The Versatile Link Common Project

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1 General Project Description

1.1 Introduction

Radiation tolerant, high speed optoelectronic data transmission links are fundamental building blocks in today's large scale HEP detectors, as exemplified by the four LHC experiments currently under commissioning. New HEP experiments or upgrades will impose even more stringent demands on these systems from the point of view of performance and radiation tolerance.
In the past, specific data transmission links have been developed by each experiment for data acquisition (DAQ), trigger, timing and control (TTC). This was justified by the different types of application being targeted as well as by technological limitations. However with today's maturity of optoelectronic and CMOS technologies it is possible to envisage the development of a general purpose optical link which can cover all envisaged transmission applications: **a versatile link**. Such an approach has the clear advantage of concentrating the development effort on one single project targeting an optical link whose final functionality will only result from the topology and configuration settings being adopted.

The proposed development will concentrate on fast bi-directional digital optical data transmission at rates up to ~5 Gbit/s with an emphasis on SLHC level radiation resistance, low power and low mass components. The project concentrates on the technical development of the link and finishes at the pre-production readiness stage. No production level commitments are envisaged at this stage. The versatile link system is foreseen to operate in point-to-point or point-to-multipoint bidirectional[1] topologies and will most likely be made available in multimode or singlemode versions operating at 850nm or 1310nm wavelength respectively. It will have serial data interfaces and will be protocol-agnostic (within the limits set by the DC balance requirement on the data stream). Examples of applications could be a DAQ link implemented in a point-to-point configuration while a TTC link could be built around a point-to-multipoint topology, as shown in Fig 1 below.

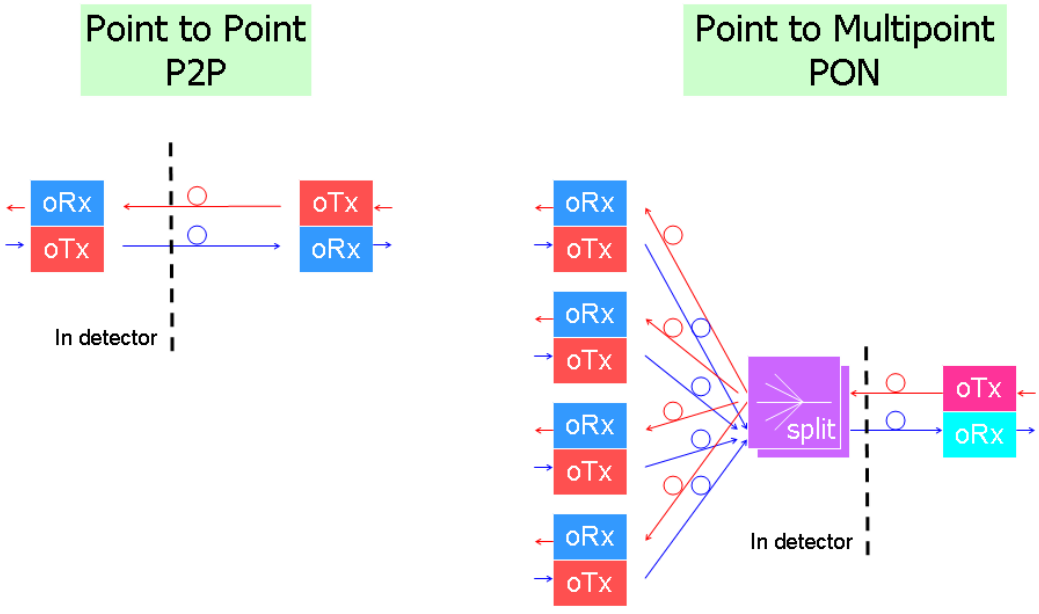


Fig. 1 Different link topologies achieved with versatile link components. On the left, a simple point-to-point architecture is shown while on the right a point-to-multipoint tree is illustrated, also referred to as Passive Optical Network (PON). oTx and oRx are optical transmitters and receivers, usually combined in one transceiver module.

[1] Bidirectionality is understood here in its most simple sense, as transfer of data in two directions over two fibers.

1.2 Relationship with other projects

The proposed versatile link project is a complex one due to the many variants and options on offer. It poses several technological challenges and requires a development effort in optoelectronics, ASIC design and system integration. It will focus mainly on the development of the physical optical layer of the system but will also investigate different architectures and topologies. It will develop and qualify **active** electro-optic components such as packaged laser transmitters and pin diode receivers, as well as validate **passive** components such as fiber, connectors and splitters. The ASIC design work associated with the transmit and receive functionality of the versatile link (laser driver and transimpedance amplifier) will be carried out in the framework of the GBT common project[2]. The high level definition of the system will be under the responsibility of the experiments interested in using the versatile link. Figure 2 illustrates as an example how an optical point-to-point link could be built with components from both the versatile link and GBT projects.

