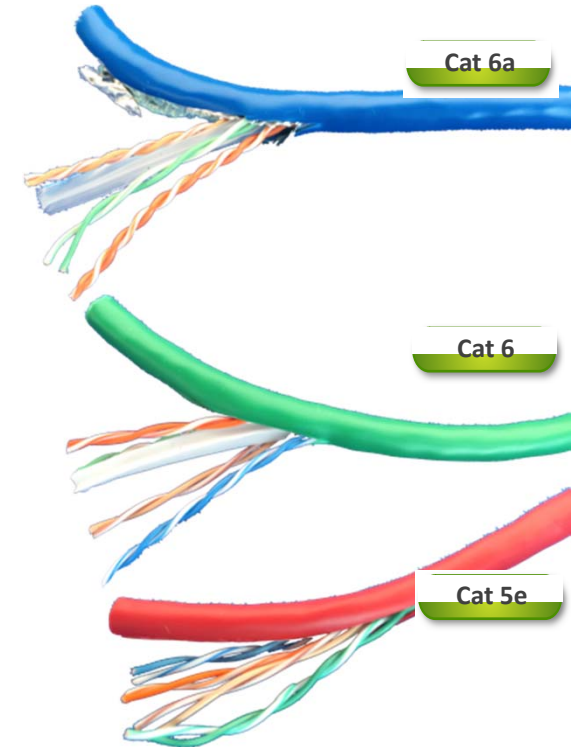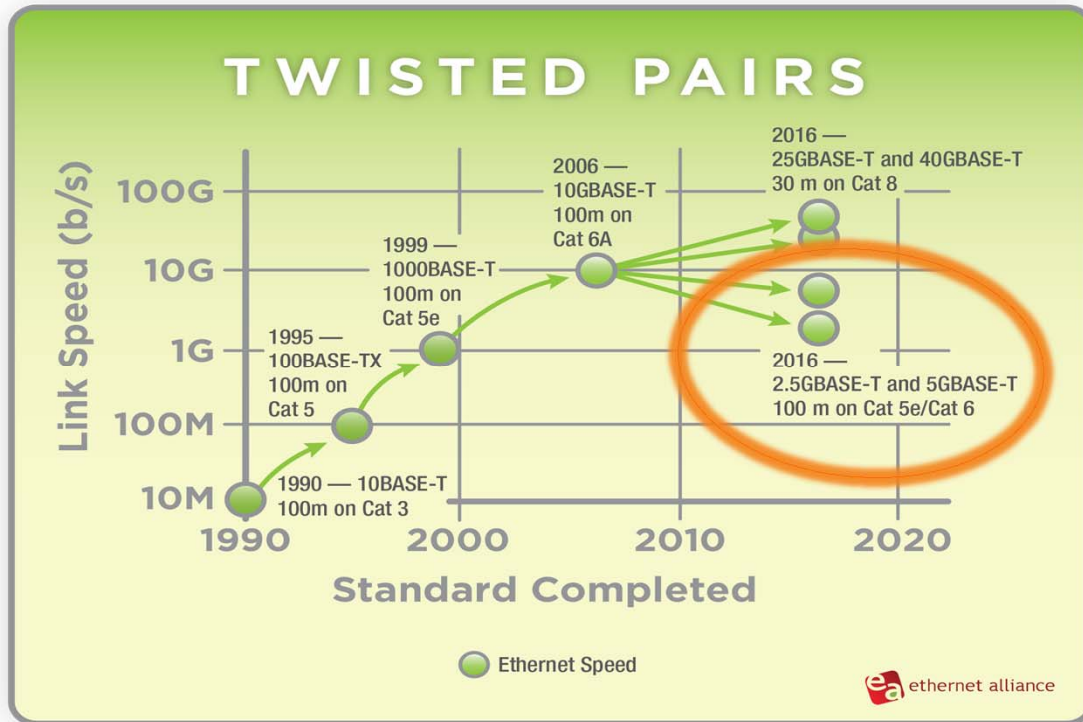# Save the Cables - Be a Hero!

George A. Zimmerman, Ph.D.      CME Consulting

Board of Directors, NBASE-T Alliance

Peter Jones, Cisco Systems       Chairman, NBASE-T Alliance

Frank Straka, Panduit            Member, NBASE-T Alliance

Jim Davis, Fluke Networks        Member, NBASE-T Alliance

# The Twisted Road of BASE-T

# 802.11ac Transitions Drive Wired Bandwidth Needs

## With 802.11ac, wireless crosses a gigabit

### Enterprise AP Radio Bandwidth



802.11 in time:
2002-2006: 802.11g/a
2007-2011: 802.11n
2013-2015: 802.11ac W1
2015-2017: 802.11ac W2

## 11n to 11ac is a rapid transition

### Enterprise AP 802.11n/11ac Transition
### Source: Dell'Oro Group Jan 2017



**NBASE-T:** SAVE THE CABLES – BE A HERO!

# The Applications Spaces of BASE-T



Source: George Zimmerman, CME Consulting
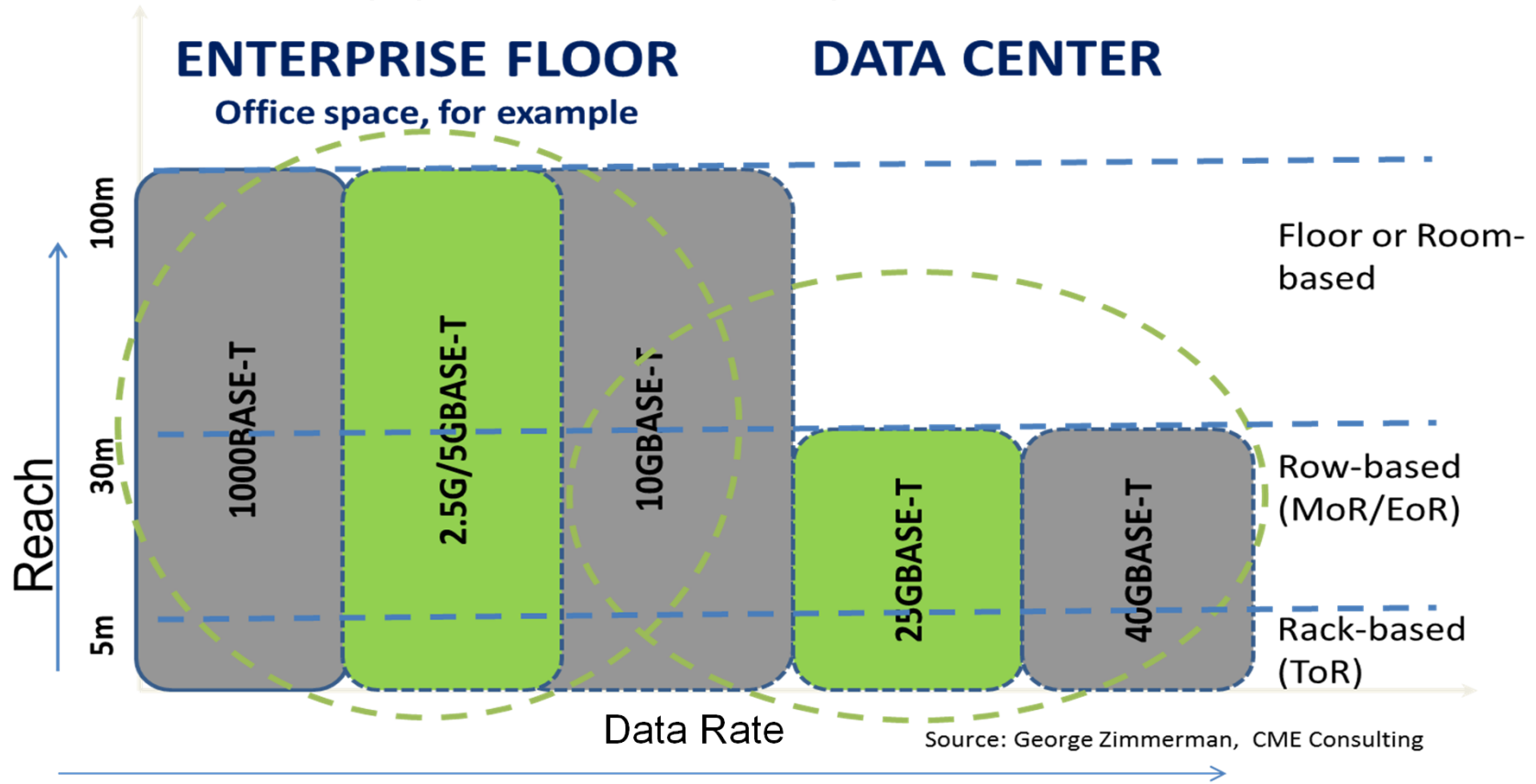
# NBASE-T Alliance<sup>SM</sup> - Overview



