IPSR (Integrated Photonic Systems Road mapping) Group

iNEMI - IPSR Phase II: Expanded-beam Module Interface Project

Recording (available up to 6 months after webinar):
https://inemi.webex.com/inemi/ldr.php?RCID=2b2cee731c909a25dea476c5f24639b3

Project Formation Leader:
Terry Smith, 3M
iNEMI Staff:
David Godlewski

February 21, 2018

Project Introduction

- The iNEMI-IPSR-AIM Board Level Interconnect program originated in MIT MicroPhotonics Consortium Technology Working Group Discussions

- The high-level goal is to assess the technology benefits and issues of using SM expanded-beam connector interfaces in board-level optical interconnect

- The program is divided into 3 major phases:
  - Phase I: Expanded-Beam Connectors for fiber-fiber connections.
  - Phases IIa and IIb: Expanded-Beam Connectors for fiber-module connections.
  - Phase III: Expanded-Beam Connectors for module-waveguide connections, for PCB-embedded waveguide technology

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Project Launch Time Line

- Hold industry "Requirements for Initiative Formation" February 21, at 11:00 am EDT

  Goal - Determination of Industry Support for Project, Member/Non member Involvement

- Hold Face-to-Face OFC 2018 Meeting March 12

- Industry Review and Development of SOW Sessions held

  Goal – Develop and Finalized SOW and Project Statement documents – with industry input Member - Non-member Involvement

  Submit to iNEMI office for review and approval followed by submittal to Technical Committee for approval vote – by May 30 or before

- Obtain Technical Committee approval vote - goal – by June 15

- Project sign-up period – June 15 – July 27

- Proposed project start – Start July 27

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Background

- Project is aligned with AIM (American Institute for Manufacturing Integrated Photonics), iNEMI, MIT MicroPhotonics Consortium, and industrial roadmaps
- These roadmaps predict that silicon-photonics-based transceiver modules will provide the most cost-effective solutions for on-board interconnections in the future
- This is based on the expected reduction of optoelectronic chip cost to be achieved via leveraging of the CMOS silicon foundry infrastructure
- Before the anticipated cost benefits of silicon photonics can be realized, new high-performance and cost-effective solutions to optical packaging and connectorization must be developed
- Optimum performance and functionality from silicon photonics devices requires single mode (SM) fiber/waveguide interconnect media

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Background

- Single mode operation requires precision (sub-micron) alignment in optical connections, both inside the package and in optical connectors; the tight mechanical tolerances needed in connector parts result in high-cost components with automated assembly and environmental reliability issues
- To address the need for improved SM connections, manufacturers have begun developing expanded-beam optical connectors, in which optical mode of the SM fiber (~ 10 microns diameter) is expanded to a larger collimated beam (e.g. 80 microns in diameter) thus relaxing mechanical alignment tolerances, and reducing the effects of physical mating and dust, etc.
- However, to date, expanded-beam versions of SM connectors have higher losses than desired by system designers, and thus have not yet been commercialized
- The overall goal of this project is to make early-phase expanded-beam connector "library elements" available to system developers, so they can assess the benefits of such connections in systems

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Tom Marrapode, Molex
Phase I Review

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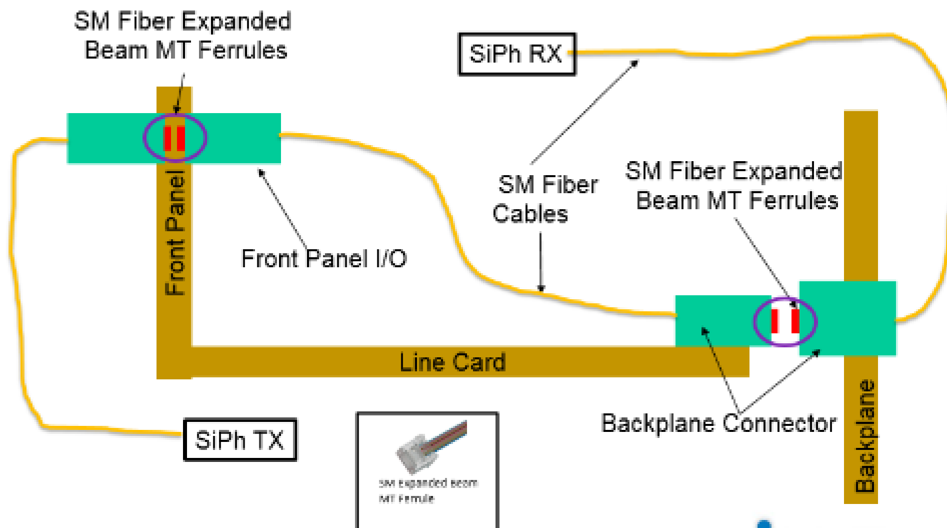
Project Overview Phase I

