PROTOCOL

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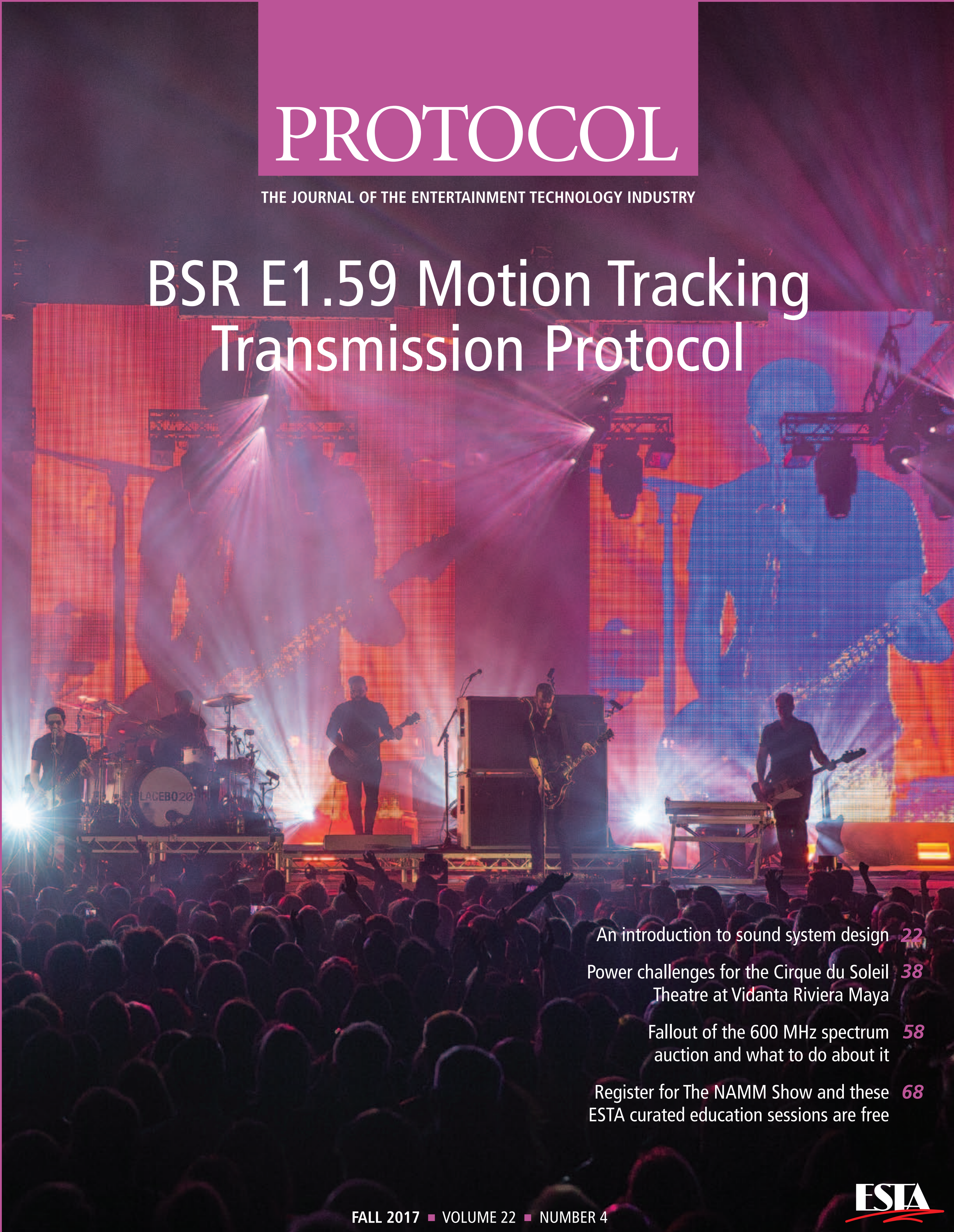

# BSR E1.59 Motion Tracking Transmission Protocol



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**Benjamin La Cour's daring scenography moves during the performance of *American Idiot Copenhagen* via a Kinesys automation system in this production at Den Grå Hal. Lighting design is by La Cour and Sune Verdier and the Kinesys is supplied by Riggingworks in Stockholm. Photo © Louise Stickland is courtesy Robe Lighting.**

# BSR E1.59 Motion Tracking Transmission Protocol

BY DAN LISOWSKI

The E1.59 Task Group is soliciting input on the conceptual model described in this article. Please submit feedback to the group at e159@esta.org, or consider joining this standards effort.

TIME IS A PRECIOUS COMMODITY. We often find ourselves short of it, especially during the technical rehearsal/programming phase of a production process. Every moment that passes is one closer to opening. The technical complexity of shows has dramatically increased over the past decade. From Broadway to Los Angeles, and from proscenium houses to concert arenas, production teams coordinate moving elements with visual/audio effects. This coordination is time-consuming—usually requiring the efforts of experienced software engineers from multiple production companies.