- NBASE-T Alliance ([www.nbaset.org](www.nbaset.org))
  - Vendor alliance for 2.5G/5GBASE-T with 45+ member companies
- Who is in the Alliance?
  - Components, silicon, systems, cabling, test and more
- What is role of the Alliance?
  - Enable widespread deployment, evolve specifications, facilitate interoperability

**Alliance Strength - Full Ecosystem**

**Promoters**

AQUANTIA · CISCO · intel · MARVELL
NXP · XILINX

**Contributors**

bel MAGNETIC SOLUTIONS · BROADCOM · cadence · CME Consulting
COMMSCOPE · FLUKE networks · IDEAL NETWORKS · Kinnex A
molex · PANDUIT · UDE · iol InterOperability Laboratory

**Adopters**

Amphenol · aruba · AUKUA SYSTEMS · CAVIUM
centec networks · Cu Copper Test · DNI · ECONET
FIT · GLGNET · LITE CONNECTOR & RF ANTENNA · MNC Mentech
Microsemi · More Than IP · NETGEAR · Pleora Technologies
PROMISE TECHNOLOGY · REALTEK · ROHDE&SCHWARZ · SpeedTech
SPIRENT · SYNOPSYS · TDK · TEHUTI NETWORKS
Tektronix · TELEDYNE e2v · XENA NETWORKS · 元册科技

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# NBASE-T Alliance & IEEE - Timeline of Success

**APRIL 2016**
15 companies showcase
NBASE-T interoperability
demos at Interop Las Vegas

**APRIL 2016**
802.3bz Sponsor
Ballot opened

**SEPTEMBER 2016**
802.3bz standard
approved

**MARCH 2017**
NBASE-T and Ethernet
Alliance joint webinar
on plugfest results

**MAY 2015**
802.3bz Technical
Baselines adopted,
compatible to NBASE-T
specification

**NOVEMBER 2015**
NBASE-T Alliance
membership hits
45+ companies

**OCTOBER 2014**
NBASE-T Alliance
launched

**JANUARY 2015**
First switch
products
announced

10 — 11 —— 2015 01 — 03 - 04 - 05 —— 07 - 08 —————— 11 ——— 2016 01 - 02 —— 04 —————————— 09 - 10 —— 12 · 2017 —————— 03 —— 05

**MARCH 2015**
802.3bz
Task Force
authorized

**AUGUST 2015**
First NBASE-T
technology plugfest

**FEBRUARY 2016**
First machine vision
products announced

**OCTOBER 2016**
NBASE-T and
Ethernet Alliance
joint plugfest

**MAY 2017**
Gold sponsor
Interop ITX
Las Vegas

**NOVEMBER 2014**
NBASE-T Physical Layer
Specification 1.0 available

**JULY 2015**
802.3bz Task Force
Review begins

**JANUARY 2016**
First access points and
test equipment products announced

**DECEMBER 2016**
NBASE-T Physical Layer
Specification version
2.3 available

**NOVEMBER 2014**
IEEE 802.3 Call
for interest

**APRIL 2015**
First multivendor
interoperability demos
for NBASE-T technology
at Interop Las Vegas

**JANUARY 2016**
802.3 Working Group
Ballot initiated

Updated February 2017, © NBASE-T Alliance, Inc.

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# NBASE-T and 802.3bz Technology – Based on 10GBASE-T

- PAM-16 with the same LDPC code for good performance
  - Good interoperability, improved robustness
  - Upper frequency of ½ (5G) and ¼ (2.5G) that of 10GBASE-T
- NBASE-T and 802.3bz are interoperable with each other
  - Joint Ethernet Alliance/NBASE-T Alliance plugfest in late 2016
  - Auto Negotiation enables multi-mode PHY operation
- Supports PoE!

# IEEE 802.3bz or NBASE-T?

- Since they are interoperable with each other, how do they differ?

- NBASE-T adds "Downshift" to 802.3bz
  - Normal Auto Negotiation selects the fastest rate both PHYs support, irrespective of the cabling, noise or environment
  - But, in 2.5G/5GBASE-T, the speed you get may depend on other links crosstalking
  - So Downshift automatically shifts the rate based on the channel noise

- w/Downshift users always get a reliable link



IEEE 802.3bz functionality + Automatic Downshift = NBASE-T 2.3 functionality

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# Alien Crosstalk Basics

- Modern (1000BASE-T and above) PHYs are limited by noise from other cables – "Alien Crosstalk"

- Worst-cases happen when cables are tightly bundled over long distances, and near the transmitter
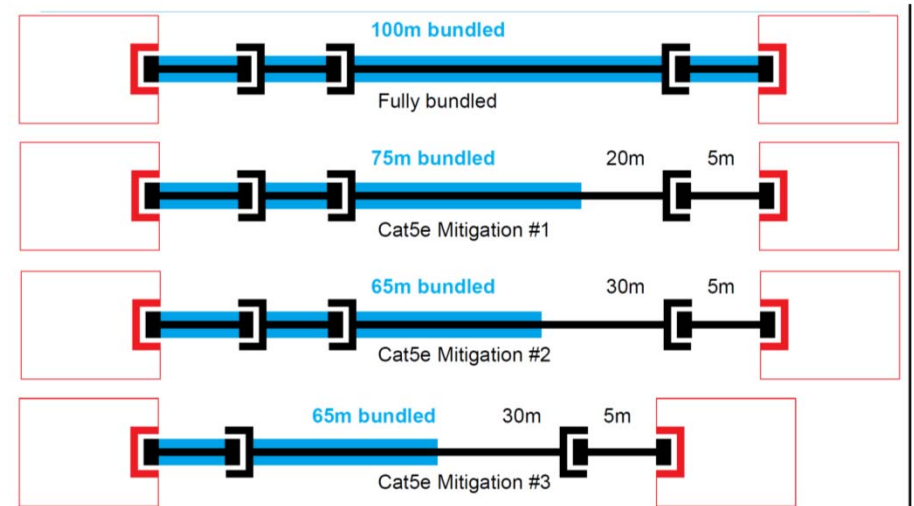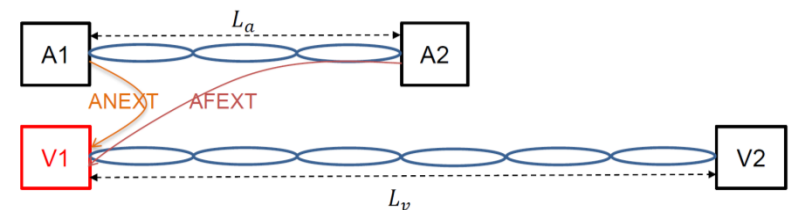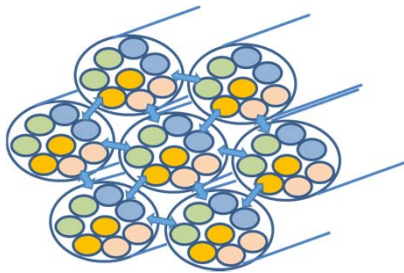
# How BASE-T is Really Deployed