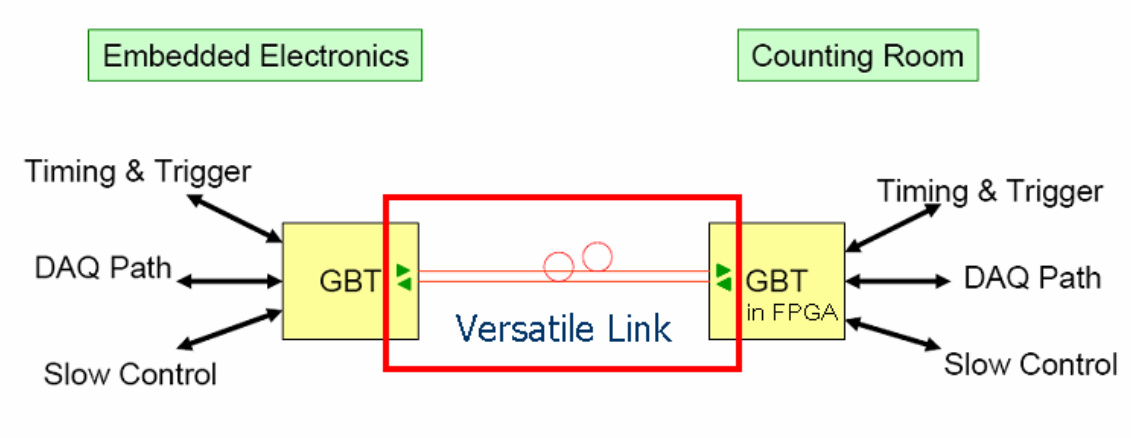


Fig. 2 The combined Versatile Link (optical system) and GBT (chipset) projects can lead to point-to-point or other topologies. The laser driver and transimpedance amplifier ASICs which are at the interface between the two projects are highlighted in green. Thanks to a well defined serial interface, the GBT chips can be used with different links, and the versatile link can be used with different chips, if available.

Apart from the GBT, several other projects will interact with the versatile link project, be it in the framework of the joint ATLAS-CMS optoelectronics working group for SLHC, of the EU-funded Initial Training Network ACEOLE, or of the SLHC programmes carried out by the different experiments and CERN. It is foreseen to organize and participate to joint meetings and thus coordinate activities as much as reasonably possible.

1.3 Project structure

The versatile link project is broken down into 6 concurrent workpackages, 3 at the system level and 3 at the components level (see Fig. 3). Each workpackage is under the technical and financial responsibility of one institute. A steering board composed of one representative from each partner institute plus one representative from the GBT project steers the versatile link project under the guidance of the project manager. The institutes report to their individual funding agencies concerning their workpackage. The project as a whole reports to the experiments via their SLHC steering groups.

[2] GBT, the GigaBit Transceiver project. P. Moreira, A. Marchioro, K. Kloukinas, "The GBT, a Proposed Architecture for Multi-Gb/s Data Transmission in High Energy Physics", proceedings of the Topical Workshop on Electronics for Particle Physics, TWEPP-07, Prague, 3-7 Sep 2007, pp 332-336.

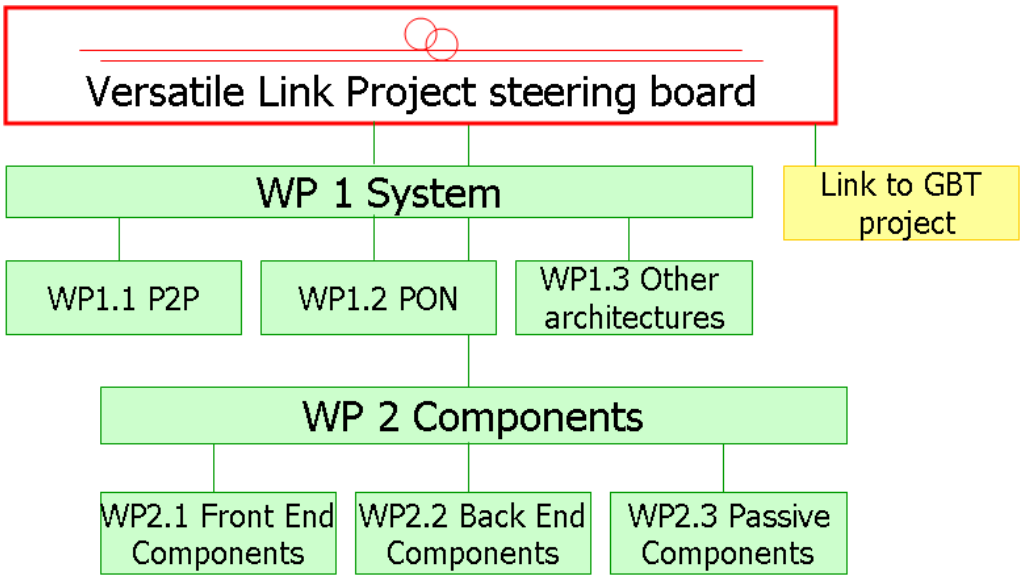


Fig. 3 Project breakdown structure

The teams responsible for system level workpackages WP1.1, 1.2 and 1.3 test the versatile link in different topologies. They define test procedures and protocols, design and build test systems and evaluate the versatile link functionality, environmental resistance and operational reliability. They feedback their results to teams working at the component level and contribute to the evaluation of links embedded in larger systems, jointly with other projects and experiments.
The teams responsible for component level workpackages WP2.1, 2.2 and 2.3 deal with the complete portfolio of versatile link components. They specify, design or select/procure the components, test them for functionality, environmental resistance and reliability, and deliver them to system level teams for testing.

1.4 Project and Associate Partners

The versatile link project partners are each responsible for a workpackage, as listed in Table 1 below. Project partners may collaborate with associate partners to work on specific, well defined tasks (see the workpackage description for more details).
Workpackages WP 1.2 and 1.3 have not yet been assigned. They will be launched once more experience will have been gained with the simpler system workpackage 1.1 and with the component workpackages 2.1 to 2.3.

