Preamble to Video Services Forum (VSF) Technical Recommendation TR-06-4 Part 8

June 16, 2026

The Reliable Internet Stream Transport (RIST) project was initiated as an Activity Group under the auspices of the Video Services Forum in 2017. The RIST Protocol is defined by TR-06-1 (RIST Simple Profile, published in 2018 and updated in 2020), TR-06-2 (RIST Main Profile, published in 2020 and updated in 2021 and 2022), and TR-06-3 (RIST Advanced Profile, published in 2021 and updated in 2022).

The TR-06-4 series of recommendations define ancillary features for the RIST protocol that are applicable to multiple profiles. This series includes:

- TR-06-4 Part 1, Source Adaptation, published in 2022.
- TR-06-4 Part 2, Use of Wireguard VPN in RIST Devices, published in 2023.
- TR-06-4 Part 3, RIST Relay, published in 2023.
- TR-06-4 Part 4, RIST Decoder Synchronization, published in 2024
- TR-06-4 Part 5, RIST Multicast Discovery, published in 2023.
- TR-06-4 Part 6, RIST Transport Stream Program Selection, published in 2024.
- TR-06-4 Part 7, RIST Satellite-Hybrid: In-Band Method, published in 2025.
- TR-06-4 Part 9, RIST OTA-Hybrid: IP Transport Method, published in 2026.

This document is TR-06-4 Part 8, RIST Satellite-Hybrid: Out-of-Band Method. Satellite is the ideal way to distribute content to many geographically distinct locations. However, typical geo satellite distribution methods are unidirectional, and, depending on frequency used, may be subject to interference or rain fade. This Technical Recommendation describes a method to use the satellite (or any unidirectional transmission method based on MPEG-2 transport streams) as the primary distribution channel, while using RIST to recover any data that is corrupted or lost in transit. Unlike TR-06-4 Part 7, this Technical Recommendation does not require any data insertion or modification of the transport stream; it is intrinsically backward-compatible with legacy receivers. It is called “Out-of-Band” since all the recovery actions happen over the Internet.

Work continues within the group towards developing additional RIST specifications that include additional features. As the Activity Group develops and reaches consensus on new functions and capabilities, these documents will also be released in support of the RIST effort. For additional information about the RIST Activity group, or to find out about participating in the development of future specifications, please visit Activity Groups – Video Services Forum.

Video Services Forum (VSF) Technical Recommendation TR-06-4 Part 8

Reliable Internet Stream Transport (RIST) Satellite-Hybrid: Out-of-Band Method

Approved June 16, 2026

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Executive Summary

Satellite distribution is the ideal way to send the same content to many locations that are geographically distributed. However, typical geo satellite distribution methods are unidirectional, and, depending on the frequency, may be subject to interference or rain fade.

This Technical Recommendation describes a method to use the satellite (or any similar unidirectional one-way transmission method employing MPEG-2 Transport Streams, such as DVB-T) as the main distribution channel, with RIST as a backup to recover data that is lost or corrupted in the space segment. The method is backward-compatible with existing legacy receivers and does not require any changes to the transport stream sent to the satellite; all recovery actions are done through the Internet. It is called "out-of-band" due this fact.

Recipients of this document are invited to submit technical comments. The VSF also requests that recipients notify us of any relevant patent claims or other intellectual property rights of which they may be aware that might be infringed by any implementation of the Recommendation set forth in this document, and to provide supporting documentation.

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1 Introduction (Informative)

As broadcasters and others increasingly utilize unconditioned Internet circuits to transport high-quality video, the demand grows for systems that can compensate for the packet losses and delay variation that often affect these streams. A variety of solutions are currently available on the market; however, incompatibility exists between devices from different suppliers.

The Reliable Internet Stream Transport (RIST) project was launched specifically to address the lack of compatibility between devices, and to define a set of interoperability points using existing or new standards and recommendations.

Satellite distribution is the ideal way to send the same content to many locations that are geographically distributed. However, satellite transmission may be subject to localized degradation due to rain fade, interference, and other factors. Additionally, in many geo distribution cases, the satellite link is unidirectional, from one source to a multitude of receivers – no return channel exists. One possible approach to solving this content delivery problem is to augment satellite delivery using the Internet. The basic idea is to use the satellite for the "heavy lifting" (transmitting as much data as viable), with the Internet to "fill in the gaps". In other words, any data that is corrupted or lost in transit is retransmitted over the Internet using RIST, and only to the locations that need it. If there is a complete satellite fade (e.g., due to rain), the Internet can be temporarily used to deliver the complete signal. This way, if a region is experiencing any sort of fade or interference, only the receivers in that region need to use the Internet.

