IEEE802.3aq Channel Modeling Ad-Hoc

Recent Progress, Future Goals & Plans

Ian White

List of participants in the Ad-Hoc

Stewart Goudie	Acuid	**Stefano Bottacchi**	Infineon
Albrecht Rommel	Acuid	**Jesper Hanberg**	Intel
Lars Thon	Aeluros	**John Ewen**	JDS Uniphase
David Cunningham	Agilent Technologies	**Yi Sun**	OFS
Piers Dawe	Agilent Technologies	**John George**	OFS
Sudeep Bhoja	Big Bear Networks	**Heider Ereifej**	Optium
Jonathan King	Big Bear Networks	**Yu Sun**	Optium
Ali Ghiasi	Broadcom	**Al Brunsting**	Panduit
Jonathan Ingham	Cambridge University	**Chet Babla**	Phyworks
Richard Penty	Cambridge University	**Nick Weiner**	Phyworks
Tom Lindsay	ClariPhy	**Ben Willcocks**	Phyworks
Norm Swenson	ClariPhy	**Petre Popescu**	Quake
John Abbott	Corning	**Gary Shaulov**	RSoft Design Group
Michael Sauer	Corning	**Brent Whitlock**	RSoft Design Group
Steve Swanson	Corning	**Abhijit Shanbhag**	Scintera Networks
Jim Morris	DOC	**Paul Kolesar**	Systimax Solutions
David Srodzinski	Elonics	**Hank Blauvelt**	Xponent
Henry Wong	Gennum		
Steve Ralph	Georgia Tech		
Petar Pepeljugoski	IBM Research		

Activities to date - Telecons

- Two telecons held to date: 17 June & 30 June

- High level of attendance

- Minutes have been distributed to the 10GMMF reflector

Key Decisions

- Distillation of tasks into one sheet

- Appointment of Task leaders

- Request for Task goals and timelines to be agreed by Task Groups

List of Tasks and Leaders

Ad-hoc chair   Ian White

Active Tasks

Task 1	FDDI-grade/OM2/OM3 model	Richard Penty
Task 2	Time-varying study & modal noise	Jonathan King
Task 3	Input and output parameters	Lars Thon
Task 4	Launch and filter modeling	Yu Sun
Task 8	Validation	Nick Weiner

