University, Ames, Iowa	J. Cochran
	Iowa	University of Iowa, Iowa City, Iowa	U. Mallik
	UCI	University of California, Irvine, California	A. J. Lankford
	Louisiana Tech	Louisiana Tech University	M. Wobisch
	Massachusetts	Department of Physics, University of Massachusetts, Amherst	S. Willocq
	MIT	Massachusetts Institute of Technology, Department of Physics, Cambridge, Massachusetts	F. E. Taylor
	Michigan SU	Michigan State University, Department of Physics and Astronomy, East Lansing, Michigan	R. Schwienhorst
	Michigan	University of Michigan, Department of Physics, Ann Arbor, Michigan	B. Zhou
	New Mexico	Department of Physics, New Mexico University, Albuquerque	S. Seidel
	NYU New York	New York University, Department of Physics, New York	P. Nemethy
	Northern Illinois	Northern Illinois University, Dekalb, Illinois	D. Chakraborty
	Ohio SU	Ohio State University, Columbus, Ohio	K.K. Gan
	Oklahoma	Department of Physics and Astronomy, University of Oklahoma	P. Skubic
	Oklahoma SU	Oklahoma State University, Oklahoma	F. Rizatdinova
	Oregon	University of Oregon, Eugene, Oregon	J.E. Brau
	Pennsylvania	Department of Physics, University of Pennsylvania, Philadelphia, Pennsylvania	H.H. Williams
	Pittsburgh	University of Pittsburgh, Pittsburgh, Pennsylvania	J. Boudreau
	Santa Cruz UC	Institute for Particle Physics, University of California, Santa Cruz, California	A. Seiden
	Dallas SMU	Department of Physics, Southern Methodist University, Dallas, Texas	R. Stroynowski
	SLAC	SLAC, Stanford	S. Dong
	Stony Brook	State University of New York at Stony Brook, New York	D. Tsybyshev
	Tufts	Tufts University, Medford, Massachusetts	K. Sliwa
	Urbana UI	High Energy Physics, University of Illinois, Urbana, Illinois	M. Neubauer
	Seattle Washington	Department of Physics, Department of Mechanical Engineering, University of Washington, Seattle, Washington	H. J. Lubatti
	Wisconsin	Department of Physics, University of Wisconsin, Madison, Wisconsin	S. L. Wu
	Yale	Yale University, New Haven, Connecticut	K. Baker