A requirement for the solution to this problem is that it must co-exist with current receivers to allow for gradual deployment. Such receivers expect a traditional MPEG-2 Transport Stream. The method presented in this Specification does not require any changes to the Transport Stream. Broadcasters utilizing this solution can then gradually deploy the solution as needed, with high-priority sites being upgraded first.

This Technical Recommendation describes a method to use the satellite forward path in a way that is compatible with legacy receivers, and RIST to correct any lost data. It is called "out-of-band" because no additional data is added to the satellite path, and all recovery happens over the Internet. This solution is not limited to satellite; it can also be used to augment any large-scale point-to-multipoint network that uses a transport stream without an IP layer.

1.1 Contributors

The following individuals participated in the Video Services Forum RIST working group that developed this technical recommendation.

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1.2 About the Video Services Forum

The Video Services Forum, Inc. (www.vsf.tv) is an international association dedicated to video transport technologies, interoperability, quality metrics and education. The VSF is composed of service providers, users and manufacturers. The organization's activities include:

- providing forums to identify issues involving the development, engineering, installation, testing and maintenance of audio and video services;
- exchanging non-proprietary information to promote the development of video transport service technology and to foster resolution of issues common to the video services industry;
- identification of video services applications and educational services utilizing video transport services;
- promoting interoperability and encouraging technical standards for national and international standards bodies.

The VSF is an association incorporated under the Not For Profit Corporation Law of the State of New York. Membership is open to businesses, public sector organizations and individuals worldwide. For more information on the Video Services Forum or this document, please e-mail opsmgr@vsf.tv.

2 Conformance Notation

Normative text is text that describes elements of the design that are indispensable or contains the conformance language keywords: "shall", "should", or "may". Informative text is text that is potentially helpful to the user, but not indispensable, and can be removed, changed, or added editorially without affecting interoperability. Informative text does not contain any conformance keywords.

All text in this document is, by default, normative, except the Introduction and any section explicitly labeled as "Informative" or individual paragraphs that start with "Note:"

The keywords "shall" and "shall not" indicate requirements strictly to be followed in order to conform to the document and from which no deviation is permitted.

The keywords "should" and "should not" indicate that, among several possibilities, one is recommended as particularly suitable, without mentioning or excluding others; or that a certain

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course of action is preferred but not necessarily required; or that (in the negative form) a certain possibility or course of action is deprecated but not prohibited.

The keywords "may" and "need not" indicate courses of action permissible within the limits of the document.

The keyword “reserved” indicates a provision that is not defined at this time, shall not be used, and may be defined in the future. The keyword “forbidden” indicates “reserved” and in addition indicates that the provision will never be defined in the future.

A conformant implementation according to this document is one that includes all mandatory provisions ("shall") and, if implemented, all recommended provisions ("should") as described. A conformant implementation need not implement optional provisions ("may") and need not implement them as described.

Unless otherwise specified, the order of precedence of the types of normative information in this document shall be as follows: Normative prose shall be the authoritative definition; Tables shall be next; followed by formal languages; then figures; and then any other language forms.

3 References

VSF TR-06-1:2020, Reliable Internet Stream Transport (RIST) Protocol Specification – Simple Profile

VSF TR-06-2:2024, Reliable Internet Stream Transport (RIST) Protocol Specification – Main Profile

VSF TR-06-3:2024, Reliable Internet Stream Transport (RIST) Protocol Specification – Advanced Profile

VSF TR-06-4 Part 2:2023, Reliable Internet Stream Transport (RIST) – Use of Wireguard VPN in RIST Devices

VSF TR-06-4 Part 3:2023, Reliable Internet Stream Transport (RIST) – RIST Relay

VSF TR-06-4 Part 5:2023, Reliable Internet Stream Transport (RIST) – RIST Multicast Discovery

VSF TR-06-4 Part 6:2024, Reliable Internet Stream Transport (RIST) – Transport Stream Program Selection

VSF TR-06-4 Part 7:2025, Reliable Internet Stream Transport (RIST) – Satellite Hybrid: In-Band Method

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ISO/IEC 13818-1:2023, Generic coding of moving pictures and associated audio information, Part 1: Systems

SMPTE 2022-2-2007, Unidirectional Transport of Constant Bit Rate MPEG-2 Transport Streams on IP Networks

Any mention of references throughout the rest of this document refers to the versions described here, unless explicitly stated otherwise.

