

**Ladder Diagrams for Error  
Recovery For FCP -2 Rev 04  
Out-Of-Order Delivery- Annex D**

**Carl Zeitler**

**Compaq Computer Corporation**

**March 28, 2000**

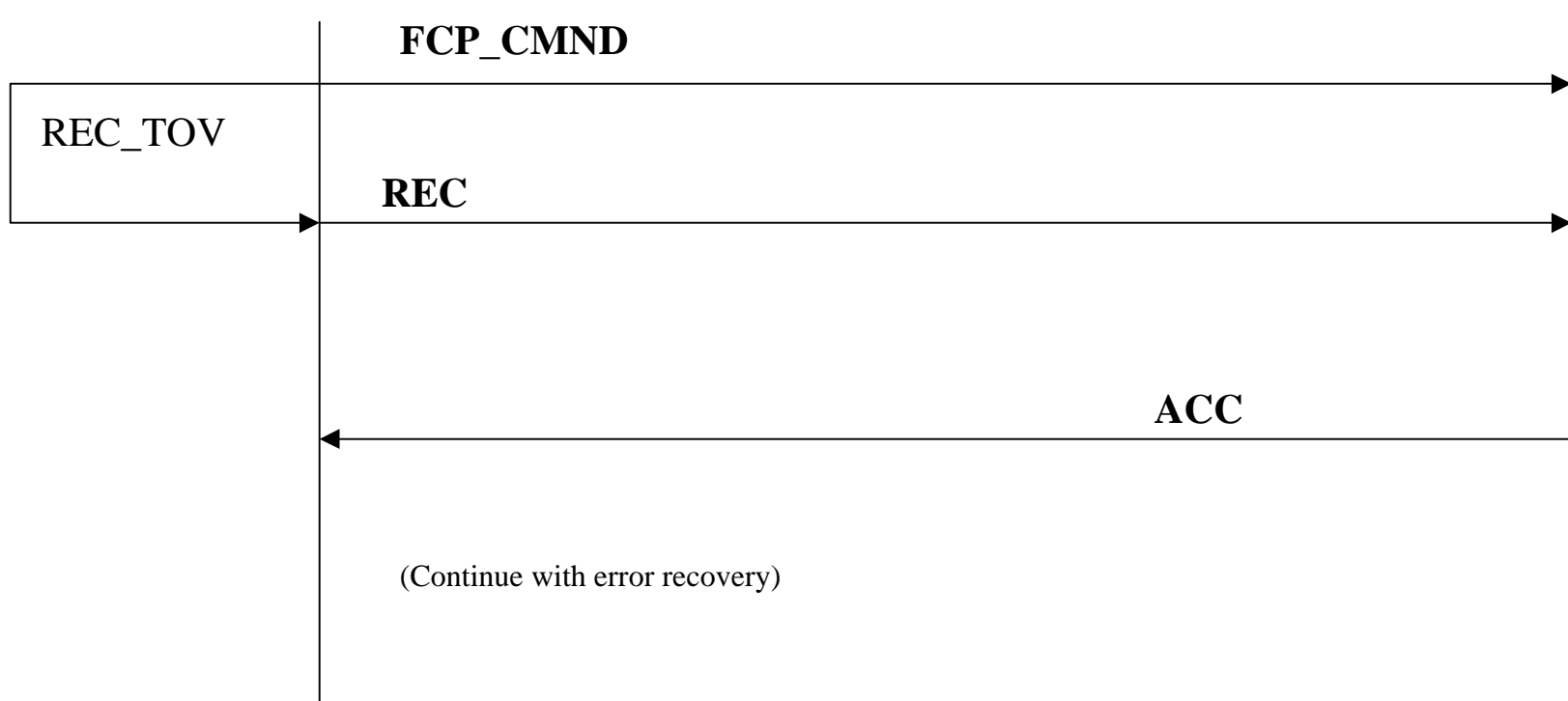
**T10/00-137r2**

Reference: T11/00-133v1

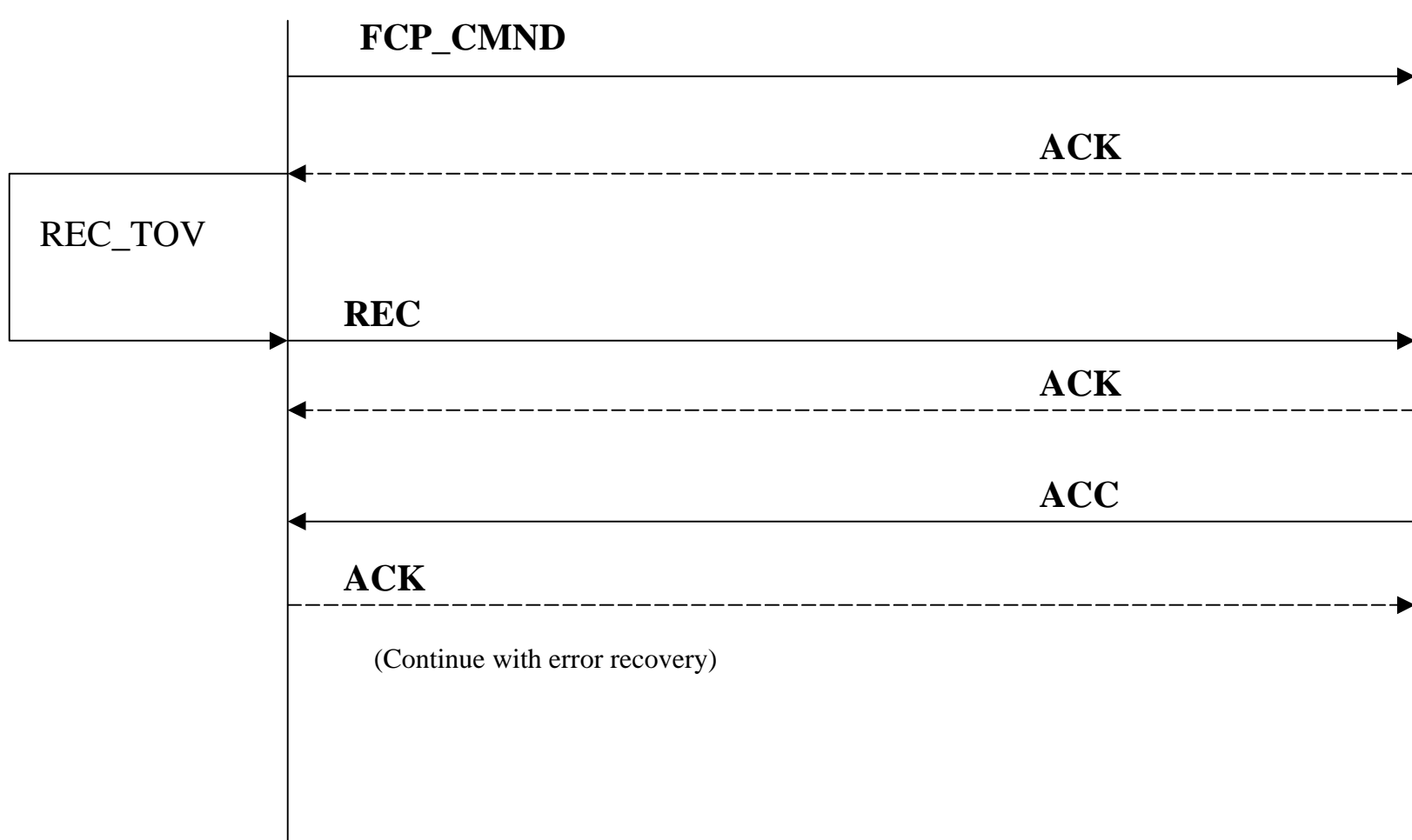
# Summary of Major Changes

- Removed the use of REC for Class 2 except for data transfer error cases.
  - REC gives no new info over and above ABTS
  - Simplifies Class 2 recovery
  - Class 2 recovery more consistent within itself
- Added text to show payload of BA\_ACC
- Removed the optional issue of RRQ from the Flow Diagrams
- Added RR\_TOV timeout to FCP\_RESP (See D.5)
- Added D.5 and D.5a to cover action item--double error situation and possible OX\_ID confusion.
- D.13 Class 3, split out REC lost and REC Response lost cases.
- Removed last chart, Use of REC in Class 2. REC is useful in cases where FCP\_DATA frames are lost and the whole data transfer sequence is not necessarily repeated.