Need Being Addressed:

- The assessment of the performance of prototypes of board-level interconnect systems based on single-mode (SM) fiber, expanded-beam optical coupling, and silicon photonics transceivers. This activity will allow evaluation of existing and developing components, and thereby will identify gaps in the board-level technologies needed for practical implementation.



Proposed Solution:

- This need was one of three identified in the 2016 Roadmap as being critical to the wide spread implementation of board level integrated photonic systems. The team has met weekly this fall to develop this self-funded project to address the need.

Funding

- This project is self-funded by the industrial participants

Constraints:

- This solution is dependent on all participants honoring the commitments they have made to the project
- Participants will be required to sign a statement of work (SOW) and IP Agreement.

Timeline:

- One Year (2017)

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Phase I Participants

Affiliation	Participant	Title	Proposed Contributions
Molex	Tom Marrapode, IPSR Project Leader	Director of Advanced Technology Development	Interconnects; backplane, front panel, I/O and cables Prototype single mode expanded beam MT ferrules
Celestica	Tatiana Berdinskikh	Principal Optical Engineer	Rack Hardware
Juniper Networks	Valery Kugel	Distinguished Engineer	Link test parameters and performance evaluation In house testing
US Conec	Darrel Childers Sharon Lutz	Director of Development Product Manager	Prototype single mode expanded beam MT ferrules. Interconnects; backplane, front panel, I/O
3M Company	Terry Smith	Senior Staff Scientist	Organizer-Planning for next phases
US Competitors	John Mac Williams	Principle	Advisor-Planning for next phases
MIT	Kazumi Wada	Professor	Advisor-Planning for next phases
Senko	Tiger Ninomiya	Business Development	Observer
IPSR	Robert Pfahl	Director of Roadmapping	Facilitator-Planning for next phases

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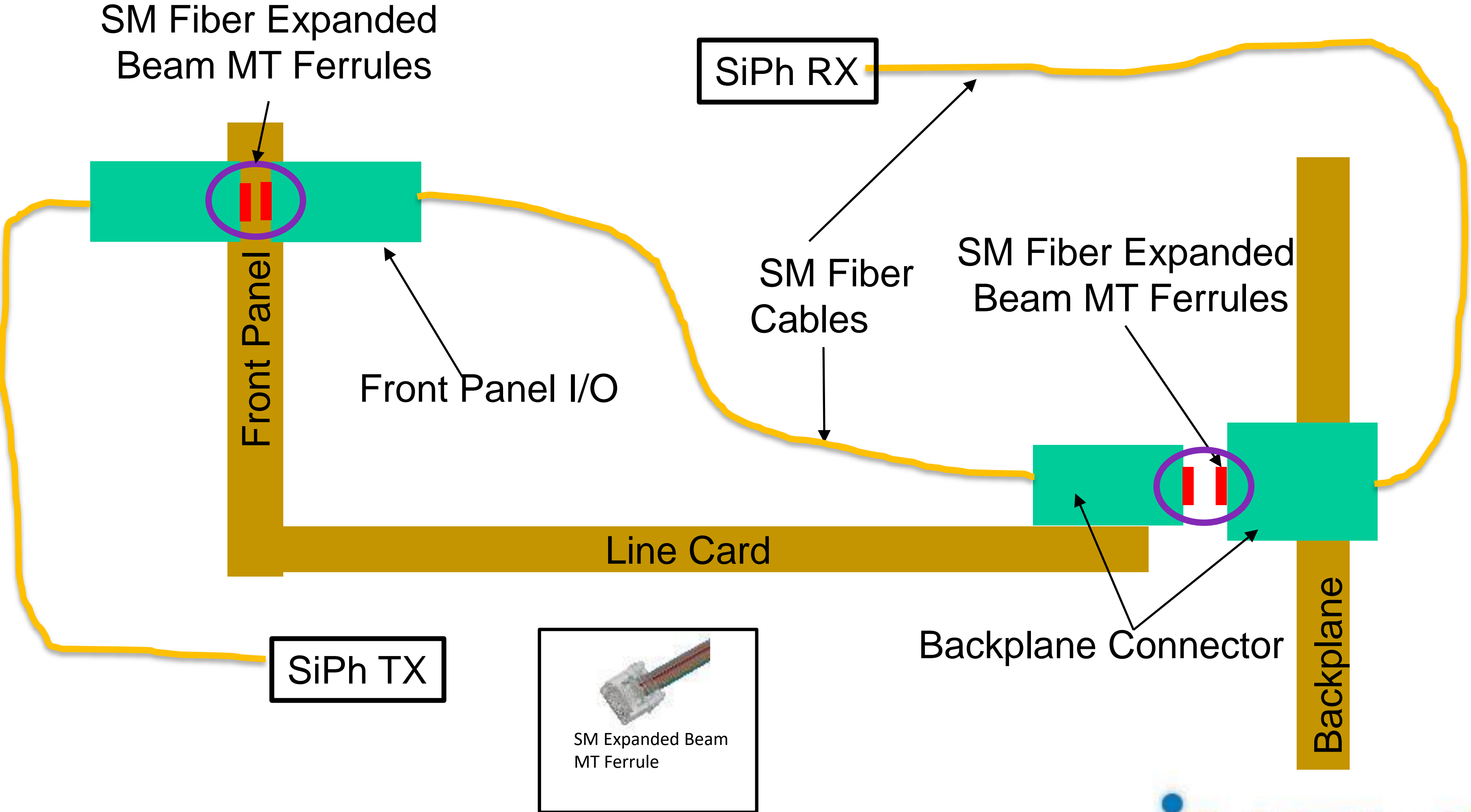
Phase I Specific Component and System Characterizations

