Benefits of DALI for Lighting
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What can DALI do?

Digital control of light quality with intelligent feedback

- Precise, repeatable **light-output control** and standardized dimming curve

- **Occupancy and light-level sensing**
  - DALI-2 sensors and other input devices provide information to the system

- **Luminaire, energy & diagnostics data**
  - Data for enhanced asset management & performance monitoring

- **Emergency lighting**, automated tests

- **Colour control** for human-centric lighting, enhanced comfort and well-being

- DALI is already positioned for the **Internet of Things (IoT)**

- New specifications enable DALI connectivity via **wireless networks** and **IP-based networks**
DALI for dimming

Accurate, repeatable, standardized light-output control

• Certified DALI-2 control gear follow a standardized dimming curve
  – Dimming curve is designed to match human-eye sensitivity and brightness perception
• Testing procedure requires measurement of light output

If you ask for 50% light output, you get 50%

Consistent from fixture to fixture

Consistent between manufacturers
DALI for colour control

- Enables control of the colour output of two or more lamps from DALI control gear

- Allows simple control of colour:
  - RGBWAF for individual control of each colour channel
  - Tc (tunable white) for colour-temperature control

- Allows precise and repeatable selection of colour:
  - $xy$ coordinate (chromaticity)

- DALI scenes allow recall and smooth fading of colour as well as brightness

- For colour accuracy, $xy$ and Tc colour types allow calibration
DALI-2 certification for colour control

- DALI-2 tests are available for 3 colour types
  - Tests are based on Part 209. Colour control gear are also known as device type 8 (DT8)

<table>
<thead>
<tr>
<th>Colour type</th>
<th>Common name</th>
<th>Also known as</th>
<th>Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tc (colour temperature)</td>
<td>Tunable white colour control</td>
<td>DT8(Tc)</td>
<td>Allows control of the correlated colour temperature (CCT) along the black-body line, from warm white to cool white.</td>
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<tr>
<td>RGBWAF</td>
<td>RGB colour control</td>
<td>DT8(RGB)</td>
<td>Allows simple control of up to 6 channels of colour (Red, Green, Blue, White, Amber and Free-colour).</td>
</tr>
<tr>
<td>xy coordinate</td>
<td>xy colour control</td>
<td>DT8(xy)</td>
<td>Allows precise and repeatable selection of the colour co-ordinates from the CIE colour space chromaticity diagram (1931).</td>
</tr>
</tbody>
</table>
DALI-2 certification for colour control

- DALI-2 certification is offered for:
  - Tunable white: Tc only
  - RGB colour control: RGBWAF only
  - Multi-type colour control: All 3 colour types available in the same product
DALI for emergency lighting

• Widely used globally as a robust and reliable solution
  – Provides light when the mains supply fails
  – Safety-critical feature mandated by various regulations

• DALI enables illumination and emergency lighting on same network

• DALI enables automated self-testing:
  – Many countries have a legal requirement for periodic testing
  – Function test: quick test of battery, charging circuit, driver/relay and lamp
  – Duration test: checks operation for the rated duration (e.g. 1h, 3h...)

DALI Alliance presentation
DALI-2 certification for emergency lighting

• DALI-2 certification of control gear for self-contained emergency
  – “Self-contained” means the battery is inside, or placed next to, the luminaire

• DALI provides data e.g. test results, information on failures, battery charge levels, lamp operating hours
  – Monitor and report real-time energy usage (Part 252)
DALI for wellbeing and comfort

Efficient, human-centric lighting

- Daylight harvesting: adjust intensity according to ambient light levels through the day
  - DALI-2 light-level sensors
- Match lighting levels to actual utilization of spaces
  - DALI-2 occupancy sensors
- Colour-temperature control according to time of day and/or individual preference
  - DALI-2 tunable white
- Personal control of lighting via user interfaces
  - DALI-2 input devices such as push-buttons, rotary controls or touch panels
- Building occupants experience improved comfort and wellbeing
  - Higher productivity, better staff retention
DALI for energy efficiency

- DALI builds on energy efficiency gains from using LEDs and basic lighting control (switches, dimmers)

  - LED + sensing + intelligence
  - LED + sensing
  - LED + dimming
  - LED
  - Legacy

