# Digital Program Insertion (DPI) White Paper

## Introduction

Digital Program Insertion, frequently called "DPI" by those familiar with the technology, is suddenly the focus of worldwide attention. Why is this and what impact does it have on broadcast operations?

This paper will explain why interest is so high and what the users expect the technology to accomplish for them. It will also discuss some of the system issues that users must consider. Finally, the paper will examine what has been happening with regards to Standards as well as what capabilities vendors have already implemented.

## The Need for Splicing

Why might someone need to switch or splice video signals? The answer is as simple as the need to change camera angles, view pre-produced footage during a live event or switch to a feed from a remote location. All of those events require the ability to switch sources. Since viewers would likely complain if it disrupted their program, switching needs to be "seamless."

Users of non-compressed video systems (usually referred to as "baseband" systems) are accustomed to switching (splicing) analog signals. All that is required is a vertical-interval switcher and two sources to switch between. Of course, those two sources have to be properly timed to each other (done via "genlock" synchronization). This technology is simple, widespread and inexpensive.

For transmission systems, where the splicing equipment is remotely located from the production "headend," a form of "out-of-band" signaling was devised. This out-of-band signaling has standardized (de facto) on the DTMF ("Dual Tone Multi-Frequency") code sequences utilized in digital telephony for dialing and control. There is no standardization of the sequences themselves, leaving users to employ a number of specialized detectors that service each specific program provider's sequence. These detectors translate the sequence into one or more contact closures.

When digital compression technology was first introduced, many users did not believe that general purpose splicing of compressed signals would ever be possible, especially in a Multi-Program Transport Stream (MPTS). The technical issues are indeed formidable.

Hybrid compressed/baseband systems were created where splicing is still accomplished in the uncompressed domain. What this means is that most signals go through several compression/decompression steps en route to the viewer. This situation is referred to as concatenation of compression and the results are often ugly. Nonetheless, splicing is possible and the existing DMTF tone sequence mechanism remains in place.

Over the past several years, a number of companies have produced general-purpose splicers that function without decompressing the MPEG-2 signal. Interestingly, they will perform splicing in MPTS as well as in Single-Program Transport Streams (SPTS). When it became clear this technology would indeed be available and function well, broadcaster interest in it grew rapidly. It was realized that if the splicing triggers were carried in digital form, new and expanded capabilities would also become possible.

Drafting of the Standards began several years ago, focusing initially on the splicer/server portion of the system, and permitting continued utilization of the existing contact closure mechanisms. The Standards for the in-band signaling between the compression system and the splicer/server were devised shortly thereafter.

### What is the situation today?

Standards are in place to facilitate interoperable systems in most aspects. More importantly, the messaging between the video compression system and the remotely-located splicer is standardized. Missing at this moment is a completed standard defining the messaging between the triggering system, usually known as an Automation System (AS), and the Digital Compression System (DCS), which actually places the splicing messages at correct points in the Transport Stream (TS).

## Program Insertion vs. Ad Insertion

Since television broadcast operations are based on different business models, the DPI Standards were developed with a variety of operations in mind. This fact may be lost on those who use seemingly contradictory terms for the technology. Among these terms are "Program Insertion" and "Ad Insertion," both of which actually refer to DPI functionality.

### Some different models

In operations funded by advertising, the insertion of advertisements into programming breaks is a key element of the operation's consideration. In certain parts of the world, the cable systems that ultimately distribute the programming may be permitted, under certain circumstances, to insert advertisements at specified points in the program. In North America, these points are termed "avails."

In operations where advertising revenue is not a factor, there is often a desire to insert local content or promotions into a national feed. Typically, this will be local news, but other programming may be inserted as well. Currently this requires decoding, analog switching, and re-encoding. It also requires local staff to perform the switching.

In some ad-funded operations, operators may wish to lower staff costs by centralizing program origination and most switching. This model is often called centralcasting. Here too, local news and other programming must be switched into the network feed at the appropriate times. In addition, the desire to retain local advertising revenue means that some commercials must be inserted as well. Thus a centralcasting model will include both program and ad insertion.

### Are they incompatible?

The Standards as adopted provide for both program and ad insertion.

## Terminology

Those broadcasters who do not rely on advertising revenue may not wish to discuss the technical details of DPI in terms of advertisements.