- Designers of NBASE-T recognized many links would support rates above 1Gbps
  - Wireless Access Points were installed in links that were fanned out, allowing less than worst-case alien crosstalk

- Alien crosstalk impacts the speed you can get above 1Gbps
  - Cat5e and Cat6 are not specified for alien crosstalk
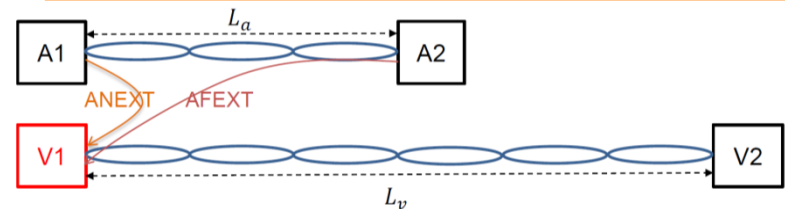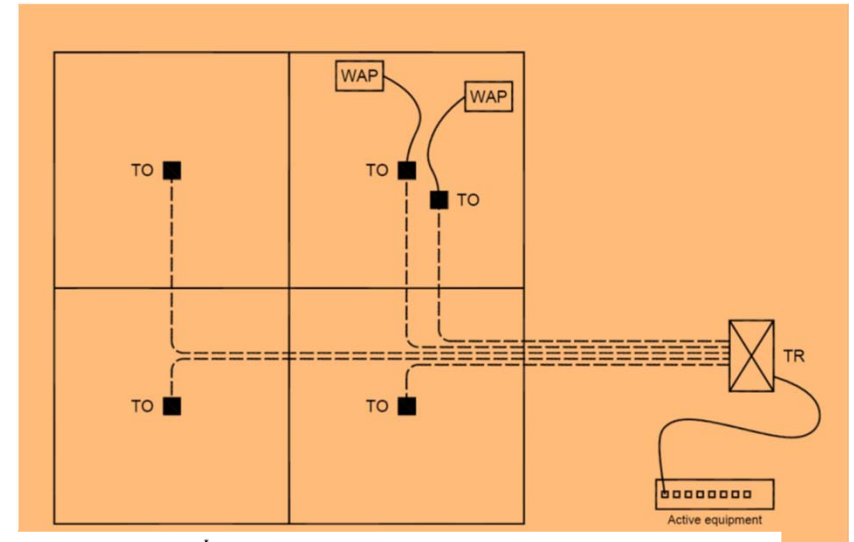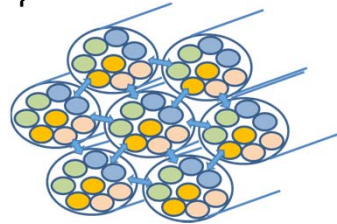
# What You Will Hear Today

- **Peter Jones** will discuss the NBASE-T Alliance and a systems vendor's perspective
  - Why you want to use it, what to look for
- **Frank Straka** will discuss meeting NBASE-T requirements from a cabling vendor's perspective
  - What you can expect of Cat5e and Cat6 and how to improve performance (if needed)
- **Jim Davis** will discuss what to look for and how to check your installation for NBASE-T
  - How standards relate and how to assess your existing installation

# NBASE-T™ 2.5GBASE-T/5GBASE-T Why, Where & When

Peter Jones

Principal Engineer – Cisco Systems

Chairman – NBASE-T Alliance

# 802.3 Ethernet and 802.11 WLAN –Deployments Today

1000BASE-T
Power over Ethernet

**Access Switch**

Mostly 1000BASE-T ports

PoE PSE (15/30/60W, *4PPoE)*

**Cabling**

Cat 5e/6/6A up to 100M

New installs moving to Cat 6A for 10+yr life

**Access Point**

Connects 802.11 to 802.3

PoE  PD (Powered Device)

Footprint sensitive (e.g. power, heat, etc.)

11acWave 2 drives backhaul traffic > 1 Gb/s

***No easy way to get above 1Gb/s***

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A L L I A N C E

# Why 2.5G and 5G BASE-T?

- Between 2003 to 2014 **~70 billion meters** of Cat 5e and Cat 6 cabling were sold….
  - ~90% of installed base
  - Enormous network infrastructure investment

- Existing specifications supported 1Gb/s over this cable, but we knew faster data rates were possible

- BASE-T allows incremental upgrade

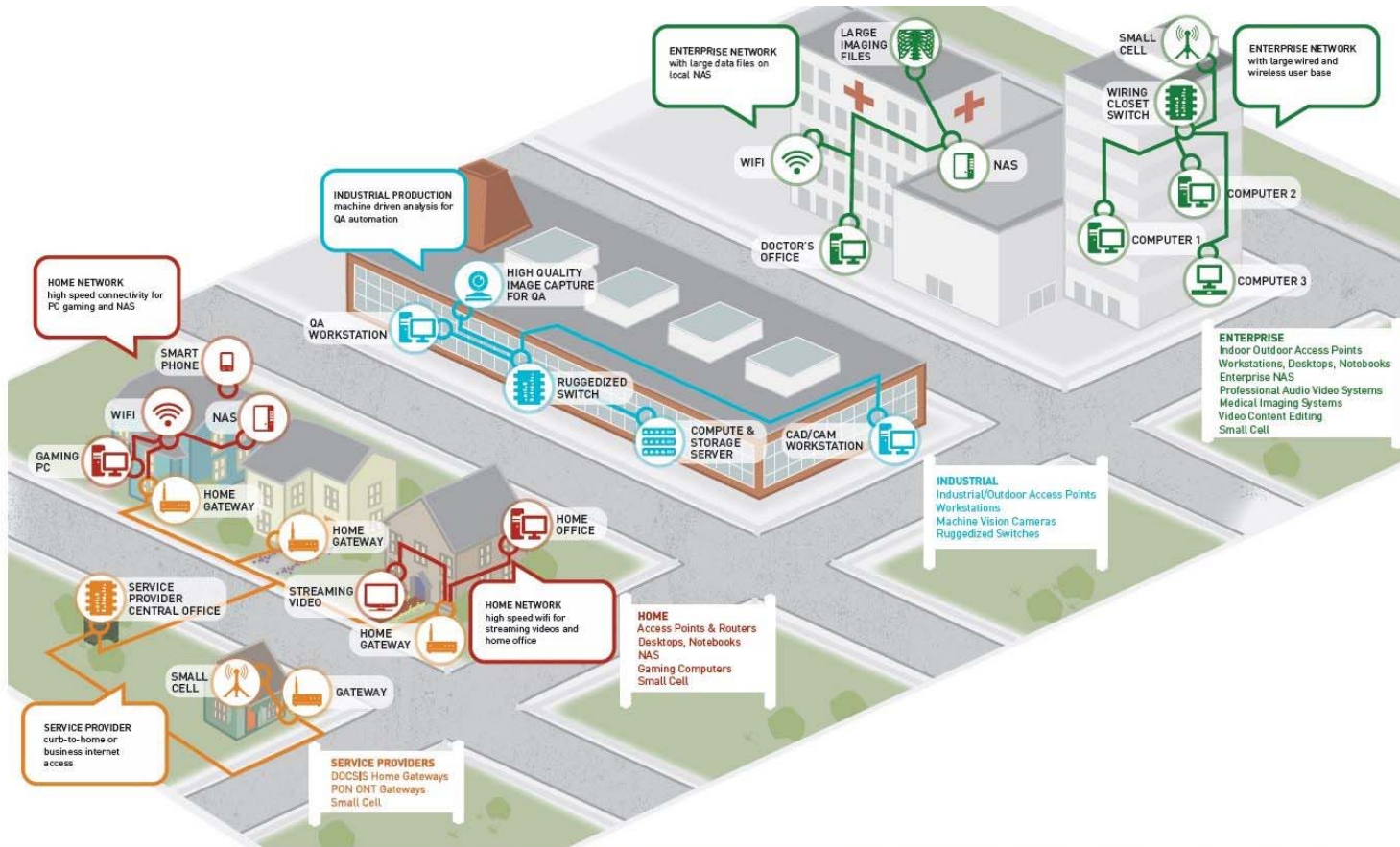  **Let's get more value from this asset!**