- Connector loss
- Wavelength dependence of connector loss
- Connector return loss
- Connector polarization-dependent loss
- Connector re-mating loss variation
- Signal Bit Error Rate vs. connector number and loss (up to 25 Gbps/channel)

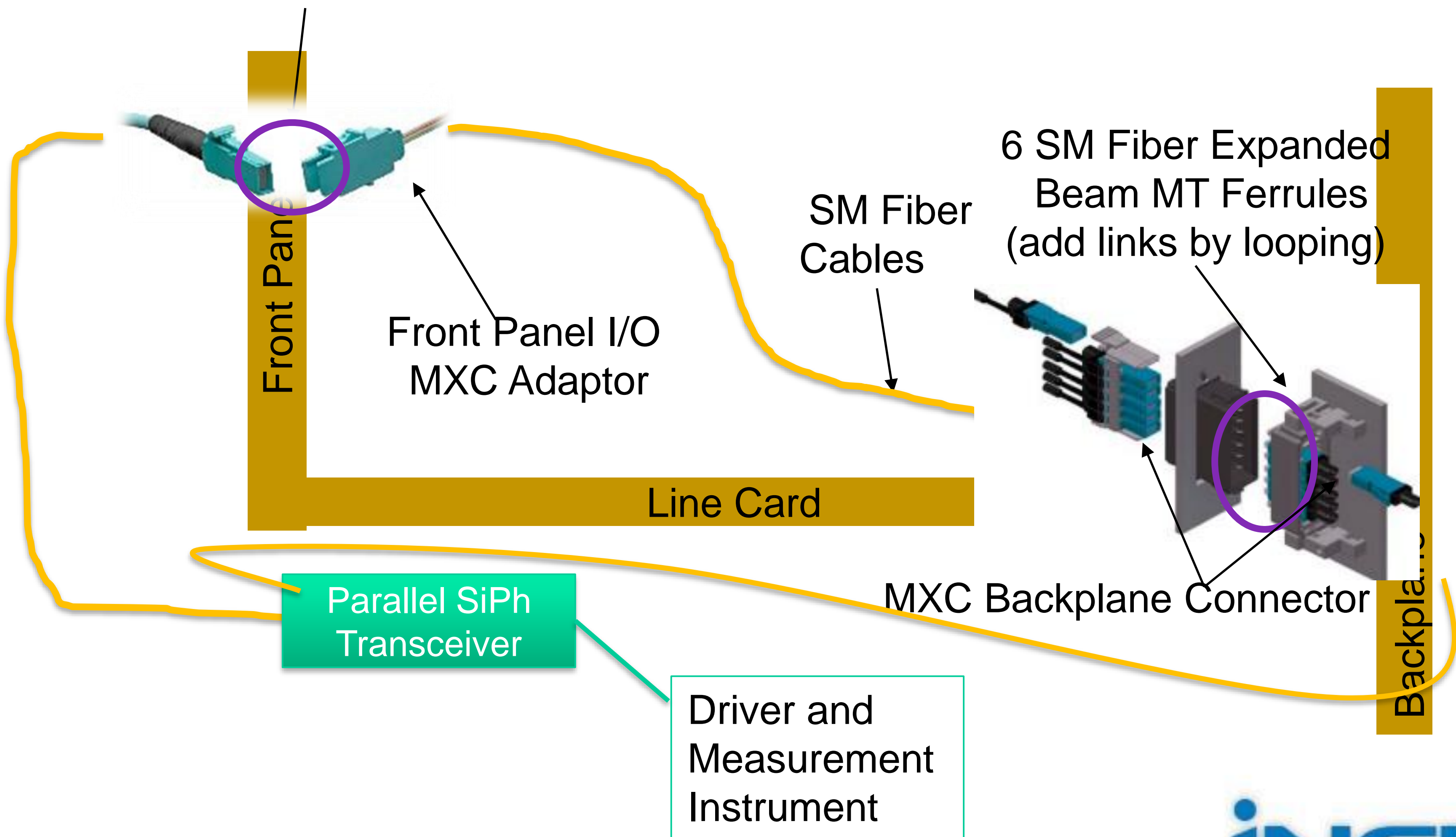
Additional Proposed Testing :

