

iNEMI Statement of Work (SOW)
Environmentally Conscious Electronics TIG
iNEMI HFR-Free Development of Technology Envelopes Project

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Purpose:

Identify HFR-free PCB materials and technology design guidelines which allow drop-in replacement capability of HFR-free materials with standard FR-4 PCB designs. Identify supply chain readiness, supply capability and reliability characteristics for “HFR-free” alternatives to conventional printed wiring board materials and printed wiring board assemblies.

Background and Motivation:

The European Union's Restriction on the use of certain Hazardous Substances (RoHS) Directive prohibits the use of polybrominated biphenyls (PBBs) and polybrominated diphenyl ethers (PBDEs) in nonexempt electronic equipment. These compounds, used as flame-retardants, have been shown to present unacceptable risks to human health and the environment. Although PBBs and PBDEs are typically not used in circuit board materials, stakeholders are beginning to urge the electronics industry to take a precautionary stance on the use of other non-regulated halogenated organic substances, such as brominated epoxies for circuit board applications.

For this reason, many companies have set their own specific transition dates to move to HFR-free technology. This has, however, created some confusion in the supply chain since these dates vary by company. To alleviate this, the goal of this project is to identify a specific transition target date which OEMs / ODMs / EMSs / Suppliers can work towards to facilitate a smooth and timely transition.

Goals of the Project:

1. Identify an acceptable industry conversion timeline
2. Identify commercially viable materials
3. Benchmark past work and focus on critical knowledge gaps and technical issues
4. Build on industry knowledge and capability, including the iNEMI HFR-Free PCB Material Evaluation Project
5. Define the electrical signaling requirements and test conditions as well as delivering design guide collaterals that demonstrate laminate interchangeability for all relevant market segments
6. Define the material set parameters and test conditions for all relevant market segments
7. Leveraging prior investigations, carry out the necessary testing to characterize viable materials
8. Analyze results
9. Publish material set envelope for use by industry that meets all market segment requirements – signaling, mechanical, quality / reliability, SMT yield, and environmental
10. Investigate possible development of an industry standard utilizing design guidelines generated in project

Is / Is Not:

This Project <u>IS</u>:	This Project IS <u>NOT</u>:
A technical evaluation of key electrical and mechanical properties of HFR-free Materials	An EHS assessment
Focused on those design attributes which are of most value to the broader industry	Biased towards specific laminate suppliers, geographies, or market segments
Building on learning from prior investigations	A repeat of prior work
Focused on circuit board materials and solder joint reliability – Board / Component Interaction	Focused only on materials characterization
Focused on generating data / design guidelines for development of an industry standard	

Scope of Work:

Phase I: Design

Review prior work and make recommendations for testing needed. Investigation should take into account needs of electronic product sectors represented by iNEMI membership.

1. Identify candidate materials

Poll the supplier base, keying in on candidate materials that are commercially viable with consideration for market segment applications.

- Identify candidate HFR-free laminate materials to allow drop-in replacement for standard FR-4

2. Identify key performance characteristics and test criteria

Assess prior studies and identify critical knowledge gaps or technical issues. Make recommendations for performance tests needed. Review results of prior industry and member company investigations.

- Output broadband frequency dependant dielectric constant and loss tangent of candidate halogen free laminate materials (10KHz - 20GHz)
- Simulate results of high speed buses DDR3, PCI2,3 ... others?

3. Design test vehicle(s) and test methodologies, leverage standards where possible

Specify test vehicle criteria required for performance testing. Agree on a minimal number of test vehicle designs and test requirements.

Phase II: Test

Develop, manage, and execute performance testing.

1. Develop evaluation plan and schedule

Outline key mechanical and electrical performance characteristics and resource and time constraints. Focus on electrical characteristics, delamination and Via & PTH reliability, pad cratering and solder joint reliability.

- Build systems with dielectric materials that comply with the proposed HFR-free dielectric spec
- Provide data that shows comparison to identical FR4 systems
- Determine compatibility of candidate laminate materials with higher temperature assembly process reflow environments (mixed solder: 245 C / Pb-free, 260C).

2. Procure parts and test vehicles

Obtain needed evaluation materials. Consider lead times needed to synch with evaluation schedule. Solicit participation from supply partners.

3. Assign teams to carry out completion of the testing in a standardized fashion

Each test should be carried out in a manner that produces meaningful results. Industry standards should be followed where applicable. Testing should be coordinated to allow correlation of results and sharing of test materials.

4. Perform mechanical and reliability testing on test vehicles

Leverage capabilities and expertise of participating members and supply partners. Follow test procedures carefully and record positive and negative results.