Energy efficiency doesn't stop at dimming/occupancy

- With increased interaction, using connectivity solutions and data, even more energy savings are possible
DALI and the circular economy

- DALI enables modular systems/designs
  - Enables components to be interchangeable
  - Certified, interoperable

- Replacement components from multiple sources enable supply-chain longevity
  - Removes supply-chain constraints: Not reliant on single supplier
  - Future-proof by backwards compatibility

- DALI enables the potential to extend the lifetime of luminaires and luminaire designs
  - Easily upgradeable
  - Plug and Play if socketed and standardized e.g. Zhaga-D4i

Source: Zhaga
Source: Signify
DALI data
DALI for data

DALI is built to enable smart, data-rich networks

• Feedback & exchange of data is enabled by two-way communication
  – Control gear provide data on output level, lamp failure, emergency test data and more

• DALI-2 sensors and other input devices
  – Environmental information and user inputs

• DiiA Specifications for data storage and reporting
  – Data for enhanced asset management, performance monitoring & diagnostics, real-time energy usage
  – Data for luminaires, control gear & light sources
Elements of lighting intelligence

Source: Helvar
• Sensors provide information for automated control
• User inputs allow occupants to make adjustments
  – Dimming, colour, scene recall etc

• DALI-2 input device types include:
  – Push-buttons
  – Absolute input devices (switches, sliders, rotary controls)
  – Occupancy sensors (movement or presence type)
  – Light sensors (illuminance level)

• Other sensor types in development include:
  – Colour sensors
  – General-purpose sensors

• Operation can be event driven, or by polling, or by periodic transmission.
DALI data specifications

- Data for enhanced asset management & performance monitoring
- Data storage in DALI memory banks, with standardized format & locations

DALI Part 251 – Luminaire Data
- Information about the luminaire (e.g. GTIN, light output, CCT & CRI, light distribution etc) can be stored in the control gear
- Enables asset management

DALI Part 252 – Energy Reporting
- Provides real-time power & energy usage for control gear

DALI Part 253 – Diagnostics & Maintenance
- Operating data for control gear and lamps, including failure conditions, run-time data
- Enables predictive maintenance

These specifications are available from DiiA, and are also included in ANSI C137.4
Using DALI data

In the factory:
Luminaire data is programmed into drivers

During operation:
Performance monitoring
• Energy usage data can be used e.g. for billing

In the field:
Automated commissioning
• When installed, luminaires can automatically transfer data to a remote network
• Reduces human error, saves installation time and cost
• Operator has a full map of asset information

During operation:
Predictive maintenance
• Diagnostics data allows network operator to anticipate need for maintenance
• Repair team has knowledge of location and type of fixture
D4i and IoT luminaires
D4i overview

• D4i is an extension of DALI-2 certification
• D4i components have a compulsory set of features
  – Based on power-supply and data specifications from DiiA

• All D4i LED drivers provide luminaire, energy & diagnostics data

• D4i enables DALI inside intelligent, IoT-ready luminaires
  – Other D4i implementations are also permitted

• D4i simplifies addition of sensors and communication devices to luminaires

• D4i enables plug-and-play interoperability when combined with a connector system
  – e.g. Zhaga Books 18 & 20, or NEMA/ANSI
D4i example: Indoor luminaire

DALI Part 250 (integrated bus power)
DALI Parts 251-3 (luminaire, energy & diagnostics data)

D4i LED driver with integrated bus power supply and DALI data

Power

Data

Intra-luminaire DALI bus

LEDs

Sensor/communication device

DALI Part 351 (luminaire-mounted control devices)
D4i example: Two-node outdoor luminaire

- DALI Part 150 (AUX power supply)
- DALI Part 250 (integrated bus power supply)
- DALI Parts 251-3 (luminaire, energy & diagnostics data)
- Optional 24V AUX supply
- D4i LED driver with DALI data & integrated bus power supply
- LEDs
- Wireless communication node
- Intra-luminaire DALI bus
- Sensor node
- DALI Part 351
- Remote lighting control network
Zhaga-D4i certification