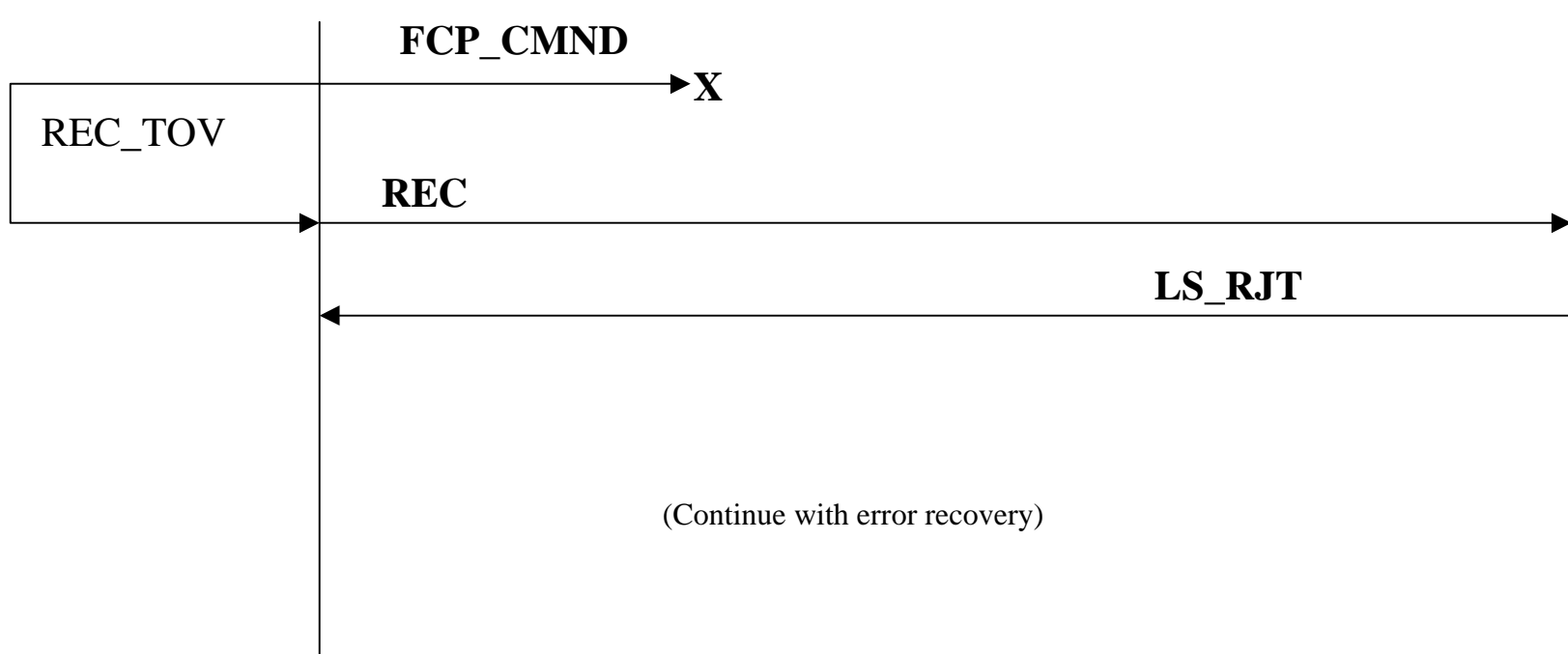
# D.1 Class 3 Error Detection



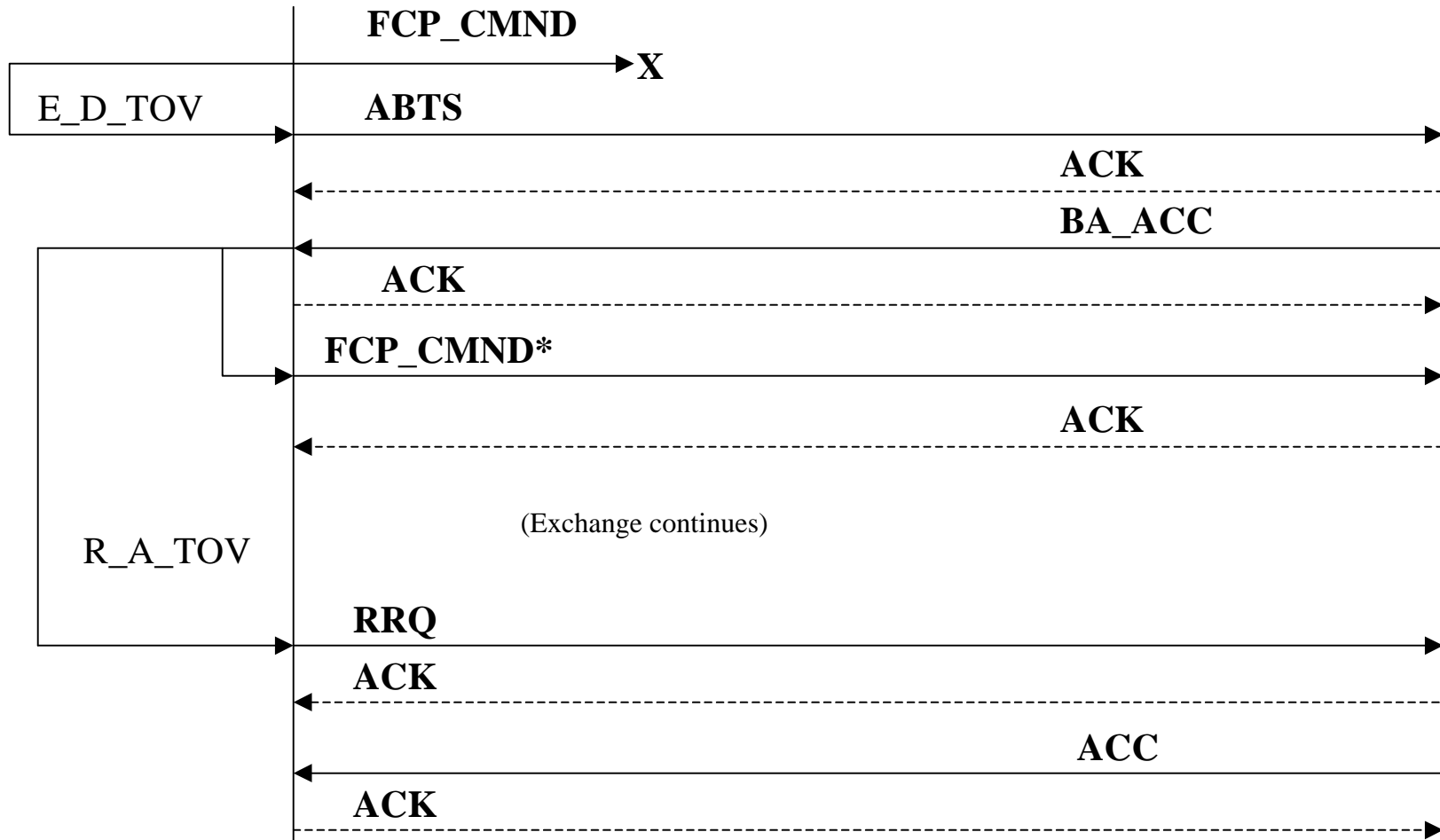
# D.1 Class 2 Error Detection



# D.2 Class 3 FCP\_CMD Lost



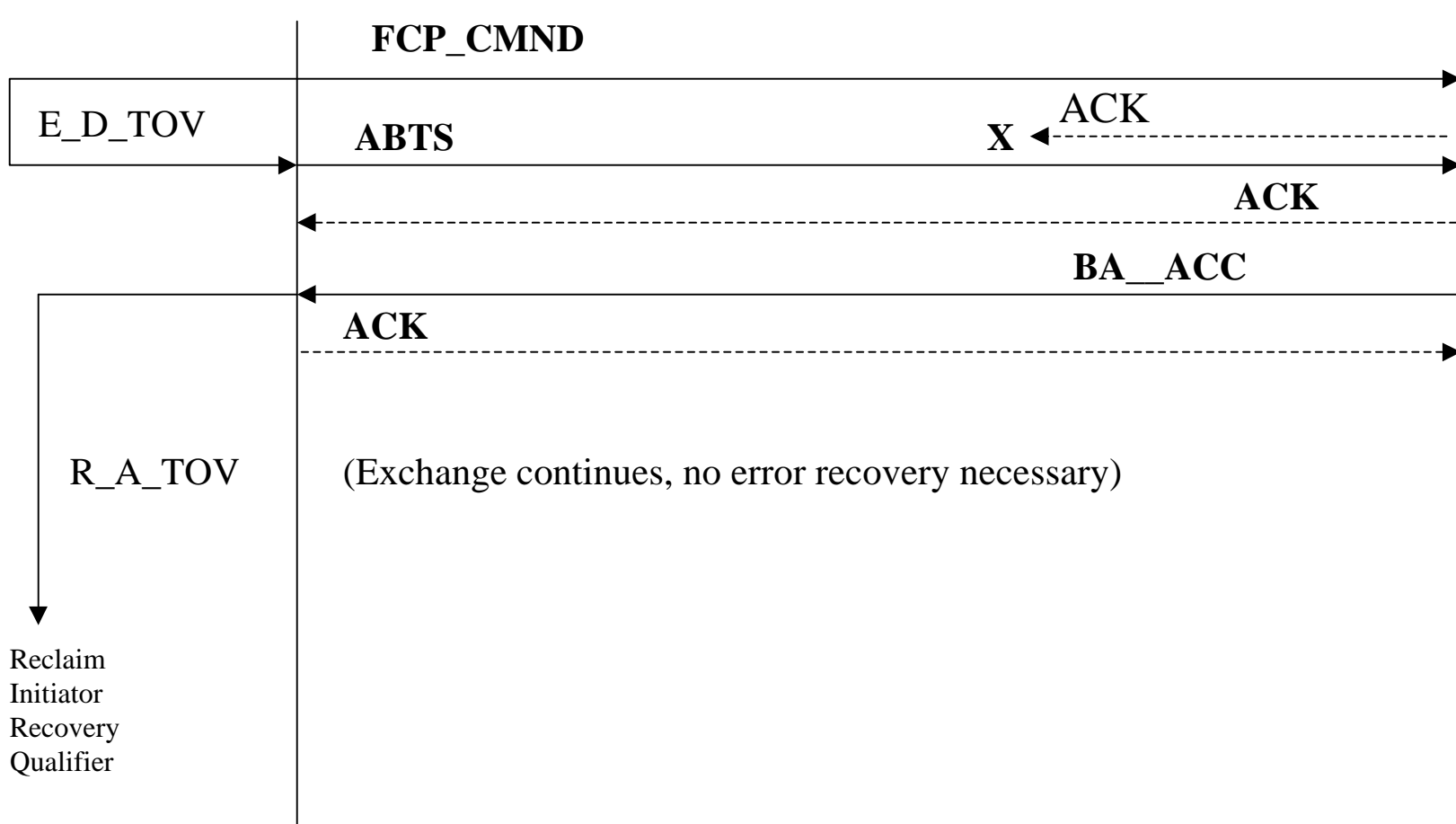
# D.2 Class 2 FCP\_CMD Lost



## Error Recovery

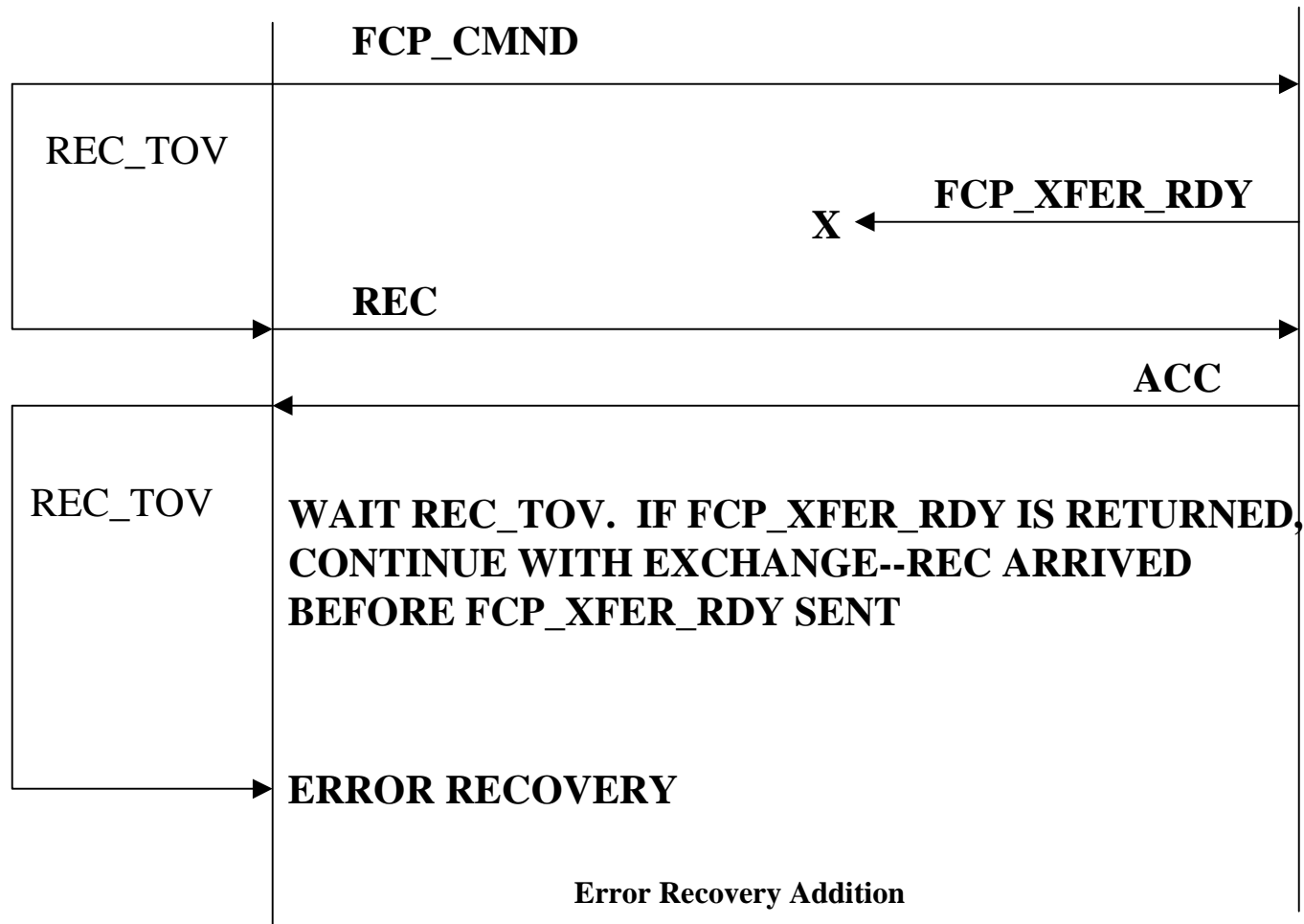
The BA\_ACC indicates that the FCP\_CMD was never received. (BA-ACC payload : SEQ\_ID Validity = invalid, Low SEQ\_CNT= 0, High SEQ\_CNT= SEQ\_CNT of ABTS frame.) Both the Initiator and Target establish Recovery Qualifiers. FCP\_CMD\* is resent in a new Exchange with a new SEQ\_ID.

## D.2.1 Class 2 Lost ACK on FCP\_CMND



No error recovery. The BA\_ACC Payload indicates that FCP\_CMD was received. The BA\_ACC payload is SEQ\_ID Valid, SEQ\_ID value of FCP\_CMD, low SEQ\_CNT=high SEQ\_CNT=SEQ\_CNT of FCP\_CMD. Note that the issuance of RRQ is not necessary in this case, since the Target will not have established a Recovery Qualifier. However, the Initiator cannot reclaim the resources associated with its Recovery Qualifier until R\_A\_TOV time-out expires.