ANNEX 2: List of Funding Agencies and Representatives

Argentina	Agencia Nacional de Promoción Científica y Tecnológica; Ministerio de Ciencia, Tecnología e Inovación Productiva de la Nación	Lino Barañao
Armenia	Yerevan Physics Institute	Ashot Chilingarian
Australia	Australian Research Council (ARC)	Geoffrey Taylor
Austria	Bundesministerium für Bildung, Wissenschaft und Kultur	H. Schacher, H. Borns
Azerbaijan	Academy of Science of Azerbaijan	Nazim Mamedov
Belarus	The State Science and Technology Committee, Council of Ministers of the Republic of Belarus	Alexander Shumilin (Chairman)
Brazil	Rede Nacional de Fisica de Altas Energias (RENAFAE)	Ignacio De Bediaga
Canada	Natural Sciences and Engineering Research Council of Canada (NSERC) Canada Foundation for Innovation (CFI)	Pierre J. Charest Guy Levesque
Chile	Comisión Nacional de Investigación Científica y Tecnológica (CONICYT)	Maria Elena Boissier
China	National Natural Science Foundation of China (NSFC)	Y. Zhang
Colombia	Departamento Admininistrativo de Ciencia, Tecnología e Innovación - COLCIENCIAS	Alejandro Olaya
Czech Republic	Ministry of Education, Youth and Sports (MEYS)	O. Novak
Denmark	National Committee for Research Infrastructure	Peter Hansen
France IN2P3	Institut National de Physique Nucléaire et de Physique des Particules (IN2P3); Centre National de la Recherche Scientifique (CNRS)	Reynald Pain, Patrice Verdier
France CEA	Commissariat à l'Energie Atomique et aux Energies Alternatives (CEA)	Vincent Berger (Head of DRF), Anne-Isabelle Etienvre (Head of IRFU)
Georgia	Ministry of Education and Science (MES)	A. Jejelava
Germany BMBF	Bundesministerium für Bildung und Forschung (BMBF)	Volkmar Dietz
Germany DESY	Deutsches Elektronen-Synchrotron (DESY)	Manfred Fleischer
Germany MPI	Max-Planck-Institut für Physik	Siggi Bethke
Greece	National Centre for Scientific Research (GSRT)	Costas Fountas
Hong Kong	Hong Kong Research Grants Council (RGC)	Benjamin W. Wah
Israel	Israel Committee on High Energy Physics (ICHEP)	Eliezer Rabinovici, Y. Rozen
Italy	Istituto Nazionale di Fisica Nucleare (INFN)	Fernando Ferroni
Japan	The High Energy Accelerator Research Organization (KEK)	Atsuto Suzuki
Morocco	Centre National pour la Recherche Scientifique et Technique (CNRST)	Said Belcadi
Netherlands	Nationaal Instituut voor Subatomaire Fysica (NIKHEF)	Arjen van Rijn, Stan Bentvelsen
Norway	Norwegian Research Council	B. Jacobsen
Poland	Ministry of Science and Higher Education	D. Drewniak
Portugal	Fundação para a Ciência e Tecnología (FCT)	G. Barreira
Romania	Institute of Atomic Physics (IFA)	Florin-Dorian Buzatu, A. Fazacas, R. Savu
Russia	Ministry of Education and Science	G. Trubnikov
JINR	Joint Institue for Nuclear Research (JINR)	Victor Matveev
Serbia	Ministry of Science and Environmental Protection	Djordje Sijacki
Slovak Republic	Ministry of Education, Science, Research and Sport of the Slovak Republic (MINEDU)	Z. Hlavacikova
Slovenia	Ministry of Education, Science and Sport	Z. Stancic
South Africa	Department of Science and Technology (DST)	Daniel Adams
Spain	Ministerio de Economía, Industría y Competitividad (MINEICO)	Mario Martinez
Sweden	Research Council (Vetenskapsrådet)	Sven Stafström, Niklas Ottosson
Switzerland	The Swiss National Science Foundation (SNSF)	M. Türler
Taiwan	Ministry of Science and Technology (MOST)	Shih-Chang Lee
Turkey	Turkish Atomic Energy Authority (TAEK)	Z. Alper
United Kingdom	Science and Technology Facilities Council (STFC)	Tony Medland, Grahame Blair
USA DOE	US Department of Energy (DOE)	A. Patwa, S. Rolli
USA NSF	National Science Foundation (NSF)	M. Coles
CERN	European Organization for Nuclear Research	Eckhard Elsen

ANNEX 3: Breakdown and cost estimates of Phase-II Upgrade Common Items

A detailed work breakdown structure (WBS) has been developed to understand the needs for support and additional infrastructure of the ATLAS Phase-II upgrade projects as well as possible. The table below shows the first two levels of the WBS, together with the corresponding cost estimates. Some more details about the main cost drivers can be found in Annex 5.