4 Solution Requirements (Informative)

Satellites are the ideal solution to the problem of simultaneously distributing the same content to many geographically distributed receivers. Content is uplinked only once and retransmitted by satellite to all receivers at the same time. Adding a new receiver only requires putting up an antenna and pointing it; there is no additional burden or extra capacity required on the system. However, satellite systems can suffer from degraded operation due to factors such as rain fade, interference, and similar issues.

For a broadcaster delivering signals to affiliates, occasional interference and outages are obviously not acceptable. Therefore, additional measures need to be taken to ensure reliable delivery.

The solution considered in this Specification is to augment the traditional satellite delivery with the Internet. Use the satellite for the "heavy lifting" bulk delivery, and "fix any remaining problems" with the Internet. If a site is suffering from interference or rain fade, send a recovery stream to that site only, and include in this recovery stream only the blocks of data that were lost or corrupted.

A diagram of the solution is shown in Figure 1. The solution is required to comply with the following requirements:

1. Satellite is the primary distribution method.
2. The satellite channel is unidirectional; there is no return channel.
3. The Internet is used only to recover dropped or corrupted data.
4. Data recovery is seamless with no glitches.
5. The solution needs to be capable of delivering a complete feed in case of satellite outage.
6. The satellite signal is compatible with legacy receivers. More specifically, this means:
    a. The signal sent to the satellite is a traditional Transport Stream with one or more programs, and it must include at least one PCR PID.
    b. The Transport Stream is not modified in any way.

The following are specific requirements:

1. In many applications, the signal going to the modulator has been encrypted. Therefore, the solution cannot rely on specific fields in the transport stream payload.
2. Satellite modulators typically add or delete NULL packets for rate matching, and re-stamp PCRs to keep compliance. The solution cannot rely on the number and/or

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distribution of NULL packets, and it needs to account for small changes to the PCR value.

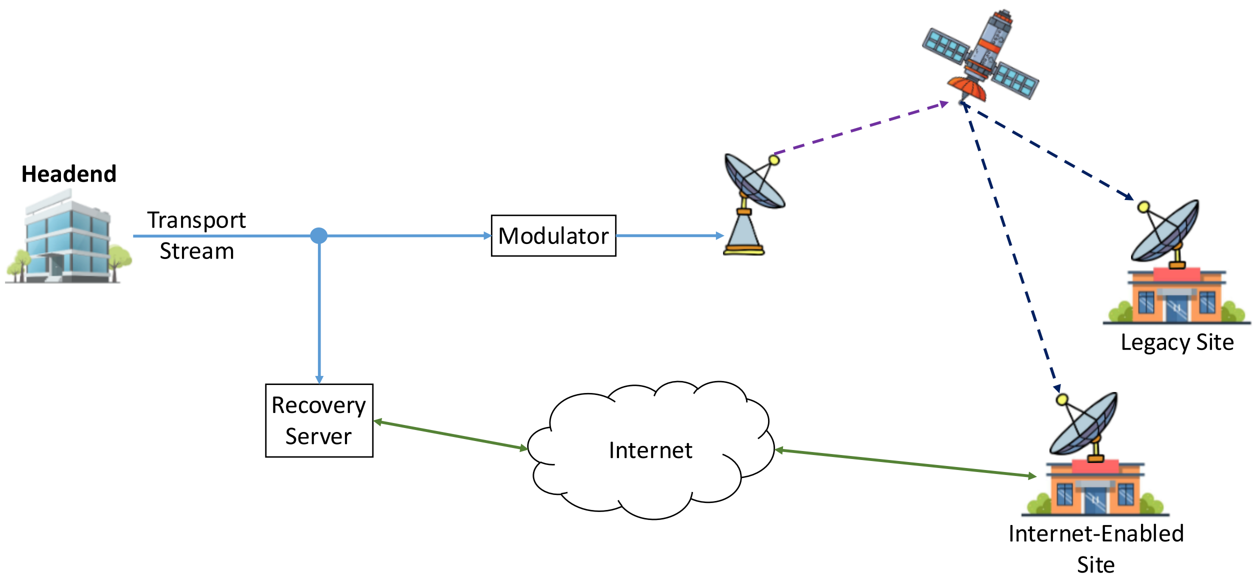

Figure 1: Solution Overview

5 Solution Architecture (Informative)

The basic solution architecture is shown in Figure 2. The operational flow is as follows:

1. The original Transport Stream is sent both to the modulator and to the Recovery Server.
2. The Recovery Server creates and buffers an RTP stream, as if it were sending the Transport Stream over RIST, using RIST Simple or Advanced Profiles, and saves it to a buffer.
   Note: the buffer at the recovery server needs to be large enough to accommodate the satellite round-trip latency, plus the worst-case Internet latency to all the receivers. This buffer size typically will be on the order of several seconds.
3. Lost or corrupted packets are requested by Internet-connected receivers using the STC-based NACK method described in Section 6. Internet-enabled sites can keep a connection to the Recovery Server using RIST Main Profile or RIST Advanced Profile tunnels.
4. Lost packets can also be requested using standard RIST NACK messages.
5. In case of a complete fade, receivers can use the Full Stream Request Messages from TR-06-4 Part 7 Section 7 to obtain a full copy of the stream.
6. Optionally, Internet-connected receivers can use TR-06-4 Part 6 to select only a subset of programs they require, avoiding retransmission of unnecessary data.

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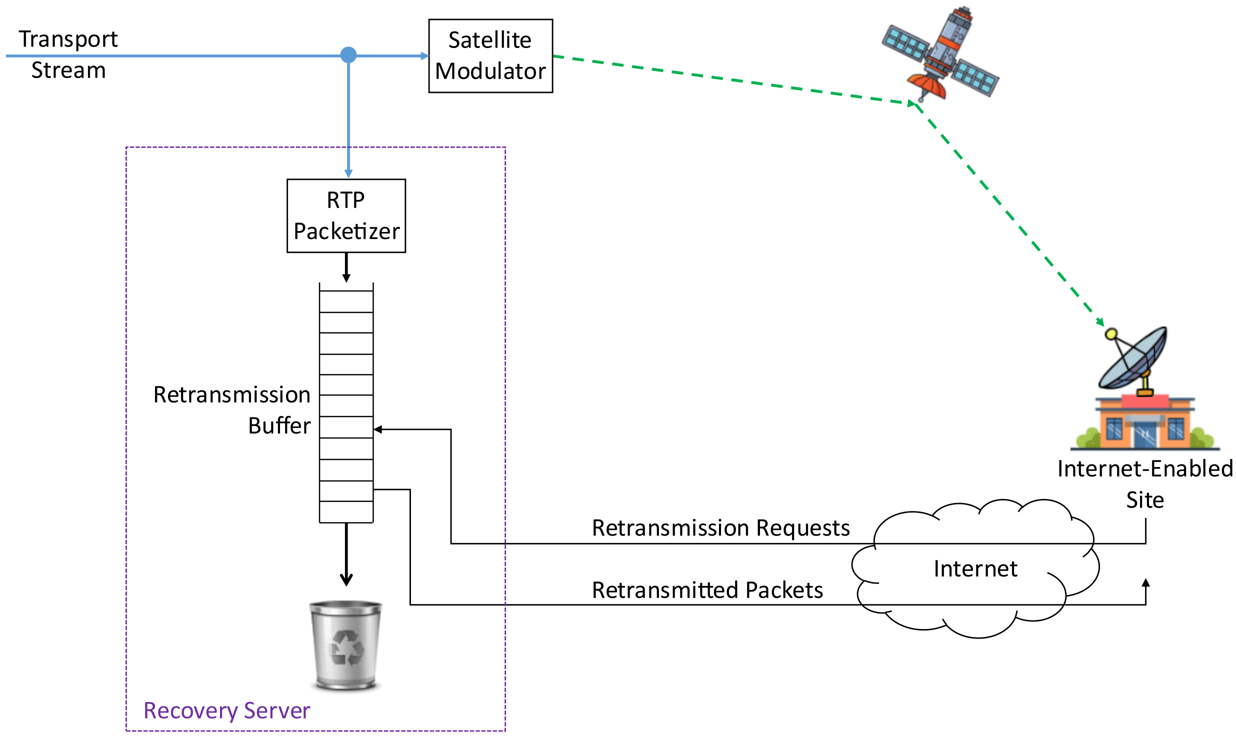

Figure 2: Solution Architecture

6 RIST Message Extensions

If the receiver detects a loss, it requests retransmission of the lost content. The exact means by which the receiver detects the loss are left at the discretion of the implementer; the following methods may be used:

- The stream bit rate is known from the satellite symbol rate and FEC parameters. If not enough bits are received during a period of time, the receiver may request retransmission of that block of data.
- Occurrences of Continuity Count (CC) errors.
- Occurrences of signaled Transport Error Indication in the packet header.