  **What can we enable?**

**10 meters of BASE-T cabling** for every man, woman, and child on Earth …

```
Installed Cable Plant
2014
Cat 5e   Outlets   539 M
Cat 6    Outlets   743 M
Cat 6a   Outlets   111 M
Cat 7    Outlets    10 M
Total              1.4 B
```

Chart axis: 0, 200, 400, 600, 800, 1000, 1200, 1400, 1600, 1800

Years: 2003, 2007, 2011, 2015

Legend: ■ Cat 5e outlets  ■ Cat 6 outlets  ■ Cat 6a outlets  ■ Cat 7 outlets
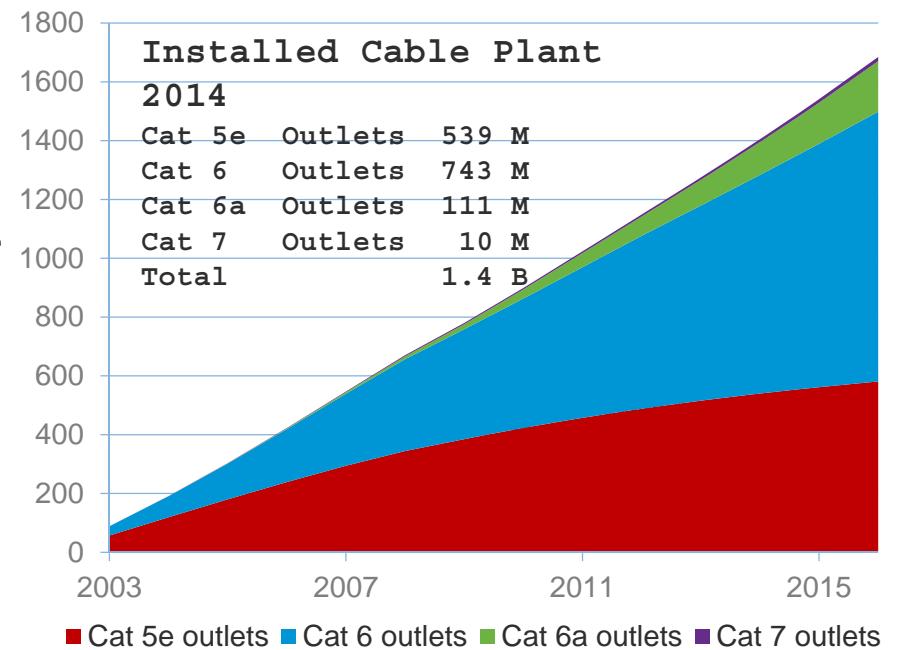
Source: BSRIA December 14

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# NBASE-T Alliance Application Areas



Enterprise:
- Switch
- Wireless AP
- Desktop
- Storage Server
- Small Cell

Industrial:
- Switch
- Wireless AP
- Workstation
- Storage/Compute
- Machine Vision

Industrial:
- Switch
- Wireless AP
- Storage Server
- Home Gateway
- Streaming

Service Provider:
- Small Cell
- Home Gateway

# NBASE-T/802.3bz Joint Plugfest – October 2016 at UNH-IOL

***Wide Industry Representation*** including

Aquantia, Aukua, Berk-Tek, Broadcom, Cisco Systems, Dell,

Extreme Networks, Fluke, Huawei, Intel, Marvell, Panduit,

Rohde & Schwarz, Tektronix

***More than 1,100 tests*** including

Conformance –IEEE 802.3bz and NBASE-T specifications

Linkup – ability to connect with other devices

FER – monitoring of errors in data frames

Downshift – slower data rate responding to cable noise

***99+% success rate*** for Linkup and FER tests

***Post event blog and results webinar***



iol UNH_IOL
@UNH_IOL
Following

Checking in from the @EthernetAllianc and @NBASETAlliance group test event for 2.5/5Gbps @IEEE802.3bz product deployment! #interoperability

Blog: www.nbaset.org/99-percent-success-rate-2-5g-5gbase-t-ethernet-plugfest-shows-technology-ready-primetime/

Results Webinar: https://www.brighttalk.com/webcast/6205/245401/5g-and-5gbase-t-technology-multi-vendor-interop-here-today

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# NBASE-T Alliance at Interop 2017 Las Vegas



See http://www.nbaset.org/showcasing-nbase-t-interoperability-2017-interop-itx//
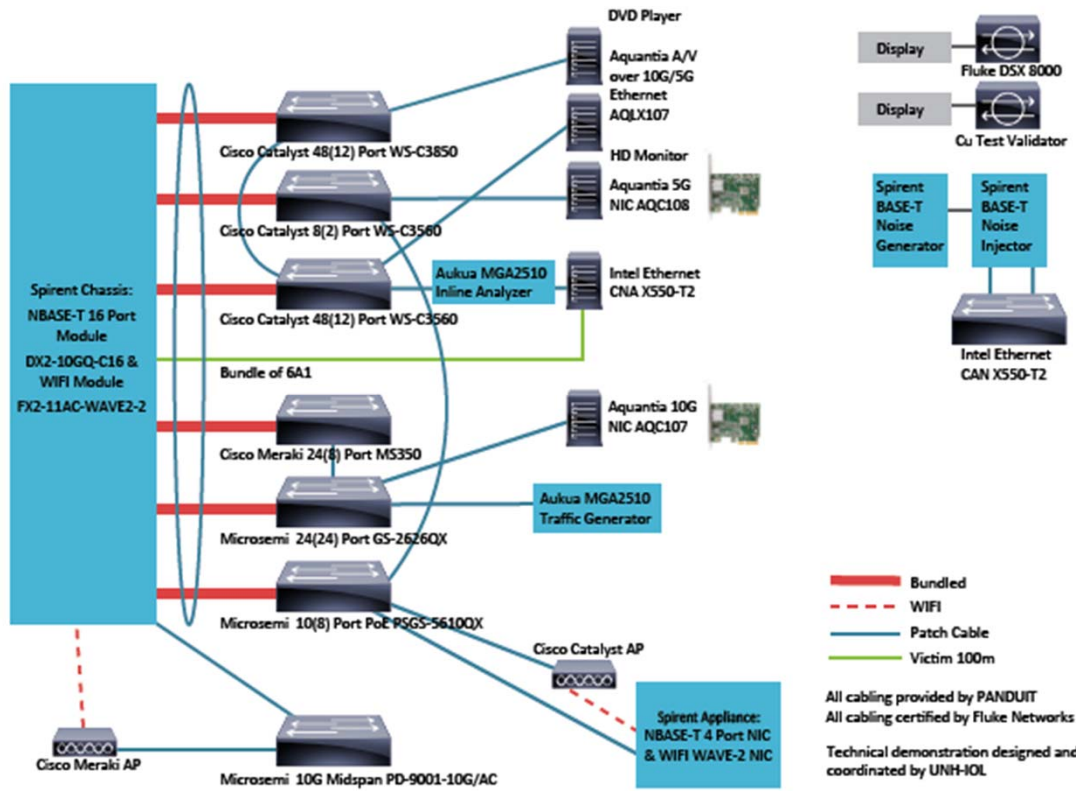
**NBASE-T:** SAVE THE CABLES – BE A HERO!

