SEVENTH FRAMEWORK PROGRAMME
THE PEOPLE PROGRAMME

Grant agreement for: **Initial Training Networks**

Annex I - "Description of Work"

Project acronym:	ACEOLE
Project full title:	Data Acquisition, Electronics, and Optoelectronics for LHC Experiments
Grant agreement no.:	211801
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PART A:

A 1 List of beneficiaries and project summary

A 1.1 List of Beneficiaries

Beneficiary Number	Beneficiary name	Beneficiary short name	Country	Date enter project	Date exit project
1	European Organization for Nuclear Research	CERN	Switzerland	month 1	month 48

Table 1: The nine associated partners of the ITN

N°	Associated Partner	Short name of the associated partner	Country	Level+	Status*
1	AGH, University of Science and Technology, Krakow; Faculty of Physics and Applied Computer Science	AGH Krakow	Poland	2	HEE
2	Force10 Networks Inc.	Force10	UK & USA	2	CE
3	Instituto de Engenharia de Sistemas e Computadores, Porto; Telecommunications and Multimedia unit	INESC Porto	Portugal	2	RO
4	Istituto Nazionale di Fisica Nucleare; Laboratori Nazionali di Legnaro	INFN - LNL	Italy	2	RO
5	PANalytical BV	PANalytical	Netherlands	2	CE
6	SCK.CEN, the Belgian Nuclear Research Centre; Advanced Reactor Instrumentation	SCK.CEN	Belgium	2	RO
7	University College, London; Dept. Electronic & Electrical Engineering	UCL	United Kingdom	2	HEE
8 9	VTT Technical Research Centre of Finland, Oulu. VTT Technical Research Centre of Finland, Espoo	VTT Oulu VTT Espoo	Finland	2	RO

+ Level: 2 = provider of research training and complementary skills courses, as well as secondment opportunities.
* Status: HEE = Higher Education Establishment; CE=Commercial Enterprise; RO=Research Organization.

A.1.2 Project Summary

Keywords

Pixel detectors, materials analysis, microelectronics, mixed-signal design, optoelectronics, telecom technology, computer technology, data acquisition, network technology.

Abstract

The project is a mono-site Initial Training Network (ITN) with CERN as main host institution, and offering research training in the application of advanced microelectronics, optoelectronics, networking and real-time data processing technologies in the world's state-of-the-art particle detector systems at the Large Hadron Collider (LHC), and a future upgraded Super-LHC (SLHC). This ITN will help strengthen Europe's human resources in key technologies for enhancing industry competitiveness in domains where there exist technology gaps with other high-tech economies.

The LHC will start operation in 2008. The commissioning, operation and future upgrades of the LHC detectors offer tremendous opportunities for research training in an international, multidisciplinary environment. Training projects will have concrete objectives and deliverables in the domains of precision particle tracking systems, electronics and optoelectronics for their readout, switching fabrics and real time processing systems for data acquisition.

CERN contributes to overcoming fragmentation in European Research through its well-established international network of universities, partnerships with technology research centres, technology transfer policy, and history of joint developments with industry. This ITN will complement and reinforce that contribution.

The young researchers will be supervised by internationally recognized experts and have access to state-of-the-art equipment. Hands-on project training will be supplemented with formal training courses in relevant and related fields, and a wide variety of complementary training courses, colloquia and seminars. Mobility within the ITN will ensure exposure to complementary research and industry environments.

Supervision will follow a model similar to CERN’s established and successful Doctoral Student program, in which projects are defined and monitored by a CERN supervisor in collaboration with a university professor.

PART B:

B.1 Description of the joint Research Training Project

B.1.1 Project Overview

The project is a mono-site Initial Training Network (ITN) with CERN acting as main host institution, complemented with the 9 associated partners listed in table 1 (page 3), of which 2 are from the industry sector. It will provide research training in the application of advanced microelectronics, optoelectronics, networking and real-time data processing technologies in the particle detector systems at CERN's Large Hadron Collider (LHC), and at a future upgraded Super-LHC (SLHC).

The methodology is based on hands-on training in R&D projects driven by the concrete requirements of CERN's LHC physics programme, supplemented with formal training courses in relevant and related fields, and a wide variety of complementary training courses, colloquia and seminars.

B.1.2 Concept and Project Objectives

The ACEOLE project focuses on detector, electronics and data acquisition (DAQ) developments needed for the future luminosity upgrade of experimental facilities at the LHC. The work addresses five parallel research themes implemented in the corresponding work packages outlined in table 2.

Table 2: Overview of the five research training work packages of this ITN

(S)LHC Subsystem	**W.P. No.**	**Work Package (Research Training Theme)**	**N^{o}. ESR**	**N^{o}. ER**
Detector	**1**	Pixel detector systems for particle tracking (and imaging).	1	1
Electronics & optoelectronics readout system	**2**	Radiation-hard ASIC building blocks for detector data readout.	1	-
	3	Radiation & magnetic field tolerant power management systems for front-end on-detector electronics.	1	-
	4	Radiation-hard, non-magnetic optical transmission systems for data transfer, timing & trigger distribution, & control functions.	3	2
Data acquisition	**5**	Data acquisition and high level triggering systems.	6	2
		TOTALS =>	**12**	**5**

B.1.2.1 Work Package 1: Pixel Detector Systems for Particle Tracking and Imaging

CERN has developed pixel detectors for high-precision measurement of particle tracks in experiments at the LHC and other domains (medical imaging, materials analysis, and others). Key challenges are the reduction of the thickness of the detector material, as this material distorts the physics interactions, and developing low-cost interconnection techniques to construct affordable large area hybrid pixel arrays. Advances in industry-based ultra-high density interconnect and assembly technology will be investigated in order to address these challenges.

The research objectives for an Experienced Researcher (ER) and an Early Stage Researcher (ESR) in the context of these pixel developments are:

- The development of experiments covering large areas with existing pixel detector tiles for X-ray imaging, X-ray diffraction (~ month 12). Evaluation of experimental results (~month 18)
- Study of potential moderately large area tiling solutions (~month 12); the design of low-mass assemblies suitable for tiling moderately large areas of pixel arrays (~month 24); construction and evaluation of demonstrator assemblies implementing the most promising tiling solution(s) (~month 36) for particle tracking and/or photon counting applications.

B.1.2.2 Work Package 2: Building Blocks and Demonstrator ASICs for SLHC

The LHC tracking detectors are read out by embedded radiation-hard front-end ASICs. A set of radiation-hard ASIC building blocks and functions implemented in 130nm CMOS will be needed to support development of front-end electronics for future upgrades of the LHC detectors.

The objective of at least one ESR project will be to develop one or more of the required low-power, ultra-radiation-hard ASIC building blocks or functions (in first instance a PLL) in 130nm CMOS technology. This will involve learning the radiation-tolerant design methodology and CAE tools and establishing a specification (~month 6); the design of a prototype ASIC (~month 18); organizing its fabrication; carrying out electrical and functional characterization before and after irradiation (~month 27); concluding with the design, fabrication, characterization and documentation of a final version.

B.1.2.3 Work Package 3: On-detector Power Management Schemes

In order to preserve the resolution of the track measurements special attention has been paid to minimize the amount of material in the detector. Reduction of front-end electronics power, and efficient on-detector power distribution schemes will be essential in order to limit the amount of material in the form of cabling and cooling infrastructures. Two main approaches are considered for more efficient methods of delivering power to the on-detector electronics: one consists in exploring ***DC-DC conversion*** to bring higher voltages and lower currents inside the tracker (SCT) volume, and the other in exploring ***serial powering schemes***.

