COIN Soap Box Meeting #5 (SBM#5)

Downhole Control Line Wet Connectors: Hydraulic, Electric And Fiber Optic Connectors. Are They Reliable Completion Options Today?

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Fiber Optic Down Hole connectors

- Task is worth the effort
  - Value is in the monitoring, otherwise effort would have long been abandoned by the operating companies and service companies
- Service Companies efforts
  - Fiber Optic down hole wet connect in West Africa. Limited details avail
  - Baker Hughes. Testing and stack up completed. Target in well deployment 3Q2011
- How do we get to a reliable down hole wet connect?
  - Just like eating an elephant. One bite at a time
  - So, let's size the elephant!

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Sizing the elephant

- On one side. The light source
  - Interrogator (Optical budget, stability, reliability, cost)

- On the other side. The light path
  - Surface cable
  - Umbilical
  - UTA (umbilical termination and the bulkhead connector)
  - Flying lead or infield umbilical
  - SDU
  - Flying lead or infield umbilical
  - Another SDU ?
  - Tree and penetrator – ROV bulkhead - TH connector – Dry mate
  - Down hole cable
  - Down Hole connector
  - Down hole cable
  - Monitoring zone of interest

- And, quality of the fiber itself: How will it age under the environment ?

If reliability is desired, focus needs to be at the system level

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Slide courtesy of Deutsch Offshore
Subsea & Downhole Optical connectors:

Topside

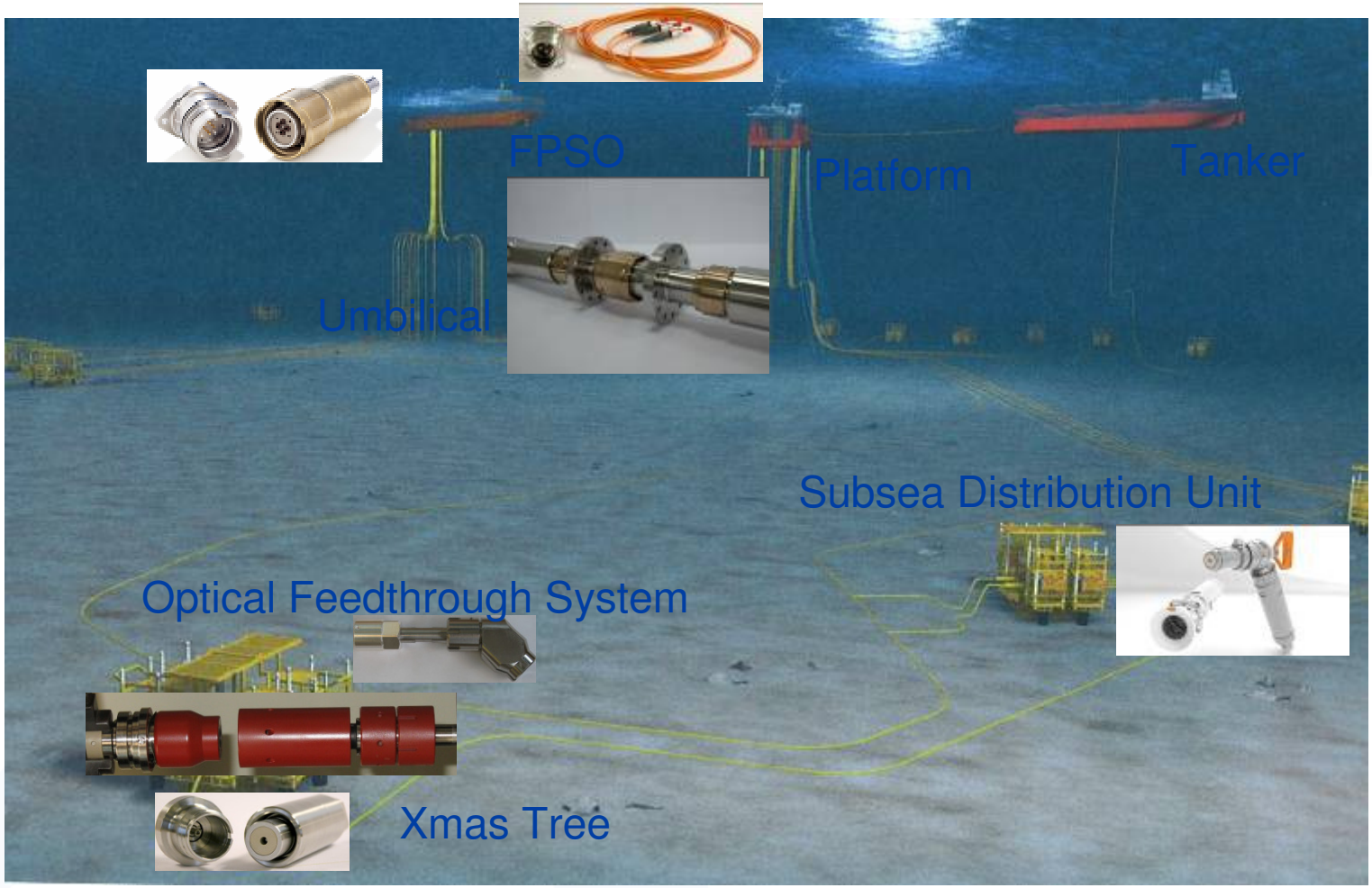
60 bar

Seabed

450 bar

DownHole

1000 bar to 2000 bar



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The balancing act: “Managing your losses”

For illustration purpose only	Optical Losses (for illustration purpose only. Change losses as needed)
Umbilical	0.7 db/km (assuming SM)
UTA	0.5 db (umbilical) + 0.5 db (Bulkhead)
Flying lead	0.7 dB/km
SDU	0.5 dB
Flying lead	0.7 dB/km (assuming SM)
SDU	0.5 db
Tree and penetrator	0.5 BK – 0.5 Dry – 1 Wet – 0.5 Dry
Down hole Cable	0.7 db/km (assuming SM)
Down Hole Wet mate	0.5 db
Down hole Cable	0.7 db/km (assuming SM)
Splice	0.5 dB
Down Hole cable	0.7 db/km (assuming SM)
Summary of losses	**0.7 dB x XX km + 6 dB losses (pristine fiber)** **Versus YY dB optical buget of the interrogator**

Reliability: Some of it + Rest of it = All of it !!!!

For illustration purpose only	Reliability (for illustration only)	Reliability (for illustration only)
Umbilical	99%	98%
UTA (umbilical + bulkhead)	99%, 99%	98%, 98%
Flying lead	99%	98%
SDU	99%	98%
Flying lead	99%	98%
SDU	99%	98%
Tree and penetrator (bulkhead, dry mate, TH wet mate, dry mate)	99%, 99%, 99%, 99%	98%, 98%, 98%, 98%
Down hole Cable	99%	98%
Down Hole Wet mate	99%	98%
Down hole Cable	99%	98%
Splice	99%	98%
Down Hole cable	99%	98%
Overall success rate	**99%^16 = 85 % success rate**	**98%^16 = 72 % success rate**

Reliability: Some of it + Rest of it = All of it !!!!

Reliability: 85%-72% or lower to be expected based on system architecture discussed.

Should we declare the reliability of the (monitoring) system hopeless, or should we revise the aim and accept the above?

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Roles and responsibilities - Defining the objective

Which requirement are we working with?

- Need to have DTS at XX,000 ft in lower completion

or

- Measurement capable of detecting 0.5 deg C over 1 hour interrogation time under XYZ field layout with given BHT and BHP across zone between 17,050 and 17,120 ft?
- Field is expected to have a work-over in XX years

From above should we (as in svc companies and operator)

- Review the optical budget, optimize the layout ?
- Perform simulations. Will the interrogator yield the desired results ?
- Revising the SOR as needed ?
- Documented accepted expected results ?

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You Can't Hit a Target if you're Aiming at the Sky

- Are the expectations aligned?
  - Setting the right expectation (svc company/operator)

    It is accepted that wells will require remedial actions (i.e. work-over) in XX years, yet the connectors are expected to make it to life of field (20 yrs-30 yrs). Should this be revisited?
  - Should the connectors be put on automatic work-over schedule?