Workpackage	*Description*	*Project Partner*	*Contact Person*
Proj. mgmt	Presides project steering board	CERN	Francois Vasey
WP 1.1	P2P architecture	Southern Methodist University, USA	Jingbo Ye
WP 1.2 and 1.3	PON and other architectures	*open*	
WP 2.1	Front-end components	CERN, Switzerland	Jan Troska
WP 2.2	Back-end components	Fermilab, USA	Alan Prosser
WP 2.3	Passive components	University of Oxford, United Kingdom	Cigdem Issever

Table 1 Project Partners

1.5 Workpackages

Each workpackage is under the responsibility of one institute (see Table 1). The project-level description given in this section is a general one with more details to be found in section 3, where each workpackage is presented individually as a sub-project.
The architectures investigated in the three system-level workpackages are highlighted in Fig.4. The point to point architecture **(WP1.1, P2P)** is the simplest implementation of an optical link. Operated with the GBT chipset for instance, the P2P versatile link architecture will allow to transfer through one bidirectional and symmetric link all necessary data to read-out and operate a front-end module (see Fig. 2). The passive optical network architecture **(WP1.2, PON)** is well suited to broadcast identical information to several destinations and to retrieve time multiplexed control data from the front-end. It is a bidirectional asymmetric architecture, as implemented in most fiber-to-the home developments nowadays. A PON versatile link would be ideal to implement a future

bidirectional TTC distribution tree for instance. The "other" architectures studied in **WP 1.3** will be combinations of the P2P and PON architectures, optimizing throughput and fiber usage. Workpackages 1.2 and 1.3 will not be immediately activated, waiting for experience to be gained from WP 1.1.

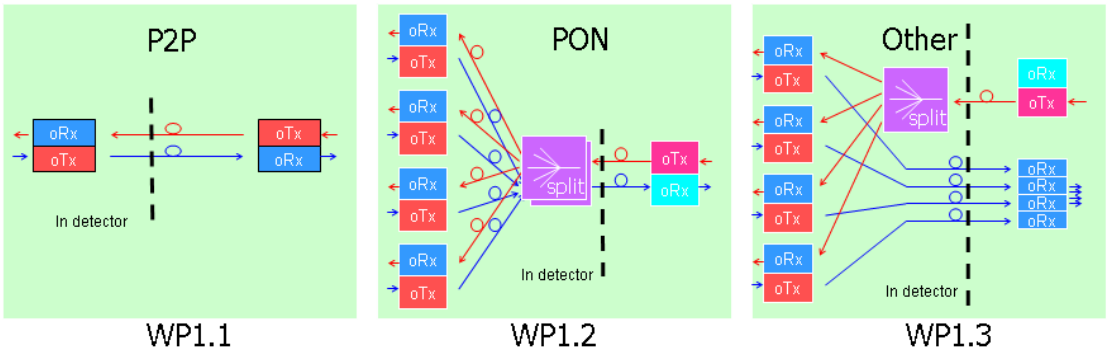


Fig. 4 The three system-level workpackages

The component portfolio developed/characterized in the component-level workpackages is shown in Fig. 5.
The only component fully developed by the versatile link project is the front-end transceiver (**WP 2.1**). It is used as unique front-end module in all topologies: P2P as well as PON and combinations of the two. The front-end transceiver is developed in two flavors: SM (1310nm) and MM (850nm). It is a radiation resistant, low mass, low power module which will be developed jointly with industry, and will integrate the laser driver and transimpedance amplifier ASICs designed in the framework of the GBT project. The back-end components (**WP 2.2**) are standard components selected to be compatible with the front-end transceiver in the different architectures under study. Different brands and types of components will be evaluated and compared in terms of functionality, environmental resistance and reliability. A short-list will be established and maintained until the project reaches the commercial production stage. The passive components (**WP 2.3**) are commercial off-the-shelf components (as in WP 2.2) which need to be evaluated and compared. Besides functionality, environmental resistance and reliability, radiation resistance will also be investigated for the various technologies under study.

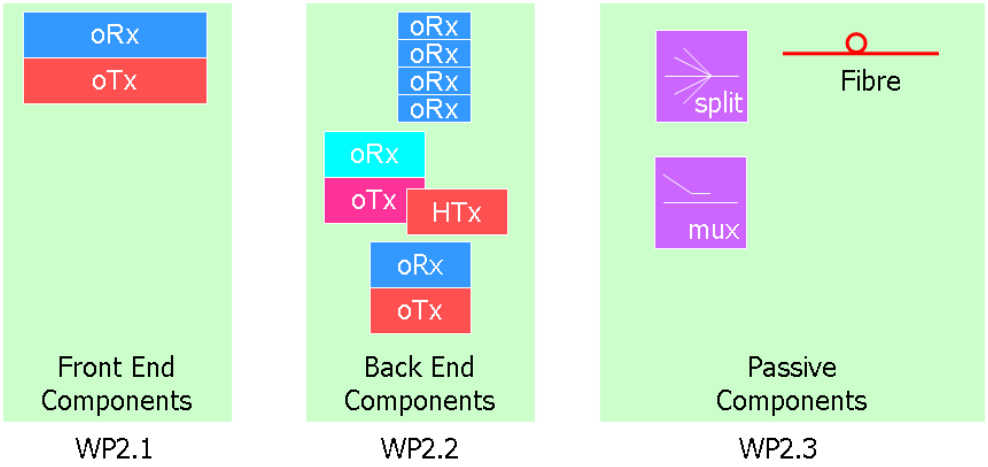


Fig. 5 The three component-level workpackages and the investigated portfolio of components

1.6 Timescales

The versatile link project is subdivided in three phases and officially started on 1 Apr 2008:

- Phase 1: proof of concept
- Phase 2: feasibility demonstration
- Phase 3: pre-production readiness

Each phase lasts 18 months, while the following phase is defined after 12 months already in order to allow time for approval and funding if necessary. See Table 2 below for details.

month	6	12	18	24	30	36	42	48	54
Start date: 01 Apr 08			Sep 09			Apr 11			Sep 12
1. Proof of concept	→→	→→	→↘						
Phase 2 definition		↓							
2. Feasibility			approve	→→	→→	→↘			
Phase 3 definition					↓				
3. Preprod readiness						approve	→→	→→	→→

Table 2 versatile link project timescales

The detailed schedule will be redefined after each phase to account for possible variations in resource allocation and timescales of other projects.