This article will outline the steps that our industry is undertaking to streamline this coordination in order to provide more time and opportunity for these dazzling motion effects in all levels of production.

This is a snapshot in time in a continuous development process. A full white paper with further technical details will be available on the ESTA TSP website by the end of 2017. This article will cover the proposed direction and philosophical concepts present in the draft standard.

The project proposal (which is how all standard-development projects begin) was derived from the thesis research of Dane Styczynski (University of Wisconsin-Madison, MFA 2015). Dane's thesis examined the potential of using current ESTA standards to communicate motion control data between systems. Following a presentation on his proposal, the Control Protocol Working Group of ESTA's Technical Standards Program approved a motion to start development of a new ANSI standard for streaming motion data in entertainment systems. This newly formed BSR E1.59

Task Group is a unique collaboration containing members from both the Control Protocol Working Group (CPWG) and Rigging Working Group (RWG). The members of the CPWG are experts in developing entertainment industry communication protocols. The members of the RWG are experts in the primary source data, stage motion control systems. Together, the task group has the collective experience to undertake this development.

## . . . an industry-wide, fully interoperable, open standard for motion tracking is long overdue.

We (the E1.59 Task Group) believe that an industry-wide, fully interoperable, open standard for motion tracking is long overdue. Industry professionals have spent too much time trying to integrate motion systems with lighting and projection systems, or even with other motion systems. Our intention is to build off the groundwork laid by protocols such as PosiStageNet, BlackTrax, and EtherCAT. We aim to incorporate the lessons learned from implementing these and other entertainment networking standards to develop a useful protocol with an eye toward future needs.

This standard will focus on reporting data about objects in motion. An object in motion could be a scenic element, a piece of machinery, a dancer, or a chunk of confetti fluttering from the grid to the ground. While the genesis of this standard focused on motion control systems as the primary data provider, the scope has expanded to include any device capable of transmitting accurate motion data. The configuration and functionality of these objects is outside the scope of this standard.

Definitions:

*Producer*: the sender of motion tracking data

*Point*: the smallest, indivisible component having properties of motion

*Receiver*: the communication destination capable of interpreting motion data

The first important concept that the task group addressed was how communication networks would ideally be utilized for this protocol. To promote maximum flexibility, four communication paradigms were established as core to the protocol.

One-to-One (**Figure 1**): One Producer transmits data to one Receiver. Simplest network architecture. Typical in current systems where a motion control system transmits Point data to a media server.

One-to-Many (**Figure 2**): One Producer transmits data to multiple Receivers. This communication paradigm is desirable when multiple systems desire Point data. An example system could be an optical motion tracking system that transmits data to a media server, sound system, and light tracking interface.