Herein, the term "long-form" insertion will refer to program length insertions of 10 minutes or longer in duration, and "short-form" will describe those insertions of shorter duration. Please note that short-form insertions include identifications and promotions as well as advertisements, and long-form insertions may also be advertisements (paid programming, for example).

## Do the Standards provide all the necessary tools?

At present the only ratified Standards (1) provide for server/splicer communications at splice-points (and emphasize short-form content), and (2) provide for the cue messages to be inserted in the TS. There is no ratified standard to cover the mechanism to generate the cue messages. There is, however, a proposed standard for this. Implementation of this draft Standard or use of a proprietary mechanism are all that are available at the moment. Also missing are clarifications for splicer behavior when there is no server present (long-form insertion system as shown in Figure 3). Splicing in the SCTE 30 paradigm makes the server the master. Without a server present the splicer behavior is not fully defined.

System Interoperability Testing

In the United States, an industry organization called CableLabs has undertaken initial testing of equipment supporting the server/splicer standard and the cue message standard. These tests have focused exclusively on short-form insertions. A number of splicer manufacturers have not yet written software to support long-form insertion.

### What DPI Standards are relevant?

Two bodies have been working on DPI Standards. The lead body has been the Society of Cable Telecommunications Engineers or SCTE. SCTE is a North American professional organization of engineers who specialize in cable system design, implementation and maintenance. It is assigned by the State Department of the United States as the drafting body in this area of technology.

The second body is the International Telecommunication Union or ITU. The ITU is a body of the United Nations chartered with developing international Standards for telecommunications. ITU Study Group 9 deals with these subjects and has adopted SCTE 35 as ITU-T Recommendation J.181.

SCTE 35 (also ratified as ITU-T J.181 and formerly known as SCTE DVS/253)

This Standard defines the cue messages that are embedded in the TS.

SCTE 30 (formerly known as DVS/380)

This Standard defines the communications between a splicer and a server in response to the messages defined in SCTE 35.

DVS/379r1

This draft document is a guideline to the usage of SCTE 35 and SCTE 30. It clarifies obscure points and makes implementation suggestions.

DVS/525r2

This draft document proposes a draft Standard for communications between an automation system (or other source of stimulus) and an encoder which will generate SCTE 35 messages in response to such stimulus. Please note the number following the "r" will change as the document evolves.

### How does one obtain copies of these Standards?

All of the SCTE Standards are available at the following URL: http://www.scte.org/Standards/standardsavailable.html. ITU Standards may be purchased online at: http://www.itu.int/publications/bookstore.html.

## System Architectures

High level system architecture drawings are supplied for a short-form oriented system and for a long-form oriented system. The short-form oriented system drawings include one of a "hybrid" system to provide the reader with a better understanding of this level of technology.

Please note that the short-form oriented system and the long-form oriented system differ very little in construct.

## High-level System Architecture of a Short-form Oriented System

The overall system consists of many components that must interact according to certain expectations. The operators are currently using "hybrid" systems which are only one step away from pure analog. The typical system components are (1) a Traffic and Billing System, (2) an Automation System (AS), (3) a Conditional Access (CA) System, (4) a Digital Compression System (DCS), (5) a Transmission System, and (6) (at the receive end) a Commercial Insertion System (currently analog).

The context that this signaling must function in is shown in the next two drawings. Block diagrams for both a current hybrid system (Figure 1) as well as a future fully digital system (Figure 2) are provided. Please note that the Transmission System is bundled into the Digital Compression System for simplicity.