- Dust contamination induced connector loss (Test TBD)
- Environment Thermal Aging, Humidity Aging, Thermal Cycling, and Humidity/Condensation Cycling testing

Phase I Demonstrator: High Level



Proposed Phase I Demonstrator Interface: Juniper, Molex, USCONEC



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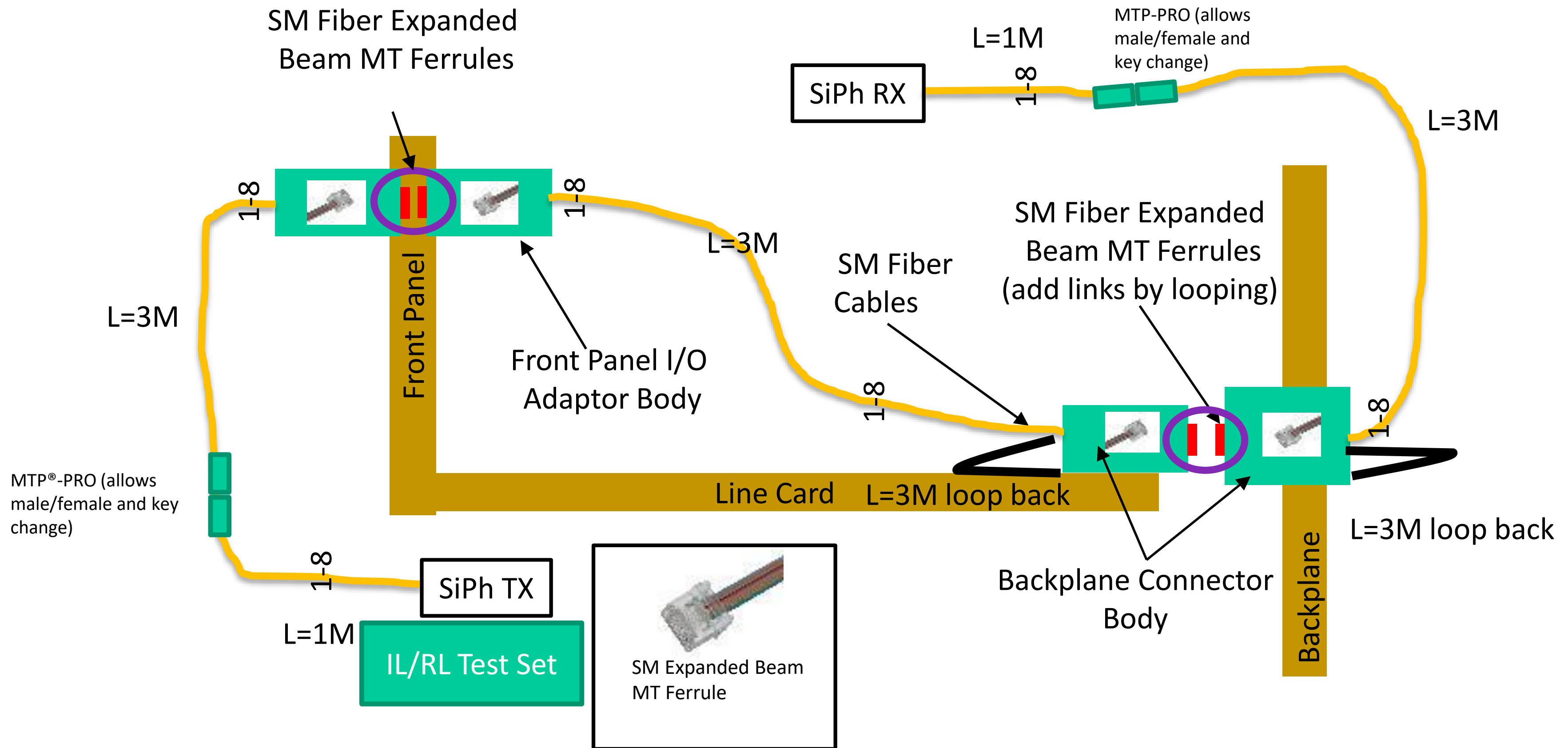
Optical Cable Details, up to 5 Mated Pairs