WBS	Description	kCHF
7	**Common Items**	**24'420**
7.1	**Project Management**	**-**
7.1.1	Global Project Plan	-
7.1.2	Installation schedule	-
7.1.3	Resources & Costing	-
7.1.4	Management tools	-
7.1.5	Documentation Web service	-
7.1.6	Quality Assurance	-
7.2	**Experiment Layout**	**4'775**
7.2.1	Mechanical Interfaces & Envelopes	-
7.2.2	Decommissioning	260
7.2.3	Shut Down configurations	485
7.2.4	Cabling	3'490
7.2.5	Infrastructure Integration	540
7.3	**System interfaces & Facilities**	**9'583**
7.3.1	Detector F/E DAQ	-
7.3.2	Detector DCS interface	-
7.3.3	Control Network	100
7.3.4	Cooling & Ventilation	2'400
7.3.5	Detector Cooling	2'355
7.3.6	Gas systems	100
7.3.7	Electrical network	4'628
7.4	**Common Electronics**	**3'207**
7.4.1	Front-Ends electronics	-
7.4.2	Power distribution	614
7.4.3	Central DCS	767
7.4.4	Central DSS	561
7.4.5	Modular electronics	170
7.4.6	Rack infrastructure	1'095
7.5	**Safety**	**2'112**
7.5.1	Fire Detection and extiction systems	1'021
7.5.2	Radioprotection management	740
7.5.3	Work environment/conditions	301
7.5.4	General safety infrastructure	50
7.6	**Machine Interfaces**	**1'155**
7.6.1	HL-LHC liaison	-
7.6.2	ATLAS simulations	-
7.6.3	Forward detectors	60
7.6.4	Machine Interface definition	1'095
7.7	**System Support**	**2'872**
7.7.1	New Small Wheel	-
7.7.2	Muons MDT & RPC	2'102
7.7.3	BW and EO	36
7.7.4	BIS7/8	-
7.7.5	ITK	518
7.7.6	LAR & TileCal	129
7.7.7	HGTD	87
7.8	**Shielding**	**516**
7.8.1	SX1 shielding (fast neutrons)	488
7.8.2	Additional shielding	28
7.8.3	NJD	-
7.9	**Surface facilities**	**200**
7.9.1	Storage	-
7.9.2	SR1 extension	-
7.9.3	B180 labs	-
7.9.4	Workshop	-
7.9.5	BB5	-
7.9.6	SDX1	200

ANNEX 4: Sharing of the 2018 Phase-II Upgrade Common Fund budget by Funding Agency

In accordance with Article 4.4, the total budget for the Phase-II Upgrade Common Fund of 24’420 kCHF (Annex 3) is spread flat over 9 years, from 2018 to 2026. The budget to be shared among the Funding Agencies during this period is thus 2’713.3 kCHF/year. The sharing is calculated year-by-year in the same way as for M&O-A (Article 4.5): the contributions from the Funding Agencies for year *n* will be calculated in proportion to the number of scientific authors counted for M&O on September 9 in year *n-1*.

The table below shows the 2018 contributions by Funding Agency thus obtained on the basis of the M&O author count snapshot taken on 09.09.2017:

Funding Agency	**M&O author counts on 09/09/2017**		**Common Fund Contribution [kCHF]**
Argentina	6	0.32%	8.7
Armenia	0	0.00%	-
Australia	15	0.80%	21.7
Austria	3	0.16%	4.3
Azerbaijan	1	0.05%	1.4
Belarus	2	0.11%	2.9
Brazil	14	0.75%	20.2
Canada	65	3.46%	94.0
Chile	10	0.53%	14.5
China NSFC+MSTC	48	2.56%	69.4
Colombia	4	0.21%	5.8
Czech Republic	39	2.08%	56.4
Denmark	11	0.59%	15.9
France IN2P3	114	6.08%	164.9
France CEA	24	1.28%	34.7
Georgia	6	0.32%	8.7
Germany BMBF	153	8.16%	221.3
Germany DESY	37	1.97%	53.5
Germany MPI	21	1.12%	30.4
Greece	15	0.80%	21.7
Hong Kong	10	0.53%	14.5
Israel	29	1.55%	41.9
Italy	169	9.01%	244.4
Japan	76	4.05%	109.9
Morocco	11	0.59%	15.9
Netherlands	24	1.28%	34.7
Norway	16	0.85%	23.1
Poland	29	1.55%	41.9
Portugal	15	0.80%	21.7
Romania	16	0.85%	23.1
Russia	64	3.41%	92.6
JINR	26	1.39%	37.6
Serbia	5	0.27%	7.2
Slovak Republic	10	0.53%	14.5
Slovenia	8	0.43%	11.6
South Africa	9	0.48%	13.0
Spain	49	2.61%	70.9
Sweden	30	1.60%	43.4
Switzerland	25	1.33%	36.2
Taipei	8	0.43%	11.6
Turkey	11	0.59%	15.9
United Kingdom	191	10.18%	276.3
US DOE HEP	274	14.61%	396.3
US NSF HEP	65	3.46%	94.0
US DOE NP	6	0.32%	8.7
US NSF NP	4	0.21%	5.8
CERN	102	5.44%	147.5
Other	6	0.32%	8.7
Total	**1876**	**100.00%**	**2'713.3**

ANNEX 5: Summary of the main cost drivers

The relatively large increase of 7 MCHF of the Common Item costs with respect to the Scoping Document (CERN-LHCC-2015-020, LHC-G-166) is due mainly to the much better understanding of the needs of the upgraded detector for:

- Electrical Infrastructure
- Cooling and Ventilation and Detector Cooling
- Cabling
- Rack Infrastructure

The main cost drivers in these four areas are briefly discussed in the following.