The objective of at least one ESR project will be to develop radiation-tolerant ASIC building blocks for an upgraded front-end readout circuit for the ATLAS tracker. These building blocks will be compatible with architectures employing serial powering and/or the local DC-DC conversion approach. This will involve becoming proficient in the radiation-tolerant design methodology and CAE tools (~month 6); the design of a prototype building block (~month 18); its fabrication, electrical, functional and radiation characterization (month 24). Subsequently an optimized version of the building block will be designed and integrated into a full ATLAS tracker demonstrator ASIC (~month 31). This will be followed by participation in the integration and evaluation of the ASIC in an ATLAS tracker demonstrator module (~month 36).

B.1.2.4 Work Package 4: Optical Transmission Systems for SLHC Experiments

A tracking detector operating at the SLHC will require ten times more readout data bandwidth and radiation tolerance than at the current LHC detectors. As described above it is important to limit the amount of material in the detector, therefore the work package will develop versatile multi-Gigabit speed, radiation-tolerant, low-mass, high density, non-magnetic optical link technology to cover data transmission requirements for SLHC.

The versatile digital link project will be structured to provide research training tasks for three ESRs and two ERs. The work package will have four sub-projects with the following objectives:

4.1 *Network architectures for particle physics applications*: Point to Point (P2P) and Passive Optical Network (PON) standards, simplified protocols, system simulations and prototyping, test procedures and tools. Assemble a commercial PON demonstrator (~month 9) and another built with versatile link components (~month 18); documentation of demonstrator and results of system tests (~month 34).

4.2 *Characterization*: Characterization and analysis of electro-optic components in isolation and embedded in their package, with report on results at ~month 12.

4.3 *Radiation resistance and reliability:* Assessment of radiation resistant transceiver ASICs, test and qualification of packaged optoelectronic components. Estimation of components' and system reliability through activation energy calculation and accelerated ageing tests. Establishment of irradiation methodology and development of test setups (~month 12); irradiation runs, analysis (~month 24); further irradiation runs, accelerated ageing and reliability tests (~month 36).

4.4 *Optical Packaging:* Dense assembly of high speed electronic and optoelectronic components, light in- and out-coupling, high frequency electrical connectors, signal integrity, Electro Magnetic Interference (EMI) reduction, thermal conductivity, low-mass non-magnetic rugged packaging. Report on environmental testing of packages (~month 12); documentation of system test setup and report comparing different module types (~month 36).

B.1.2.5 Work Package 5: Data Acquisition for the LHC Experiments

Real-time event data collection and filtering at the LHC experiments is achieved by large-scale, high performance distributed data acquisition (DAQ) fabrics built with commercial components, including computing nodes, network interfaces, data switches, and network storage systems. They have thousands of computing nodes and use switching fabrics handling several hundred Gbps sustained data traffic. At SLHC the DAQ system will have to handle multi-Terabit bandwidths.

Work package 5 will provide research projects for 6 ESRs and 2 ERs distributed across the DAQ groups of the 4 LHC experiments (ALICE, ATLAS, CMS, LHCb). Their main objectives will be:

(i) Initial ramp-up of the DAQ networks to full production size; development of techniques for profiling and monitoring the network performance and the optimization of the routed network. (Reports at ~ months 16, 25 and 35).
(ii) Inclusion of fault handling in the DAQ systems in order to achieve high data taking efficiency. Fault tolerance needs to be addressed at all levels, from transmission errors of event data through the switching fabric up to failures of computing nodes, and provides projects ranging from low levels, such as device drivers, up to the high level overall experiment run control system. (Reports at ~ months 16, 25 and 35).
(iii) At least one ESR will work on optimisation of the networked data storage system in the areas of data reliability and storage virtualization. (Reports at ~ months 16, 25 and 35).
(iv) Studies for DAQ Upgrades for SLHC Experiments: the proposed architecture for the SLHC DAQ systems is based on the expectation of a scalable multi-Terabit/s network becoming available from industry in the next decade. The work will involve tracking of networking technology and an R&D effort on constructing an event collection system with multi-Gbps links. (Reports at ~ months 25 and 35).

B.1.3 Overall Approaches and Methodology

B.1.3.1 S&T Approach and Methodology

The objectives of the scientific and technical research projects have been described in the previous sections. They will be achieved through the five parallel work packages listed in table 2. Each of these work packages will involve collaboration between CERN and one or more of the associated partners. The following subsections briefly describe in turn each of the five research work packages and the roles of associated partners.

B.1.3.1.1 Work Package 1: Pixel Detector Research Collaboration

The pixel development projects will provide research training in the context of the Medipix Collaboration, which exploits synergies between the particle tracking pixel developments and pixel sensor systems for imaging, and has institutes and companies active in various medical imaging applications, instrumentation for synchrotron radiation facilities, materials analysis, astronomy, etc. In particular, CERN has a technology transfer agreement with the associated industry partner PANalytical to employ the Medipix pixel technology in a commercial instrument for the materials analysis market. In this context PANalytical will offer opportunities for the secondment of young researchers for practical training on their premises in order to familiarise them with the demands and future challenges of such applications. VTT Espoo is a member of the Medipix3 Collaboration and brings a long experience in high density interconnect to the collaboration. It is expected that an ESR and an ER spend time in both places (CERN and VTT Espoo, as indicated in table 4) in order to better understand the needs of the physics users on the one hand and the possible solutions presented by the latest interconnect technologies on the other.

B.1.3.1.2 Work Package 2: Developing Building Blocks and Demonstrator ASICs for SLHC

INESC Porto will collaborate with CERN on an individual ESR research training project to develop a low-phase noise low-bandwidth Phase-Locked Loop (PLL) to synthesize clocks with high spectral purity (less than 10 ps rms jitter), survive high radiation levels (~1 MGy) and be immune to Single Event Upsets. The circuit will be fabricated in an advanced commercial-grade 130 nm CMOS technology, will use both full-custom and standard cell design techniques, and employ the radiation-tolerance-by-design methods developed at CERN for the LHC. Secondment of the ESR to INESC Porto will take place as indicated in table 4. Built-in self test features will be also included in order to detect degradation of the ASIC performance.

B.1.3.1.3 Work Package 3: Developing power management systems for on-detector electronics

AGH Krakow will collaborate with CERN on radiation-tolerant ASIC developments for the ATLAS SLHC tracker upgrade, which will implement and evaluate architectures compatible with efficient on-detector powering. Senior scientists from AGH Krakow are deeply involved in the electronics for the ATLAS inner tracker detector, and will contribute to the research training of an ESR in the framework of R&D for a future upgrade of the tracker. The ESR will be seconded to AGH Krakow for part of the Fellowship, as indicated in table 4, in order to perform ASIC design work, evaluation and testing of prototypes.

B.1.3.1.4 Work Package 4: Radiation-hard, non-magnetic optical transmission systems

This work package, which aims to develop a versatile bi-directional, radiation-hard, non-magnetic, low-mass, high-speed link suitable for use in upgraded SLHC detectors, will be broken down into the 4 subprojects with the objectives described in the previous section (1.2.4). It will support three ESRs and two ERs working on these sub-projects. The project will be carried out with industry partners and selected institutes from the LHC Collaborations, coordinating and reporting their work through the joint ATLAS-CMS Working Group on Optoelectronics for SLHC. The ITN associated partners UCL, INESC Porto, SCK.CEN and VTT Oulu will bring their own specialized expertise:

(i) UCL will contribute to circuit design, and system level and architecture work with emphasis on Passive Optical Networks (PON).

(ii) INESC Porto will be involved in the experimental characterization of semiconductor laser devices and in the optimization of their electrical matching to the laser driver ASIC.

(iii) SCK.CEN will team up for the reliability and radiation resistance aspects of the project.

(iv) VTT Oulu will collaborate in the environmental, EMI and thermal impedance testing of the low-mass optical packages developed to meet the requirements for SLHC.