Phase III: Results

Compile results, assess significance, make recommendations, and publish report.

1. Assess technology readiness / identify gaps

Flag unexplored issues and identify technical risks that need to be resolved before materials can be widely adopted. Make recommendations for future work.

2. Assess manufacturing capability and supply capacity

Work with suppliers and EMS's to identify barriers to supply chain viability. Interpret implications of performance testing in terms of manufacturing capability.

3. Publish results

Compile and edit concise summary of methods, meaningful results, and recommendations. Goal is to issue the final report to members by Y/E 2010 with public release by IPC/APEX 2011.

Anticipated Outcome

- **Validate electrical and mechanical properties and generate generic design guideline**
 - Loss tangent and Dk modeling over required range of signal speed, bus designs
 - Signal Integrity Capability / Validation (DDR2, DDR3 etc)
 - Mechanical performance validation for lead free assembly and rework (delamination)
 - Critical Test Parameter Evaluation (CAF, IST, flex, etc.)

- **Validate Board Level Reliability Capability**
 - PCB Modulus / Thickness Impact on Mechanical Capability
 - HF Board Level Assy / Rework Process Characterization
 - Mechanical Characteristics (Pad Crater / Ball Pull etc)
 - CTE Characteristics
 - SJR (Shock / TC etc)
 - HF Component / HF PCB

- **Generate Industry Design Guidelines for drop-in replacement of HF materials to Standard FR-4 designs, and initiate development of HF PCB Material Design Guidelines for Material Interchangeability as an industry standard**

Participant Profile:

iNEMI's member companies will encourage the participation of individuals from different disciplines and divisions within their organizations to contribute on the range of tasks outlined in the project plan. The group should include representatives of:

- OEMs / ODMs
- Component and board manufacturers
- Assembly EMS providers
- Dielectric material suppliers

Resources Required from Participants:

The HFR-Free Development of Technology Envelopes Project asks each participating company to commit to the following:

- 1) Provide at least one man-month or equivalent in-kind support (e.g. materials, test samples, equipment, etc.) annually.
 - a. Agree to commit appropriate resources to meet accelerated project timeline and targeted end dates.

- 2) In the event project expenses are incurred, the costs will be shared evenly among participants.

- 3) Agree on identifying a transition date to HF PCB Material.

Project Participant Commitment Matrix:

Phase I Tasks	Team Leader	Company Support	Key Contact
Identify Candidate Materials			
<ul style="list-style-type: none"> • Material Supplier 			
Identify Key Performance Characteristics			
Test Vehicle Identification			
<ul style="list-style-type: none"> • Provide Component Test Vehicle 			
<ul style="list-style-type: none"> • Provide PCB Test Vehicle 			
<ul style="list-style-type: none"> • Provide TV / PCB Design Service 			
<ul style="list-style-type: none"> • Provide PCB Assembly Capability 			

Phase II Tasks	Team Leader	Company Support	Key Contact
Develop Test Plan / Schedule			
Procure Components & PCBs			
TEST Plan / Schedule			
<ul style="list-style-type: none"> • IST 			
<ul style="list-style-type: none"> • CAF 			
<ul style="list-style-type: none"> • Flexural Modulus 			
<ul style="list-style-type: none"> • Cu Peel Strength 			
<ul style="list-style-type: none"> • Tg / z-Axis CTE 			
<ul style="list-style-type: none"> • Solder Mask Adhesion 			
<ul style="list-style-type: none"> • Insulation resistance 			
<ul style="list-style-type: none"> • Solder Float / Cross Section 			
<ul style="list-style-type: none"> • Microhardness 			
<ul style="list-style-type: none"> • Permittivity (Dk) and Loss Tangent (Df) up to 30GHz 			
<ul style="list-style-type: none"> • Moisture Diffusivity Impacts on Insertion Loss 			
<ul style="list-style-type: none"> • Capacitance 			
<ul style="list-style-type: none"> • CAT Trace and Space 			
<ul style="list-style-type: none"> • Drill Registration 			
<ul style="list-style-type: none"> • Temp Cycle (HATS) 			
<ul style="list-style-type: none"> • Transient Bend 			
<ul style="list-style-type: none"> • Rework 			
<ul style="list-style-type: none"> • Board Side Ball Pull 			
<ul style="list-style-type: none"> • TCT 			
<ul style="list-style-type: none"> • Mechanical Shock 			
<ul style="list-style-type: none"> • Monotonic Bending 			
<ul style="list-style-type: none"> • FA 			