1.7 Deliverables

Phase 1: proof of concept

- Tentative specifications for components and systems based on experience
- Non-exhaustive portfolio of components shown to meet (even partially) the tentative specifications
- Development of architecture demonstrator(s) for P2P and PON networks
- Development of test bench(es) for components and systems
- Development of a Front-End Transceiver prototype
- Preliminary irradiation test results
- Preliminary functionality test results for components and systems
- Recommendations for phase 2

Phase 2: Feasibility study

- Detailed specifications for components and systems based on phase 1 recommendations and interaction with users
- System and architecture demonstrators with validated components
- Components and Variants shortlist
- Evaluation of production costs versus volume
- Complete set of irradiation test results for front-end and passive components
- Front-end Transceiver package definition and industrial prototype fabrication integrating GBT ASICs and validated optoelectronics

Phase 3: Pre-production readiness

- Specification freeze
- Formal market survey
- Validation of samples supplied in market survey framework (functionality and radiation hardness)
- Manufacturers shortlist
- Production funding matrix

2 Resources

2.1 Personnel

month	6	12	18	24	30	36	42	48	54
year	1 (2008)			2		3	4 (2011)		
	Phase 1			Phase 2			Phase 3		
WP 1.1 SMU	0.5 +1 from reference link project			1.5			1.5		
WP 1.2									
WP 1.3									
WP 2.1 CERN	4			?			?		
WP 2.2 Fermilab	1.5			2			2		
WP 2.3 Oxford	2.8			1.7			1.7?		
TOTAL (FTE)	9.3								

Table 3 available personnel (FTE, averaged over 18 months, 1 FTE is understood as one person available full time during the entire project phase)

3 Detailed Workpackage description

3.1 WP 1.1 Point-to-Point architecture

Project partner: Southern Methodist University (Physics Department),
Work Package Coordinator: Jingbo Ye, SMU
Associate patner: Institute of Physics, Academia Sinica, Taiwan (Suen Hou and P.K. Teng)

The point to point architecture **(WP1.1, P2P)** is the simplest implementation of an optical link as illustrated in Fig. 4, yet it is the fundamental building block for all other connection configurations. Tests at P2P level provide a reference to point-to-multipoint and other architectures. According to the overall project plan, work and deliverables in WP1.1 are the following:

3.1.1 Phase 1 (Proof of Concept)

- Development of architecture demonstrator(s) for P2P network.
- Development of test bench(es) for components and systems
- Development of test procedures

With preliminary front-end and back-end transceiver specifications, we plan to use commercially available transceivers that have the same or similar specification to demonstrate the P2P network. The initial selection of the transceivers can be carried out with a Bit Error Rate Tester available at SMU that has a serial bit rate up to 12 Gbps. After the initial selection of the transceivers we plan to use FPGA based serializer and deserializer to provide the high speed serial data stream to the input of the transmitters and to de-serialize and perform error check on the data from the receivers of the front-end and back-end transceivers. This system becomes the architecture demonstrator for the P2P network. This system or one of its replicas is also a test bench for components and systems (other configurations) during the components development as well as for the irradiation tests. The present FPGA based serializer and deserializer reaches a data rate of 6 Gbps (example: Stratis II GX, 0.6 Gbps to 6 Gbps).

The development part of this work can come from the reference link project we are proposing through the Joint ATLAS-CMS Opto-electronics Working Group, subgroup C. And because of this, we anticipate the work load of 0.5 FTE only for the transmit/receive components selection phase and the specific technical documentations.

3.1.2 Phase 2 (Feasibility Study)

With the test bench developed in phase 1, we plan to perform the following three tasks in phase 2:

- Functional tests and in-system validations of the components developed or validated in WP2.1, 2.2 and 2.3.
- Performance comparison with benchmark reference chain developed during phase 1.
- In-system radiation resistance verification of the front-end transceiver developed from WP2.1.

Tests include specification compliance and failure mode analysis (together with the design team of the components). In system irradiation tests and reliability studies will be carried out when the components will comply with all functional specifications. They will consist of total dose, total fluence, SEU and accelerated ageing tests.

We anticipate the work load of 1.5 FTEs for the laboratory tests as well as the preparation and conducting of the irradiation tests.

3.1.3 Phase 3 (Pre-Production Readiness)

The work aspect for WP1.1 in phase 2 and phase 3 differs only in statistics. A procedure will be established to systematically test the optical link components under evaluation with good statistical confidence in the test results. Both functionality and irradiation in-system tests will be performed. Together with results from other workpackages, a conclusion on the pre-production readiness will be formed.

We anticipate the work load of 1.5 FTEs for this work phase.

Our funding source is DOE and NSF through US-ATLAS. Official endorsement of this project from SLHC upgrade steering groups is essential for us to request funding from our funding agencies. For the work in phase 1, since we plan to combine the work with the reference link proposal from the Joint ATLAS-CMS Opto-electronics Working Group, it is essential that the reference link proposal be granted before we can start our work in this

project. The reference link proposal has been sent to US-ATLAS and US-CMS, and recently to the steering groups for SLHC upgrades and the ILC R&D programs.