Electrical infrastructure

The total cost of this WBS item is **4628 kCHF** as detailed in the table below.

WBS Code	Element	Contact Person	Upgrade Total CORE Cost [kCHF]
7	Common items (Technical Coordination)		
7.3.7	Electrical network	W. Iwanski	**4628**
7.3.7.1	Normal Power (SDX1)		460
7.3.7.2	New Diesel UPS (SDX1)		1992
7.3.7.3	New bc UPS SX1 (USA15/UX15)		1125
7.3.7.4	Normal UPS (US15)		175
7.3.7.5	bc UPS (US15)		190
7.3.7.6	New Diesel Surface		278
7.3.7.7	Normal Power (USA15/UX15)		194
7.3.7.8	bc UPS USA15		214

A detailed study has been performed to quantify the needs of the upgraded detector in terms of electrical power, classifying the needs by type (uninterrupted or normal power) and the location where the power is needed (surface or service caverns). The result is that an additional 1.8 MW are needed in the underground caverns for the powering and read-out of the detectors (the main contributors are the ITk, LAr Read-out and TDAQ). On the surface, an additional 1.2 MW are needed for the upgraded HLT farm and for the primary chiller for the CO2 detector cooling plant used by the ITk. The costs for these new installations have been evaluated with the CERN EN-EL group who will be the main supplier for these improvements. The cost estimates are based on the costs of similar installations at the time of the original construction of ATLAS, which have been escalated to account for the increased costs of material and labour today.

Cooling and Ventilation

The upgraded ATLAS detector will consume substantially more electrical power in the underground caverns (about 1.8 MW as discussed above). To cope with this additional power dissipation, a corresponding increase in the capacity of the cooling and ventilation systems is required.

The present cooling tower circuit at Point 1 has a remaining margin of 9 MW. However, to access this additional capacity, the temperature difference between the supply and return water must be increased. The chilled water system has only 300 kW of margin. The mixed water circuit has 1 MW of margin, which can only be accessed if the electronics in the racks can be operated at higher temperature (by increasing the difference between the water temperature at the rack output compared to the rack input).

In order to provide additional cooling capacity to the ATLAS systems, the proposed solution involves detaching the circuits dedicated to the ventilation of part of the surface buildings, and to the rack cooling in SDX1, from the existing chilled and mixed water production stations. The detached circuits will be connected to a new cooling plant to be located in SU1. This new plant will produce the required chilled water via water-cooled chillers, providing an additional cooling capacity of 2 MW.

The total cost of these new installations, plus the modifications needed for the existing installation, has been estimated to be **2400 kCHF** by the CERN EN-CV group who will be the main supplier for these improvements.

In addition to the increased needs for cooling and ventilation for the general infrastructure discussed above, the new CO2 cooling plant for the ITk detector will need a primary chiller providing about 340 kW of cooling power at -60°C. The space in the cooling room in USA15 is tight and therefore the primary chiller is foreseen to be moved up to the surface where the present thermosiphon chiller is located.

The total cost for this new chiller is **2355 kCHF**. This estimate is based mainly on the previous experience of the cost of the thermosiphon. The breakdown of the costs is detailed in the table below.