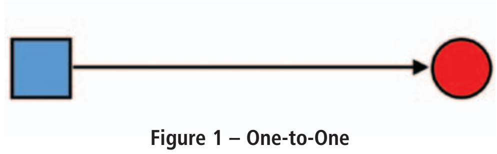

**Figure 1 – One-to-One**

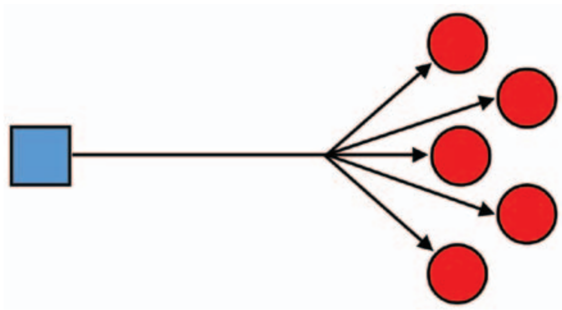

**Figure 2 – One-to-Many**

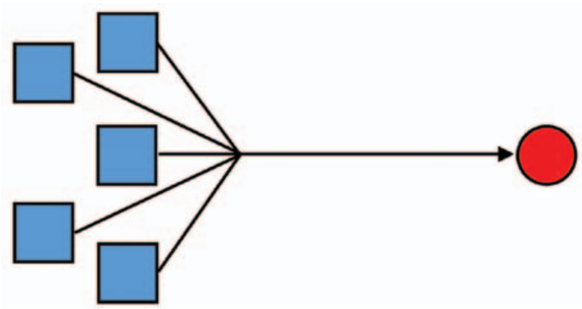

**Figure 3 – Many-to-One**

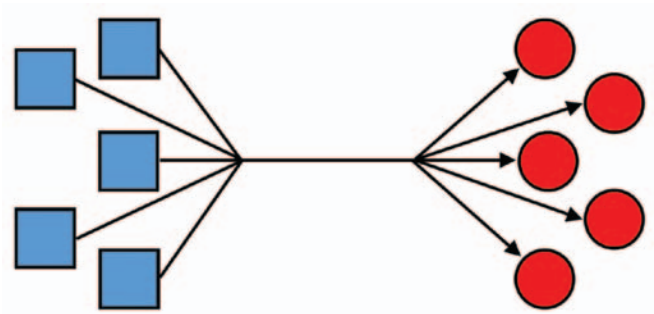

**Figure 4 – Many-to-Many**

Many-to-One (**Figure 3**): Multiple Producers transmit data to a single Receiver. This communication paradigm is the most forward thinking and innovative of the list. Many individual position-tracking devices can exist on the same network and transmit to a single Receiver. The Receiver in this case could be any of those previously listed as well as a motion control system or other intermediary. To function in large quantities, these individual Point Producers will be uniquely identifiable and configurable into user groups.

Many-to-Many (**Figure 4**). Multiple Producer transmit data to Multiple Receivers. This all-encompassing communication paradigm functions as a combination of the previous two types (One to Many and Many to One).

With the real-time reporting needs and these communication paradigms in mind, multicast UDP is being considered as the transport layer protocol. The overall protocol will use an architecture similar to that of sACN (*ANSI E1.31*), with a motion-focused payload. The data will be in big-endian order and all numbers will be stored in high precision integer form, rather than using floating-point math.

The proposed base units for linear position (x-z), velocity ($V_{x\text{-}z}$), and acceleration ($A_{x\text{-}z}$) are in microns (µm, 1/1,000,000th of a meter) and associated time-based derivatives (µm/sec and µm/sec2). This seemingly insignificantly tiny measurement scale was agreed upon following thoughtful deliberation and calculation. The paramount reason to use microns is to eliminate the use of decimals throughout base units. Decimal numbers are most often represented in computation systems as floating-point number datatypes, which are fraught with calculation delays and other pitfalls.

The selection of microns over millimeters as the base unit was agreed upon based on anticipated travel distance and accuracy in velocity and acceleration units. A 4-byte signed integer has a range from -2147483648 to 2147483647, which when converted into meters from micron units has a range from approx. -2,147 meters to 2,147 meters. The task group assumes that this bound is within normal entertainment industry operating parameters. A similar rationale is being considered for rotational units. The unit of millidegrees provide enough accuracy in both angular velocity and acceleration calculations.

Each Producer utilizing this protocol will self-assign the following:

- A human-readable name (16 bytes)
- A computer-understandable, universally unique identifier (16 bytes)

These identifiers will be combined with the following in every packet:

- Protocol Identifier (8 bytes)
- Packet Sequence Number (4 bytes)
- Version Identifier (2 bytes)

Each Point will be unique within a producer and will contain the following:

A computer-understandable, producer-unique identifier (2 bytes)

- Point Timestamp (4 bytes)
  - Our standard will include guidance on the synchronization of time, referencing *IEEE 1588*, but the synchronization method is beyond the scope of this phase of the standard.
- Type of Point Data Structure (1 byte described in more detail below)
  - Length of Data Structure (1 byte)
  - Point Data (1-256 bytes)

The draft standard currently defines four unique data structures. These data structures contain different variations of position, velocity, and acceleration in both linear and rotational aspects depending on the needs of the system. The addition of the Length data in the Point header allows additional user defined data structures to be implemented on an individual production basis.

Type 0: $x, y, z$

Type 1: $x, y, z, V_x, V_y, V_z, A_x, A_y, A_z$

Type 2: $\theta_x, \theta_y, \theta_z, \omega_x, \omega_y, \omega_z, \alpha_x, \alpha_y, \alpha_z$

Type 3: $x, y, z, V_x, V_y, V_z, A_x, A_y, A_z, \theta_x, \theta_y, \theta_z, \omega_x, \omega_y, \omega_z, \alpha_x, \alpha_y, \alpha_z$

Type 0 is the simplest of the data structures. This data structure contains only the current position of the point in all three linear directions (x, y, and z). This data type is appropriate for slow translation-only motion or for use by Producers that do not have the ability to calculate/communicate velocity or acceleration values.

Type 1 is the complete translational motion data structure. This data structure contains the current position as well as the current velocity and acceleration values. These values are extremely useful when tight visual synchronization is desired. For instance, these velocity and acceleration values can be input into a feedforward calculation performed by a media server to anticipate where an object will be at a near future time.

Type 2 is the complete rotational motion data structure.

Type 3 is the complete linear and rotational data structure.

The E1.59 Task Group is soliciting feedback on the conceptual model above. Does this planned architecture address the needs of the industry and your implementation? If not, what needs still need to be addressed? Are there additional requirements or other items to report?

Please submit feedback to the group at e159@esta.org, or consider joining this standards effort by becoming a member of the Rigging or Control Protocols Working Group. Application forms can be found at http://estalink.us/zm9e1. ■

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