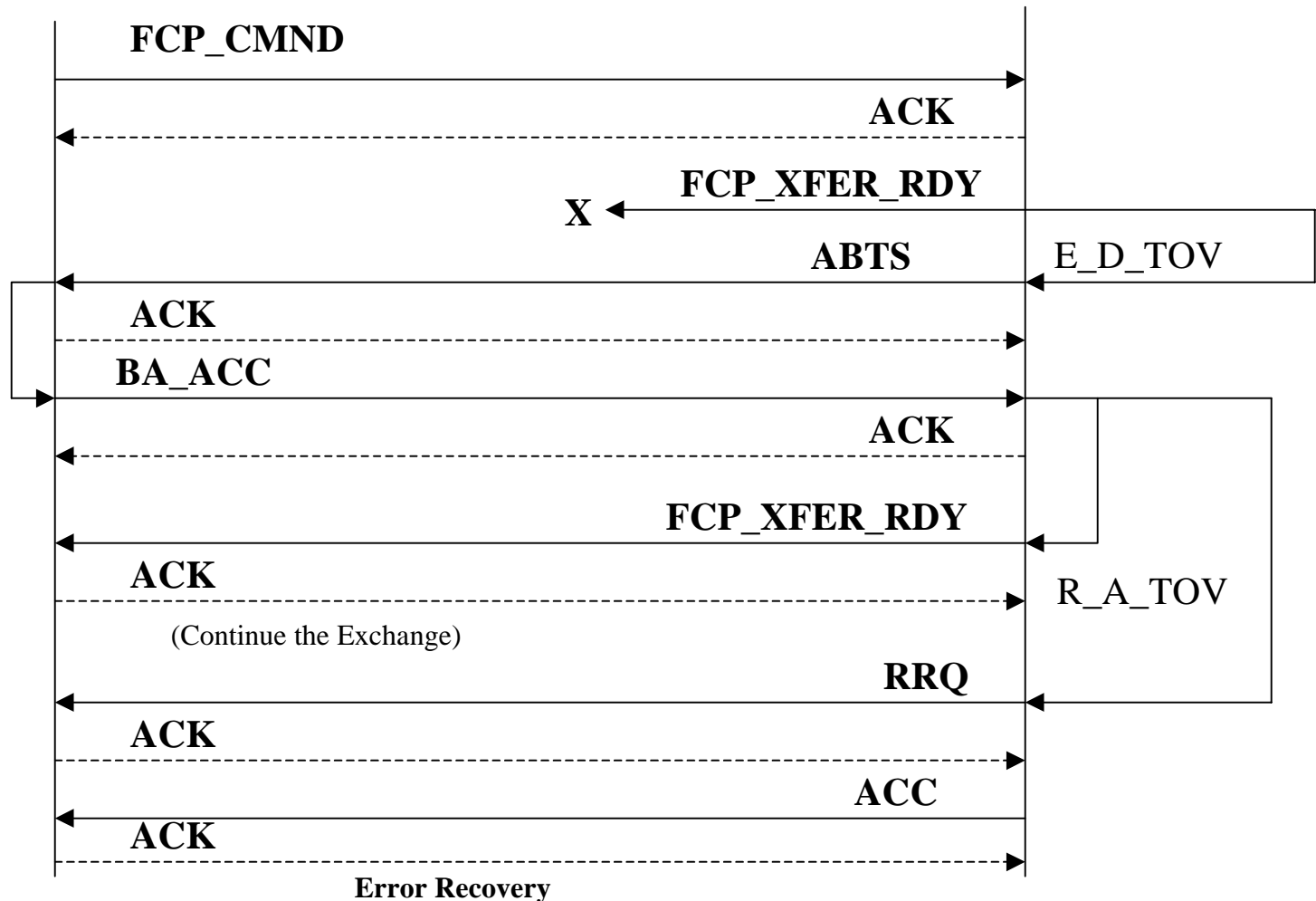
# D.3 Class 3 FCP\_XFER\_RDY Lost



A new SEQ\_ID must be used for the retransmission of the FCP\_XFER\_RDY.

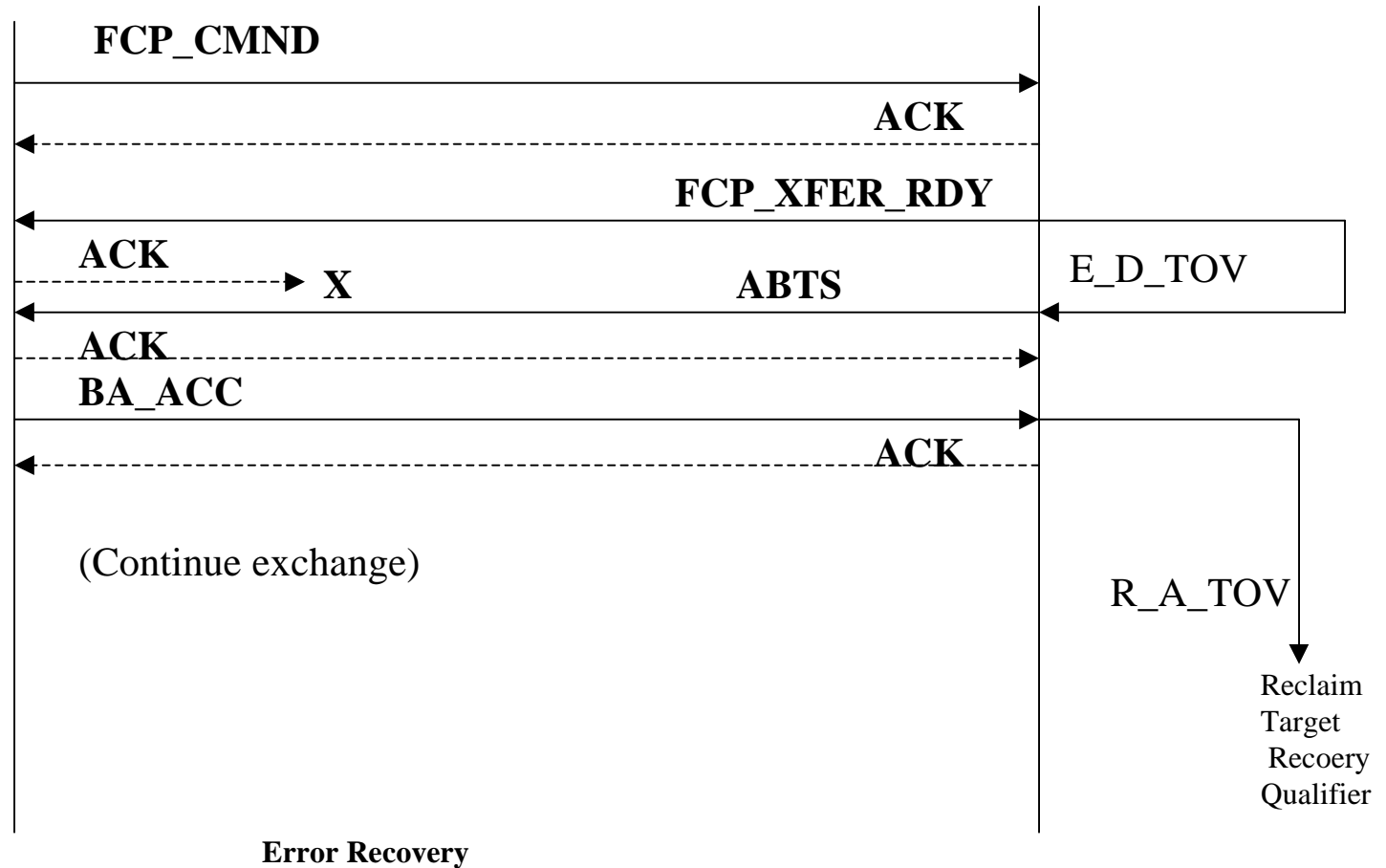


## D.3 Class 2 FCP\_XFER\_RDY Lost



The BA\_ACC indicates that the FCP\_XFER\_RDY was never received by the Target. (BA\_ACC Payload is SEQ\_ID invalid, low SEQ\_CNT=0, high SEQ\_CNT =SEQ\_CNT in ABTS frame = 1.) Both Target and Initiator must establish Recovery Qualifiers. A new SEQ\_ID must be used in the retransmission of FCP\_XFER\_RDY and the SEQ\_CNT value used must be one greater than the value used in the ABTS frame. REC/ACC are not shown.

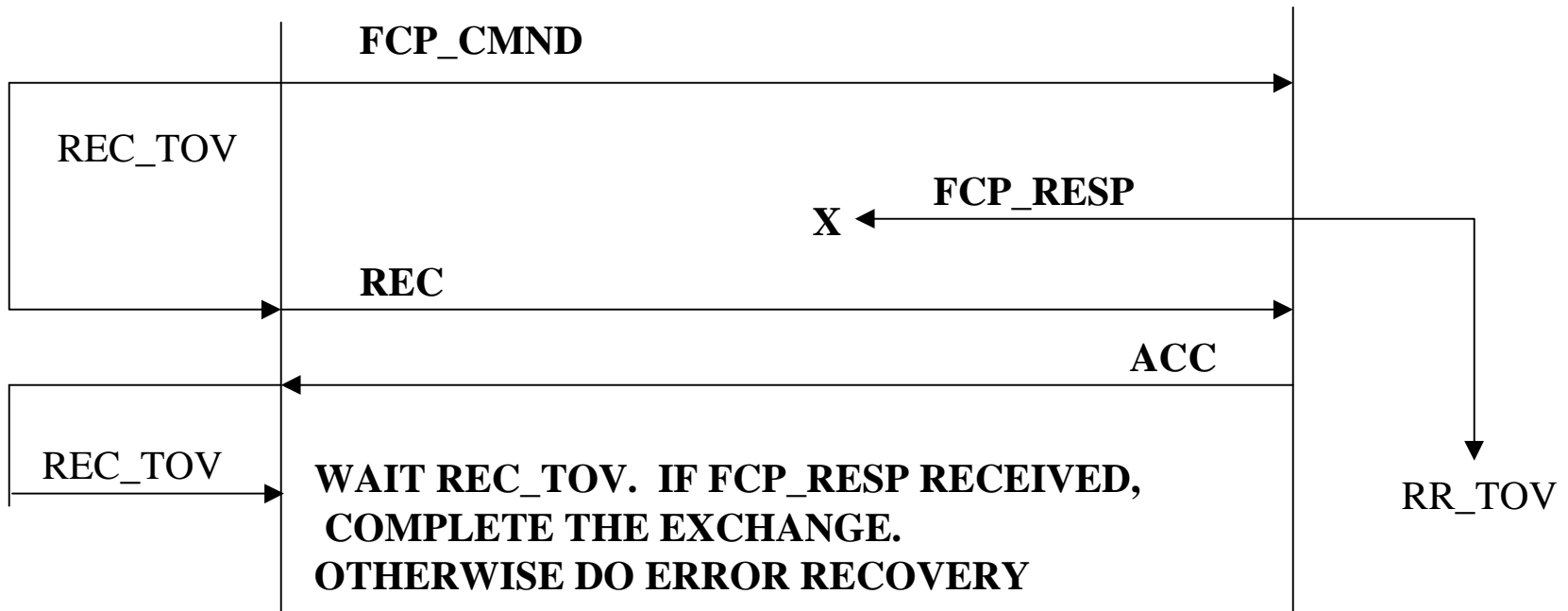
## D.4 Class 2 FCP\_XFER\_RDY Rcvd, ACK Lost



None:

The BA\_ACC indicates that the FCP\_XFER\_RDY was received by the Target, ACC Payload of SEQ\_ID valid, SEQ-ID =SEQ\_ID of the FCP\_XFER\_RDY frame, low SEQ\_CNT=high SEQ\_CNT=SEQ\_CNT of the ABTS frame. No error recovery is required. Note: There is no need for the Target to issue the RRQ since no Recovery Qualifier was established by the Initiator in this case. It must still let R\_A\_TOV expire before reclaiming the resources associated with its Recovery Qualifier.