- Understanding the well environment HT/HP/H2S, H2 etc. and impact on DH monitoring the system (including down hole connector)
  - Life time of the monitoring system (connectors included) and reservoir conditions (fluid properties, T, P, protection, maintenance etc). Are they compatible ? How do we test for it.
  - What standards do we go to?

- Planning for the right technology – Top to Bottom !!!!
  - "A chain is only as strong as its weakest link"
  - What standards do we go to?

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You Can't Hit a Target if you're Aiming at the Sky

Cables/Connectors/Monitoring -

- Deployment procedures or practices.
  - Aligned goals or conflicting goals between various parties involved in the deployment ?
- Operators involved (i.e. Experience and expectation)
  - Simple things such as a splice takes time. Does the operator understand this, and level of work involved?
- Interrogators and Power source(s)
  - Is the right interrogator deployed for the right job, meeting the environment (power, humidity, temperature), and requested task.
- Data management
  - Bits and bites dripping at the WHO.
  - Than what do we do with it, how do we manage the data?

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One bite at a time. Focus on Down Hole connector

- Step One
  - Key components evaluation
  - Selection of technology

Step Two
- Component and System Design evaluation

Step Three
- Field Test the hardware.
- Full stack ups
- Refine well clean up procedures

Step Four
- Manufacture production equipment
- Test (SIT)
- Review results
- Train and practice deployment, do it again
- Deploy

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One bite at a time: Monitoring progress

- Agreed to quality plan

- Quality is not measured in weight of the paperwork
  - Monitor the relevant factors
    - Standards available ? Than enforce them!
    - Seafom starting development of tree TH and sea floor connectors.
      → Need to enlarge standards (SEAFOM or others) to down hole connectors
    - Review test and test conditions

- Collaboration/team-spirit between operators and all 3rd party suppliers (umbilical, tree, connector, etc) to minimize the chances of unintended failures, or unintended consequences of one's action.
  → CWOPS, complete SIT's

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One bite at a time: SIT done, job complete?

- SIT Completed (and passed) => All good to go.
  Is this the end?

<u>Next in line:</u>

- Deployment techniques
- Training, training and more training of Field Engineers
- Down hole environment.
  - Different crews will have different success
    - Post Mortem. Looking at the good-the bad-the ugly
- Managing the goals and potential conflicts.
  - Rig crew. As fast as possible
  - Monitoring crew. Slow and steady wins the race

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One bite at a time: Conclusion

- Resolve conflicts in system approach and restrictions between suppliers and operator.
- Define the monitoring objective clearly
- Manage your losses. “Less is more”
- Reliability. Define, test, verify
- Success.
  - Define into measurable quantities, plan for it, measure it
- Learn from experience

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The Baker Hughes “elephant”– DHWC

Down Hole Wet connect objectives

- Two different sizes down hole wet connect.

Project Challenges

- Debris, pipe dope, scale, sand and propant, scale etc
- Must align 6 fibers with sub-micron accuracy
- Must be compatible/tolerant with dowhole environment
- Required close collaboration work with customer, vendors, internal cross division engineering groups
- Show repeatability in connection (lab-stack up)
- Testing lab, in well and SIT
- QRD