Fellows will be seconded to the premises of the associated partners, as indicated in table 4, in the context of these developments. UCL, INESC Porto and SCK.CEN may provide academic supervision to ESRs who might wish to earn a PhD degree.

B.1.3.1.5 Work Package 5: LHC and SLHC Data Acquisition Research Developments

Between them the four LHC experiments (ALICE, ATLAS, CMS and LHCb) will provide research training projects in performance profiling and optimization of the LHC data acquisition systems for up to six ESRs and two ERs. As indicated in table 4, Force10 will host interns so that they gain first-hand experience with network R&D and diagnostics tools, and are provided with advice in the optimization and profiling of the DAQ networks. ESRs will have the opportunity to obtain formal certification of their network proficiency by taking the CCNA exam (configuration, operation and optimization of switched networks). INFN Legnaro will collaborate on the implementation of fault tolerance in the experiment run control.

Close collaboration will take place with Force10 and other companies for the investigation and evaluation of emerging higher-speed network technologies as the basis for a future upgrade of the DAQ systems for operation at SLHC.

B.1.3.2 Training Approach and Methodology

There can be no better training for young researchers than to participate in frontier science projects driven by world-renowned scientists, such as those at CERN and its associated partner institutes. The ITN will prepare young scientists for their future roles in European Research by exposing them to well-established research environments that are international, multidisciplinary and intersectorial (mixing universities, specialized technology research centres, and small industries).

Applied electronics and informatics research projects in the CERN Physics Department, of the kind undertaken in this project, are driven by the concrete needs and requirements of the physics programme, and should lead to the development of reliable, professionally engineered systems that are fully integrated and made operational in an experiment. The ITN will employ an R&D methodology which includes the following steps:

- Understand the “problem” and through discussions between engineers and physicists develop a concept for a “solution”;
- Through study of the literature, conference attendance, interactions with advanced technology suppliers (industry and/or specialized institutes) understand previous approaches to similar problems and the state-of-the-art; explore potential architectural and technology options;
- Carry out feasibility studies based on theoretical analysis, modelling and/or simulation; understand achievable performance and the limitations (e.g. power dissipation, cost);
- Establish partnerships for the R&D; propose and document a development plan; obtain Management approval and commitment to provide required resources;
- Development and characterisation of a prototype or demonstrator in the laboratory and/or in a beam test. Peer review of results and approval for next phase:
- Detailed specification, review and approval of an engineering design; construction and testing in the lab; integration into a larger set up for system-level verification in a beam test;
- Production readiness review, organization of large volume production and test (mostly through competitive tendering by industry);
- Installation and commissioning in the experiment. Calibration and performance optimization. After operational experience propose improvements for future upgrades of the experiment or future experiments.

The ITN’s young researchers will take part in as many project phases as is possible within the limited duration of their Fellowships. They will be given a complete overview of the project and will be embedded in small, dedicated teams working within multi-institute networks. These teams are either independent (e.g. Medipix) or, in the majority of cases, form part of the larger LHC

Collaborations (e.g. ATLAS/CMS optoelectronics working group) and are regulated by formal Memoranda of Understanding which define the contributions, roles and deliverables of each member institute. Team objectives and progress will be subject to external peer review and regular detailed reporting in open Collaboration meetings (typically lasting for one week and organized several times per year). The individual projects of the recruited young researchers will form part of their team's larger objectives, and the young scientists will be expected to report within team meetings and possibly also at the Collaboration meetings. Team objectives and deliverables are defined in work packages whose compatibility and integration with the overall SLHC detector upgrade project work is managed and coordinated through Upgrade Steering Committees within each experiment (e.g. ATLAS and CMS). At the highest level of technical and scientific project management an LHC Committee (LHCC) sets milestones, monitors progress via regular reviews, and also carries out reviews at key project milestones (e.g. technical design report, production readiness review, etc).

B.1.3.2.1 Formal training plan

On arrival at CERN, the researchers will follow an induction session, which ensures that integration into the working environment is optimised in terms of time and efficiency by offering basic training and awareness of CERN activities, organization, procedures, policies, social activities and facilities. After the general induction session, a personal career development plan comprising scientific and training objectives is defined in an induction interview with the supervisor. These objectives will be regularly reviewed. Clear milestones will allow all parties to monitor progress.

The young researchers will take advantage of CERN's formal training programme, covering a number of different types of learning (summarized in table 3), many directly relevant to their projects, and all of which will broaden their horizons.

The CERN seminars and colloquia will provide highly relevant and topical training by specialists in particle detectors, electronics, and informatics.

The technical training programme provides a rich spectrum of courses covering engineering software packages, modern electronics design methods and tools, database technology, programming languages, and office automation software.

For all of CERN's training programmes, great care is taken to ensure that the quality of the speakers remains very high, with world leaders in their field often providing the training.

Table 3: Relevant elements of CERN's formal training programmes

Type of training	***Content***
Academic Training	• Lectures in particle physics and related fields of applied science at postgraduate level
CERN Schools	• School of Computing (an annual event organized in different countries) • Objective: enhance relations between young students and senior physicists and engineers
CERN Seminars and Colloquia	• Regular specialist seminars throughout the year on detectors, accelerators, electronics, informatics, theory, and the LHC Project; delivered by specialists in each domain
International Workshops and Conferences	• Organized on specific topics uniting specialists from CERN, other labs, institutes, universities and industry, e.g. the annual CERN-sponsored 5-day Topical Workshop on Electronics for Particle Physics (TWEPP); the Institute of Electronic & Electrical Engineers - Nuclear and Plasma Sciences Society (IEEE-NPSS) Real Time Conference; the 18-monthly international Conference on Computing in High Energy Physics (CHEP).
Management & Communication courses	• Extensive curriculum of management and communication topics ranging from basic communication to project management and team management for supervisors. • Language courses (English and French).
Safety training	• Compulsory sessions for everyone at CERN (hazards and risks for all environments)
Summer Student Programme	• 6 weeks July & August, 3 hours per day on topics including detectors, electronics, DAQ • 3rd year undergraduate level
Technical Training	• On-demand training via 1- to 5-day courses and seminars • Topics include electronics, software & systems technologies, engineering, office software and automation.
Web-based training	• Many of the lectures, seminars and courses are recorded and available via the web • Instructor-led topics also available in the form of web-based training

The Marie Curie ESRs and ERs will be strongly encouraged to take advantage of all of these programmes, including the complementary training provided by the Management, Communications and Language courses.

B.1.3.2.2 Hands-on project based training plan

Training Plan on Pixel Detectors, Electronics and Optoelectronics

The work packages described above provide hands-on, project-driven learning. This will be supplemented by external training at the associated partners, as indicated in table 4. INESC Porto has research activities on optoelectronics and optical communications, and on analogue and digital microelectronics design and test. The microelectronics activity at INESC Porto includes design and application of custom computing ASICs, dynamic reconfigurable Field-Programmable Gate Array (FPGA) applications, custom and semi-custom design of analogue and RF cells, as well as design for testability and built-in self-test of mixed-signal, radiofrequency (RF), and digital circuits. Recently a new "Optical Communications Laboratory" has been setup targeting two main areas: fibre supported radio/microwave systems and wavelength-division-multiplexed (WDM)/all-optical networks. Training in these domains will be organized using the lab facilities available at INESC Porto and at the Faculty of Engineering of the University of Porto.

Training through the associated partner AGH Krakow will capitalize on its expertise in ASIC development of particle tracking detectors and innovative powering schemes. UCL will provide training in network architectures and protocols and SCK.CEN will provide training for reliability and radiation testing. The industrial partners PANalytical, VTT Espoo and VTT Oulu will provide appropriate specialized training in pixel detector-based industrial instrumentation, ultra-high density area array electrical interconnect and optical packaging technologies through the secondment of researchers on their premises.