# NBASE-T – Key Analyst Messages

As DX demands that **enterprises rely on** a broad set of connected devices and network applications over **wired and wireless networks**, network access **infrastructure must evolve** to keep the digital enterprise running. IEEE 802.3bz has the potential to help enable the digital enterprise to use not only WLAN but also wired connectivity to its highest potential while deriving **maximum value from the cable plant.**

**Nolan Greene, senior research analyst, IDC Network Infrastructure Group**
**The Newly Ratified IEEE 802.3bz Ethernet Standard: What Enterprise IT Needs to Know – December 2016**
 http://www.idc.com/getdoc.jsp?containerId=US40815516/

Despite the limited availability of products, market shipments of **NBASE-T surged in the second half of 2016**.     As merchant silicon-based products come to market, we expect adoption to accelerate, and have raised our **2017 forecast to surpass five million ports**. Concurrently, the transition to 802.11 ac Wave 2  Access Points is occurring faster than we previously predicted and is on track to be complete by mid-2017.  Clearly, **Enterprise users are hungry for multi-gigabit bandwidth** to support traffic from their wireless devices.

**Tam Dell'Oro, founder & CEO, Dell'Oro Group**
**Enterprises Eager for Upgrade to NBASE-T Ethernet Switches, Wave 2 Wireless LAN —February 2017**
http://www.delloro.com/news/enterprises-eager-upgrade-nbase-t-ethernet-switches-wave-2-wireless-lan-according-delloro-group

"We believe the **Apple iMac Pro announcement** is an early indicator of a significant shift away from 1 Gbps and towards higher speeds in how we connect devices to the network," said. "**NBASE-T technology plays a critical role** in this migration, and we're excited to see the ecosystem expand beyond enterprise networking and WiFi Access Point connections."

**Alan Weckel, founder and technology analyst at 650 Group**
http://www.nbaset.org/catching-the-nbase-t-wave/

**NBASE-T:** SAVE THE CABLES – BE A HERO!

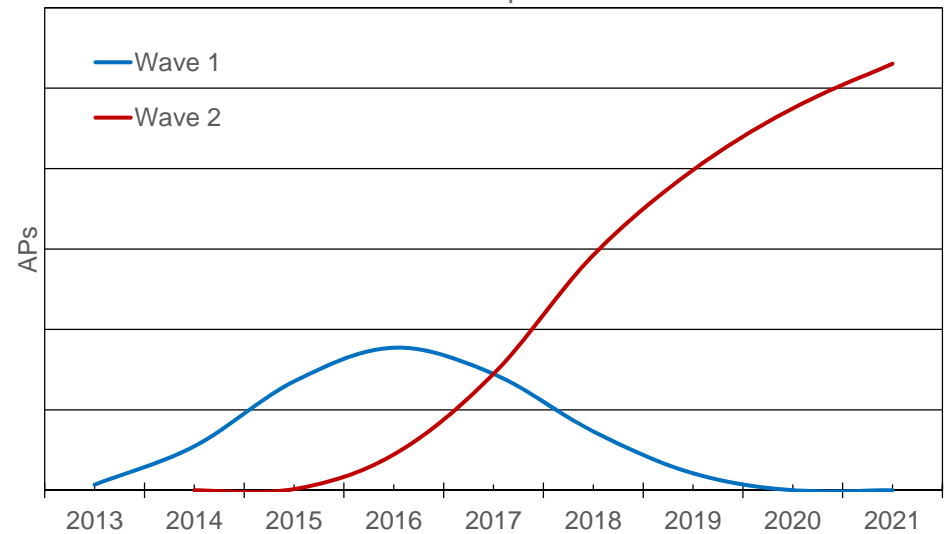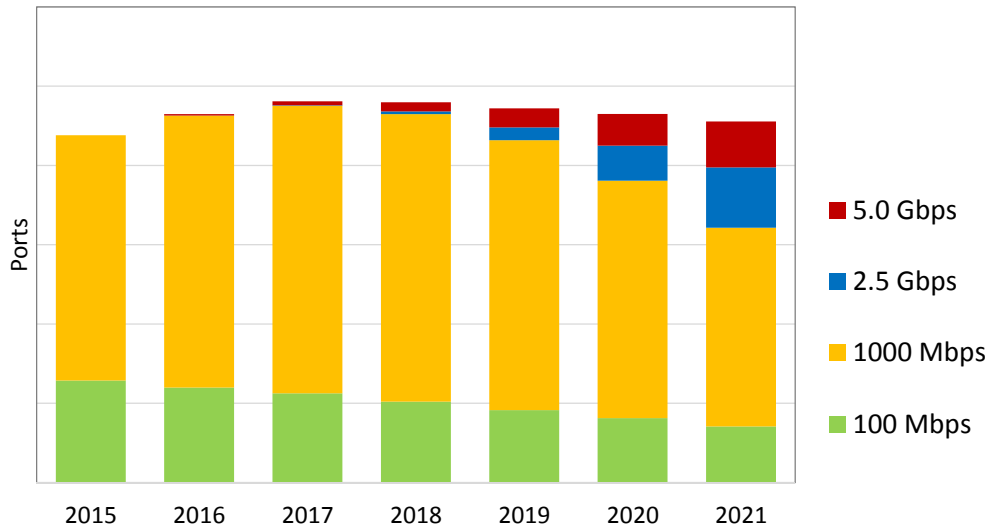# 802.11ac and 2.5G/5G BASE-T Forecasts

**There is a rapid transition from 11n to 11ac**

**Wave 2 started ramping in 2016, exceeds Wave 1 in 2017**

100M/1000M to 2.5G/5G transition
Source: Dell'Oro Group Jan 2017



Enterprise AP 802.11ac Wave Transition
Source: Dell'Oro Group Jan 2017



**2.5G / 5G BASE-T Ethernet is rapidly being adopted**

# NBASE-T Recent Products



http://www.buffalotech.com/products/terastation-5010-series

https://www.asus.com/us/Networking/XG-C100C/

**Vision**Systems DESIGN
2017 **Innovators Awards**
**GOLD**

3.5 mm headphone    USB 3    Thunderbolt 3 (USB-C)

SDXC card slot    Ethernet

https://www.apple.com/imac-pro    https://www.e2v.com/products/imaging/cameras/uniiqa-4k-mono-and-colour/

BICSI Fall CONFERENCE & EXHIBITION 2017

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# Using Your Existing Cables at 2.5 and 5GBASE-T

## Frank Straka

## Product Line Manager - Panduit

# Data Rates Above 1Gig

- Yesterday:
    - 1000BASE-T → 10GBASE-T

    Category 5e/6    Category 6A

- Today
    - 1000BASE-T → 2.5GBASE-T → 5GBASE-T → 10GBASE-T

    Category 5e/6    Category 6A
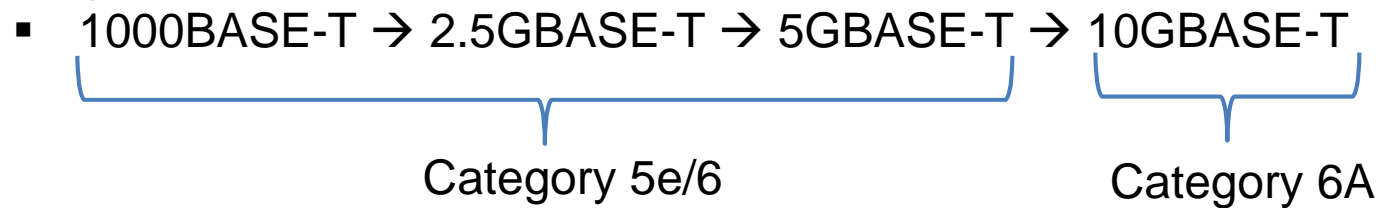
# Category Comparison