When the receiver detects data loss or corruption, it requests retransmission of a block from the Recovery Server using the STC-based NACK message described in this section. The receiver shall identify the requested block using a **Reference PCR** as the block start, and a **Block Duration**, defined as follows:

- **Reference PCR:** this is the last good PCR received from the satellite feed prior to the corrupted/lost block, satisfying the following conditions:
    - o There shall be at least 5 (five) good transport packets (of any PID) between the packet bearing the Reference PCR and the start of the lost/corrupted block.

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- There shall be at least 5 (five) transport packets (of any PID) between the packet bearing the Reference PCR and any other PCR-bearing packet in the same PID as the reference PCR.

- **Block Duration:** this is the size of the requested block, expressed in 90 kHz ticks.

Upon reception of this NACK message, the Recovery Server shall identify the RTP packet that includes the transport packet that has the closest PCR to the requested Reference PCR, start retransmission from this RTP packet. The Recovery Server shall transmit enough RTP packets to satisfy the requested Block Duration. RTP packets sent by the Recovery Server in response to these NACK requests shall be marked by the server as retransmissions but setting the LSB of the SSRC field to "1" (one) as specified in TR-06-1.

In case of lost RTP packets, the receiver shall request retransmission using the standard RIST NACK messages appropriate for the profile being used.

6.1 RIST Simple Profile STC-Based NACK Message

RIST Simple and Main Profiles use several Application-Defined RTCP messages, with different subtypes. The STC-Based NACK Message uses a new subtype, as shown in Table 1.

Table 1: RIST APP Subtypes

Subtype	Message	Specification
0	Range NACK Message	TR-06-1 Section 5.3.2.2
1	Sequence Number Extension Message	TR-06-2 Section 8.4
2	RTT Echo Request	TR-06-1 Section 5.2.6
3	RTT Echo Response	TR-06-1 Section 5.2.6
4	Reserved	
5	Full Stream Request Enable	TR-06-4 Part 7 Section 7.1
6	Full Stream Request Disable	TR-06-4 Part 7 Section 7.1
7	**STC-Based NACK Message**	**TR-06-4 Part 8 Section 6.1**

The format for the STC-Based NACK message is shown in Figure 3.

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```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|V=2|P| Subtype |   PT=APP=204  |             length            |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                  SSRC of media source                         |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                         name (ASCII)                          |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|         PCR_PID           |        Clock_ref_base_high        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|    Clock_ref_base_low     | Block_duration (90 kHz STC ticks) |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 3: RIST Simple STC-Based NACK Message

The fields shall be set as follows:

version (V): 2 bits

Identifies the version of RTP, which is the same in RTCP packets as in RTP data packets. RIST STC-Based NACK packets shall have V=2.

padding (P): 1 bit

Indicates whether there is padding at the end of the packet. RIST STC-Based NACK Packets shall have P=0.

Subtype: 5 bits

This field identifies the type of message. It shall be set to “7” as per Table 1.

Payload type (PT): 8 bits

This is the RTCP packet type that identifies the packet as being an Application-defined Message. This field shall be set to 204.

Length: 16 bits

The length of this packet, expressed in 32-bit words minus one, including the header and any padding. This field shall be set to the value of “**4”**, since the size of STC-Based NACK Message is five 32-bit words.

SSRC of media source: 32 bits

This field is normally set to the SSRC of the media source being requested. If the receiver does not know this value (e.g., at startup), it shall set to **0 (zero)**. Once the value is known, the receiver shall set this value to the actual SSRC of the media source.

Name (ASCII): 32 bits

This field identifies the application. For RIST packets, it shall have the value 0x52495354, the ASCII codes for “RIST”.

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PCR_PID: 13 bits

This field shall be set to the PCR PID containing the Reference PCR for the request.

Clock_ref_base_high: 19 bits

This field shall be set to the highest significant 19 bits of the 33-bit program_clock_reference_base value in the Reference PCR for the request.

Clock_ref_base_low: 14 bits

This field shall be set to the lowest significant 14 bits of the 33-bit program_clock_reference_base value in the Reference PCR for the request.

Block_duration: 18 bits

This field shall be set to the requested block duration, expressed in 90 kHz ticks.