In addition, the ESRs working on ASIC design will be able to follow external commercial training courses, such as the use of specific CAE software tools needed for their projects, e.g. the integrated circuit design tools from Cadence and other CAE suppliers. Those ESRs involved in microelectronics developments will also be able to deepen their knowledge through selective participation in the well-known, high-quality series of courses organized by Mead SA (Lausanne) and given by world experts in microelectronics.

Training Plan on Data Acquisition

The ESR training plans in DAQ will have two different phases. They will start with a 6 month familiarisation phase of training on the job in their respective experiments. The experience from this phase will allow them to understand the needs for optimisation and profiling of the DAQ networks. In this first phase the ESRs will also be introduced to the data storage system of the LHC experiments. A first workshop will be organised to exchange information between the four experiments and industry experts from the industrial partner Force10 and from other companies supporting the integration of their products into the data acquisition systems.

In the next phase some of the researchers will begin, still constantly supervised by experts from within the experiments, to devise strategies for network profiling and optimisation and start implementing them. Others will study the optimisation of the storage system in the areas of data reliability and storage virtualization. This period will also include training in the storage hardware and software in collaboration with the company Quantum, whose cluster file software is currently in use by ALICE. For those working on network profiling and optimization their practical experience will be complemented by following one or several industry-standard certified courses, such as CCNA (Cisco Certified Network Associate). The deepened knowledge acquired in these courses will then be applied to the practical problems, closely followed by another workshop. In this phase the ESRs concentrating on network aspects will be hosted as interns by Force10, for periods of 2 to 4 weeks each in order to obtain first-hand experience with network R&D, profiling and diagnostics.

Armed with this additional experience the ESRs will then continue to work in the DAQ systems of the experiments, which they will help decisively to bring up to production quality.

In a later phase the trainees will participate in studies for DAQ upgrades for the SLHC experiments, possibly based on emerging scalable multi-Terabit/s network technologies.

B.1.3.3 Management of the ITN

Details of the organizational management of the ITN are fully described in section 2.2.1.

***Risk Management*:** the ITN’s work will form part of CERN’s overall R&D programme, and is potentially subject to circumstances beyond its direct control; e.g. startup delay or problem-fixing shutdown of the LHC machine; unforeseen withdrawal of access to the ASIC technology planned to be employed. Contingency plans have already built in the possibility to exercise and optimize DAQ networks by injecting simulated data at the front-ends. If required, alternative suppliers of similar ASIC technologies are accessible via services such as EuroPractice or CMP (Grenoble).

B.1.3.4 Size of the Research Training Programme

The network as a whole undertakes to provide a minimum of 492 person-months of Early Stage and Experienced Researchers whose appointment will be financed by the contract. Quantitative progress on this, with reference to the table contained in Part C and in conformance with relevant contractual provisions, will be regularly monitored via the ITN supervisory board (see figure 2).

The R&D training projects will have a mix of tasks of different levels of complexity, expected duration, and calling for more or less previous research experience as shown in table 4.

Table 4: Distribution of different categories of researchers between the 5 research work packages

Work Package	**ESR person-months** Includes secondment to associated partners	**ER person-months** Includes secondment to associated partners	**Secondment** to associated partners (person-months)	**Visiting Scientist person-months** (>10 yr experience)
1. Pixel detectors	1 x 36	1 x 18	3 (PANalytical) 6 (VTT Espoo)	1 (PANalytical) 1 (VTT Espoo)
2. Design of ASIC building blocks	1 x 36		11 (INESC Porto)	1 (INESC Porto)
3. Tracker powering	1 x 36		9 (Krakow)	1 (Krakow)
4. Optoelectronics	1 x 36 1 x 36 1 x 36	1 x 6 1 x 12	9 (UCL) 7 (INESC Porto) 9 (SCK.CEN) 6 (VTT Oulu)	2 (UCL) 2 (INESC Porto) 2 (SCK.CEN) 2 (VTT Oulu)
5. Data Acquisition	2 x 36 (CMS) 2 x 36 (ATLAS) 1 x 36 (ALICE) 1 x 36 (LHCb)	1 x 12 (CMS) 1 x 12 (ATLAS)	2 x 1 (Force10) 2 x 1 (Force10) 1 (Force10) 1 (Force10)	3 (INFN LNL)
TOTALS	12 x 36 = **432**	5 x 12 = **60**	-	**15**

B.2 Implementation

B.2.1 Planning of research work, milestones and deliverables

The R&D activities of the ITN are broken down into five work packages (1-5) summarized in the following tables. Management of the ITN (W.P. 0) is described in section 2.2 and the planning of conference and visiting scientists' contributions (W.P. 6) in section 2.3.

In this planning the timing of individual work packages is estimated in elapsed months from the effective first day of the involved ER/ESR's employment contract. The maximum duration of a work package will be 36 months. However, in practice it is expected that the recruitment process will result in individual fellowship starting dates being smeared out across the first project year. Therefore the 3-year plan described here will in reality span the full 4 years of the overall project.

Work package number	**1**	**Start date or starting event:**	Month n
Work package title	Development of pixel detectors		
Activity Type	RTD		
Person-months	54		
Associated Partners	PANalytical, VTT Espoo		
Objectives	Develop techniques to assemble low cost, low mass, moderate to large area pixel detectors for photon counting X-ray imaging systems and particle tracking at the SLHC.		
Description of work	1. Development of experiments for tiling large areas with existing pixel detector tiles. 2. Study and evaluate tiling solutions for assembling moderate to large area pixel arrays.		
Deliverables	D11 Report on low cost bump bonding solutions and design of test components D12 Report on the full evaluation programme D13. Report on tiling solutions suitable for HEP and materials analysis D14. Documentation and conference paper on tiling solutions attempted and conclusions		

Work package number	**2**	**Start date or starting event:**	Month n
Work package title	ASIC building blocks for SLHC		
Activity Type	RTD		
Person-months	36		
Associated Partners	INESC Porto		
Objectives	Develop radiation-tolerant ASIC building blocks in 130nm CMOS technology for detector upgrades at the SLHC.		
Description of work	1. Establish functional and performance specifications of selected building block(s); 2. Design, fabricate and laboratory test prototype; irradiation testing. 2. Design, fabricate, test final version and carry out system-level integration tests.		
Deliverables	D21. Sign-off specification document for ASIC (IP block) D22 Completion of testing and irradiation of prototype ASIC with conference report or journal publication D23 Complete testing/irradiation of final ASIC and system-level integration test. Final conference report and/or journal publication		

Work package number	**3**	**Start date or starting event:**	Month n
Work package title	On-detector Power Management schemes		
Activity Type	RTD		
Person-months	36		
Associated Partners	AGH Krakow		
Objectives	Develop radiation-tolerant ASIC components compatible with efficient power management in SLHC detectors and evaluate them in system level demonstrators.		
Description of work	1. Design, prototype and lab characterization of selected rad-tolerant ASIC block. 2. Evaluate its performance in the radiation environment expected at SLHC trackers. 3. Integrate ASIC block into full ATLAS tracker demonstrator ASIC. 4. Participate in preliminary system tests using the full ATLAS tracker ASIC.		
Deliverables	D31 Deliver proto detector module using shunt regulator D32 Report or conference paper on performance of shunt regulator in the prototype detector module D33 Delivery of full ATLAS SCT readout chip D34 Report/conf. paper on test results of detector module incorporating the shunt regulator.		