Inactive/Merged Tasks

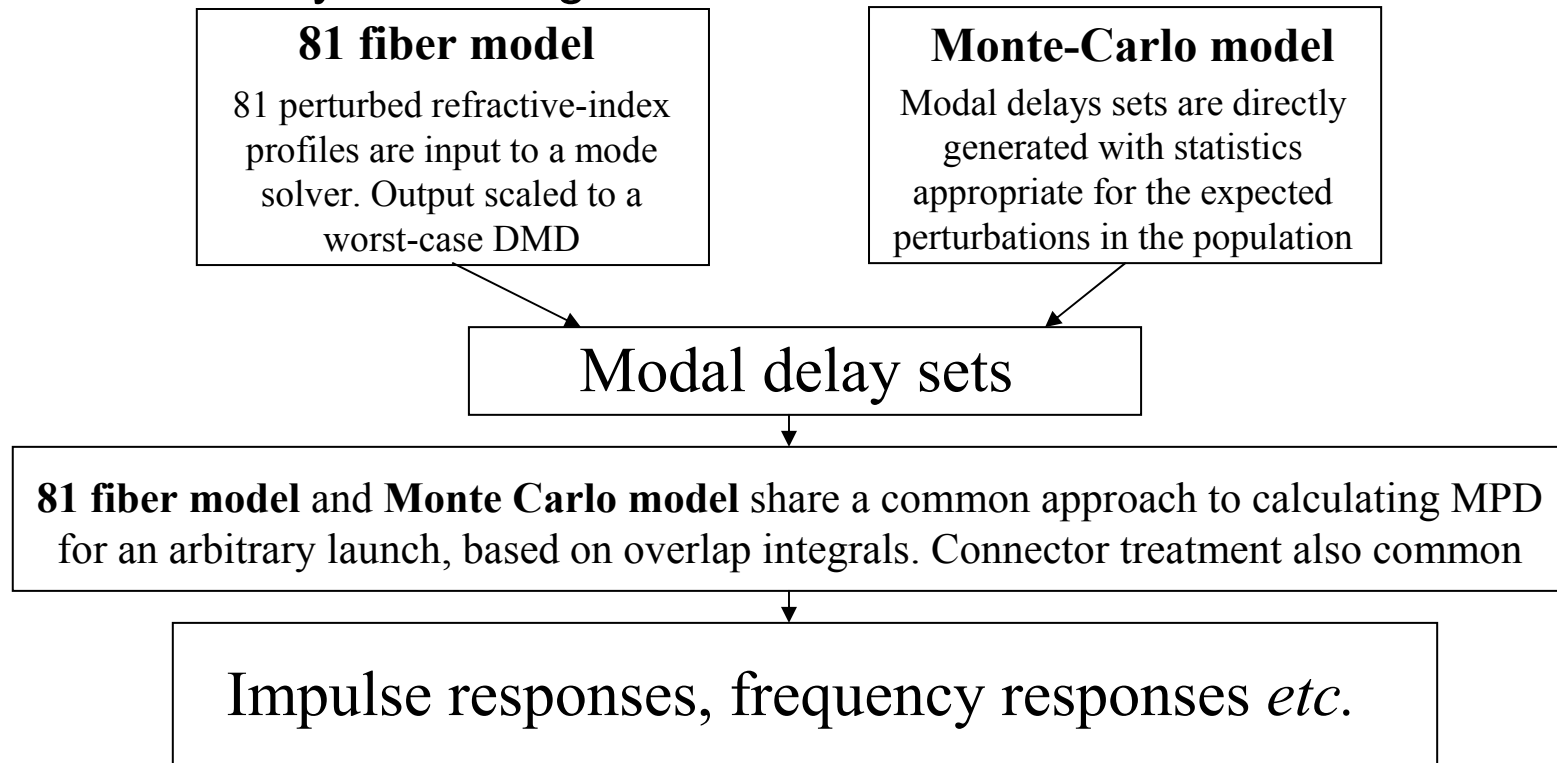|		
Task 5	Modal noise	- Merged with Task 2
Task 6	Jitter	- Deemed out of scope
Task 7	Connectors	- Merged with Task 1

Task 1 Summary

FDDI-grade/OM2/OM3 Fiber Model

Participants

- Stewart Goudie, Acuid
- Albrecht Rommel, Acuid
- Lars Thon, Aeluros
- David Cunningham, Agilent
- Piers Dawe, Agilent
- Sudeep Bhoja, Big Bear
- Jonathan King, Big Bear
- Ali Ghiasi, Broadcom
- Jonathan Ingham, Cambridge
- Richard Penty, Cambridge
- John Abbott, Corning
- Steve Swanson, Corning
- Jim Morris, DOC
- David Srodzinski, Elonics