Since the block duration is an 18-bit field, the maximum block size that can be requested using this message is 2.9127 seconds. This is considered sufficient for lost/corrupted blocks; for larger blocks, receivers may switch into Full Stream recovery mode as described in TR-06-4 Part 7, or may send additional STC-based NACK messages covering additional time periods; the Reference PCR for such requests will come from the transport stream data recovered in the previous time period.

If the server supports program selection (TR-06-4 Part 6), only the requested programs shall be transmitted in response to an STC-Based NACK message. The receiver shall not use the PCR PIDs from programs that are not selected in the STC-Based NACK Message.

6.2 RIST Advanced Profile STC-Based NACK Message

For TR-06-3 Advanced Profile, a new tunnel control message (see Section 5.3) is defined. This new tunnel control message is indicated in Table 2.

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Table 2: RIST Advanced Profile Control Index Values

Control Index	Message Type	Mandatory
0x0000	NACK Bitmask	
0x0001	NACK Range	
0x0002-0x0003	TR-06-4 Part 1 Link Quality Reports	
0x0004	TR-06-4 Part 4 Sender Synchronization Message	
0x0005	Full Stream Request Enable	
0x0006	Full Stream Request Disable	
0x0007	**STC-Based NACK Message**	
0x0008-0x000F	Reserved for future NACK messages	
0x0010	RTT Echo Request	
0x0011	RTT Echo Response	Yes
0x0012-0x001F	Reserved for future RTT messages	
0x0020	ST 2022-5 FEC Row Packet	
0x0021	ST 2022-5 FEC Column Packet	
0x0022	ST 2022-1 FEC Row Packet	
0x0023	ST 2022-1 FEC Column Packet	
0x0024-0x002F	Reserved for future FEC messages	
0x0030-0x77FF	Reserved for future control messages	
0x7800-0x7FFF	Reserved for private vendor use	
0x8000	RIST Main Profile Keep-Alive message	Yes
0x8001	Flow Attribute message	
0x8002-0x800F	Reserved for future tunnel messages	
0x8010	Advanced Profile SRP authentication for PSK sessions	
0x8011	PSK Future Nonce Announcement Message	
0x8012-0x801F	Reserved for future authentication messages	
0x8020	Control Message Unsupported Response	
0x8021-0x802F	Reserved for future error messages	
0x8030-0x804F	TR-06-4 Part 3 RIST Relay Messages	
0x8050-0xF7FF	Reserved for future control messages	
0xF800-0xFFFF	Reserved for private vendor use	

The format for the new control messages from Table 2 is shown in Figure 4.

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```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|     Control Index = 0x0007    |             Length            |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                      SSRC of Media Source                     |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|         PCR_PID         |        Clock_ref_base_high          |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|    Clock_ref_base_low     |    Duration (90 kHz STC ticks)    |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 4: STC-Based NACK Control Message

The fields for the message in Figure 4 shall be set as follows:

Control Index: 16 bits

This field identifies the type of message. This field shall be set to 0x0007 as indicated in Table 2.

Length: 16 bits

Senders shall use this field to indicate the size of the Advanced Profile Control Message following the Length field, in bytes. This field shall be set to the value of **“12”**.

SSRC of media source: 32 bits

This field is normally set to the SSRC of the media source being requested. If the receiver does not know this value (e.g., at startup), it shall set to **0 (zero)**. Once the value is known, the receiver shall set this value to the actual SSRC of the media source.

PCR_PID: 13 bits

This field shall be set to the PCR PID containing the Reference PCR for the request.

Clock_ref_base_high: 19 bits

This field shall be set to the highest significant 19 bits of the 33-bit program_clock_reference_base value in the Reference PCR for the request.

Clock_ref_base_low: 14 bits

This field shall be set to the lowest significant 14 bits of the 33-bit program_clock_reference_base value in the Reference PCR for the request.

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Block_duration: 18 bits

This field shall be set to the requested block duration, expressed in 90 kHz ticks.

If the server supports program selection (TR-06-4 Part 6), only the requested programs shall be transmitted in response to an STC-Based NACK message. The receiver shall not use the PCR PIDs from programs that are not selected in the STC-Based NACK Message.

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Appendix A Block Recovery Example (Informative)

As an example, let us assume a satellite feed running at 30 Mb/s, as illustrated in Figure 5. This figure shows a block of 105 Transport Stream (TS) packets, from which the Recovery Server formed 15 RTP payloads. In the example, TS packets marked as **V** are video, **A** are audio, **P** are PCR-bearing packets, and **N** are NULL packets. The first RTP payload in this block has a PCR value of 2,000, which is encoded as base=6 and extension=200 (2000 = 6×300+200).