Work package number	**4**	**Start date or starting event:**	Month n
Work package title	Optical transmission systems for SLHC experiments		
Activity Type	RTD		
Person-months	126		
Associated Partners	INESC Porto, SCK.CEN, UCL, VTT Oulu		
Objectives	Develop radiation-tolerant, low-mass, non-magnetic, high-density, multi-Gigabit/sec optical interconnect solutions for massively parallel data transmission, global clock and trigger distribution, control and monitoring functions in SLHC experiments.		
Description of work	4.1. Architecture studies, evaluation of PON networks for application in SLHC experiments. 4.2. Characterization of semiconductor lasers (standalone and embedded in optical package). 4.3. Radiation resistance and reliability; test setups, measurements, analysis, ageing. 4.4. Electro-optical & environmental characterization of optical packages.		
Deliverables	D411 Report on extendibility of PON concept to HEP D412 Conference report on demonstration of PON protocol for HEP application D413 Documentation on hard, soft and firmware, system test results D421 Report on laser electrical impedance measurements and models D422 Report on proposed matching networks, recommendations to designers and experimental results D431 Report on analysis of high fluence test data and proposed methodology D432 Conference report on irradiation tests D433 Conference report on irradiation and reliability tests D441 Report on environmental, EMI and thermal impedance testing D442 Conference report with comparisons between different module types D443 Documentation on hard, soft and firmware, system test results		

Work package number	**5**	**Start date or starting event:**	Month n
Work package title	Data Acquisition for (S)LHC experiments		
Activity Type	RTD		
Person-months	240		
Associated Partners	Force10, INFN-LNL		
Objectives	Profiling & performance optimization of DAQ networks of the LHC experiments; fault tolerance for the DAQ systems. Evaluation of multi-Gigabit/s technology for DAQ in SLHC		
Description of work	1. Network ramp-up to full production size; techniques for profiling network performance; optimization of the routed network. 2. Include fault handling in the DAQ systems in order to achieve high data taking efficiency. 3. Optimise the networked data storage system for data reliability and storage virtualization. 4. Studies for DAQ upgrades for SLHC experiments: tracking of networking technology and an R&D effort on constructing an event collection system with multi-Gbps links.		
Deliverables	D51 & D52 Intermediate report/conference papers on network optimization / data storage systems / fault tolerance in run control / design of DAQ for future SLHC upgrade D53 Prepare final report/conference papers		

Figure 1 and table 5 provide an indicative overview of the work plan, the milestones, the deliverables and internal peer reviews for the research training work packages described in the preceding sections.

Milestones are key points in the scientific work plan at which peer reviews will typically be organized before proceeding to the next steps. These reviews will be organized by the work package leaders and the supervisors, and will involve visiting scientists from the associated partners and other experts selected from outside the ITN.

Figure 1 Indicative work plan overview for the 5 research work packages
D denotes 'deliverable'; M denotes 'milestone'; TC denotes 'training course(s)'; W denotes 'workshop'; I denotes 'internship'.   (Please refer to table 5 for more information on milestones and deliverables)

	RESEARCH TRAINING THEME AND TASK DESCRIPTIONS	1st ESR or ER year (months)				2nd ESR or ER year (months)				3rd ESR or ER year (months)			
		3	6	9	12	15	18	21	24	27	30	33	36
Theme 1:	**Development of pixel detectors**												
1.1	Training HEP and Materials analysis; workshops				W11								
1.2	Research low cost bump bonding and test preparation				D11								
1.3	Assembly of parts and test						M11						
1.4	Report and conclusion						D12						
1.5	Training HEP and Materials analysis; workshops				W11				W12				W13
1.6	Study of large area tiling solutions				D13								
1.7	Realisation of solutions								M12				
1.8	Report												D14
Theme 2:	**Rad-tol ASICs for LHC detector upgrade**												
2.1	Training (CAD tools; PLL; rad-tol ASIC design)	TC21			W21				W22				W23
2.2	Spec & design the prototype ASIC (or block)		D21				M21						
2.3	Fabricate, perf. test and irradiate prototype									D22			
2.4	Design, fabricate, characterize, document final PLL										M22		D23
Theme 3:	**Power management for LHC detectors**												
3.1	Training (CAD tools; rad-tol ASIC design)	TC31			W31				W32				W33
3.2	Design prototype distributed shunt regulator						M31						
3.3	Fabricate, lab test, integrate in proto detector module								D31				
3.4	Evaluation & radiation hardness tests of proto module										D32		
3.5	Integrate shunt regulator into full ATLAS SCT ASIC											M32	
3.6	Fabricate final ASIC, preliminary tests, write report												D33 D34
Theme 4:	**Optoelectronics for physics experiments**				W41				W42				W43
4.1	Architecture : PONs for HEP (1 ESR + 1 ER)												
	concept study		D411										
	demonstrator and test			M41			M42		D412				D413
	on secondment to UCL (tentative, 9m)												
4.2	Characterization of semiconductor lasers												
	electrical impedance measurements		D421										
	electrical models and impedance matching				D422								
	equalization and pre-emphasis (see also proj. 2)												
	on secondment to INESC (tentative, 7m)												
4.3	Radiation resistance												
	Methodology for high doses/fluences				D431								
	Setups, tests, analysis				M43				D432				
	reliability, accelerated ageing								M44				D433
	on secondment to SCK (tentative, 9m)												
4.4	Optical packaging												
	environmental testing (temp, magn.field, mech stress)				D441								
	EMI testing												
	thermal impedance (based on optical spectrum)			M45				M46	D442				D443
	on secondment to VTT Oulu (tentative, 6m)												
Theme 5:	**Data acquisition for LHC experiments**												
5.1	Introduction to DAQ networks/storage; & workshops		W51				W52			W53			W54
5.2	Optimization of LHC DAQ networks/storage systems												
5.3	DAQ upgrade studies and technology evaluation												
5.4	Training by industry / secondment to industry			TC51	I51		I52			I53			
5.5	Prepare papers on system optimization / upgrades						D51			D52			D53

Table 5 **Indicative project milestones and deliverables featuring in figure 1**
D denotes ‘deliverable’; M denotes ‘milestone’; TC denotes ‘training course(s)’;
W denotes ‘workshop’; I denotes ‘internship’

Theme number	Del. no.	Titles of the Research Training Themes and description of deliverables and milestones	Nature[1]	Dissemination level	Delivery date[2]
		General global project deliverables			
	M01	Kick-off meeting of the project Supervisory Board and Management Committee.		n.a.	0
	M02	First ESR appointment		n.a.	1
	M03	Complete selection and recruitment of all ESR s		n.a.	12
	D01	First periodic report	R	Public	12
	D02	Second periodic report	R	Public	24
	D03	Third periodic report	R	Public	36
	D04	Fourth periodic report	R	Public	48
	D05	Final project report	R	Public	48
1		**Development of pixel detectors**			
	D11	Report on low cost bump bonding solutions and design of test components	R	Public	10
	M11	Low cost bumping test structure design	O	Restricted	16
	D12	Report on the full evaluation programme	R	Public	18
	W1n	Organize a workshop on pixel detectors (Medipix collaboration-related)		n.a.	12, 24,36
	D13	Report on tiling solutions suitable for HEP and materials analysis	R	Public	12
	M12	Design of various tiling solutions	O	Restricted	24
	D14	Documentation and conference paper on tiling solutions attempted and conclusions	R	Public	36
2		**Development of radiation-tolerant ASIC (or block) for LHC detector upgrades**			
	TC21	Complete initial training courses (ASIC design, CAD tools, theory of phase-locked loops etc)		n.a.	6
	D21	Sign-off specification document for ASIC (IP block)	R	Public	6
	W2n	Organize microelectronics user group @ TWEPP workshop		n.a.	12,24,36
	M21	Tape out prototype design ready for submission	O	Restricted	18
	D22	Completion of testing and irradiation of prototype ASIC with conference report or journal publication	P + R	Public	27
	M22	Tape out final ASIC design ready for submission	O	Restricted	29
	D23	Complete testing/irradiation of final ASIC and system-level integration test. Final conference report and/or journal publication	D + R	Public	36
3		**Power Management of LHC on-detector electronics**			
	TC31	Training courses in microelectronics design methods, CAD tools, design of circuits for regulators, etc		n.a.	6
	W3n	Participation in the annual TWEPP workshops		n.a.	12,24,36
	M31	Tape out of distributed shunt regulator ASIC	O	Restricted	18
	D31	Deliver proto detector module using shunt regulator	P	n.a.	24
	D32	Report or conference paper on performance of shunt regulator in the prototype detector module	R	Public	29

1 The nature of the deliverable is coded as follows: **R** = Report, **P** = Prototype, **D** = Demonstrator, **O** = Other
2 For research themes 1-5 the delivery dates are measured in months from the start of individual ESR contracts.