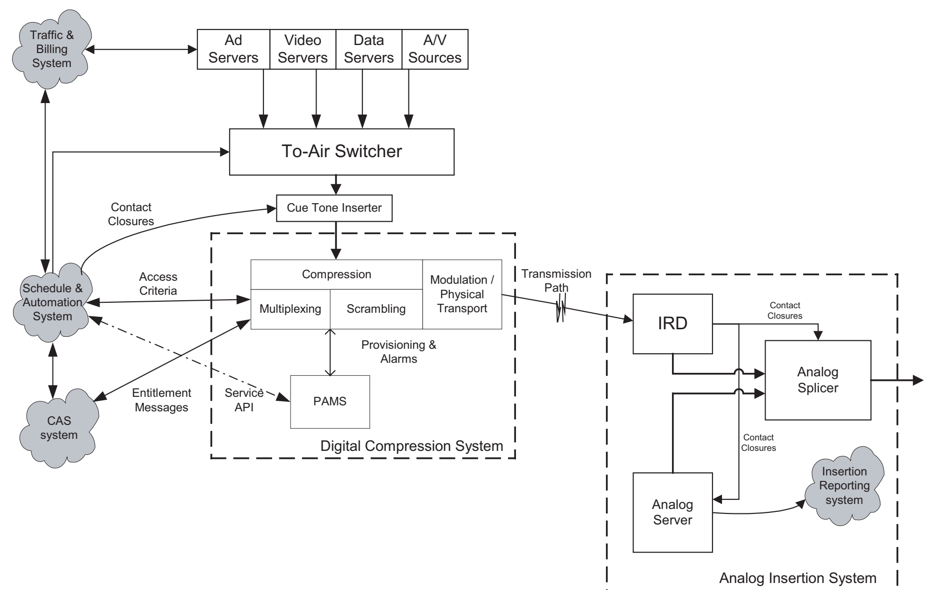


**Figure 1** Hybrid Short Form Oriented System Block Diagram

## The Hybrid System

The signal flow begins with baseband video and audio signal(s), which are played back (for entertainment applications) or created live (for news and sports applications). The basic play-out is under the logical control of a Traffic and Billing System (the "cloud" on upper left) and the physical control of an Automation System (the "cloud" in the middle left). The positions of advertising avails are signaled via DTMF analog cue tones inserted into a non-program audio channel.

These baseband signals are then compressed into an MPEG-2 Transport Stream (TS) by the DCS. (Usually as an MPTS rather than a SPTS). The DCS normally includes several encoders, multiplexers, and almost certainly conditional access. All of these components are under the watch of a master Provisioning and Alarm Management System, or "PAMS." The PAMS function is frequently referred to as a "Network Management System" (NMS) by various vendors. However, since PAMS itself is frequently under the supervision of a higher level network management system, this paper will use the term PAMS instead of NMS, which more precisely describes its functionality.

The TS is transmitted via various physical media (satellite RF, terrestrial microwave RF, fiber optics, or other wideband technology) to the insertion point, where an IRD, a server, and a splicer (or more properly, a switcher) reside. The IRD decodes the TS back to baseband video and audio, which is frequently analog composite. Additionally, the IRD generates contact closures in response to the cue tones. These contact closures are used to trigger behaviors in both the server and the switcher.

The action of this insertion system is then reported to an Insertion Reporting System, which manages the proper billing of the advertisers. In most cases, the Insertion Reporting System has no direct ties to the distributor's Traffic and Billing System (the "cloud" at the upper left of the diagram).

## User Expectations

Customer expectations of system performance are modest — clean video switches but no "frame accuracy." The only real change to what had been an all-analog system was the addition of compression and digital transport.

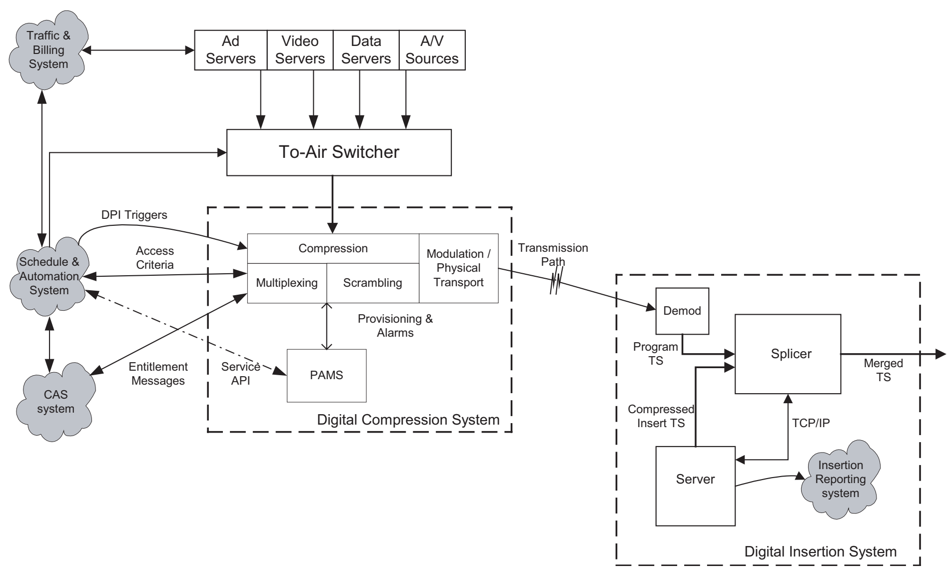


**Figure 2** Digital Short Form System Diagram

## A Fully Digital System

Most of the system functions in the same manner as the hybrid system. Once again, the Traffic and Billing System is the basic driver and the Automation System handles the physical control. The first major difference is that instead of triggering cue tones, the Automation System will trigger the DCS to place SCTE 35 messages in the Transport Stream.