- Henry Wong, Gennum
- Petar Pepeljugoski, IBM Research
- Joerg Kropp, Infineon
- John Ewen, JDS Uniphase
- Yi Sun, OFS
- John George, OFS
- Heider Ereifej, Optium
- Yu Sun, Optium
- Nick Weiner, Phyworks
- Petre Popescu, Quake
- Gary Shaulov, RSoft
- Brent Whitlock, RSoft
- Abhijit Shanbhag, Scintera
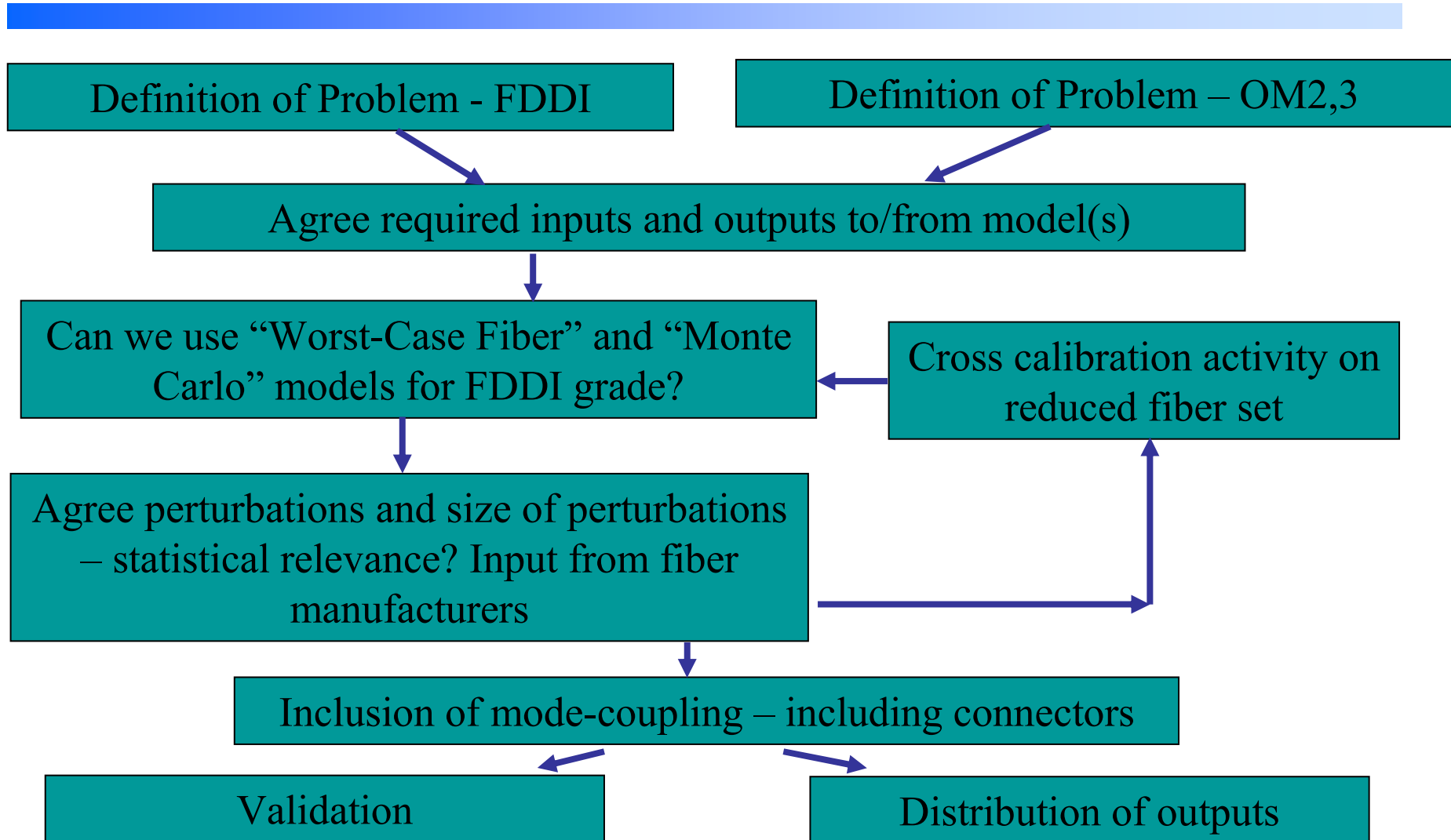- Paul Kolesar, Systimax