3.2 WP 1.2 and 1.3 PON and other architectures

Will be activated once more experience will have been gained with WP 1.1, WP 2.2 and WP 2.3.

3.3 WP 2.1 Front-End components

Project partner: CERN
Work Package Coordinator: Jan Troska, CERN

The major deliverable of Phase 3 of this WP is a Versatile Transceiver (VTRx) for use in Versatile links. A VTRx will contain one transmitter and one receiver along with a laser driver and receiver amplifier, packaged in a form that is compatible with installation on-detector (size and mass) and overall able to withstand the environmental requirements (radiation, magnet field). The packaging will be based upon an existing commercially available transceiver platform that will be customized in collaboration with one or more industrial partners. There will be a number of variants containing optoelectronic components that differ in their wavelength of operation based upon the requirements set in phases 1 & 2 of the overall Versatile link project.
Interaction with ASIC designers of laser driver and receiving amplifier circuits, as well as the members of the other Versatile Link WorkPackages is a key activity of the effort in WP 2.1.

3.3.1 Phase 1 (Proof of Concept) Deliverables

- Tentative Specifications for on-detector components based upon experience gained both from previous generations of optical link and from the ongoing work for phase 1
- Proof of Concept VTRx based upon the modification of an existing industrial design through insertion of chosen optoelectronic and electronic sub-components into an existing transceiver package by an industrial partner
- Preliminary functional test results of full transceivers, as well as electronic and optoelectronic sub-components
- Functional Test methods to be applied to future testing
- Preliminary radiation test results on optoelectronic sub-component radiation resistance for a range of commercially available components
- Radiation Test method to be applied to future testing

3.3.2 Phase 2 (Feasibility) Deliverables

- Detailed VTRx specification
- Detailed specifications for the sub-components used inside the VTRx (Laser diode, Photodiode, Laser Driver, Receiver Amplifier)
- Shortlist of variants for VTRx flavours (wavelength, fibre type) and associated sub-components
- Full radiation test results for the sub-components needed to cover all shortlisted variants of the VTRx. A range of irradiation sources will be used to give confidence that the VTRx will withstand the SLHC Tracking detector environment. Irradiation tests to be carried out using the test methods defined in Phase 1
- VTRx packaging design and industrial prototype fabrication containing chosen validated optoelectronic sub-components and custom radiation-resistant electronics (Laser Driver and Receiver Amplifier). The electronic sub-components could for example be sourced from the GBT project

3.3.3 Phase 3 (Pre-Production Readiness) Deliverables

- Frozen VTRx and Sub-component specifications
- Formal market survey for components and VTRx package
- Full evaluation (functionality and radiation hardness) of samples supplied in the market survey framework based upon Test Methods defined in Phase 1
- Manufacturer shortlist for optoelectronic components and packaging
- Component production and packaging flow
- Funding matrix for production

3.3.4 Detailed Project Plan for Phase 1

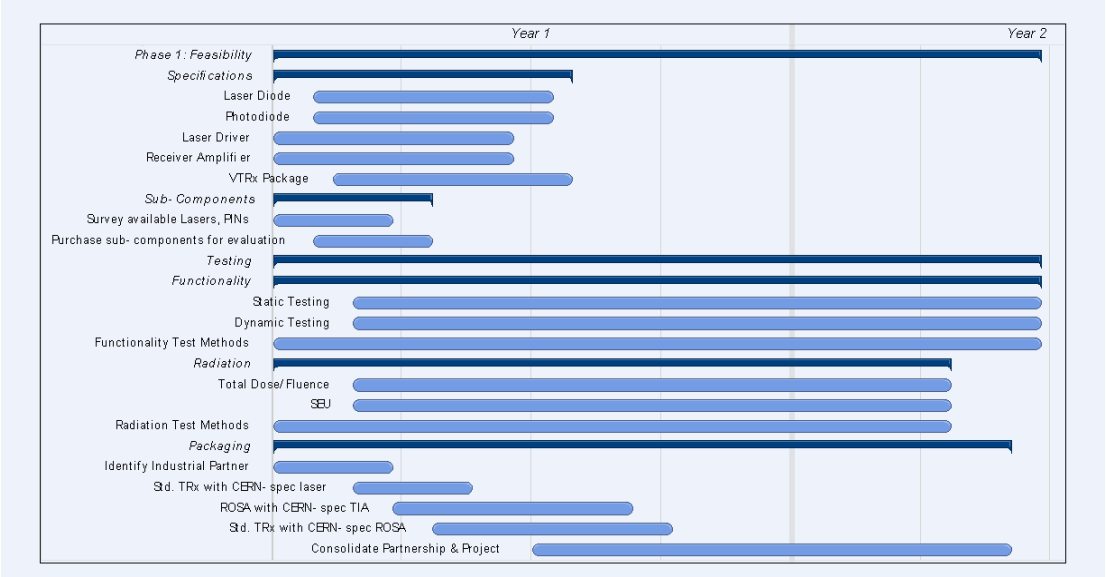


Fig. 6 Schedule for phase 1 of workpackage 2.1

3.3.5 Personnel

Personnel is known with precision for phase 1, and is assumed to remain stable during phases 2 and 3.
CERN Staff: 1FTE
Others: 3 FTE

3.4 WP 2.2 Back-End components

Project partner:Fermilab
Work Package Coordinator: Alan Prosser

Introduction:
This work plan describes the participation in the SLHC Versatile Link Common Project by members of the Electronic Systems Engineering (ESE) department at the Fermi National Accelerator Laboratory in Batavia, IL. Included in this work plan is a breakdown of the anticipated activities, a schedule for completing those activities, and the Fermilab staffing estimates to provide this support.