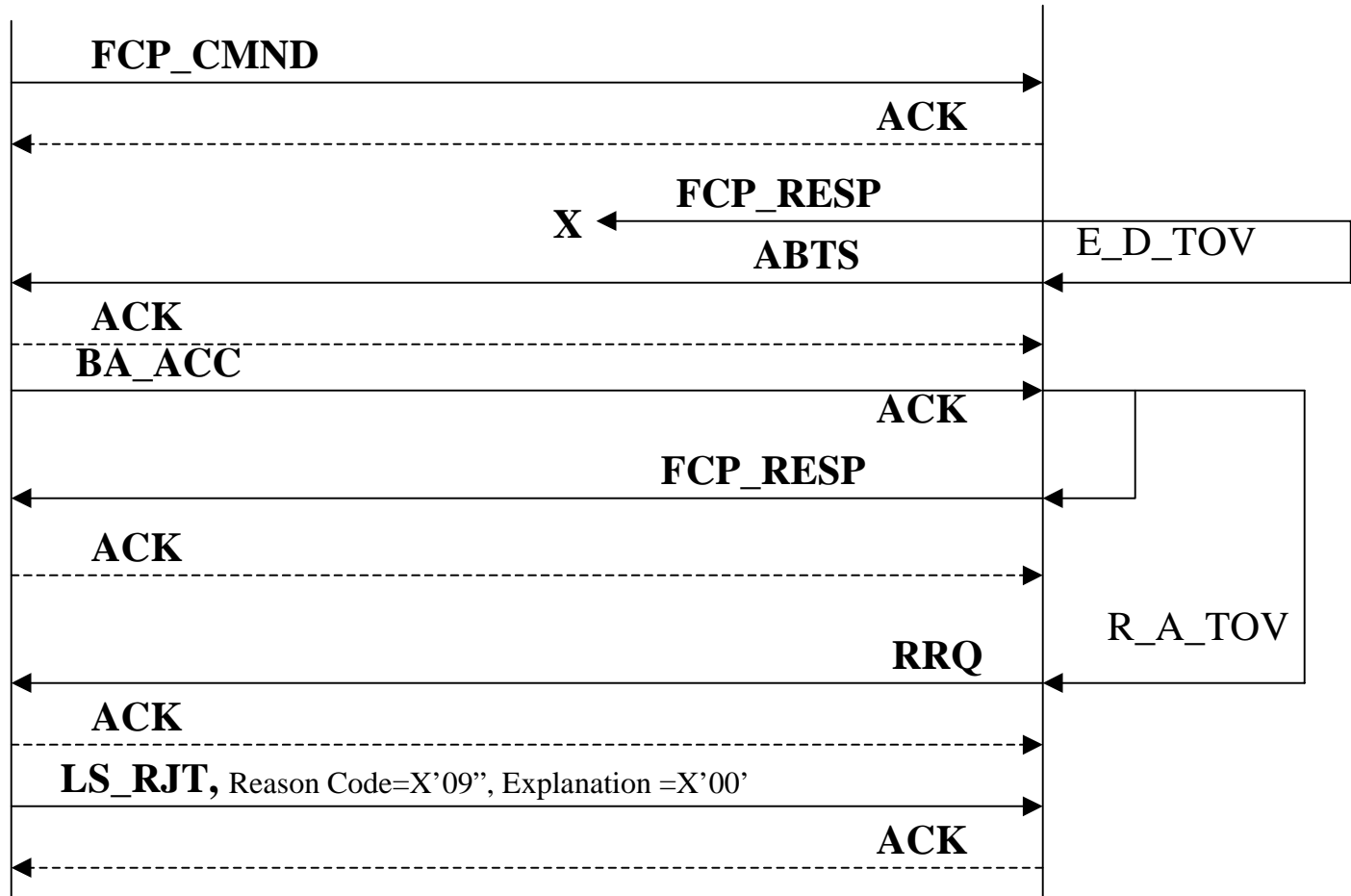
## D.5 Class 3 FCP\_RESP Lost, No FCP\_CONF Req.



Note that the Target must keep the context of this Exchange intact (ESAT in ESB indicates Open) until the OX\_ID value is reused in a new command, implicitly validating the receipt of FCP\_RESP, or for at least RR\_TOV, in order to preserve the FCP\_RESP information. This long timeout can be avoided by using FCP\_CONF. The FCP\_RESP retransmission must use a new SEQ\_ID. (Note that if recovery is done on an Exchange basis, then the Exchange can be completed in the Target and no RR\_TOV is required. If REC were then issue, the response would be LS\_RJT.)

Change to Error Recovery text: The ACC for the REC indicates the Initiator holds Sequence Initiative and the Exchange is **open** for Sequence level recovery and Complete for Exchange level recovery. (It is counter intuitive to restart and Exchange that has been completed.)

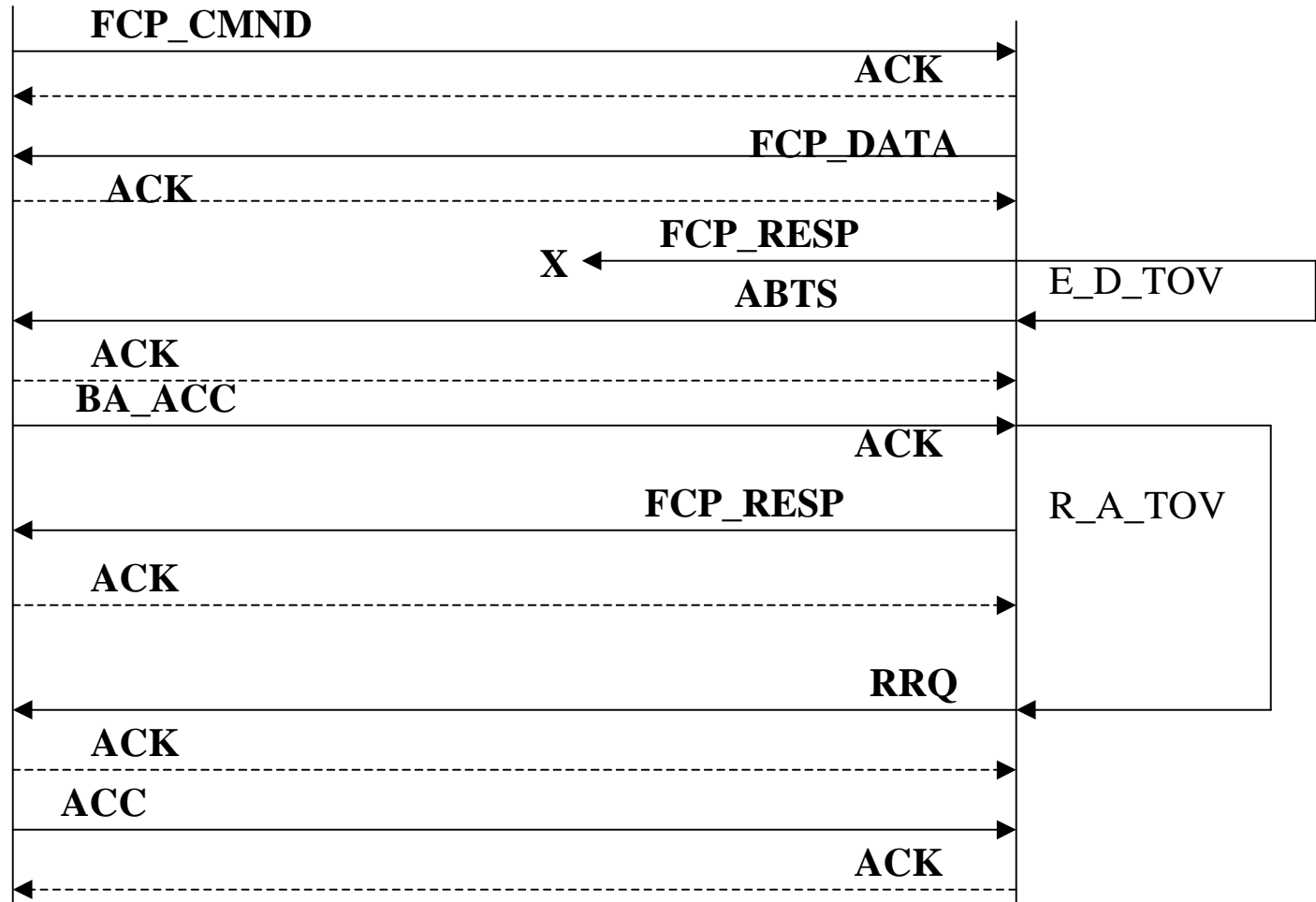
# D.5 Class 2 FCP\_RESP Lost, No FCP\_CONF Req