Phase III Tasks	Team Leader	Company Support	Key Contact
Write Project Team Report			
• Executive Summary			
• Introduction			
• Purpose of the Project			
• Materials & Methods			
• Results			
• Conclusions			
• Analysis of Success			
•			
• Write Generic iNEMI Report			
• Write External Paper			

Task Schedule:

- Phase I (Design)
- Phase II (Test)
- Phase III (Results)

Phase I

	Sep-08	Oct-08	Nov-08	Dec-08	Jan-09	Feb-09	Mar-09	Apr-09
Review prior work and make recommendations for testing needed	X	X	X	X				

Phase II	Jan-09	Feb-09	Mar-09	Apr-09	May-09	June-09	July-09	Aug-09	Sept-09	Oct-09
Develop, manage, and execute performance testing	X	X	X	X	X	X	X	X	X	X
Procure Components & PCBs										
TEST Plan / Schedule										
• IST										
• CAF										
• Flexural Modulus										
• Cu Peel Strength										
• Tg / z-Axis CTE										
• Solder Mask Adhesion										
• Insulation resistance										
• Solder Float / Cross Section										
• Microhardness										
• Permittivity (Dk) and Loss Tangent (Df) up to 30GHz										
• Moisture Diffusivity Impacts on Insertion Loss										
• Capacitance										
• CAT Trace and Space										
• Drill Registration										
• Temp Cycle (HATS)										
• Transient Bend										
• Rework										
• Board Side Ball Pull										
• Other Testing										
• Other Testing										
• Other Testing										
• Other Testing										

Phase III

	Nov-09	Dec-09	Jan-10	Feb-10	Mar-10	April 10				
Compile results, assess significance, make recommendations, and publish report										
<ul style="list-style-type: none"> Assess performance relative to market segment requirements 										
<ul style="list-style-type: none"> Assess technology readiness / identify gaps 										
<ul style="list-style-type: none"> Assess manufacturing capability and supply capacity 										
<ul style="list-style-type: none"> Report results in white paper 										
<ul style="list-style-type: none"> Present Results to iNEMI Membership – Webinar 										
<ul style="list-style-type: none"> Present Results to industry – (Example APEX) – Paper – Presentation 										

Project Monitoring Plans

- How will you ensure open lines of communication among participants?
 - Bi-weekly conference calls
 - Meeting minutes provided through email
 - Follow-up with individuals on an as-needed basis
 - Workshops and face-to-face meetings as appropriate
- Planned teleconference schedule
 - Bi-weekly conference calls
- Request progress reports as tasks are completed
- Dates of technical reviews (2 per year) and progress reports and what they will contain
- Practice risk analysis by anticipating problems and having alternate solutions ready
 - What happens if??
- Use opportunity analysis to identify new areas or topics that might be addressed in additional projects. This will prevent the scope of the current project from expanding and keep the project focused on the original goals.
- Review project requirements with suppliers before the project begins.

Outcome of the Project

- Successful completion of this project will include the publication and presentation of the knowledge gap analysis in the public domain.
- Deliverables of this project include the following:
 - Workshop and associated slides for project members summarizing preliminary assessment of the state of knowledge.
 - Final slides and publication of our knowledge assessment.
 - Project results will be shared with the industry in order to drive alignment throughout the supply chain.
 - Knowledge assessment results will be shared through presentations and industry meetings and publication in an archival journal subject to group participant approval process.
 - Updated standards will be shared through publication of the new standards

General and Administrative Guidelines

Purpose of Calls

The purpose of conference calls is to define the elements (tasks) of a Project Plan. Below is a list of specific items to be addressed during these calls:

- Identify gaps in the technology that the project will address
- Establish a clearly defined set of goals for the project
- Clearly define schedule with interim milestones
- Identify resources needed to complete tasks
- Establish consensus on possible approaches to complete the project
- Develop widely applicable generic system and technology solutions
- Develop general processes and methodologies that can be used by iNEMI members for company-specific solutions

The intent is **not** to repeat past or present studies and/or projects; but to investigate the possibilities of developing a series of related tasks (a project or series of projects) that will add to the existing knowledge base. iNEMI is a member based organization and projects are normally restricted to iNEMI members only; however, to get a broader perspective from the industry, the Project formation process is open to anyone interested participating. Participation in the Project formation process will provide a forum in which participants can help establish the agenda for the electronics industry. The ultimate goal of the Project formation discussions is to develop a formalized Statement of Work (SOW) and Project Statement (PS) for the Project (the iNEMI SOW and PS templates will be used to assist in the development of the SOW and PS).