MTP is a registered trade mark of US Conec Ltd.

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Phase I Deliverables

- Quantification of the performance achievable with singlemode expanded beam MT ferrules and silicon-photonics on-board interconnect
- Understanding of system tradeoffs in designing a silicon-photonics based on-board interconnect system
- Identification of component developments needed to fill gaps in the ecosystem of silicon-photonics-based on-board interconnect
- Build confidence for acceleration of the markets for associated silicon photonics transceivers, connector components, and fiber cables
- White Paper
- End of Project Webinar
- Phase 2 SOW Development

Terry Smith, 3M
Phase II a and b Review

IPSR Phase II: Expanded-beam Module Interface Project Purpose

- **Phase II of the AIM Photonics / iNEMI Board-Level Interconnect Demonstrator project will consist of specifying, designing, modeling, building and demonstrating a board-level optical interconnect system in which an expanded-beam optical connector interface will be developed for the chip module.**

- **Given the complexity of the challenge, and the time and cost associated with fabrication of specialized tooling for optical coupling parts, the Phase II effort is subdivided into 2 Sub-phases, IIa and IIb, each lasting approximately one year**

Each Sub-phase will be a separate iNEMI QuickTurn Project

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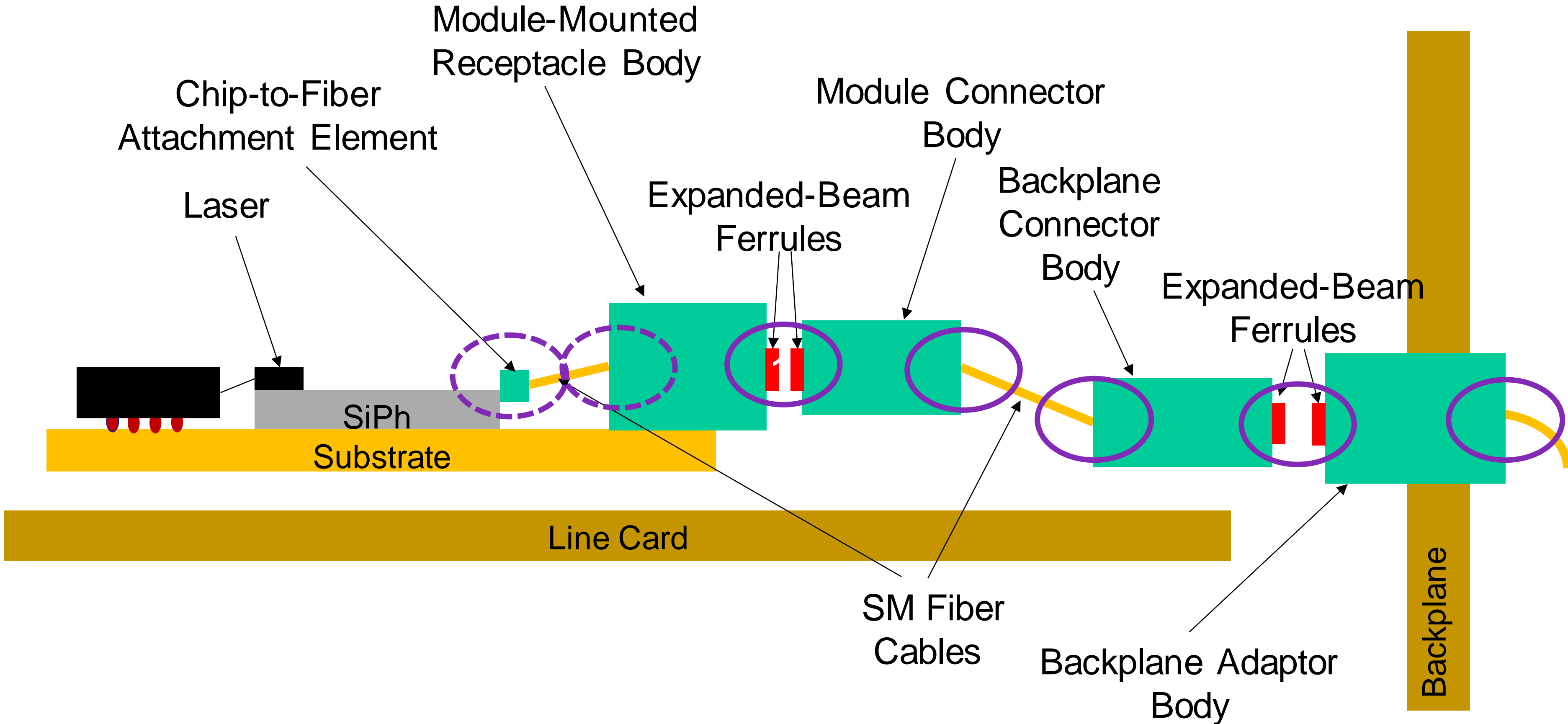
Expanded-beam Module Concept



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Scope of Work Sub-phase IIa

- **Identify participants who are committed to contributing to the design, fabrication and testing of the demonstration system.**
- **Reach agreement on the demonstration system specifications with committed participants.**
- **Model the system performance, finalize system design, and generate specifications for the required components, consistent with the resources available from participants.**
- **Complete the Statement of Work for building the demonstration system, identify resource gaps, and determine external funding needed.**