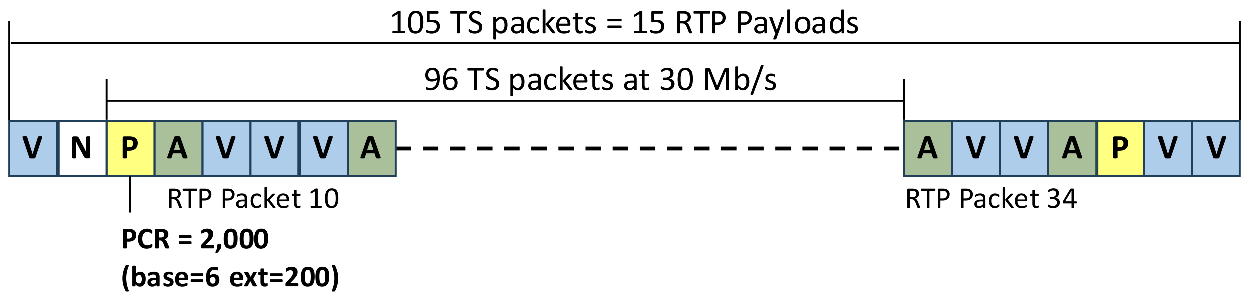

Figure 5: Example signal into the modulator

When the signal is processed inside the modulator, NULL packets may be added or removed, and PCRs restamped to match. The signal sent by the modulator to the satellite is shown in Figure 6. In this example, the modulator inserted a NULL packet before the first PCR packet in the block, restamping it. Later, somewhere inside the block, the modulator deleted a NULL packet.

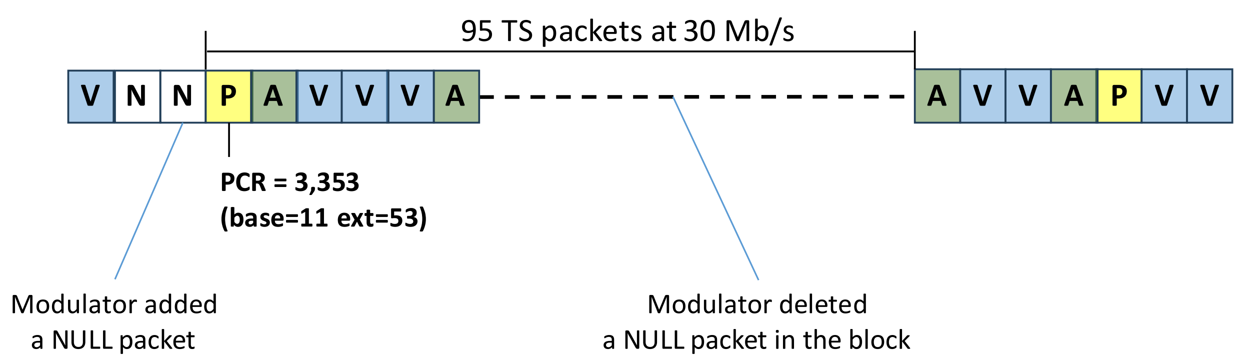

Figure 6: Signal sent by the modulator to the satellite

Let us assume that the receiver has detected one or more errors in the block. These errors are all in the block indicated in Figure 6. As far as the receiver is concerned, the block starting from the

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Reference PCR has 95 transport packets, so the duration is (95×188×8×90,000)/30,000,000=429 ticks at 90 kHz (rounded up). The receiver sends an STC-based NACK packet to the Recovery Server with the following values:

- Starting program_clock_reference_base = 11
    - Starting_clock_ref_base_high = 0x000000
    - Starting_clock_ref_base_low = 0x000B
- Starting_PCR_PID = **P**
- Block_duration = 429 (0x1AD)

As a reference, the RIST Simple Profile message corresponding to the data above is shown in Table 3.

Table 3: Example Simple Profile Message

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|V=2|P| Subtype |   PT=APP=204  |            length=4           |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                  SSRC of media source                         |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                   name (ASCII) = 0x52495354                   |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|        PCR_PID=P        |               0x000000              |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|           0x000B          |      Block_duration = 0x1AD       |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Upon receipt of the message in Table 3, the Recovery Server will look for the closest PCR to the requested value and will send RTP packets 10 through 34 in Figure 5. The receiver will then need to match the RTP packets to the received stream, but it knows that the first RTP packet contains the PCR corresponding to the request. The receiver may need to do PCR restamping, but this is straightforward since the value of the first PCR post-modulator is known.