Static Channel Model

- Two telecons to date. Agreed at July 1 telecon to take forward both "81 fiber" and Monte Carlo models
- The principal components of both models are the *modal delay sets*
- The only significant difference between the models is how these modal delay sets are generated
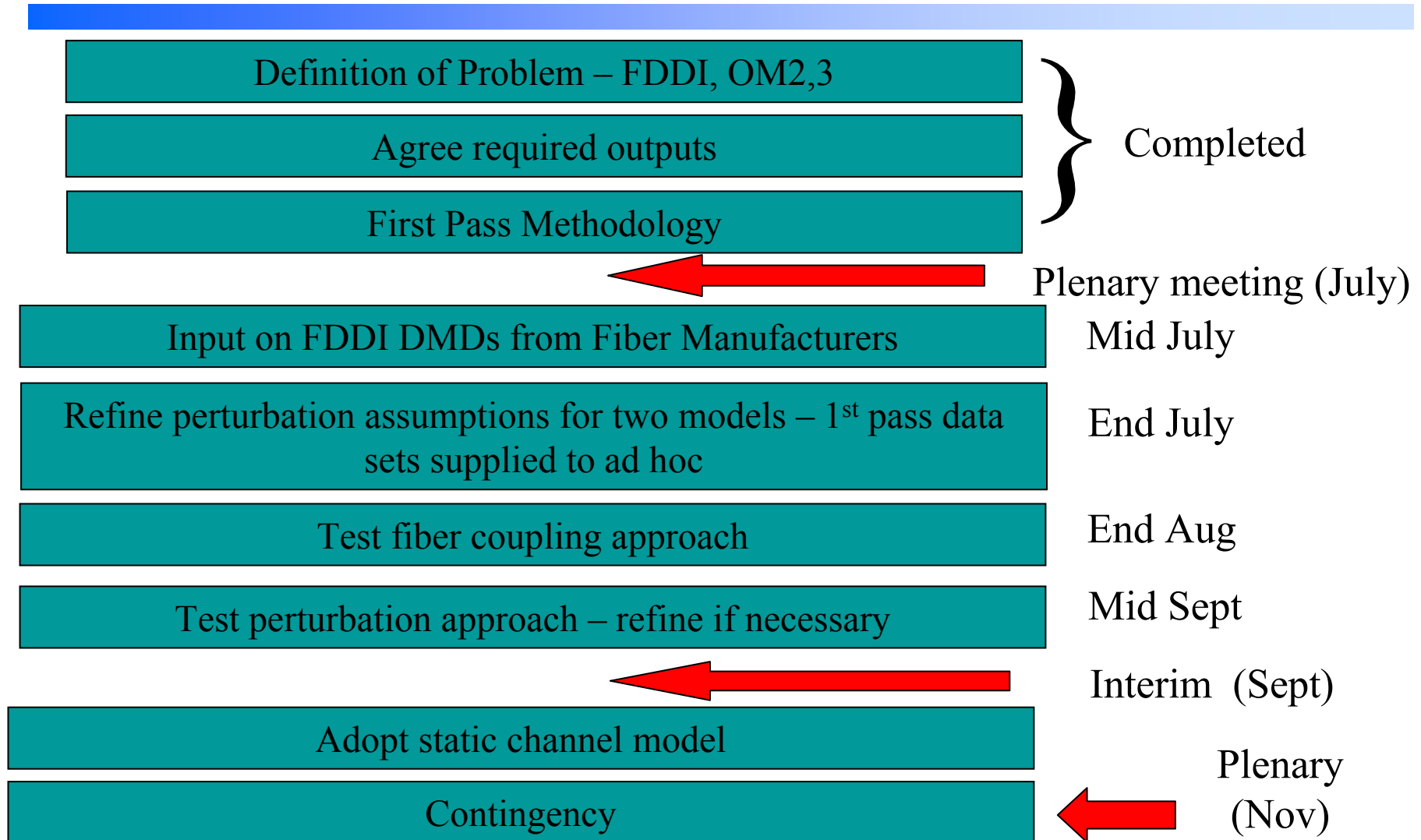
81 fiber model	**Monte-Carlo model**
81 perturbed refractive-index profiles are input to a mode solver. Output scaled to a worst-case DMD	Modal delays sets are directly generated with statistics appropriate for the expected perturbations in the population