	M32	Tape out of full ATLAS SCT readout chip integrating the shunt regulator	O	n.a.	31
	D33	Delivery of full ATLAS SCT readout chip	D		35
	D34	Report/conf. paper on test results of detector module incorporating the shunt regulator.	R	Public	36
4		**Optoelectronics for physics experiments**			
	D411	Report on extendibility of PON concept to HEP	R	Restricted	6
	D412	Conference report on demonstration of PON protocol for HEP application	R	Public	24
	D413	Documentation on hard, soft and firmware, system test results	R	Restricted	34
	D421	Report on laser electrical impedance measurements and models	R	Restricted	6
	D422	Report on proposed matching networks, recommendations to designers and experimental results	R	Restricted	12
	D431	Report on analysis of high fluence test data and proposed methodology	R	Restricted	12
	D432	Conference report on irradiation tests	R	Public	24
	D433	Conference report on irradiation and reliability tests	R	Public	36
	D441	Report on environmental, EMI and thermal impedance testing	R	Restricted	12
	D442	Conference report with comparisons between different module types	R	Public	24
	D443	Documentation on hard, soft and firmware, system test results	R	Restricted	36
	M41	PON implementation in soft and hardware	P	n.a.	9
	M42	PON demonstrator with Versatile link components	D	n.a.	18
	M 43	Ready for irradiation testing	O	n.a.	12
	M 44	Ready for reliability testing	O	n.a.	24
	M 45	Ready to characterize	O	n.a.	6
	M 46	Ready to issue recommendations to package designers	O	n.a.	19
	W4n	Optoelectronics working group @ TWEPP workshop		n.a.	12, 24, 36
5		**Data Acquisition for (S)LHC experiments**			
	TC51	Advanced (~5-days) industry training course (network management / data storage systems)		n.a.	7
	I5n	Internships with Force10 Networks		n.a.	10,18,27
	D51 D52	Intermediate report/conference paper on network optimization / data storage systems / fault tolerance in run control / design of DAQ for future SLHC upgrade.	R	Public	16, 25
	D53	Prepare final report/conference paper	R	Public	35
	W5n	DAQ workshops (2 days) organized at CERN		n.a.	6, 17, 26, 36

B.2.2 Management structure and procedures

B.2.2.1 Organizational Management of the ITN

Management of the monosite ITN is summarized in work package 0 below. The management structure is illustrated in figure 2 and the role of each body in that diagram is described in table 6.

Work package number	**0**	**Start date or starting event:**	Month 0
Work package title	ITN Management		
Activity Type	MGT		
Person-months	32 (16 for coordinator + 16 for this ITN's share of the common administration unit handling all Marie Curie projects at CERN)		
Associated Partners	AGH Krakow, Force10, INESC Porto, INFN-LNL, PANalytical, SCK.CEN, UCL, VTT		
Objectives	Provide scientific & technical coordination between CERN & the associated partners; ensure dissemination of best practice; manage and administer financial and human resources; ensure scientific and financial reporting to the Commission.		
Description of work	Recruitment; Secondment; Disseminate best practice; Organization of workshops, conferences and training events; Project reviews; Intellectual Property Rights issues; Reporting progress		
Deliverables	1. Annual S&T and management/financial reports to the Commission 2. Prepare workshops & training events indicated in tables 7 & 8 in sections 2.3.1 & 2.3.2. 3. Final S&T and management/financial report to the Commission		

Figure 2 ***ITN Management Structure***

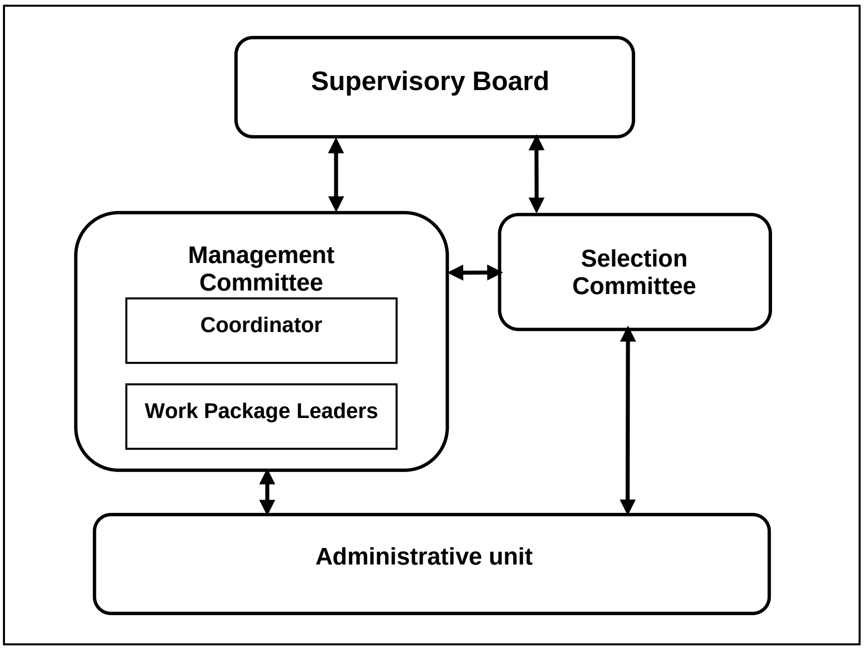

Table 6 ***Roles and responsibilities in the ITN Management***

Supervisory Board	Project Co-ordinator as Chair-person, the Chair of the Marie Curie Selection Committee, and the Head of CERN's Recruitment, Programmes & Monitoring Group in the Human Resources Department. One representative from each Associated Partner will be welcome to attend. The Supervisory Board will have a kick off meeting, with a follow up meeting after 6 months, and annual meetings thereafter.	• Approving and overseeing implementation of the training programme for scientific, technical and complementary skills, and co-ordination of the network-wide training activities; • monitoring and evaluating overall progress of the research training programme;
Management Committee	Project Co-ordinator and the individual Work Package Leaders. It will have regular meetings every 6 months, or more frequently if required. Representatives of Associated Partners will be invited to attend.	• overall management of the research programme; • implementation of the training activities with the associated partners; • management and follow-up of the progress of the individual research projects; • organization of network-wide training (courses, workshops, summer schools); • overview of the integration of the Researchers into the research team(s); • review of the Personal Career Development Plans; • dissemination of best practice and project results.
Project Coordinator	The Project Coordinator will be a senior applied scientist/engineer from CERN's Physics Department. The Project Coordinator will have appropriate career experience in the domains of electronics, optoelectronics and data acquisition for particle physics experiments.	• coordination of the ITN research training programme; • organizing and chairing the Management Committee meetings; • communication to/from the associated partners; • communication and reporting to the European Commission.
Selection Committee	The CERN Marie Curie Selection Committee will comprise the Coordinators, of all Marie Curie projects at CERN and representatives of all CERN departments. It is chaired by a senior CERN physicist. Meetings of the Selection Committee will be scheduled according to the ITN selection rounds. ITN Work Package Leaders will be invited as required.	• selection and appointment of the Researchers; • monitoring of gender balance and equal opportunities.