| TIA<br>ISO | Cat 5e<br>Class D | Cat 6<br>Class E | Cat 6A<br>Class $E_A$ |
|---|---|---|---|
| Construction | UTP or STP | UTP or STP | UTP or STP |
| Specified Bandwidth | 100 MHz | 250 MHz | 500 MHz |
| Cable Wire Gauge | 23/24 AWG | 23 AWG | 23 AWG |
| PoE Support | Yes | Yes | Optimal |
| Diameter (Approx) | .210" | .240" | .275" |
| Gigabit Ethernet | 100 m | 100 m | 100m |
| 10GBASE-T Ethernet | Not Supported | Limited distances per TSB-155-A | 100m |
| 25/40GBASE-T | Not Supported | Not Supported | Not Supported |
| Approx. Relative Installed Cost | 1 X | 1.2 X | 1.5X |
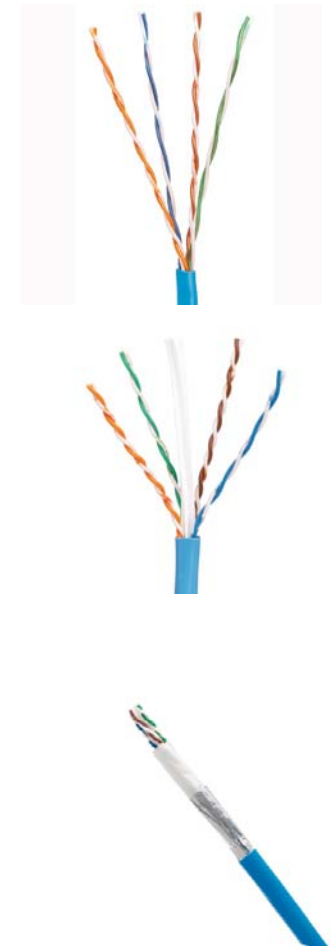
# Focus on Alien Crosstalk

- Alien crosstalk
  - Noise from external cables
  - Not specified for Cat5e or 6
  - Tightly controlled for Cat6A (5e and 6 cables cannot meet)



| Category | Class | Maximum Bandwidth | Major Improvement over Prior Class |
|----------|-------|-------------------|------------------------------------|
| 5e | D | 100MHz | N/A |
| 6 | E | 250MHz | NEXT, ACR-F, and Return Loss |
| 6A | $E_A$ | 500MHz | Alien Crosstalk |

*Category 6A recommended for new installations*

# ALSNR

- Alien crosstalk levels were first specified for 10GBASE-T using a worst-case configuration (6-around-1) and a limit-line for Cat 6a
  - However, this disqualifies cables which will work because they only exceed the limit line at a few frequencies
- Alien Crosstalk effects on receivers can be better modeled with a calculation known as the Alien Limited SNR Criterion (ALSNR)
  - Well-known theoretical result based on "Optimum Mean-Square Decision Feedback Equalization", J. Salz, Bell System Technical Journal, Vol 52 No. 8, Oct 1973

Copyright © 1973 American Telephone and Telegraph Company
THE BELL SYSTEM TECHNICAL JOURNAL
Vol. 52, No. 8, October, 1973
*Printed in U.S.A.*

## Optimum Mean-Square Decision Feedback Equalization

### By J. SALZ

(Manuscript received April 20, 1973)

*In this work we report new results relating to decision feedback equalization. The equalizer and the transmitting filter are optimized in a PAM data communication system operating over a linear noisy channel. We use a mean-square error criterion and impose an average power constraint at the transmitter. Assuming correct past decisions, an explicit formula for the minimum attainable mean-square error is given. The possible advantages of signaling faster than the Nyquist rate while decreasing the number of levels to maintain the same information rate are investigated. It is shown that, in all cases of practical interest, signaling faster than the Nyquist rate, while keeping fixed the information rate, increases the mean-square error. Finally, to illustrate the use of the results, application is made to a cable channel where the loss in dB varies as the square root of frequency. Various asymptotic formulas and curves are provided to exhibit the relationships between the quantities of interest.*

$$ALSNR_i = \left(\frac{1}{fmax}\right) \sum_{f=fmin}^{fmax} (S_i(f) - N_i(f))\Delta f \qquad (dB)$$

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# ALSNR Analysis

- Alien Limited Signal-to-Noise Ratio
  - Key parameter for 2.5 and 5GBASE-T

- Low risk for bundles up to 20 meters, regardless of channel length

- Limited risk for bundles up to 75 meters

- No risk when using Category 6A

| Bundled cabling length 0m to 50m | Category 5e | Category 6 | Category 6A |
|---|---|---|---|
| 2.5GBASE-T | | | Assured |
| 5GBASE-T | | | Assured |

| Bundled cabling length 50m to 75m | Category 5e | Category 6 | Category 6A |
|---|---|---|---|
| 2.5GBASE-T | | | Assured |
| 5GBASE-T | | | Assured |

| Bundled cabling length 75m to 100m | Category 5e | Category 6 | Category 6A |
|---|---|---|---|
| 2.5GBASE-T | | | Assured |
| 5GBASE-T | | | Assured |

| ALSNR Risk | High | Medium | Low |
|---|---|---|---|

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# Mitigation Procedures (if needed)

- Ensure your equipment is linking up at a proper rate
- If it links up at less than target rate:
  - Separate cords, unbundle horizontal cable
  - Replace equipment and patch cords with Cat6A cords
  - Replace connectors with Cat6A connectors
  - Replace horizontal cable with Cat6A cable
  - Final Step: **Enjoy the extra speed!**

# Using Cat5e and Cat6 at 2.5 and 5Gig

- Internal crosstalk (NEXT, return loss) has low risks
  - Category 5e will likely meet 5GBASE-T requirements
  - Category 6 has no risks of meeting 2.5 and 5GBASE-T internal requirements

- Alien crosstalk has elevated risks
  - **Vast majority of links have very low risks**
  - Risk with Category 5e and 6 cables on long bundled (> 75 meters) runs
  - Refer to SNR risk matrix

**Cable Bundle:** A group of cables that are tied together or in contact with one another in a closely packed configuration for at least 1 m.

# Testing Your Cables for Best NBASE-T Success

Jim Davis

Regional Marketing Engineer – Fluke Networks

# Outline

- Cabling Standards and Application Standards

- Will my cabling support NBASE-T?

  – Certified to Category 5e? Category 6?

- Things we did not consider

  – ALSNR

- What to do moving forward

  – Follow the Cabling Standards to be ready for the future

# Highway Overpass Specification

TABLE 19

Ranges for Minimum Vertical Clearance

| Type of Roadway | US |
|---|---|
| | |
| Freeway | 14 |
| Arterial | 14 |
| Collector | |
| Local | |

# The Benefits of Standards – Future-Proofing

- The Cabling Standard Specifies the 'Shape' of the road
    - The Appl                                    /ehicles
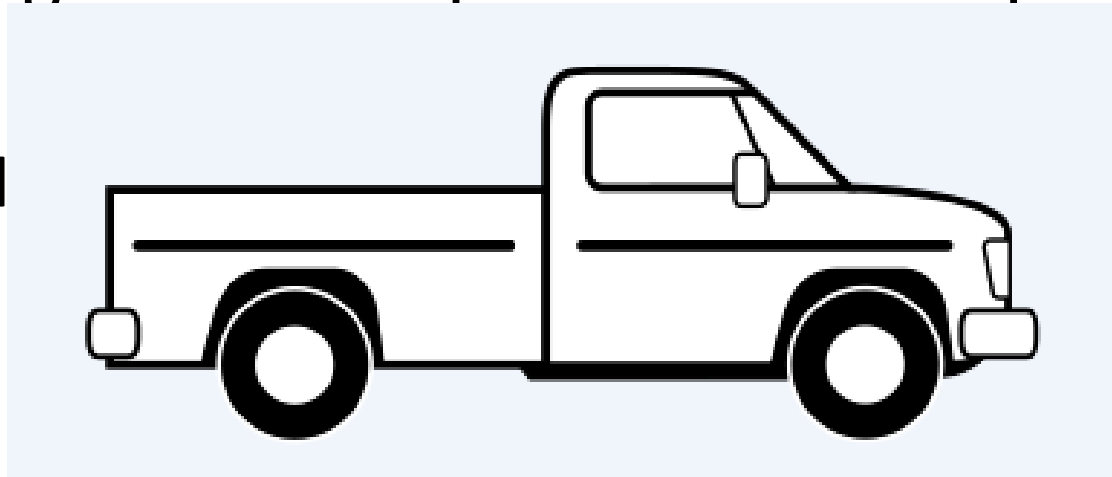
# The Benefits of Standards – Future-Proofing

- The Cab[...]f the road
  - The Ap[...]hicles
- Did you [...]lled your cab[...]?
  - Upgrading your application should be easy

# The Benefits of Standards – Future-Proofing

- The Cabling Standard Specifies the 'Shape' of the

  les

- d

  your cabling?