Modal delay sets

81 fiber model and **Monte Carlo model** share a common approach to calculating MPD for an arbitrary launch, based on overlap integrals. Connector treatment also common

Impulse responses, frequency responses *etc.*

Rationale to Methodology

- 81 fiber model gives reduced "worst case" fiber set whilst Monte Carlo approach gives large fiber set with characteristics of general fiber populations

- Both models rely on assumptions about the perturbations they use and these need to be checked and refined in the light of inputs from fiber manufacturers and users

- Reduced fiber set can be employed by users to do first pass designs and then use full Monte Carlo set for final design validation

- Allows flexibility from the user perspective

- But requires cross-validation to check that fiber sets show appropriately similar statistics

- Required outputs

  – must be sufficient for users to generate their own models at the block function level

  – modal delay time set, clear method for deriving impulse response, refractive index profile set, method for deriving transmission performance for arbitrary launches

Suggested Flow Chart

Definition of Problem - FDDI

Definition of Problem – OM2,3

Agree required inputs and outputs to/from model(s)

Can we use "Worst-Case Fiber" and "Monte Carlo" models for FDDI grade?

Cross calibration activity on reduced fiber set

Agree perturbations and size of perturbations – statistical relevance? Input from fiber manufacturers

Inclusion of mode-coupling – including connectors

Validation

Distribution of outputs

Suggested Timelines - FDDI

Definition of Problem – FDDI, OM2,3	
Agree required outputs	} Completed
First Pass Methodology	

⟵ **Plenary meeting (July)**

Input on FDDI DMDs from Fiber Manufacturers	Mid July
Refine perturbation assumptions for two models – 1st pass data sets supplied to ad hoc	End July
Test fiber coupling approach	End Aug
Test perturbation approach – refine if necessary	Mid Sept

⟵ **Interim (Sept)**

Adopt static channel model	Plenary
Contingency	⟵ (Nov)

Task 2 Summary

Time-Varying Study
&
Modal Noise

Participants

- Stewart Goudie, Acuid
- Albrecht Rommel, Acuid
- Lars Thon, Aeluros
- David Cunningham, Agilent
- Piers Dawe, Agilent
- Jonathan King, Big Bear
- Ali Ghiasi, Broadcom
- John Abbott, Corning
- David Srodzinski, Elonics
- Henry Wong, Gennum
- Petar Pepeljugoski, IBM Research
- Stefano Bottacchi, Infineon
- John Ewen, JDS Uniphase

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- Yu Sun, Optium
- Al Brunsting, Panduit
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- Ben Willcocks, Phyworks
- Petre Popescu, Quake
- Abhijit Shanbhag, Scintera
- Paul Kolesar, Systimax

Goals (to be discussed & agreed)

1) Study time variation in the impulse responses

   – Provide data to aid in the establishment of the temporal performance impact on the LRM draft specification

   – Provide input for the time varying component of RX compliance test (normative or informative)

2) Study the modal noise of the MMF channel

   – Noted to be inter-related with the time variation item above

   – Ensure that the LRM spreadsheet/model have properly accounted for the modal noise

From the Ad-Hoc call minutes

- Jonathan King indicated that he has observed significant temporal instability in the impulse responses of MMF in laboratory experiments
- Yu Sun indicated the importance of considering the speed of the variation and also the range of possible responses
- Petre Popescu suggested that the first task should be to agree the MMF model and to then introduce time-varying effects
- John Abbott expressed his interest in working on this topic and also suggested that time-varying effects should be less significant for OM3
- Petar Pepeljugoski enquired about the link between Task 2 (time variation) and Task 5 (modal noise)
- David Cunningham indicated that time-varying studies would be performed in parallel with modal-noise studies in his laboratory investigations
- It was agreed to combine Task 2 and Task 5