Dissemination of best practice

The dissemination of best practice will be coordinated by individual work package leaders and monitored by the Management Committee. Tools, technologies, methodologies and review schedules will be agreed early in the work plan in concertation with the lead scientist(s) of the associated partners.

Rules for decision-making (in the ITN)

The executive decisions for the implementation of the research training programme will be taken by the Management Committee. Any changes in the research and/or training programme will have to be approved by the Supervisory Board. Where such changes may have impact on the contractual obligations of the ITN, the Project Officer in charge of the ITN will be informed in due course.

Conflict resolution

The Marie Curie Steering Committee chairperson and the Human Resources Coordinator in charge of the specific project, with input from the researcher and the supervisor, will intervene to solve disputes amicably. In case amicable settlement cannot be reached, disputes will be settled in accordance with CERN's arbitration procedure as laid down in the Organization's Staff Rules and Regulations.

B.2.2.2 Financial Management

The financial management will be centralized in CERN's Human Resources Department, in close collaboration with the Finance Department which will take responsibility for creation of budget codes and all necessary monitoring tools as well as other formal financial arrangements. Expenditure for each Researcher is monitored closely according to expenditure type in order to ensure compliance with the relevant ceilings and rules of the Commission.

B.2.3 Planning of Conferences and Visiting Scientists' contributions

Work package 6 covers research contributions, transfer of knowledge and planning of conferences, workshops and training courses by visiting scientists:

Work package number	**6**	**Start date or starting event:**	Month 0
Work package title	Workshops, training courses, dissemination of results and transfer of knowledge		
Activity Type	RTD		
Person-months	15 (visiting scientists)		
Associated Partners	AGH Krakow, Force10, INESC Porto, INFN-LNL, PANalytical, SCK.CEN, UCL, VTT		
Objectives	Promote transfer of knowledge, contribute to S&T & complementary training, and dissemination of results.		
Description of work	1. Visiting scientists' contributions to the research work. 2. Plan, prepare and deliver dedicated training courses (by visiting scientists) 3. Organize workshops to promote training and dissemination of results		
Deliverables	1. Training courses and seminars at CERN as defined in table 8 in section 2.3.2. 2. Three workshops on electronics & optoelectronics (Sept 2009, 2010, 2011) 3. Three DAQ workshops (at CERN and/or in association with CHEP) 4. (Opto)electronics & DAQ sessions at IEEE-NSS (2011) & a project wrap-up workshop.		

B.2.3.1 Open conferences, workshops and the dissemination of results of the ITN

Apart from the dedicated workshops organized by the ITN itself, the ESRs and ERs will participate and report on their work in other highly relevant schools, international workshops and conferences, such as those described in table 7. These workshops will also incorporate dedicated courses and tutorials delivered by leading scientists in the fields (invited either from the ITN, or from external universities, research institutes and companies).

Table 7: Schools, Workshops and Conferences of particular relevance to the trainees of the ITN

Conference	Duration /Freq.	Focus	Relevant WP	EPs*
CERN School of Computing	10 day / Annual	Training young scientists/engineers in information technology	5	-
Topical Workshop on Electronics for Particle Physics	5 day / Annual	Microelectronics and optoelectronics in physics	1,2,3,4	5
IEEE NPSS Real Time Conference	6 day / Biennial	Real time computing applications in physics, accelerators, medicine and biology	5	-
IEEE NPSS Nuclear Science Symposium and Medical Imaging Conference	8 day / Annual	Instrumentation for physics, imaging and space	1,2,3,4	1.7
Computing in High Energy and Nuclear Physics Conference	5 day / every 18 months	Informatics in particle and nuclear physics.	5	3.3
Medipix	1 day / Triannual	Pixel detectors in Medical applications	1	-
LHC Expts + wrap-up	Variable	Hardware & software in LHC expts.	1,2,3,4,5	3.3
Total				13.3

* External participant-months

ESRs and ERs will be involved in the organisation of some of the Schools, Workshops and Conferences as part of their training. They will be encouraged to work with experienced organisers, with a focus on those sessions relevant to ITN researchers. A wrap-up workshop will be organized at CERN at the end of the project.

All these events will be open to external participants. In the case of the TWEPP workshop, a special half-day session on electronics and a half-day session on optoelectronics will be organized. It is expected to attract at least 50 external participants to each of these sessions (3 annual conferences × 1.7 external participant-months = 5). These sessions will be clearly identified and advertised as being sponsored by the Marie Curie ITN ACEOLE project. Similar ITN-sponsored open sessions on data acquisition will also be organized at two international CHEP Conferences (held every 18 months) and are expected to attract a similar number of external participant-days per event. A dedicated session will be organized at one of the IEEE Nuclear Science Symposium conferences.

B.2.3.2 Role of Visiting Scientists

Visiting scientists from the associated partners will be hosted at CERN for short stays as indicated in table 8, in order to:

- Prepare and deliver dedicated training events (courses, seminars and tutorials) focussed on the ITN's specific research areas (these will be open to participants from outside the ITN);
- Contribute to the research in specific work packages, review individual ESR/ER research projects at important milestones, and facilitate bi-directional transfer of knowledge (TOK) through stimulation of the researchers and staff by their presence, comments, suggestions and questions.
- Participate in the organization of the workshops described in table 7 in section 2.3.1;

Table 8: Visiting Scientists: their contributions to the research and transfer of knowledge and their specific ITN training actions (tutorials and seminars)

Associated Partner	**Visiting Scientist**	**Visit length (months)**	**W.P. for research & TOK**	**Training topic**	**No. training hours**
AGH Krakow	Senior Physicist	1	3	Architectures, performance requirements and limitations to implementing front-end electronics for silicon tracking detectors at the SLHC and/or other relevant topics	10
INESC Porto	Senior Engineer	2	4.2	Optical sources (laser diodes, EOM, EAM); Device characterization & fibre optic measurement techniques. Extraction of laser diode parameters. S-parameters/ network analyzer measurements.	6
INESC Porto	Senior Engineer	1	2	Redundancy & DFT & BIST techniques of RF, analogue & mixed-signal ASICs; Dynamic characterization of A/D converters.	6
LNL Legnaro	Senior Applied Physicist	3	5	Control and monitoring of large and widely distributed systems.	15
PANalytical	Senior Engineer	1	1	Principles and techniques of x-ray materials analysis using diffraction and fluorescence.	10
SCK.CEN	Senior Engineer	1 + 1	4.3	Reliability and radiation-tolerance qualification of optoelectronics components for extremely high dose applications	8
UCL	Senior Engineer	1	2 + 4.1	Network architecture, traffic, switching; Optical networks & topologies, Optical network standards, WDM networks & technologies. Communications circuits and ASIC design.	10
UCL	Senior Engineer	1	4.1	Core & access optical networks, Multiplexing technologies, transmission technologies, switching technologies, Devices & implementation, Network performance & measurements, optical networks for radio applications.	10
VTT Oulu	Senior Engineer	2	4.4	Photonic packaging and integration.	8
VTT Espoo	Senior Research Engineer	1	1	High-density array interconnect technology, Heterogeneous integration by direct silicon wafer bonding	3

B.3 Impact

B.3.1 Research Indicators of Progress

In order to permit the Commission to assess progress the coordination board of the ITN will prepare and submit annual reports and a final report. These will address the indicators of progress listed in table 9.

Table 9: Indicators of Progress that will be used in reporting

Indicators of progress for Research Activities:

- General progress with research activities programmed at individual, participant team and network level. Problems encountered and the nature/justification for any adjustments to the original research work plan and/or timetable.
- Highlights of scientific achievements and recognitions (such as innovative developments, scientific/technological breakthrough, publications, patents, awards and prizes, etc.).
- Progress on cross interaction among disciplines and between academic and industrial partners, other stakeholders or relevant user groups.
- Specialist exchange among network teams and visit of Senior Researchers from inside and/or outside the network.
- Individual and joint publications, directly related to the work undertaken within the project.