  – Upgrading your network should be easy

  – Will your network support NBASE-T?

# Category 5e Cabling Supports NBASE-T

- NBASE-T limits are the same as Category 5e for NEXT and Return Loss
  - However – 5 Gigabit limits are based on
  Category 5e limits extrapolated out to 250 MHz

| | 2.5G BASE-T | 5G BASE-T |
|---|---|---|
| Installed Cat 5e | ✓ | Extended frequencies required |
| Installed Cat 6 | ✓ | ✓ |
| Installed Cat 6A | ✓ | ✓ |

- To be *sure* that your existing cabling will support 2.5 and 5 Gigabits you need to compare your test results to limits out to 250 MHz
- How was your cabling certified? To What Standard?
  - Not certified?
  - Continuity?
  - Application Test?
  - Did you store your test data?

# Cabling Performance Requirements for NBASE-T
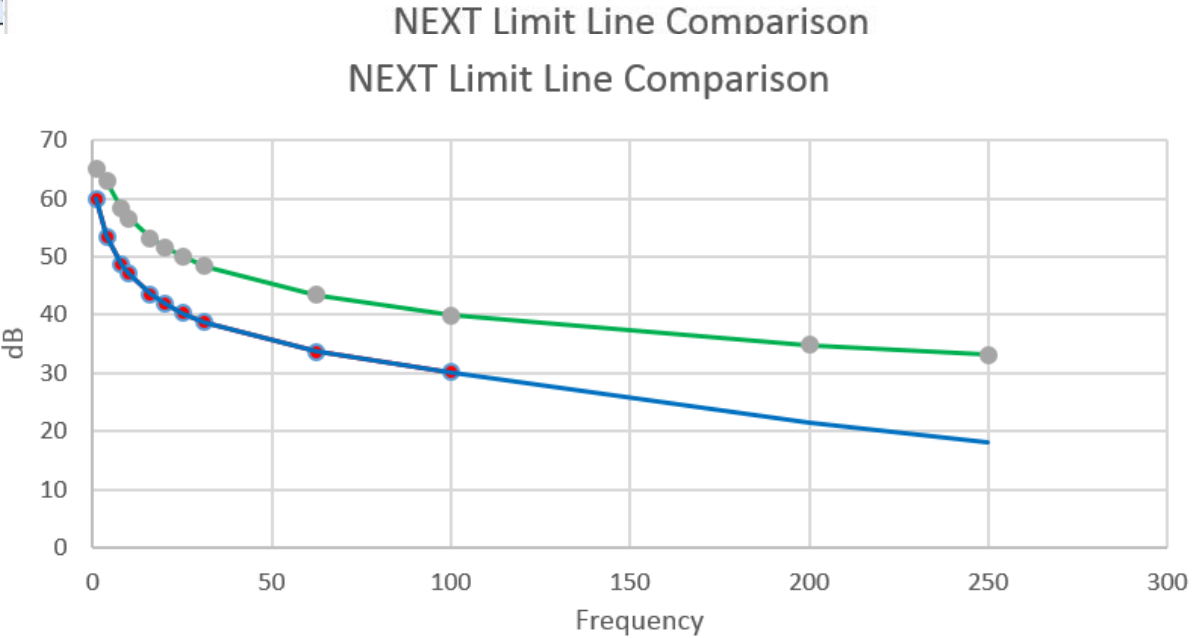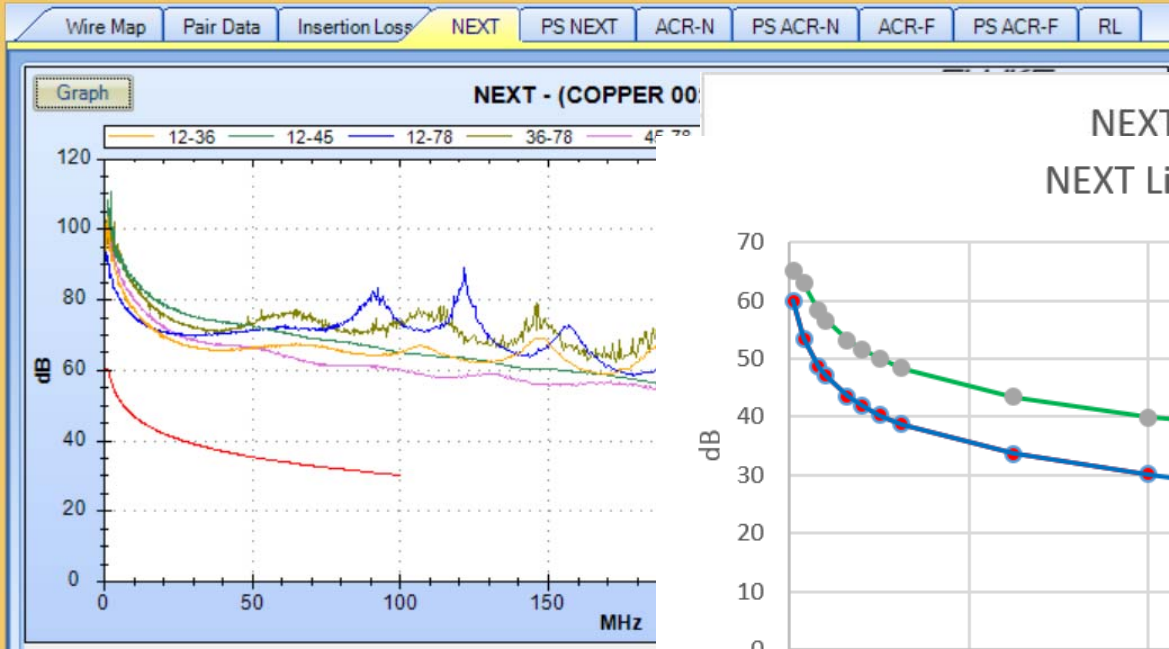
# 5GBASE-T Limits vs 1000BASE-T



**More Stringent Requirement**

1000BASE-T Vs. NBASE-T/Category 5e
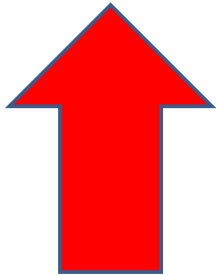
# Alien Crosstalk & Visual Inspection

- Would your cabling win a beauty contest?
  - You *might* have a problem
- How long is your existing cabling in a bundle?
  - The longer the cables are run together, the more susceptible they are to Alien Crosstalk