We expect to collaborate with colleagues at the University of Minnesota (UM). However, this document does not provide the details of that collaboration (split of assignments, manpower estimates for UM).

Scope:
The activities in WP 2.2 include the evaluation of commercially available optical communication components such as:

1. Point to point (P2P) transceivers
2. Passive Optical Network (PON) transceivers
3. Array receivers and transmitters
4. High power optical transmitters

P2P transceivers are used to implement the simplest form of network, the point to point network in which simplex links are terminated by a transmitter at one end and a receiver at the other end. Transceivers include both of these components in a single package. Devices are available which operate at 850 nm for transmission distances on the order of a few hundred meters. For longer transmission distances, devices which operate at 1310 nm are also commercially available. We propose to obtain and evaluate representative samples of both families of devices. Single mode and multimode versions of the devices will be studied.

PON transceivers represent the next level of complexity due to a higher degree of integration. This approach reduces the number of required transceivers and optical fibers by the use of passive (not requiring electrical power) optical splitters and couplers to and from a single fiber to multiple fibers near the particle detector. The kinds of components that are used may depend on the network topology to be implemented [2]. We propose to obtain and evaluate representative samples of commercially available devices which are typically used to implement different network topologies. The performance characteristics which are measured may be useful in defining the specific topology which will work best for the SLHC data networks.

High power optical transmitters and array receivers are to be investigated to determine their suitability in network applications. The higher degree of integration capable with these components offers advantages which will be attractive as more detector channels are provisioned in the proposed upgrades. We propose to investigate the use of these components after the characterization of the point to point and PON components has been begun.

Reliability of the components is an important property that must be addressed. There will be restricted opportunities to service faulty or failed components so the transmitters and receivers need to be suitably robust Reliability testing of components will be based on experience gained from the industry for the specific components. For example, for optical sources, one approach to characterizing the reliability is to maintain a constant supply current while monitoring the output power of the source. The end of life point is the time needed for the output optical power to decrease by 3 dB [5]. Industry standard or commonly accepted reliability test methods will be researched, and, if necessary, included in the set of standard test procedures (such as documented in [6]).

Collaborative Synergies:
The testing that is to be performed will make use of the standard test benches and procedures being defined as part of the Work Package 1.1 (WP1.1, Point to Point Architecture) activities. There will be a need to work closely with our colleagues addressing this work package to fully understand these test benches and methods. It will also be beneficial to provide frequent feedback on test results and lessons learned from our activities to the participants of WP1.1.

We also expect to work closely with the members of the collaboration addressing the Front End components (WP 2.1). These devices are those which interface to the fibers and are driven by or drive the back end components being evaluated in WP2.2. Instances where collaboration with other working groups is expected are indicated in the schedule below.

3.4.1 Phase 1 Activities (April 1, 2008 – Q3, 2009):

Calendar Year 2008 (Qtrs. 2, 3, 4):
Engineers: 1
Technicians: 0.5

Activities Summary:

1. Make contact with existing working groups. Learn about project (particularly activities in WP1.1). Review existing test procedures documentation [3]
2. Identify opportunities to contribute to the definition of a standard test set up if that definition is not complete.
3. Begin market survey of components and development systems (evaluation systems). Consider how these components can be integrated with the standard test set up. Initially, this will be based on "tentative specifications based on experience". However, as the project develops, we expect to participate in the refinement of specifications and the survey of components will be guided by this refinement. This requires collaboration with WP1.1 and WP2.1.

Calendar Year 2009 (Qtrs. 1, 2, 3):
Engineers: 1
Technicians: 0.5

Activity Summary:

1. Procure and test examples of candidate components based on the tentative (but evolving) specifications. Funds will need to be allocated to cover the cost of this procurement.

3.4.2 Phase 2 Activities (Q4, 2009 – Q1, 2011):

Calendar Year 2009 (Qtr. 4):
Engineers: 1.5
Technicians: 0.5

Activity Summary

1. Develop a detailed test plan consistent with the evolving test procedures indicating how those procedures will be carried out using the standard test set up. Also indicate how those procedures will permit confirmation that the tested components comply with the project requirements. Consult available standards (e.g. IEEE) for adherence to standard practices. Requires close communication with the members of subgroup C who authored [3].
2. Begin assembly, supporting development, and integration of test stations at Fermilab and Minneapolis. These may be composed of custom hardware and software that are available at Fermilab as well as commercially available systems (e.g. evaluation boards and software from component vendors) and prototypes developed by project collaborators (e.g. existing test stand components). Contact component vendors for guidance on component handling, storage, assembly practices, and operating procedures.
3. Begin testing of selected components with assembled test systems, broadening the portfolio to arrays and high power transmitters. Tests are to include verification that the components meet the functional and reliability requirements of the project.

Calendar Year 2010 (Qtrs. 1, 2)
Engineers: 1.5
Technicians: 0.5

Activity Summary

1. Documentation and refinement of test procedures and results in collaboration with subgroup C. Indicate any important observations or lessons learned that led to further modifications of current procedures.
2. Continued development of test stations at Fermilab. Document results and communicate with project collaborators. If Fermilab developed systems are used, make necessary upgrades and support available to other members of the collaboration.
3. Continue testing of selected components with assembled test systems, document and compare the results.
4. Perform evaluation of industrial quality control procedures. Consult component vendors for guidance on quality control procedures for production level engineering.
5. Perform evaluation of production costs versus volume.