Indicators of progress for Training Activities:

- General progress with training programmed at individual, participant team and network level (career development plan, supervision, coaching or mentoring in place at the host institution.
- The ratio of recruitments of ESR/ER by the (monosite) network (ratio person-months filled/offered) and time and duration of each individual appointment.
- The nature and justification for any deviation from the original plan (as referred to table A3.1 of part C) or any adjustments to the original research work plan and/or timetable.
- The number and place of the short visits/secondments undertaken or organized by each ESR and ER within the network (to associated members including number of visits of the ESR and ER to their home scientific community).
- Participation in training events and network meetings (workshops, seminars, summer schools, etc.) and to international conferences (number, names, place, date).
- Achievements regarding the acquisition of complementary skills (such as project management, presentation skills, language courses, ethics, intellectual property rights, communication, entrepreneurship, etc.).
- Level of satisfaction of the trainees (e.g. as expressed in response to questionnaire and their expectation to present their PhD thesis and when).
- Highlights on more particularly innovative developments (novel concepts, approaches, methods and/or products) and on wider societal and/or ethical components of the project, such as public outreach activities.

Indicators of progress for Management and Impact:

- Effectiveness of networking, communication and decision-making between partners (at all levels: coordinator, team leaders, supervisor, ESRs and ERs), between the network and the Commission, and with the industrial and/or other relevant stakeholders.
- Effectiveness of the recruitment strategy in term of equal opportunities (including gender balance) and open competition at international level.
- Effectiveness of the “training events and conferences” open to external participants and integration in the training programme.
- Effective contribution of Visiting Scientists to the research training programme.
- Development of any specific planning and management tool(s) and databases, management of

intellectual property and commercialization of network research output (if applicable).
- Nature and justification for adjustments, if any, to the original training plan and/or timetable (e.g. opportunities for new collaborations regarding training activities).

B.3.2 Dissemination and Impact

B.3.2.1 Dissemination of results

CERN's policy concerning the dissemination of its research results is to make them available in the public domain through refereed scientific journals, conference proceedings, documentation published on its website, or through the series of *CERN Reports* published by its own Scientific Information Service. Except as detailed in the next section, the results of this ITN will be disseminated according to this policy and using these same channels.

The dissemination of research results in the particle physics world is also made through presentations at Collaboration meetings, conferences or seminars, of which a great number are given at CERN. The Visiting Scientists will review the papers and presentations of the researchers. In particular, the fellows involved in this ITN will present their results and receive feedback in dedicated open sessions at the workshops and international conferences detailed in table 7. In order to facilitate dissemination of results the ITN Management Committee has set up a web-site www.cern.ch/aceole that will contain links to the on-line presentations made at relevant Collaboration meetings, workshops and conferences.

B.3.2.2 Management of Intellectual Property Rights

The general rules for access, use and dissemination of Intellectual Property, defined in the FP7 Rules for Participation, will be applicable to this ITN project.

The research training work with the industrial partner PANalytical will be carried out in the framework of an existing partnership agreement which has been concluded between PANalytical, CERN and the other members of the Medipix Collaboration. This ensures that the IP rights and policies of all partners are respected.

Non-disclosure agreements may be required by industrial partners (be they formally associated ITN partners or not) and/or some of the associated technology institutes before granting access to detailed information about their research work or proprietary technologies, or for example to govern the publication of comparative performance figures measured for different commercial equipment or technologies. Agreements between the ITN and some of the industrial associated partners may need to be established early in the work programme in order to ensure that the IP rights and policies of all partners are respected; that concerns in particular results which may have industrial or commercial applications. CERN's Technology Transfer Unit will assist the ITN with IPR issues and steps towards potential commercial exploitation of results, if appropriate.

As a beneficiary of an ITN Grant, CERN will ensure that the project results be disseminated as swiftly as possible. Nonetheless, the dissemination activities shall be compatible with the protection of intellectual property of the associated partners involved.

B.3.2.3 Impact

The ITN will have a beneficial impact in the following areas:

- The topics of the ITN's work packages contribute directly to priority research themes for European particle physics for the years 2008-11 as ratified by CERN Council[3];
- The ITN will improve career prospects for trainees, through collaboration with established leading scientists; mobility in an international, interdisciplinary, intersectorial network; and exposure to the complementary training programme;
- The ITN will act as a catalyst to form longer-term collaborations amongst the partners, facilitating TOK and exploitation of synergies in skills and technical infrastructures;
- The ITN will allow CERN's facilities, training capacities and research potential to be fully exploited beyond its current financial capacity to host young researchers, and to include non-CERN Member State nationals in its training programme.

A concrete example of intersectorial transfer of knowledge from this ITN is the application of CERN's pixel detector technology by PANalytical for improved instrumentation for the x-ray materials analysis market. The planned secondment of an ESR and an ER to PANalytical and the specific training planned by a visiting scientist from PANalytical will greatly contribute to enhancing this collaboration.

In the area of data acquisition there will be a very strong interaction and close collaboration with the industry sector; the extreme scale and performance requirements of the LHC DAQ systems provide the companies with test beds to evaluate their technologies and test their products to the limits of their performance/capacity, and to gain insight into possible future improvements.

Another example of research synergy and the pooling of resources is the collaboration between CERN and SCK.CEN on the assessment of optoelectronics for operation in very high radiation environments, which is relevant to both SLHC and the ITER fusion project in which the European Commission is also involved.

[3] Scientific Activities of CERN and Budget Estimates for the Years 2008-2011 and provisional projections until 2016, CERN/FC/5152/Rev., 15 June 2007.

B.5 Gender aspects

Recent surveys have shown that female students and scientists are under-represented in many engineering and scientific fields. Particle Physics is one of these fields. Since 1993, CERN has been actively applying its strong Equal Opportunities (EO) policy. With emphasis initially placed on recruitment and gender-related issues, activities have now broadened to include other EO issues such as dignity and respect, life-work balance, culture, age and gender diversity. With the aim of increasing the number of women coming into in the field of particle physics, and retaining them, CERN has also been an active member of the FP6 initiative SET-Routes and has introduced new courses in its internal Management & Communication curriculum which specifically address issues of women in management.

To minimise gender bias and achieve a broader perspective in the approach to work, statutory working groups and selection boards at CERN are required to include women and this is also the case for the Marie Curie Selection Committee. In addition, potential supervisors will be asked to pay particular attention to female candidates when applications are circulated.

To improve female participation in all job categories and at all levels, gender distribution is monitored and statistics are published annually (experience has shown the absence of any gender bias at the selection level). In training lectures and seminars, particular attention is paid to choosing, whenever possible, women scientists as speakers in order to provide positive role models to young female scientists.

PART C: OVERALL INDICATIVE PROJECT DELIVERABLES (from A3.1 of the GPFs)

A3.1:
Overall Indicative Project Deliverables

Project Number [1]	211801	Project Acronym [2]	ACEOLE

ONE FORM PER PROJECT

	Initial Training 0-5 years						Visiting Scientists						Total	Events	
	Early-Stage researchers			Experienced researchers			Visiting scientists (<10)			Visiting scientists (>10)					
	Months	Researchers	% Fixed amount contract (B)	Months	Researchers	% Fixed amount contract (B)	Months	Researchers	% Fixed amount contract (B)	Months	Researchers	% Fixed amount contract (B)	Months	Researcher event days	Number of events
CERN	432	12	0%	60	5	0%	0	0	0%	15	11	0%	507	400	9
Overall Total	432	12	0%	60	5	0%	0	0	0%	15	11	0%	507	400	9

End of Annex 1