Formalizing the Project

- It is important to create a set of goals and clearly define what will be done. These goals and tasks will be included in the project plan.

- iNEMI recognizes the need to have a clearly defined set of tasks in the form of a formalized Project Plan, and has developed a set of guidelines and templates to assist teams through the development of a Statement of Work (SOW) and Project Statement (PS) for every project proposed.
- The Project formation team will be responsible for making recommendations as to whether the project should be broken into multiple phases. If so, each phase will require a separate SOW and PS. Evaluation of progress during each phase will determine the viability of the next phase. Examples of possible phases include:
 - Phase 1 –Literature search and review of previous work and current projects
 - Phase 2 – Preliminary work to further define the technology and procedures
 - Phase 3 – Evaluation of a limited set of technical issues defined in phase 2
- The iNEMI Staff will work with the team to establish the SOW and with the Project Leader(s) (to be identified) to get iNEMI Technical Committee (TC) approval.
- After the TC has approved the SOW and PS, the Project will be advertised and participation will be open to all iNEMI members. The initial signup period is typically 30 days, at which point the project signup is closed.
- Once a project is closed any requests to participate in the project will require approval from the Project’s founding members.
- Progress of these Project formation discussions will be provided to the iNEMI Technical Committee.
- Note that we will eventually be running a multi-company project. For the project to fall under the “iNEMI umbrella” for working in a pre-competitive environment, we need a Statement of Work (SOW) and a signed Project Statement (PS) from each participating company.
- The iNEMI support staff will make arrangements to provide an overview of the project management process for any participants who have questions or would like additional information.

Sharing Files

- Any information participants would like to share with the group can be forwarded to the appropriate iNEMI staff member for distribution to the rest of the participants.

Feedback

- Participants are encouraged to provide feedback to assist in iNEMI’s efforts to improve the Project formation process.

International Electronics Manufacturing Initiative (iNEMI)

Protection from anti-trust action is a benefit of iNEMI membership, since iNEMI registers its members with the Department of Justice and the Commerce Department.

Pre-Competitive Research and Development (excerpts from iNEMI’s “Antitrust Policy & Guidelines”)

- The International Electronics Manufacturing Initiative, Inc. (iNEMI) is an industry-led consortium that performs pre-competitive research and development projects to improve the global electronics manufacturing infrastructure.
- iNEMI's primary objective is to facilitate research and development in connection with materials, components, manufacturing-related technologies and equipment for the manufacture of electronic information products.
- The essential principle that should guide the policies and activities of iNEMI to avoid antitrust violations is that not only must no illegal agreements be either reached or carried out through the association, but also iNEMI must avoid conduct that might give the appearance of an illegal agreement.

- Members can participate fully in iNEMI activities and projects with minimal possibility of antitrust problems by following a few *simple do's and don'ts*:
 1. DO schedule and attend meetings only when there are proper items of substance to be discussed that justify your attendance.
 2. DO review the meeting notice or agenda in advance of every meeting. It should be specific, without broad topics, such as "marketing practices," that might look suspicious from an antitrust standpoint.
 3. DO adhere strictly to the stated agenda. In general, subjects not included on the agenda should not be considered at the meeting.
 4. DO ensure that no matter of doubtful legality is brought up for discussion. This, of course, is counsel's responsibility; but in his or her absence, iNEMI staff representative or any member present who becomes aware of legal implications of a discussion should attempt to halt the discussion.
 5. DO make sure that minutes of all meetings are kept and that they accurately report what actions were taken.
 6. DO use iNEMI as a vehicle for promoting research and the industry as a whole.
 7. DO send copies of all iNEMI-related correspondence to the iNEMI Secretariat and advise the Secretariat of any inaccuracies in proposed statements to be made by iNEMI.
 8. DO ensure that iNEMI counsel is in attendance at all meetings of the Initiative where legally sensitive subjects might be discussed.
 9. DO check with iNEMI staff, who will likely contact counsel, if there is doubt about the legality of any iNEMI policy or program.
 10. DO cooperate with iNEMI counsel in all matters, particularly when counsel has ruled adversely about a particular activity.
 11. DON'T allow or participate in secret or "rump" meetings. At best, these meetings raise questions as to the propriety of what is discussed. They could seriously jeopardize legitimate iNEMI activities and create a risk that those activities will be investigated.
 12. DON'T allow or participate in any discussions which discourage research or research projects by persons outside of iNEMI.
 13. DON'T, without specific authorization, make public or private communications about policies or positions of iNEMI.