If the first retransmitted packet received does not contain a PCR in the PID requested, the receiver knows that (at least) the first packet in the block has been dropped, but it does not know how many packets have been dropped. At this point, it may use one or more of the following strategies:

- It can re-request the whole block.
  and/or
- Since the receiver knows the sequence number of the packet received, it can request the *N* preceding packets, where *N* is a guess of the maximum block loss in the Internet link.
  and/or

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- Keep receiving retransmissions until it gets another PCR. At this point, it can compute how many packets to receive.

In case of a full fade, when the receiver has requested a full stream from the Recovery Server, the transition in and out of the Internet stream can be done by matching PCRs. At the transition point, a PCR jitter event may happen, but most receivers are resilient against that, and no glitch is likely to occur.

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Appendix B Receiver Configuration (Informative)

The Receiver Configuration considerations listed in Appendix B of TR-06-4 Part 7 also apply to this Specification.

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Appendix C Redundancy and Scalability Considerations (Informative)

In a typical satellite deployment, there is a large number of receivers, each of which may require the full satellite signal in case of rain fade or any other outage. It is unlikely that a single Recovery Server will be able to service all the receivers. In such cases, it will be necessary to provide a bank of servers, all with access to the original stream, and these may even be geographically distributed and placed "closer" to a group of receivers.

The following options can be used in this case:

- All receivers are configured to contact the same server name or IP address, and a load balancer spreads the requests over multiple servers.
- Groups of receivers are configured to contact different servers. Receivers may be configured with a primary server and a fallback server.

If the deployment has a primary and a backup headend, the receivers need to connect to servers that are handling the stream from the headend that is online. The following options can be used in this case:

- If there is a single network of servers, the headend that is online feeds this network of servers. The offline headend does not transmit out its stream.
- If each headend has a separate network of servers, the receivers are configured with the IP/name of the primary headend servers, and the IP/name of the backup headend servers. Servers are configured to only send periodic RTCP messages if they are online. Receivers can make use of this to identify which server is currently online.

Receivers can identify a headend transition by monitoring the STC and detecting discontinuity in the value.

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Appendix D Receiver Splicing of Recovered Data (Informative)

In normal operation, the receiver will be consuming the satellite feed; occasionally, it will need to splice recovered data from the server. The streams from the server (pre-modulator) and from the satellite (post-modulator) fundamentally have the same STC per program, but since the modulator occasionally adds or deletes NULL packets for rate adaptation purposes, it restamps the PCR. In other words, the transport stream rate pre-modulator (available to the recovery server) and post-modulator (available to the receiver) are nominally the same, but the actual value may be slightly different.

When the receiver splices in a segment recovered from the server, if that is done with no re-stamping of PCRs, there is a chance that this will result in a PCR jitter exceeding the ±500 ns requirement from ISO/IEC 13818-1. Most decoders, especially consumer-grade, will handle this situation without any glitch, but the stream will be technically out of compliance. The same issue can happen when the receiver returns to the satellite segment. If the receiver does not do PCR re-stamping, it is recommended that it set the **discontinuity_indicator** bit in the adaptation field of the first PCR packet in all PCR-bearing PIDs when splicing in and out of the server stream.

Another alternative is to have the receiver re-stamp PCRs in the spliced content. For short periods of time, the PCRs can be linearly interpolated from their last value prior to the splicing and the transport rate. See equation (2-5) in ISO/IEC 13818-1 for details.

If the receiver switches into Full Stream recovery mode, the most likely scenario is that the latency from recovery server to the decoder through the Internet or terrestrial network is significantly less than the satellite latency. Therefore, the bitstream received from the recovery server will be "ahead" of the satellite stream by the latency difference plus the time the receiver took to decide to invoke Full Stream recovery. This segment of bitstream will need to be requested from the recovery server and spliced in between the last good satellite bitstream and the first received Full Stream packet. The receiver can do this by calculating the elapsed time between the two (using two PCRs in the same PID on either side of the discontinuity) and requesting the content, either by issuing one or more STC-based NACKs, or by computing the number of RTP packets required to carry that amount of bitstream, and requesting retransmission of these packets using one of the standard RIST NACK messages. In this case, the splicing discussion above still applies.

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