Comments on Related Specifications

- Input from David Cunningham:
  - No consensus from experts on previous fiber shaker FOTP-142
    - "Measurement of average modal noise power penalty for laser sources"
  - Recommend using FOTP-203, "Launched Power Distribution Measurements Procedure for Graded-Index Multimode Fiber Transmitters"
  - Description of a shaker that was based on the ones developed for modal noise measurement per the Modal Noise Test Methodology Group

Timeline & Process Forward

- First discussion called for at the Portland meeting
- Will review goals & objectives and properly bound the scope of the effort
- From sub-task 1 minutes, Time Variation input desired by September (at the latest)
- Rough timeline & active contributors to the effort will be identified in Portland
  - Expect conference calls immediately following to advance the activities

Task 3 Summary

Input and Output Parameters

Participants

- Stewart Goudie, Acuid
- Albrecht Rommel, Acuid
- Lars Thon, Aeluros
- David Cunningham, Agilent
- Piers Dawe, Agilent
- Sudeep Bhoja, Big Bear
- Ali Ghiasi, Broadcom
- Jonathan Ingham, Cambridge
- Richard Penty, Cambridge
- Tom Lindsay, ClariPhy
- Norm Swenson, ClariPhy
- David Srodzinski, Elonics
- Henry Wong, Gennum
- Petar Pepeljugoski, IBM Research
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Purpose of Task 3

- To support efficient evaluation of system performance at multiple levels of implementation detail,
  - as required by the task force,
  - by aiding the efficient exchange of data and parameters between various subtasks.

- To permit efficient cross-checking of results obtained from different measurements, tools and methodologies.

Goal

- Two main objectives:

- To define the minimum set of data and parameters that are needed for a particular system performance evaluation.

- To aid in the conversion of data into needed formats, saving time and effort on the behalf of the other members of the task force.

  - Assist in making all the great data contributed by the task force members maximally useful for everyone.

Availability and Timeline

- Cambridge/Matlab database available from Lars Thon and Jonathan Ingham, and presumably later from a non-IEEE website (copyrighted material).
  - CamMMF.all.1p0.mat, 912kB (matlab 7 only).
  - CamMMF.all.1p0.matlab6.mat, 1767kB.

- Additional activity is an ongoing effort driven by demand, contributions of data, and volunteer activity of the Task 3 members.

- Assistance is always welcome.