A joint certification program based on complementary specifications

**Specifications from DiiA enabling D4i certification**

- DALI Part 250: Integrated bus power supply
- DALI Part 251: Luminaire data
- DALI Part 252: Energy data
- DALI Part 253: Diagnostics data
- DALI Part 351: Luminaire-mounted control devices
- DALI Part 150: AUX power supply

**Book 18 & Book 20 specifications from Zhaga**

- Book 18 for outdoor:
- Book 20 for indoor:
  - Mechanical interfaces
  - Electrical pin assignment (Book 18)
  - Electrical connectors (Book 20)
  - References to D4i specs for power & control, and luminaire tests
Connectivity
DALI in an IoT world

How does DALI fit with this simple IoT definition?
• IoT: A system of devices with unique identifiers and ability to transfer data over a network

- **Addressing**: DALI devices are individually addressable
- **Data exchange**: Data exchange is inherent in DALI, due to bi-directional communication
- **Connectivity**: Multiple current & emerging options, including wireless

DALI is already positioned to participate in the Internet of Things
DALI in an IoT world – Connectivity

Current DALI capabilities:

• Multiple DALI subnets can be networked together, for building-wide control
  – A single application controller can control multiple DALI subnets
  – Several application controllers can be connected together via a backbone e.g. Ethernet-based

• DALI systems can connect with other networks via non-standardized gateways
  – e.g. Gateways connecting with building-management systems (BMS)

• D4i facilitates addition of wireless nodes (network lighting controllers) to luminaires
  – Standalone luminaires can participate in remote lighting-control networks

Emerging DALI capabilities:

DALI connectivity via wireless networks
DALI connectivity via IP-based networks
DALI in a wireless world

Two distinct solutions for combining DALI with wireless networking

- DALI Alliance has developed **new specifications** addressing **both options**
- We are developing tests to enable certification programs, in collaboration with partners:
  - Wireless to DALI Gateways
  - Wireless DALI

  **Wireless to DALI Gateways**
  Gateways allow existing DALI wired products to be used in a non-DALI wireless ecosystem

  **Wireless DALI**
  Devices communicate using existing DALI commands, carried over a wireless medium
Wireless solutions for DALI

Wireless to DALI Gateways

Wireless DALI

Wireless DALI+ devices in a mesh network
Wireless to DALI Gateways – Implementation
Introducing DALI+

- DALI+ devices communicate using existing DALI commands, carried over a wireless and/or IP-based physical medium
  - Different from the dedicated pair of wires used by DALI-2 and D4i

- New DiiA Specification supports DALI+ with IP-based carriers e.g. Thread, Ethernet, Wi-Fi
- We are developing tests → “DALI+ with Thread” certification

- Same sophisticated DALI lighting-control features as wired (DALI-2 & D4i) options
- Same access to rich set of data from control gear, luminaires and sensors
- Additional addressing features
DALI+ over Wireless – Bridges

- Bridges allow access to DALI wired luminaires or subnets, from the DALI+ wireless network
- DALI commands are used throughout, and there is no translation between protocols
IP-BLiS (IP for Building & Lighting Standards)

- Internet Protocol for Building & Lighting Standards
- A marketing organization (not a new standards organization)
- Goal: to make commercial buildings more responsive to the needs of users by promoting a secure, multi-standard, IP-based harmonized IoT solution

DALI+ with Thread is an IP-based, wireless solution
Today: Building technologies in silos

There are more connected devices in Smart Buildings every day.

Each system evolved independently with its own proprietary solutions.
Trend: Convergence of Building Systems with IT

Facilitates IoT for commercial buildings.

No silos.
No proprietary applications.

Allows multiple systems to communicate together using cloud services & cloud computing.
Conclusions

• DALI makes a significant contribution to intelligent buildings:
  – Energy efficiency
  – Data monitoring and reporting
  – Future-proofing
  – Wellbeing and comfort of occupants
  – Predictive maintenance
  – Circular economy

• Standardization and certification increases confidence in cross-vendor interoperability

• New specifications enable:
  – DALI over wireless and IP-based connectivity options
  – Gateways to other wireless ecosystems
DALI Alliance contact information

Website
www.dali-alliance.org

E-mail
info@dali-alliance.org

Paul Drosihn
General Manager
GM@dali-alliance.org

Thank you !!