At the insertion point, the required equipment is somewhat different. A simple demodulator/descrambler to recover the Transport Stream is used instead of an IRD. The demodulator has no requirement to generate contact closures, since in-band signaling is utilized (SCTE 35 messages). The demodulator's output is usually DVB-ASI.

The splicer is a true MPEG-2 splicer, not a video switcher. The server is also an MPEG-2 based device.

The splicer inserts material from the server in place of the incoming Transport Stream (TS) in response to SCTE 35 commands embedded in the TS. The resulting spliced TS is then distributed further.

### User Expectations

Customer expectations of a fully digital system's performance are fairly high (clean video switches with frame accuracy). This is a major change in expectations for DPI's behavior. It is worth noting that the delivery of clean switches is the responsibility of the splicer involved, rather than the encoder or server.

## High-level System Architecture of a Long-Form Oriented System

The diagram below (Figure 3) shows a long-form oriented system architecture. Note the obvious similarities with the short-form oriented system.

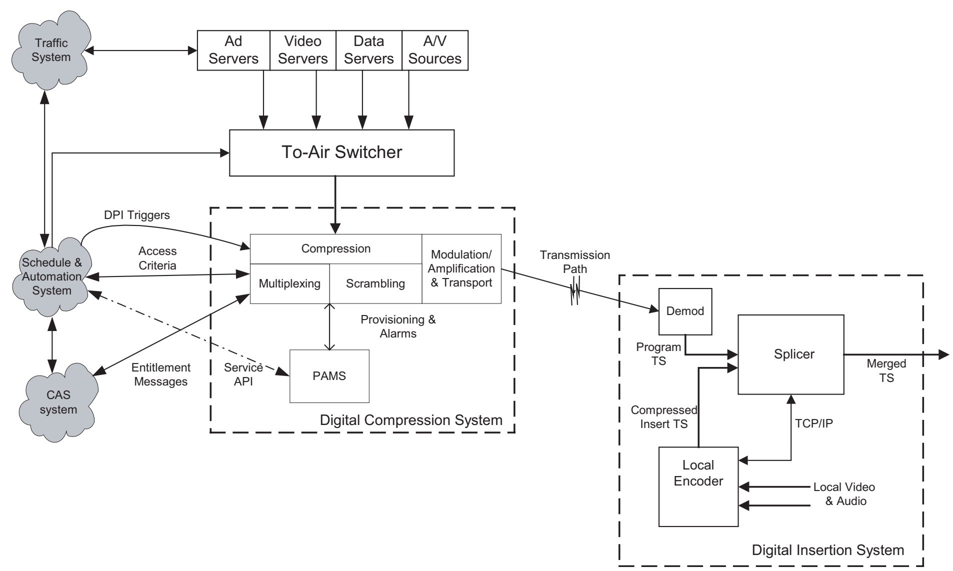


**Figure 3** Digital Long Form Oriented System Diagram

The major difference between the short-form and the long-form systems is that in the long-form system, content to be inserted originates live and is real-time compressed before insertion. This implies that the "Digital Insertion System" is more commonly referred to as a regional production center or regional bureau. While there may be stored material inserted here as well, it will typically originate as baseband video and audio (whether from tape or disk).

## Combination System Architecture

The drawing below (Figure 4) shows a combination system, in which long-form content and short-form content may originate via either live studio or MPEG-2 server.