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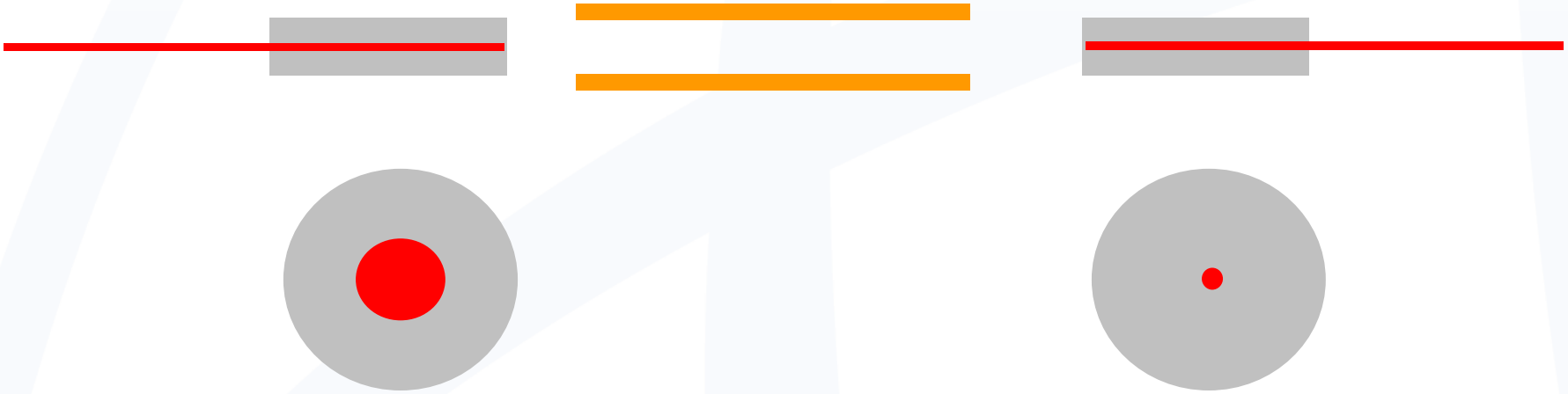
Equipment - Fiber Optic Wet Connector Design

How are fiber connections made?



Multimode Fiber

50µm Core

125 µm Cladding

Singlemode Fiber

9µm Core

125 µm Cladding

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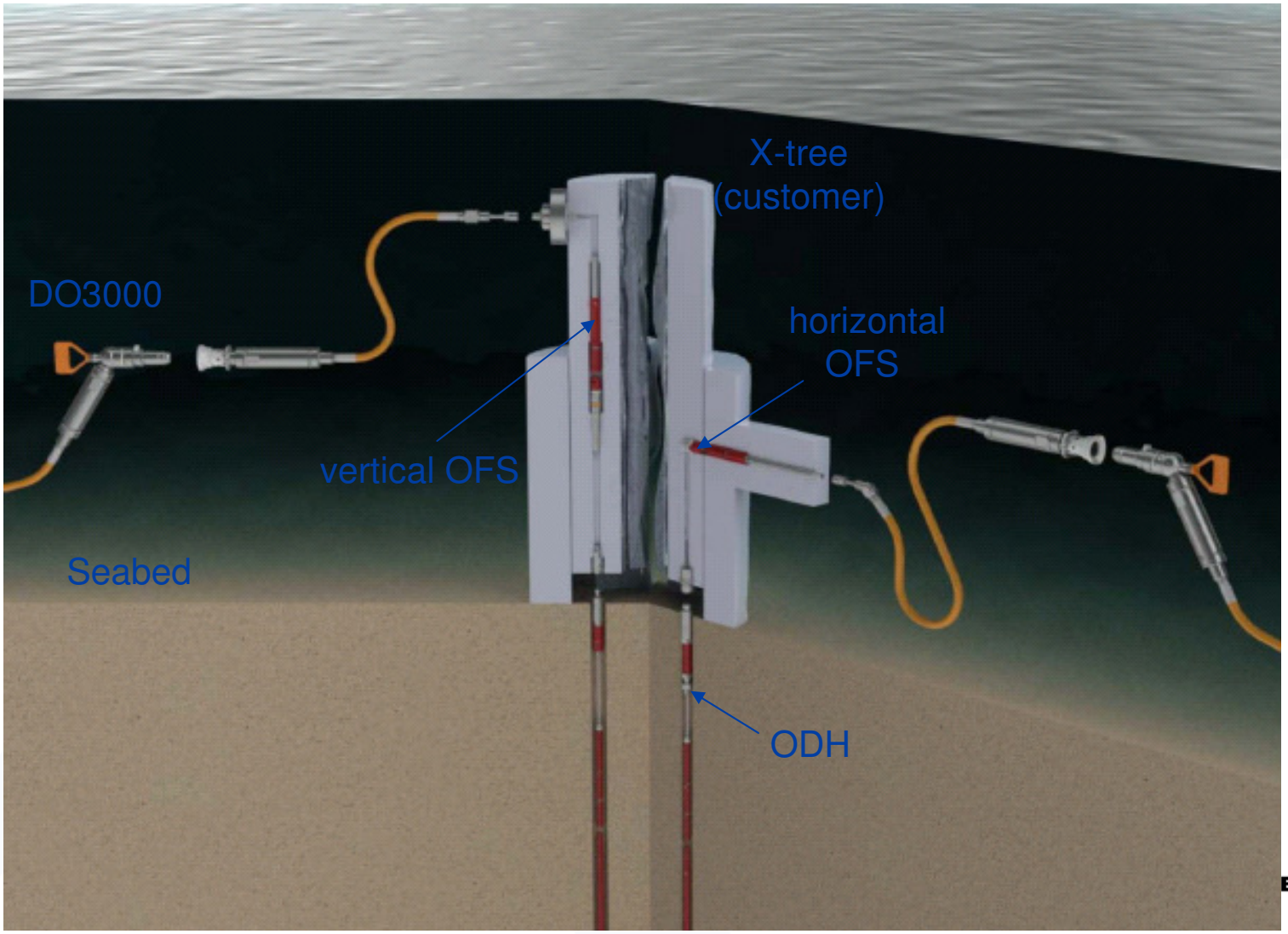
Slide courtesy of Deutsch Offshore Subsea & Downhole Optical connectors:



Baker Hughes Down Hole Wet connects

- 2 packer sizes FP and GP
- Production packer with Feed through
- Multiple length expansion joint for lower and upper expansion joints
- Packer reconnect (FO receptacle connector)
- Sand Control Packer (FO plug connector)
- Sand screen w FET with Dry Mate Connectors
- Sand Control Cross Over Tool
    - Sand Control Frac tools
- Retrieval tools

<u>Summary of BHI down hole wet connect:</u>

- Six fiber optic connections per Connector
- Two Connectors per Packer
- Designed and tested as a system
- Designed 15K, 150 deg C

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Prototype Testing

- Debris Testing
- Lab Testing
- Downhole Testing

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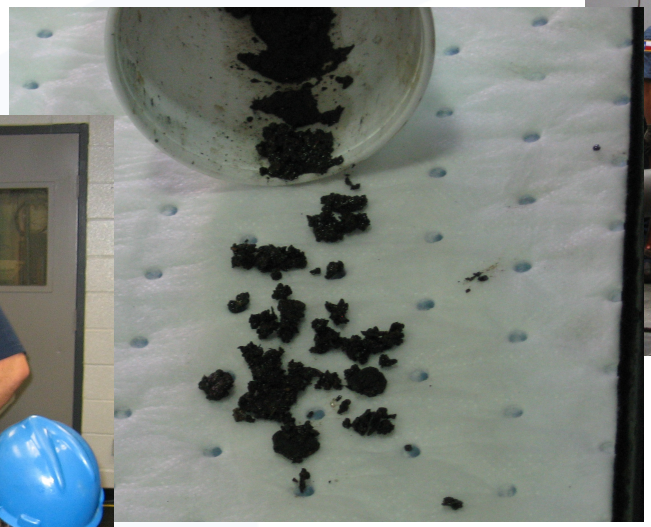
Prototype Testing – Stack Up

- 2 generic sizes
- Repeated Downhole Mate/de-mate cycles
- Connectors populated with 4 to 6 fiber optic channels simultaneously connected each mate



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Prototype Testing – Stack Up

- Integration test
- Achieved mate/demate specs in downhole environment
- All fiber optic channels simultaneously connected each mate

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Prototype Testing – Deployment

- Full gravel pack and completion
- Two downhole wet connectors
- Two downhole wet mate/De-mates
- All fiber optic channels simultaneously connected dowhole

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Baker Hughes down hole wet connect Status

- Surpassed downhole, multiple channel, fiber optic wet connections specification
- Tested gravel pack system with completion equipment
- Horizontal and vertical gravel packs tested
- Tested Frac Pack system with completion equipment
- Hardware build – ready for deployment

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Down Hole Wet Connect - Summary -

- Project Scope
  - Adopt system approach
  - Define objective
- Do your homework.
  - Optimize the system
  - Resolve conflicting goals
  - Manage your losses. More is less for optical systems
- Size your elephant
- One byte at a time
- Fiber Optic Wet Connector Design
- Testing – Prototype, Stack ups, production, SIT
- Review Status, open communication

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Thank you

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