- **Identify suitable funding sources, investigating options such as investments by the Program participants, or government funding through AIM or iNEMI.**

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Scope of Work Sub-phase IIb

- Build or source the components for the demonstration system agreed upon and designed in Sub-phase IIa (leveraging the connector and cable assembly components from Phase I).

- Build mold tooling for the molded optical coupling element ("Optical Coupling and Interconnect Component" or "OCIC') for the module package, that will couple the chip waveguide to the fiber cable connector mounted on the module. Tooling for the OCIC is expected to cost on the order of $100K to $150K, and to require about 6 months to fabricate.

- Assemble all system components, and test the system.

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IS / IS NOT Analysis

This Project IS:	This Project IS NOT:
Project 1: XXX	
Meant to assess the technical feasibility of embryonic expanded-beam board-level interconnect technology in general, prior to any attempt at standardization.	Development of a specific standard(s)
The first attempt to determine the performance and economic viability of expanded-beam SM optical interconnect systems.	Repeat of prior or existing work
Mean to identify key barriers to board-level optical interconnect, to provide guidance to all interested component developers.	Biased towards specific suppliers, geographies, or market segments
Resourced primarily from in-kind contributions from committed participants who wish to become component suppliers.	Resourced predominantly by government funding.

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Prospective Participants

Affiliation	Participant	Title	Proposed Contributions
Molex			Expanded beam connectors; cable assemblies; expanded beam receptacle for module. Molded optical coupling element to couple chip to module receptacle.
US Conec			Expanded beam connectors; cable assemblies; expanded beam receptacle for module.
TBD			Silicon photonic transceiver chips.
TBD			InP PIC transceiver chips?
TBD			Chip module design and fabrication
Juniper			System testing