Calendar Year 2010 (Qtrs. 3, 4)
Engineers: 1.5
Technicians: 0.5

Activity Summary

1. Further documentation and refinement of test procedures and results in collaboration with subgroup C. Indicate any important observations or lessons learned that led to further modifications of current procedures.
2. Continued development of test stations at Fermilab. Document results and communicate with project collaborators. If Fermilab developed systems are used, make necessary upgrades and support available to other members of the collaboration.
3. Continue testing of selected components with assembled test systems, document and compare the results.
4. Continue evaluation of industrial quality control procedures. Consult component vendors for guidance on quality control procedures for production level engineering.
5. Continue evaluation of production costs versus volume.

Calendar Year 2011 (Qtr 1.)
Engineers: 1.5
Technicians: 0.5

Activity Summary

1. Document final state of test stations for WP2.2. Review with project collaborators. If Fermilab developed systems are used, make all necessary upgrades available to other members of the collaboration as final configuration. Continue to provide support.
2. Continue testing of selected components with assembled test systems. Remove from consideration any components which have been observed to have inferior performance, excessive cost (relative to performance advantages), or poor reliability.
3. Finish evaluation of industrial quality control procedures. Document procedures with specific instructions relevant to the use of these components and procedures in SLHC.
4. Refine evaluation of production costs versus volume. This can be based on the acquisition of more detailed knowledge as well as the removal from consideration any substandard components.

3.4.3 Phase 3 Activities (Q2, 2011 – Q3, 2012):

Calendar Year 2011 (Qtrs. 2, 3, 4):
Engineers: 1.5
Technicians: 0.5

Activity Summary

1. Based on component testing, reliability studies, and cost analyses, arrive at a final specification for components for WP2.2.
2. Continue testing of selected components with assembled test systems. Remove from consideration any components which have been observed to have inferior performance, excessive cost (relative to performance advantages), or poor reliability. The purpose is to converge on a final list of components for recommendation to the project management.
3. Based on studies of industrial quality control procedures, develop the SLHC Versatile Link quality assurance plan. This plan should detail what procedures and methods are to be used and how the employment of those procedures and methods will contribute to the required level of quality and performance. All procedures and methods are to be documented with specific details relative to the use of these components and procedures in SLHC.
4. Procure a representative set of samples of candidate components and perform any quality assurance testing on this sample set. Results of this testing may serve to further reduce the list of candidates. The tests to be performed would include tests compatible with the quality assurance plan.
5. Begin the construction of a production funding matrix for the components. Such a matrix would be designed with input from funding managers on the project. Each of the components that is on the final set of selected components might have entries for component cost, lead time, risk, assessment, and existence of multiple sources.

Calendar Year 2012 (Qtrs. 1, 2, 3):
Engineers: 1.5
Technicians: 0.5

Activity Summary

1. Based on component testing, reliability studies, and cost analysis, arrive at a final specification for components for WP2.2.
2. Complete testing of final set of selected components with assembled test systems according to the final specification of components for WP2.2. Remove from consideration any remaining components which are not suitable. A complete set of test results must be available certifying the compliance with the specifications required for acceptance.
3. Complete procurement of sample quantities of any remaining selected components. Perform quality assurance testing in accordance with the SLHC Versatile Link quality assurance plan. This should include any second source components that may be needed to address possible supply issues. Results of all such procedures are to be documented.
4. Document the final list of selected components. For all elements in the list, complete the associated funding matrix. This funding matrix would be used to provide an estimate for costs at production levels.
5. Provide close out report for WP2.2.

Manpower Estimates:

Calendar Year	2008	2009	2009	2010	2010	2011	2011	2012
Quarters[(a)]	2, 3, 4	1, 2, 3	4	1, 2	3, 4	1	2, 3, 4	1, 2, 3
Project Phase	1	1	2	2	2	2	3	3
FTE-Engineer	1	1	1.5	1.5	1.5	1.5	1.5	1.5
FTE-Technician	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5

(a) Quarter 1 includes January, February, and March of the indicated calendar year.
Quarter 2 includes April, May, and June of the indicated calendar year.
Quarter 3 includes July, August, and September of the indicated calendar year.
Quarter 4 includes October, November, and December of the indicated calendar year.

References:

[1] "The Versatile Link Common Project", F. Vasey et. al., V2.2, 16.11.07.

[2] "Ethernet Passive Optical Network", B. Kramer, G. Mukherjee, A. Miaslos, http://networks.cs.ucdavis.edu/~mukherje/links/gk_wiley_bc.pdf

[3] "Joint ATLAS-CMS working group on optoelectronics for SLHC: Report from sub-group C Optical Link Evaluation Criteria and Test Procedures", C. Bruno et. al., V 2.0, 11.1.07.

[4] "Understanding Optical Communications", Harry J. R. Dutton, IBM Redbooks, http://www.redbooks.ibm.com, Sept. 1998.

[5] "Optical Fiber Communications", Gerd Heiser, McGraw-Hill, 1991, pp 181.

[6] "Lifetime Test for Optical Transmitters in the ATLAS Liquid Argon Calorimeter Readout System", C. Yang, T. Liu, C. Xiang, J. Ye, available at http://cdsweb.cern.ch/record/955111.

3.5 WP 2.3 Passive components

Project partner: University of Oxford,
Work Package Coordinator: Cigdem Issever
Associate patner: Institute of Physics, Academia Sinica, Taiwan

The scope of this work package is to evaluate and compare the following commercial off-the-shelf components:

- optical fibres and fibre ribbons,
- fibre jackets and connectors,
- optical splitters and
- passive multiplexers.