WBS Code	Element	Contact Person	Upgrade Total CORE Cost [kCHF]
7	Common items (Technical Coordination)		
7.3.5	Detector Cooling	L. Zwalinski	2355
7.3.5.1	Primary for CO2 cooling		2355
7.3.5.1.1	Primary Chiller		950
7.3.5.1.2	Insulated piping		670
7.3.5.1.3	Connection of Primary to El. Power		250
7.3.5.1.4	Connection of CO2 plant to El. Power		400
7.3.5.1.5	Connection to water circuit		85

Cabling

The phase-II upgrade requires substantial changes to the present cable plant. The new ITk will require replacement of essentially all of the present ID cables. Most other detectors will move to high-speed optical fiber plants to transmit data off the detector for each beam-crossing (at 40 MHz), requiring removal of obsolete copper cables to make way for the large number of fiber-optic cables. The total amount of work needed for cabling the upgraded detector is comparable to that needed for the cable installation which was carried out during the original construction of ATLAS.

In particular, most of the ITk power and read-out cables and fibers will be new. The LAr and Tile calorimeters plan to install large numbers of read-out fibers and new HV cables, while the muon system, needs to install power and read-out cables for the new BI chambers in the inner barrel layer. In order to make room for the new cables, a large volume of existing cables must be removed from the cable trays. This activity will be very difficult and manpower intensive. The total cost for this activity is driven by the technical manpower needed. The cost of the modification to the flexible chain and cable trays is not the driving factor, but is not negligible. The manpower required to cable ATLAS during its construction is taken as a starting reference point. This suggests that the number of FTE-years needed for cabling during LS3 would be 45. This large amount of manpower needs to be found, and initial discussions with collaborating institutes have started. In the table below the cost for the cabling of each subsystem is detailed.

Total cost for WBS 7.2.4 : **3490 kCHF**

WBS Code	Element	Contact Person	Upgrade Total CORE Cost [kCHF]
7	Common items (Technical Coordination)		
7.2.4	Cabling	B. Gorini	3490
7.2.4.1	General support		720
7.2.4.2	Environment		192
7.2.4.3	ITK		720
7.2.4.4	LAr + HGTD		288
7.2.4.5	TileCal		216
7.2.4.6	Muons		540
7.2.4.7	Cable trays and furnitures		286
7.2.4.8	Counting rooms		528

Rack Infrastructure

After LS3, the majority of the trigger and detector readout electronics installed in the electronics room in USA15 will be upgraded. The new electronics will either be based on the new ATCA modular standard or based on PC systems housing custom PCIe boards. The number of crates and the number of PC units required to support the substantial increases in trigger and readout requirements for Phase-II will exceed the available space in the racks currently installed in USA15. As the available floor space in the electronics room places strong constraints on the number of additional racks that can be installed, Technical Coordination is investigating the possibility of replacing many of the existing racks with taller ones, capable of housing 3 ATCA shelves, in contrast with the 2 ATCA shelves that can be fit in one of the standard racks currently installed in USA15.

Considering that fully populated ATCA racks are extremely noisy, it has been decided to group all ATCA electronics in the first two rows in both Level 1 and Level 2 of the electronics room in USA15 and to isolate them from the other rows of racks using noise-reducing walls.

A preliminary analysis of the Phase-II designs presented in the TDRs indicates a total of 67 taller racks to be installed and equipped with appropriate electrical and cooling infrastructure. This is a complex upgrade, given the large potential power dissipation of 3 fully populated ATCA shelves in each rack.

In addition to the ATCA racks discussed above, 40 deeper racks will need to be installed to host server PCs, since the standard ATLAS racks are incompatible with the form-factors used by future commodity PC servers.

Given the increased weight of the taller ATCA racks and the deeper PC server racks, additional work will be required to reinforce and strengthen the false floor of the electronics room in USA15.

The costs of these activities have been evaluated by requesting initial offers for all hardware components required for this upgrade (racks, improved electrical infrastructure, rack cooling equipment like heat exchangers, noise reduction and cancellation equipment for the racks, plus material and manpower for the noise reducing walls). Details are summarized in the table below.

Total cost for WBS 7.4.6 : **1095.5 kCHF**

WBS Code	Element	Contact Person	Upgrade Total CORE Cost [kCHF]
7	Common items (Technical Coordination)		
7.4.6	Rack infrastructure	B. Gorini	**1095,5**
7.4.6.1	New rack installation/arrangement		601,4
7.4.6.2	Noise Mitigation		193,6
7.4.6.3	Rack cooling upgrade		100,5
7.4.6.4	Floor Consolidation		200