## Error Recovery

BA\_ACC indicates that FCP\_RESP was never received by the Initiator (Payload is SEQ\_ID invalid, low SEQ\_CNT=0, high SEQ\_CNT=SEQ\_CNT in ABTS frame=1.) Both Initiator and Target must establish Recovery Qualifiers. A new SEQ\_ID must be used in the retransmission of FCP\_RESP and the SEQ\_CNT value used must be one greater than the value used in the ABTS frame.

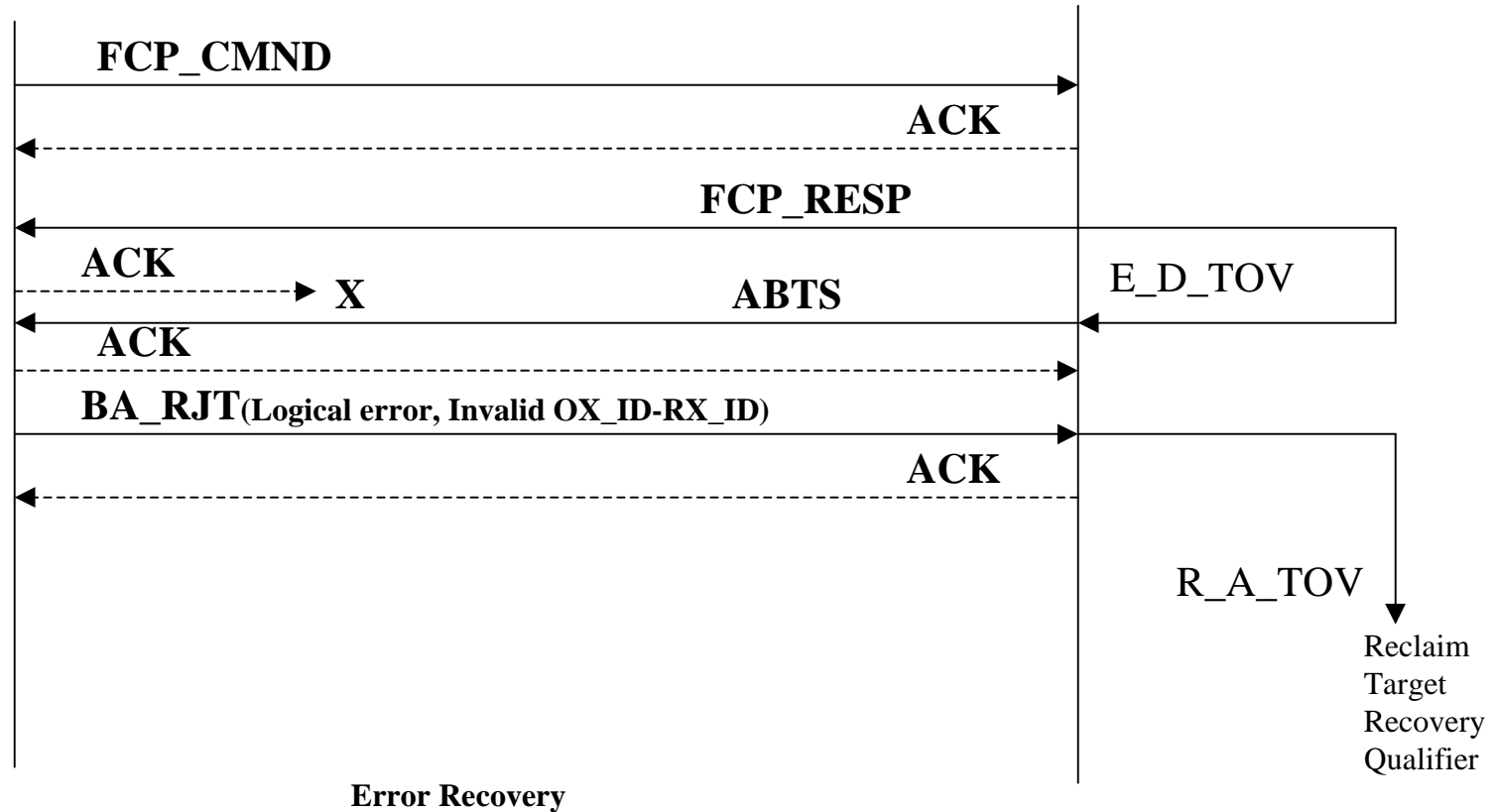
# D.5a Class 2 FCP\_RESP Lost after a Write Cmnd, No FCP\_CONF Req.



## Error Recovery

BA\_ACC indicates that FCP\_RESP was never received by the Initiator (Payload is SEQ\_ID valid, SEQ\_ID=SEQ\_ID of FCP\_DATA Sequence, low SEQ\_CNT=0, high SEQ\_CNT=SEQ\_CNT in ABTS frame=1.) Both Initiator and Target must establish Recovery Qualifiers. A new SEQ\_ID must be used in the retransmission of FCP\_RESP and the SEQ\_CNT value used must be one greater than the value used in the ABTS frame.

# D.6 Class 2 FCP\_RESP Rcvd, ACK Lost

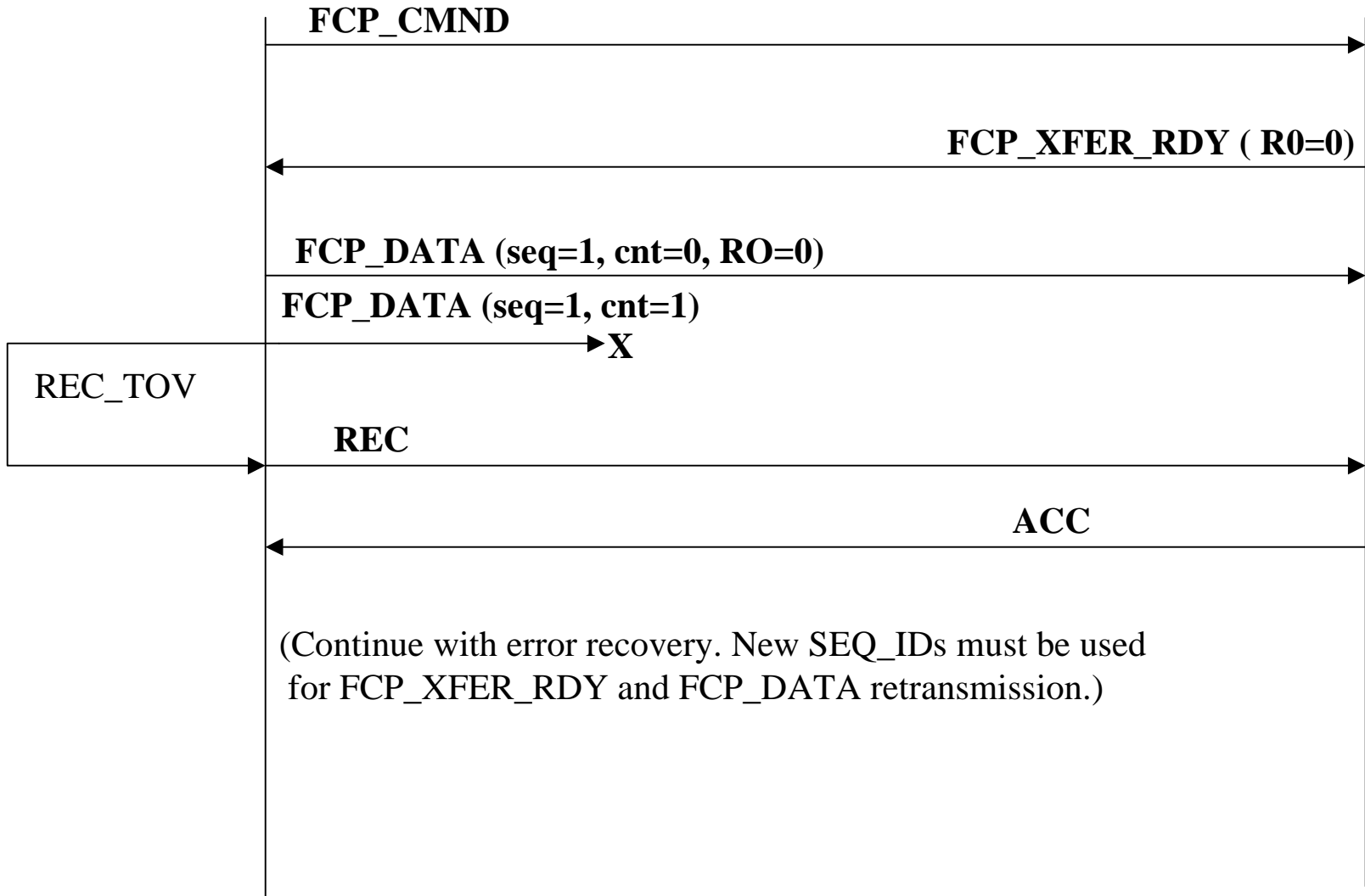


None:

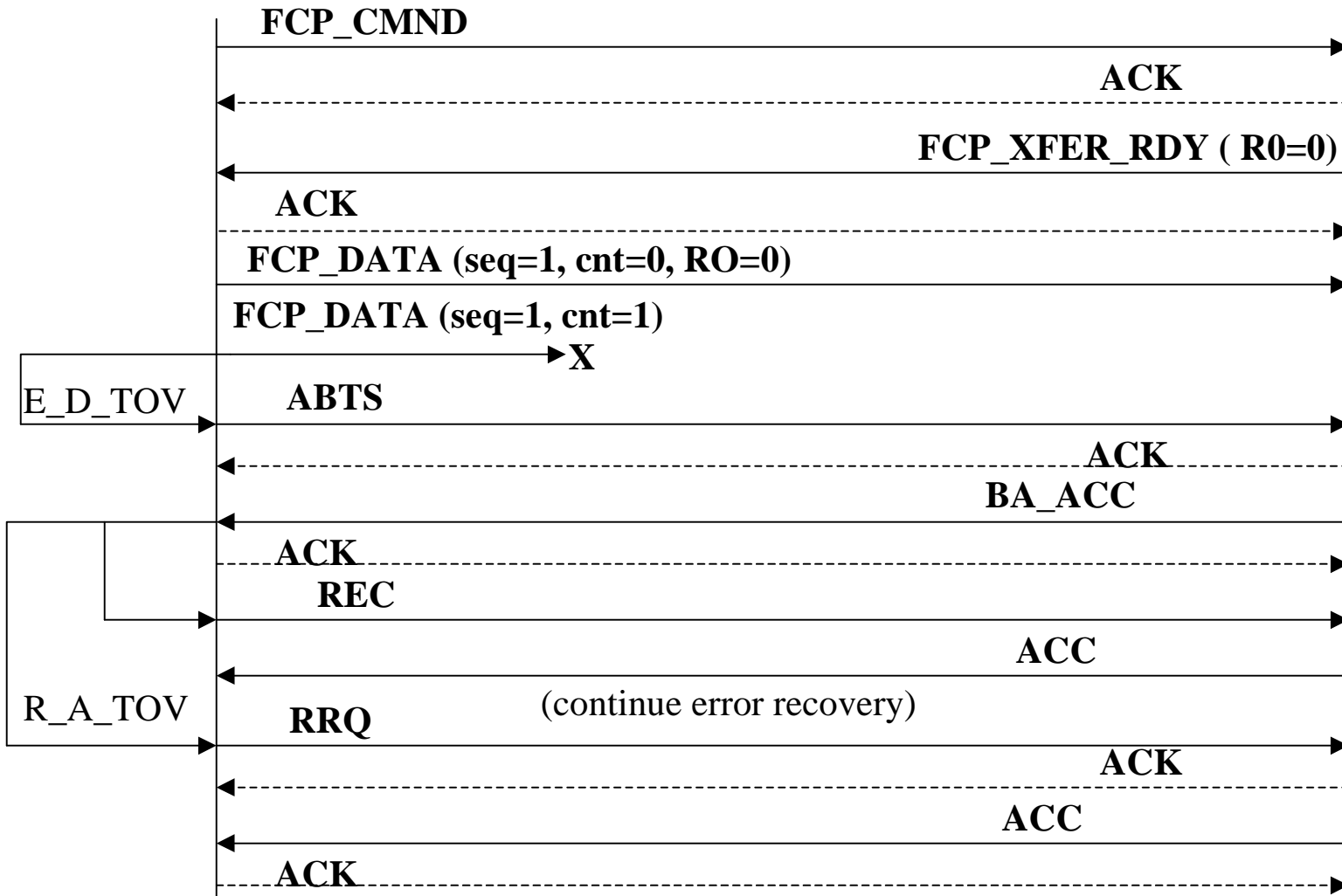
The BA\_RJT for the ABTS indicates the Exchange is unknown and therefore complete and no error recovery is required. The Target must establish a Recovery Qualifier. The associated resources cannot be reused for a period of R\_A\_TOV.

Note: The Target need not issue RRQ as no Recovery Qualifier was established by the initiator.