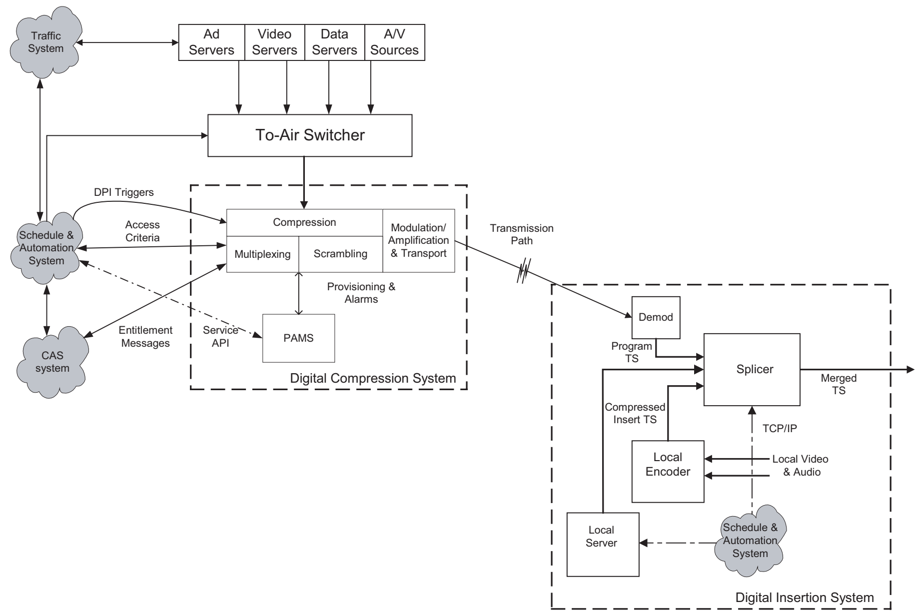


Figure 4 Combination Form Insertion System

Note a new element shown in the Digital Insertion System: a local Scheduling and Automation System that acts in response to the network headend system. The local system reacts to SCTE 35 messages, determines the source of the insertion material and tells the splicer which source will be utilized.

## User Expectations

Customer expectations of DPI system performance are fairly high (clean video switches with frame accuracy). This is a major change in expectations for DPI's behavior.

# Summary

While the technology for Digital Program Insertion is rapidly becoming available, completion of the standardization efforts may take several more years. Harmonic, committed as firmly as ever to open Standards, has implemented both the SCTE 35 cue messages and the Automation System to Compression System triggering API based on DVS/525r2, the current draft Standard. Harmonic recognizes that its implementation will need to accommodate any changes to the draft as it becomes formally ratified.

Harmonic is committed to ensuring its customers have a fully interoperable open Standards system that permits customers to protect their investment and lower their risk of technological obsolescence.

## Informative Annex -- Important technical details

The following sections provide important technical details that some readers may not wish to pursue. For those who do, there will be a fundamental discussion of system functional components and data communications timelines.

## Fundamental System Components

The diagram below is based on Figure 6-1 from the SCTE 30 Standard, and shows a single encoder and single splicer. As shown in Figure 2, the encoder is part of a larger Digital Compression System, which normally includes several other encoders (for other channels), multiplexers, and almost certainly conditional access.

The diagram in Figure 5 introduces a key function that did not appear in earlier drawings, and may (for some) be considered a function of the Automation System. This function is called the "Service Mapper." It serves to map program names (or other Automation System concepts) to physical encoders in systems where the encoders are frequently reassigned to new programs. Such systems are fairly common in sports applications, but less so in entertainment or news applications.

The particular requirements of TCP/IP based messaging may be another reason an Automation System might implement a Service Mapper function, since most Automation Systems evolved with serial communications and permanent connectivity with devices. The Service Mapper, in this case, can act as the "proxy" for the Automation System in its communications with the Digital Compression System.