Besides functionality, environmental resistance and reliability, radiation resistance will also be investigated for the various technologies under study.

Section 3.5.1 will outline in detail WP 2.3 in phase one, section 3.5.2 and 3.5.3 will give a brief outline of the phases two and three. Table 5 summarizes the available personnel for this work package.

Month	6	12	18	24	30	36	42	48	54
Year	1 (2008)			2		3	4 (2011)		
	Phase 1			Phase 2			Phase 3		
Academics	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4*[3]	0.4*[3]
Electronics Eng	0.6	0.6	0.6	0.6	0.6	0.6	0.6	*0.6*	*0.6*
Design Office	0.1	0.1	0.1	0.1	0.1	0.1	0.1	*0.1*	*0.1*
Technicians	0.6	0.6	0.5	0.5	0.5	0.5	0.5	*0.5*	*0.5*
PhD Students	1.5	1.5	0.5	0.0	0.0	0.0	0.0	*0.0*	*0.0*
Total FTE	3.2	3.2	2.1	1.6	1.6	1.6	1.6	*1.6*	*1.6*

Table 5: Available personnel in WP 2.3 in FTE.

3.5.1 Phase 1 (Proof of Concept)

The initial aim of WP 2.3 is to determine specifications for the passive fibre components. The main goal of WP 2.3 in phase 1 of the project is to have a portfolio of fibres (850 nm and 1310 nm), fibre jackets, fibre ribbons, connectors and splitters (fused taper splitters and planar lightwave splitters) which fulfils the tentative specifications. It also includes the identification of reliable companies which are willing to collaborate on a long term basis with the versatile link project. Table 6 shows the time line of phase 1 for WP 2.3.

We intend to first survey previous work and tests, to evaluate possible suppliers of suitable components and to identify a set of candidate fibres (SM, GRIN, SIMM), fibre jackets, fibre ribbons, connectors and splitters. This first non-official market survey will be based on advice from academic and industry contacts.

The necessary tests systems[4] for the component tests will be developed making as much use of the existing setups at CERN and Oxford as possible.

Prior to any radiation test the performance, the mechanical properties and functionality of the components will be characterized in the laboratory.

In phase 1 we intend to irradiate the components with gammas up to a dose of 50 Mrad, which corresponds to 3000 fb^{-1} with a safety factor of 1.5 [[i]]. The radiation tests will be performed at the gamma source of the Belgian Nuclear Research Centre, SCK [[ii]]. In phase 1 we only plan to irradiate the components with gammas. We foresee, depending on the results of the first tests, up to four trips to SCK. At each radiation cycle we will irradiate sets of fibres, jackets, connectors and splitters at the same time at two dose rates. We will monitor the optical performance of fibres and splitters during and after irradiation.

The performance, mechanical properties and functionality will be re-evaluated after radiation and feedback will be given to the companies.

We intend to identify at least two companies for each component type and technology.

[3] Entries in this column are based on the assumption that the to be approved round of funds by the UK funding agency STFC will continue to support the personnel beyond 2010.
[4] mechanical and environmental tests, radiation tests

One year into phase 1 we will define the details of phase 2 and ask for its approval. At this time we will also start to identify possible cable and packaging options defined in close collaboration with the other work packages.

Month	2		4		6		8		10		12		14		16		18	
Year (tbc)	1(2008)												2(2009)					
Unofficial Market Survey	Fibres, Jackets, Splitters and Connectors																	
Purchase Components																		
Setup and Optimize Test Systems	Mechanical and Optical Performance																	
Measure performance and reliability					Optical, mechanical			Optical, mechanical										
Gamma irradiation (low (L), medium (M), high (H) dose)							MH					LH or MH				LH or MH		
Feedback to Companies																		
Portfolio of fibres, splitters, jackets and connectors																		
Identify Cabling and Packaging Options																		
Phase 2 definition																		
2. Feasibility																	Approval of phase 2	

Table 6: First 18 months (phase 1) of WP 2.3. The shaded tasks depend on the outcome of the previous tests.

3.5.2 Phase 2 (Feasibility)

The aim of phase 2 is to have a complete set of irradiation test results for passive components and to provide a shortlist. We intend to further irradiate the short-listed candidate samples with neutrons. The same set of tests performed in phase 1 will be performed in phase 2: optical performance, functionality, mechanical reliability.

In this phase we would like to also check stability of the quality of the components from different batches, which the selected companies provide.

In Phase 2 we will investigate optical MUX. We will determine preliminary specifications based on discussions with the optical links system's designers and the specifications of available commercial components. We will purchase samples and evaluate their performance.

3.5.3 Phase 3 (Pre-Production Readiness)

In phase 3 we will freeze the specifications of the passive components, perform a formal market survey and validate the samples which will be supplied in the market survey framework (functionality, mechanical reliability, radiation tolerance). The goal is to have a manufacturer shortlist and to have a production funding matrix at the end of this phase. This will be done in collaboration with CERN.

3.5.4 Missing Resources

As shown in

Table the available man power drops from 3.2 FTE to 1.6 FTE from phase One to phases 2 and 3. We need to find PhD students or post doctorial researchers (1 – 1.5 FTE) for phases 2 and 3 in order to have the necessary personnell to conclude this work package successfully at the end of phase 3.

3.5.5 References

[i] R. Boyd et al., "Joint ATLAS-CMS working group on optoelectronics for SLHC, Report from sub-group B, Optical Readout System Irradiation Guidelines", https://edms.cern.ch/document/882783/2.6

[ii] https://www.sckcen.be/sckcen_en/index.shtml