Task 4 Summary
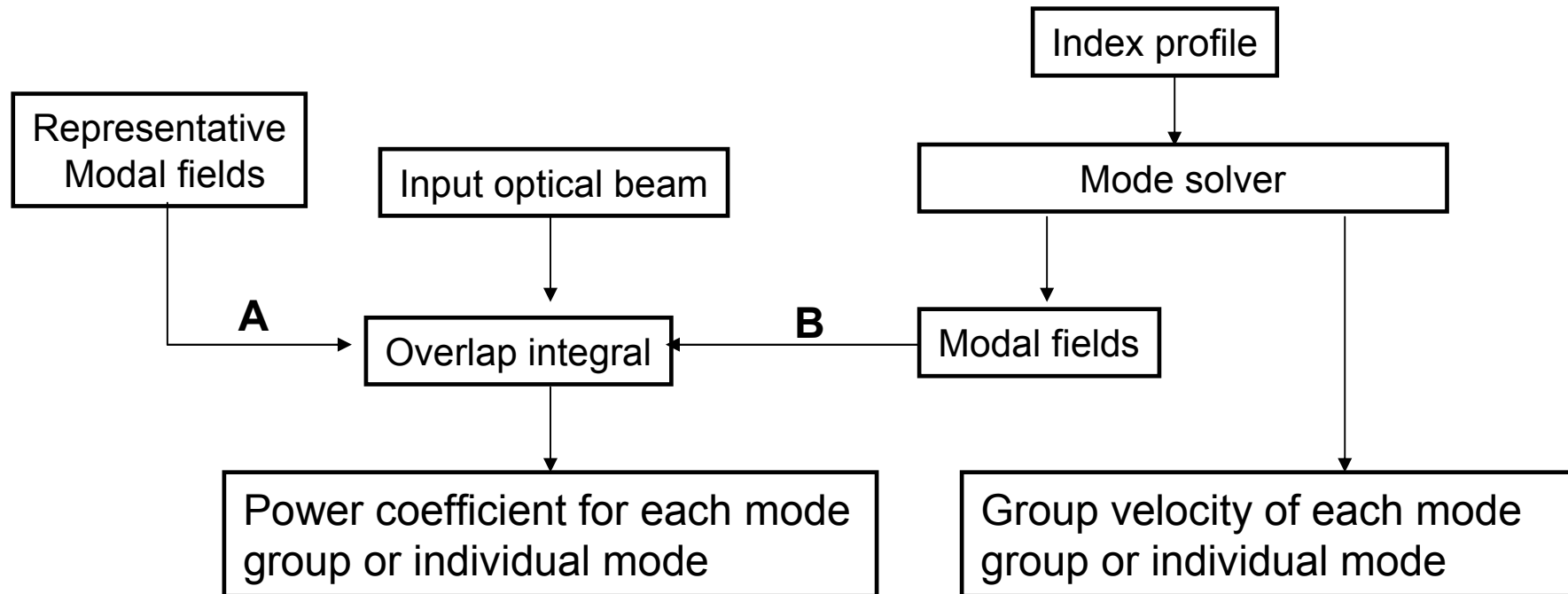
Launch and Filter Modeling

Participants

- Yu Sun (task chair)

- Participants of July 6 conference call:

- John Abbott, David Cunningham, Joerg Kropp, Jim Morris, Petar Pepeljugoski, Stephen Ralph, Gary Shaulov, Yi Sun, Brent Whitlock
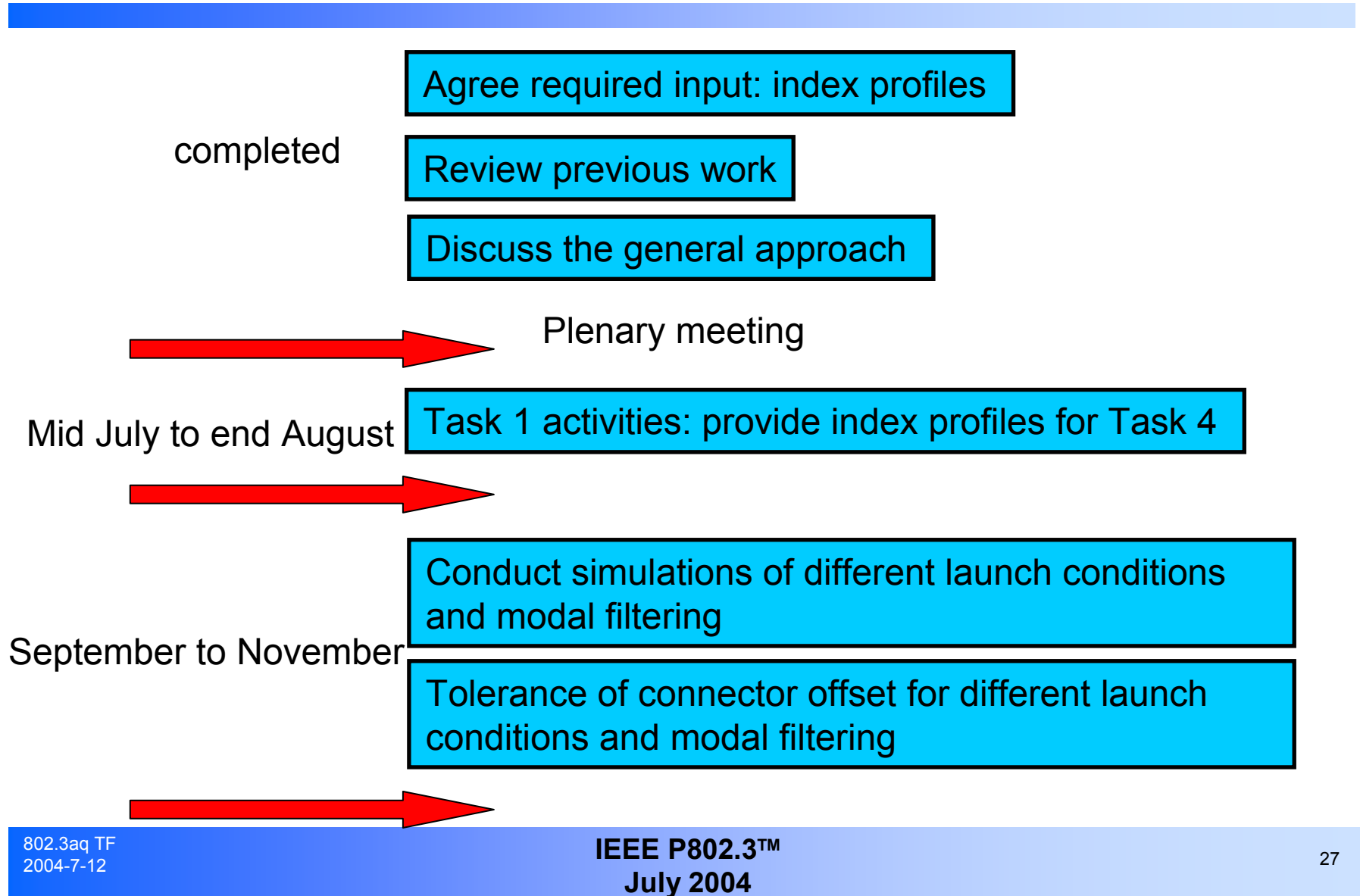
Activities

- Agree what is needed in a channel model in order to do launch and filter modeling

  Refractive index profile is necessary for users to generate modal fields

- Define launching conditions studied in this group (center launch, offset launch, vortex, etc)

- Review of previous work

    1. Vortex launch (Jim Morris)
    2. Modeling using index perturbations (John Abbott)
    3. RSoft MMF simulation tools (Brent Whitlock)

- Discuss the general time line of this sub task group

General approach

Representative Modal fields

Index profile

Input optical beam

Mode solver

A

Overlap integral

B

Modal fields

Power coefficient for each mode group or individual mode

Group velocity of each mode group or individual mode

- Some models give accurate results whilst only requiring mode group data and representative modal fields.
- Some contributors interested in "exact" modal fields.
- Both method A (the use of representative modal fields) and method B (the use of exact modal fields) will be pursued.

Suggested timelines

Agree required input: index profiles

completed

Review previous work

Discuss the general approach

Plenary meeting

Mid July to end August | Task 1 activities: provide index profiles for Task 4

September to November

Conduct simulations of different launch conditions and modal filtering

Tolerance of connector offset for different launch conditions and modal filtering

Task 8 Summary

Validation

Participants

- Stewart Goudie, Acuid
- Albrecht Rommel, Acuid
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- Piers Dawe, Agilent
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Validation approaches

- Validation of model in terms of 10 GbE extended reach operation

- Determination of any new measurements / field tests needed for validation

- Identification of issues relating to compliance

Suggested timelines

Plenary meeting

Mid July to end August

Task 1 activities: provide responses for Task 8

Task 8 activities: agree range of 10 GbE test conditions needed to agree validation

September to November

Compare output of model with 10 GbE extended reach tests

Identify any issues which need to be taken into account in setting compliance