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Schedule with Milestones

Timeline	Milestones	Deliverables	Success Criteria
1Q	Agreement by prospective participants on demonstration system configuration, test plan and performance targets.	Final system and performance specification document.	Mutual agreement on specifications.
1Q	Commitment by organizations to contribute to the system design, fabrication and testing program.	Letters of commitment	Commitments from organizations with combined range of expertise adequate to successfully execute the program.
2Q	Final system design, with specifications for all components.	Design document with specifications for all components, and identification of sources for all components.	Completion of design document acceptable to all participants, with commitments for all essential tasks.
3Q	Detailed Statement of Work for fabrication and testing of components and system.	SOW for Phase IIb	Mutually acceptable SOW for Sub-phase IIb
3Q	Completed design for OCIC	OCIC design document, ready for quotation by tool shop.	Successful design review for OCIC
3Q	Phase IIb cost projection	Quotation for building mold tooling, as well as identification of any other costs requiring government funding support.	Completed cost analysis, for use in proposal for government funding.
4Q	Phase IIa completion	Completed Phase IIb proposal. Final report webinar.	Commitment of participants to supply all required Phase IIb resources. Successful identification of source of external funding for Phase IIb.

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Deliverables

- White Paper
- End of Project Webinar
- Phase 3 SOW Development

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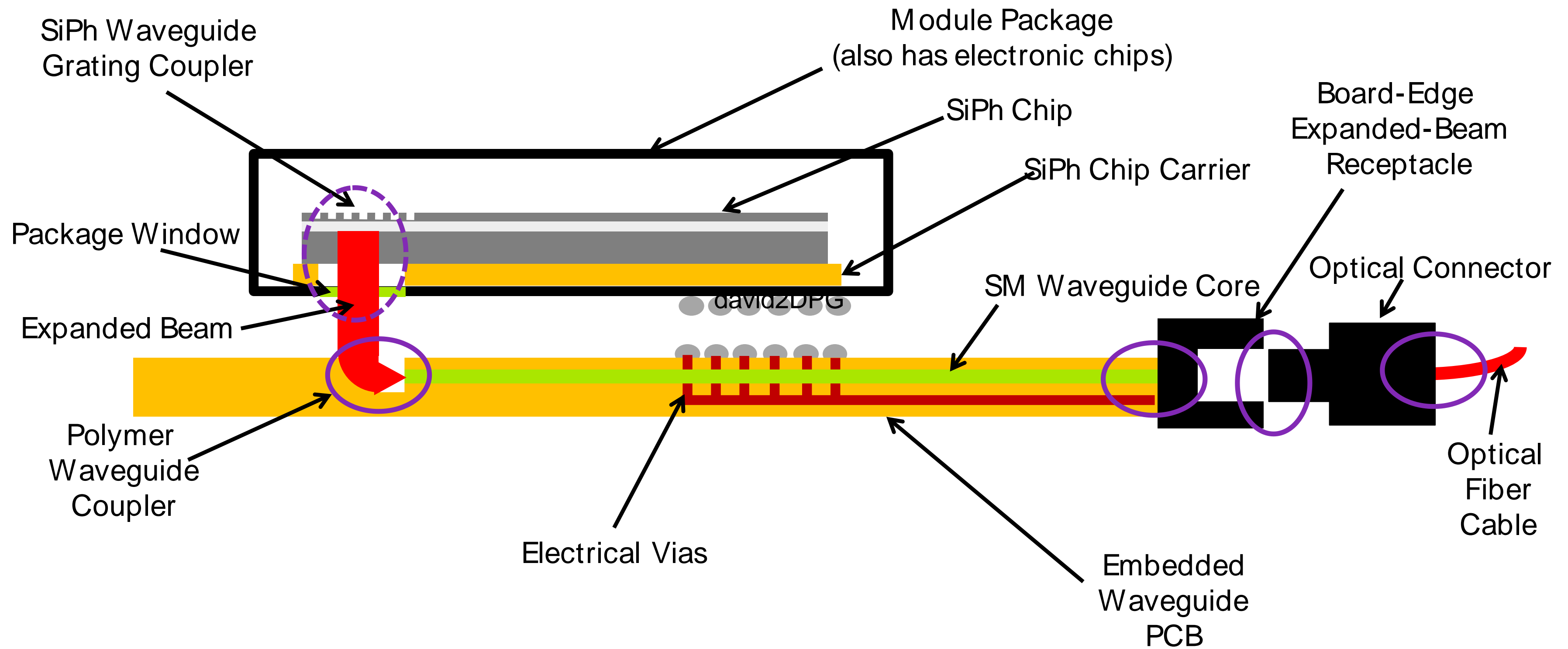
Phase III: Module & Optical PCB Concept



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Questions

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