# Did You Save Your Test Results?

## Find your longest links

### Sort them by length to identify any links that may be vulnerable

| | Cable ID | Date / Time: | Status | Length(m) | Headroom | Info | Test Limit |
|---|---|---|---|---|---|---|---|
| 1 | TR-1A-I17 | 05/14/2015 01:30:42 PM | PASS* | 79.7 | 0.9 (NEXT) | | TIA Cat 6A Perm. Link |
| 2 | TR-1A-I18 | 05/14/2015 01:33:18 PM | PASS | 79.7 | 5.1 (NEXT) | | TIA Cat 6A Perm. Link |
| 3 | 006 | 07/20/2015 12:23:06 PM | PASS | 75.3 | 12.1 (NEXT) | | TIA Cat 5e Channel |
| 4 | LOBBY ENTRANCE PP-H47 SW-00A5-41 | 11/03/2015 02:02:15 PM | PASS | 72.4 | 20.8 (NEXT) | | TIA Cat 5e Perm. Link |
| 5 | E02 | 02/17/2015 08:58:17 AM | PASS | 66.2 | 7.5 (NEXT) | | TIA Cat 5e Perm. Link |
| 6 | 11 | 07/20/2015 02:42:10 PM | PASS | 62.7 | 5.0 (NEXT) | | TIA Cat 5e Channel |
| 7 | 005 | 07/20/2015 12:28:29 PM | PASS | 62.3 | 6.7 (NEXT) | | TIA Cat 5e Channel |
| 8 | LOBBY ELEVATOR PP-H48 SW00A5W-42 | 11/03/2015 01:45:45 PM | PASS | 60.6 | 7.5 (NEXT) | | TIA Cat 5e Perm. Link |
| 9 | INDIGO PPA-16 SW-41 | 11/04/2015 12:15:34 PM | PASS* | 57.7 | 5.7 (NEXT) | | TIA Cat 5e Channel |
| 10 | E05 | 02/17/2015 08:56:30 AM | PASS | 56.7 | 7.4 (NEXT) | | TIA Cat 5e Perm. Link |
| 11 | E01 | 02/17/2015 08:58:47 AM | PASS | 56.3 | 6.4 (NEXT) | | TIA Cat 5e Perm. Link |
| 12 | SR TO HK 13 | 08/03/2015 11:33:37 AM | PASS | 55.9 | 5.3 (NEXT) | | TIA Cat 6 Perm. Link |
| 13 | E06 | 02/17/2015 08:55:43 AM | PASS | 55.9 | 6.6 (NEXT) | | TIA Cat 5e Perm. Link |

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# Sheaths on Ladder Rack – Pretty, but...
## Alien Crosstalk not Considered
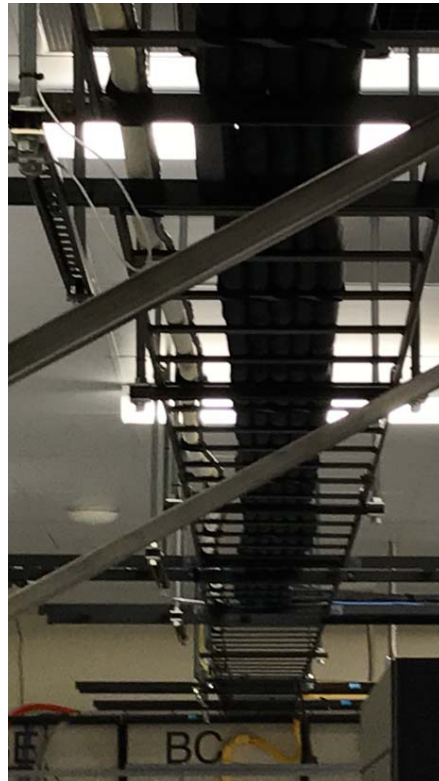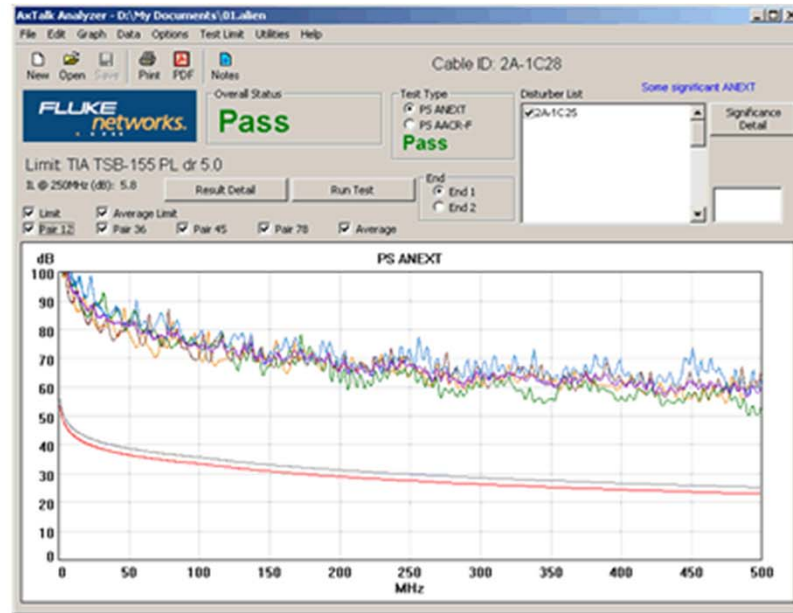
# How to Test Alien Crosstalk

- Power Sum Alien Near End Crosstalk
  - Main Tester on 'Disturbed' or 'Victim' Cable
  - Remote Tester on 'Disturber' – Cycle through all disturbers
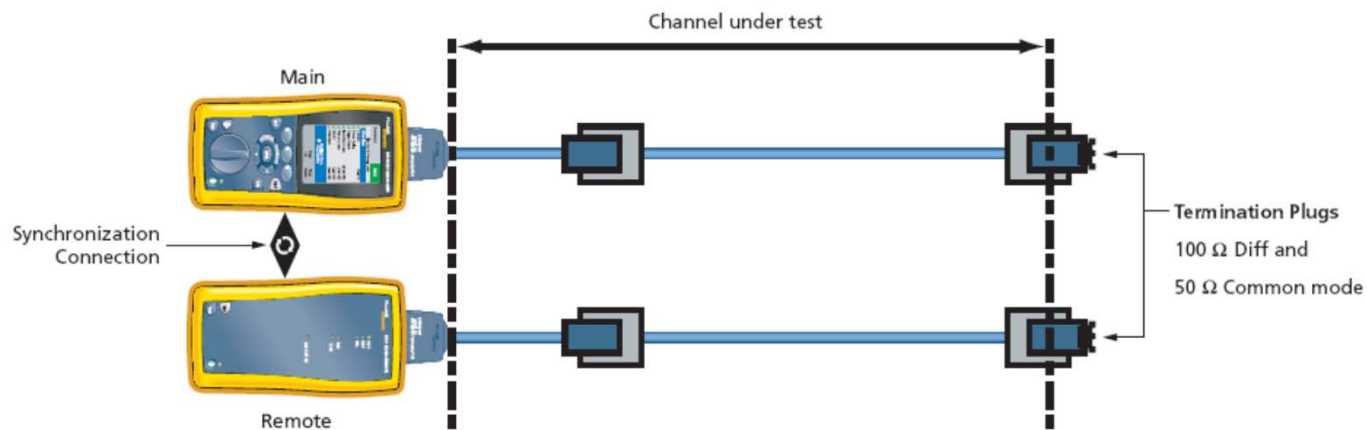
# PS ANEXT Measurement in Motion

# Testing Your Cables Checklist

- Follow and Certify to Category 5e Cabling Limits
  - Category 6 is better
- Re-certify as needed
- Visual Inspection on links for ALSNR susceptibility
- Follow today's standards for ability to support tomorrow's applications
  - ANEXT testing for Category 6A

# NBASE-T Alliance Wrap-up

- NBASE-T provides 2.5Gbps and 5Gbps over installed cabling
  - Interoperable with IEEE 802.3bz (2.5GBASE-T and 5GBASE-T)
  - NBASE-T Downshift adapts to cabling to achieve the best performance
- Interoperable NBASE-T products are providing Wave 2 802.11ac wireless and other needs at > 1Gbps wired access
- Cabling standards and guidelines are in their final stages to support NBASE-T and 802.3bz rollouts
- Field test procedures to maximize performance are available

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# Thank You!