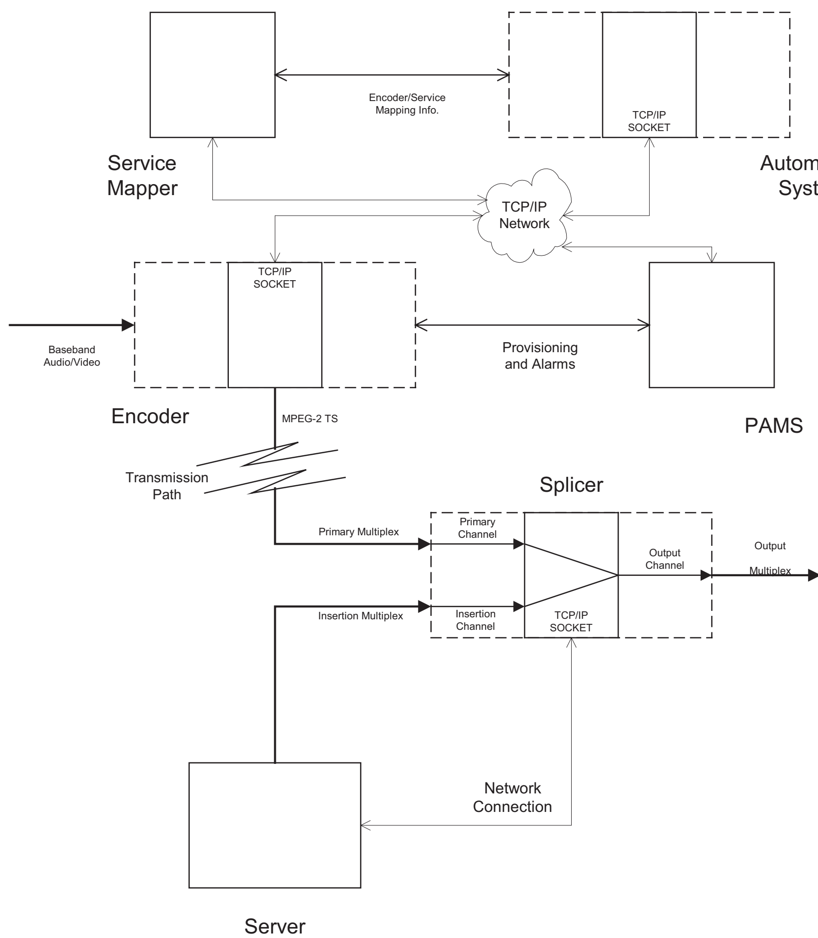


Figure 5 DPI Basic System Components

## Data Communications Considerations

Both SCTE 30 and DVS/525r2 require periodic "Alive_Request" and "Alive_Response" messages (between the encoders and the Automation System as well as between splicers and servers). This may be a compelling reason an Automation System will wish to have a Service Mapper function added (see Figure 6 for more detail).

Additional traffic may be considered a burden to an Automation System and the Service Mapper would be an easy way to offload it. While the block diagram shows the Automation to Service Mapper as a TCP/IP communication, it could also be implemented as a permanent serial connection.

Note that there are two independent TCP/IP networks shown, one at the distribution head-end and another at the splicing point. Neither of these should be connected to either the commercial Internet or any other WAN. They are intended to be strictly private, closed networks for the use of the Automation and Compression systems.

As a result, latency in a moderately trafficked TCP/IP network should be much less than 1 video frame time (33.37 ms for NTSC and 40 ms for PAL). Thus the Automation System may confidently assume the encoder will receive a trigger within the current video frame. As a result, the use of time-stamping is not required.

## Implementation

The drawing below (Figure 6) shows the overall timeline of the messages between some of the various devices in Figure 5. Please note that only the Automation System to Encoder messages are shown. Refer to SCTE 30, Figure 10-1, for the matching diagram of the splicer and server communications.

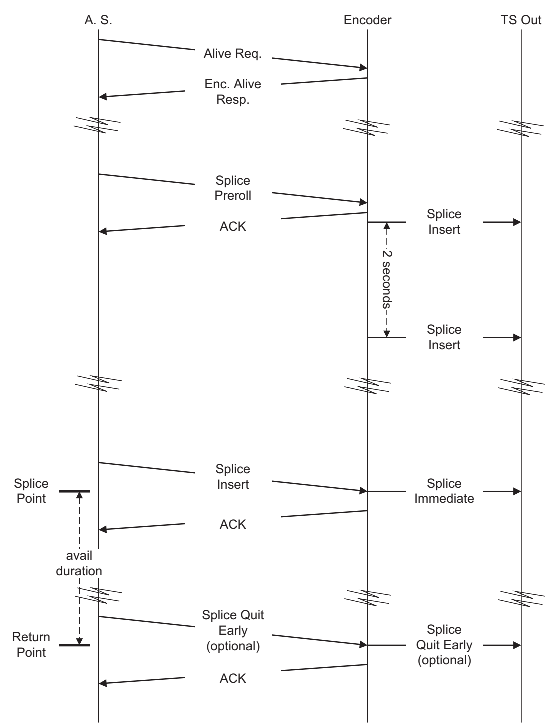


**Figure 6** Automation System/Encoder Message Timeline

**Note** The abbreviation "ACK" is used to indicate a message signaling acknowledgement of the Automation System's message.

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