# D.7 Class 3 Lost Write Data, Last Frame of Seq.



# D.7 Class 2 Lost Write Data, Last Frame of Seq.

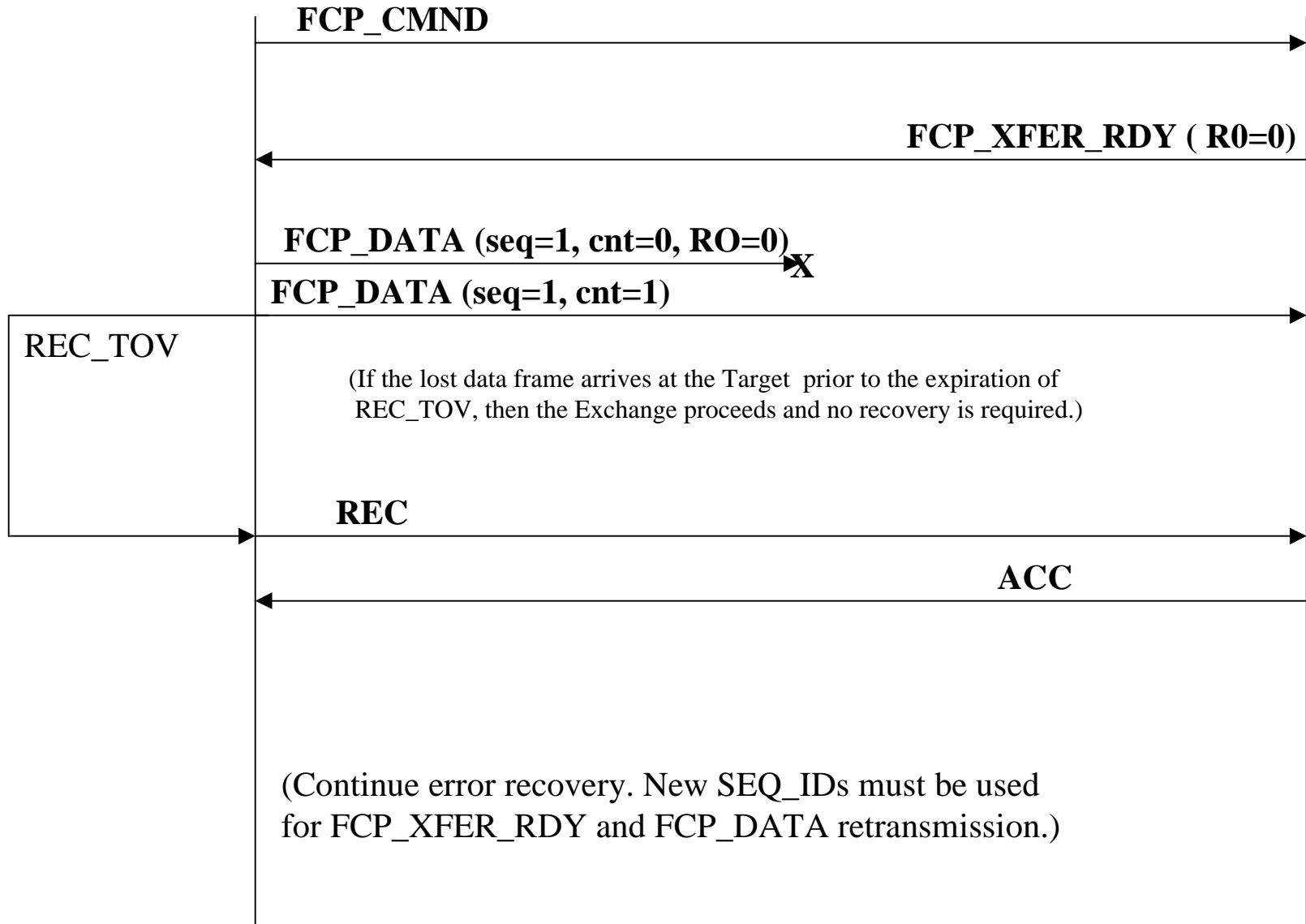


## Error Recovery Addition

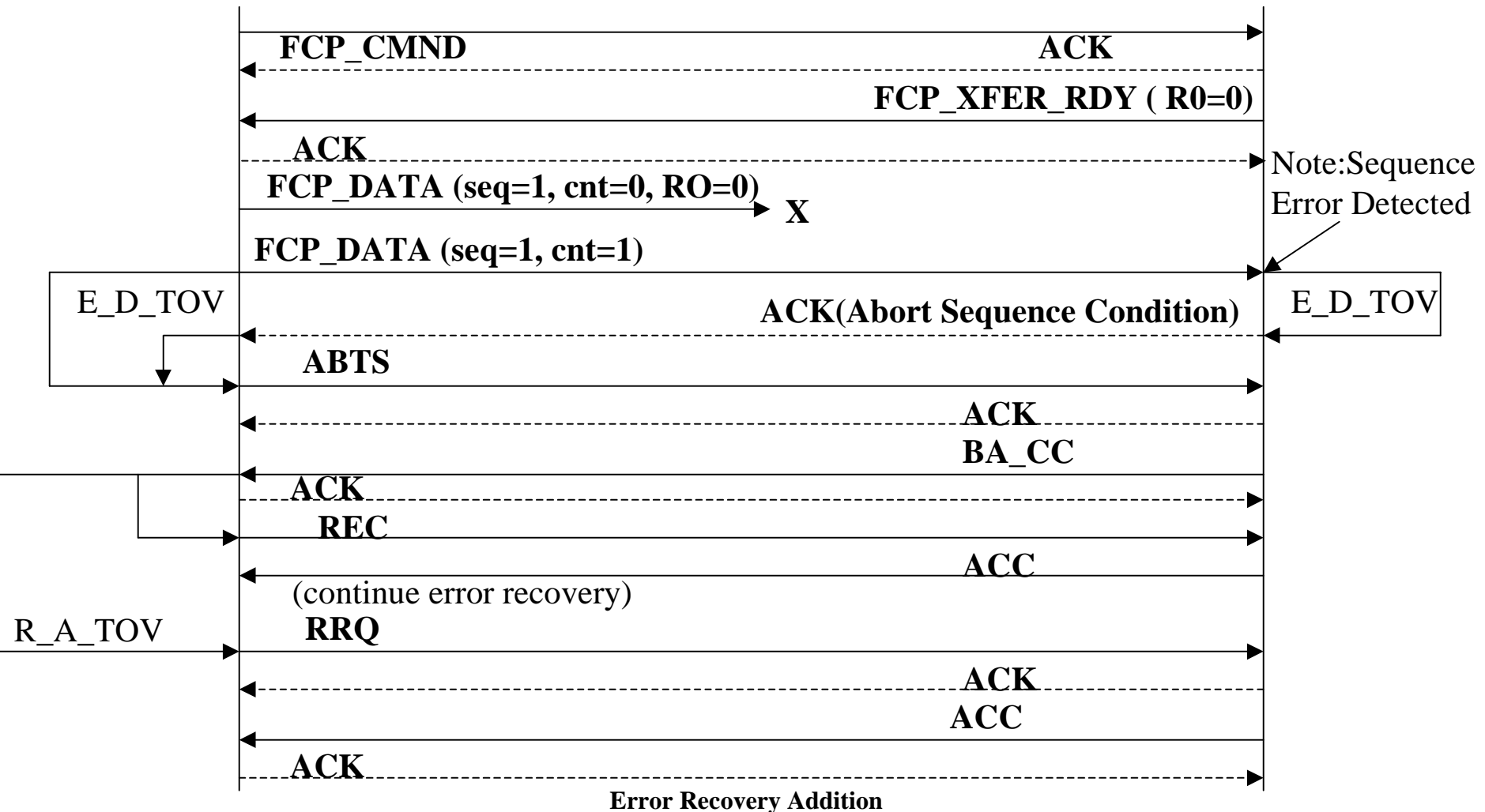
BA\_ACC indicates by its payload, that FCP\_DATA Sequence was not completely received (Payload: SEQ\_ID valid, SEQ\_ID value = SEQ\_ID of FCP\_CMND, low SEQ\_CNT of 0 not equal to high SEQ\_CNT of 2). New SEQ\_IDs shall be used for the retransmission of FCP\_XFER\_RDY and FCP\_DATA. For Class 2 the starting SEQ\_CNT value used with FCP\_DATA must one greater than the value used in ABTS. The ACKs for REC/ACC are not shown.



# D.8 C1 3, Lost Write Data, Not Last Fr. of Seq.

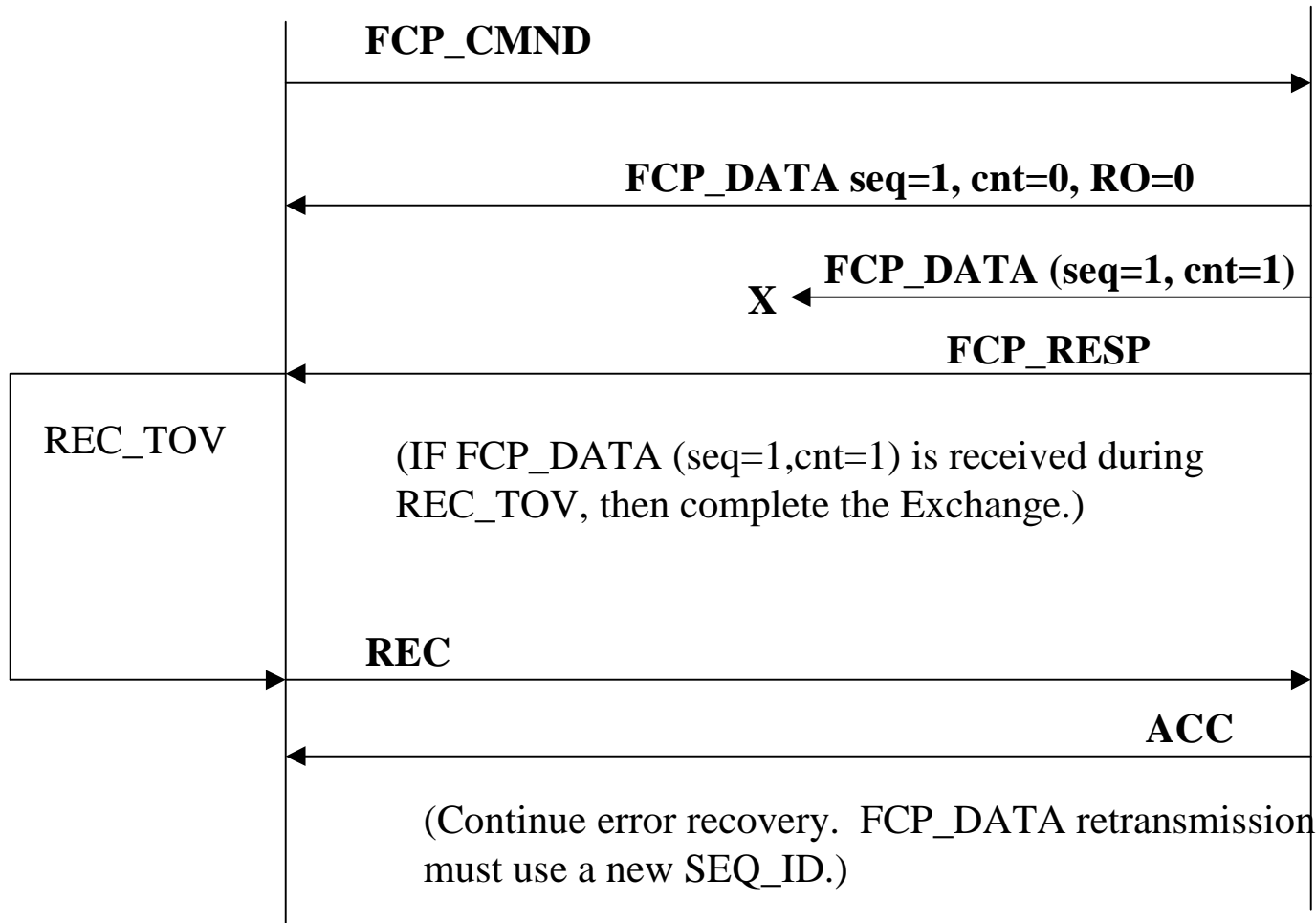


# D.8 Class 2 Lost Write Data, Not Last Frame of Seq.

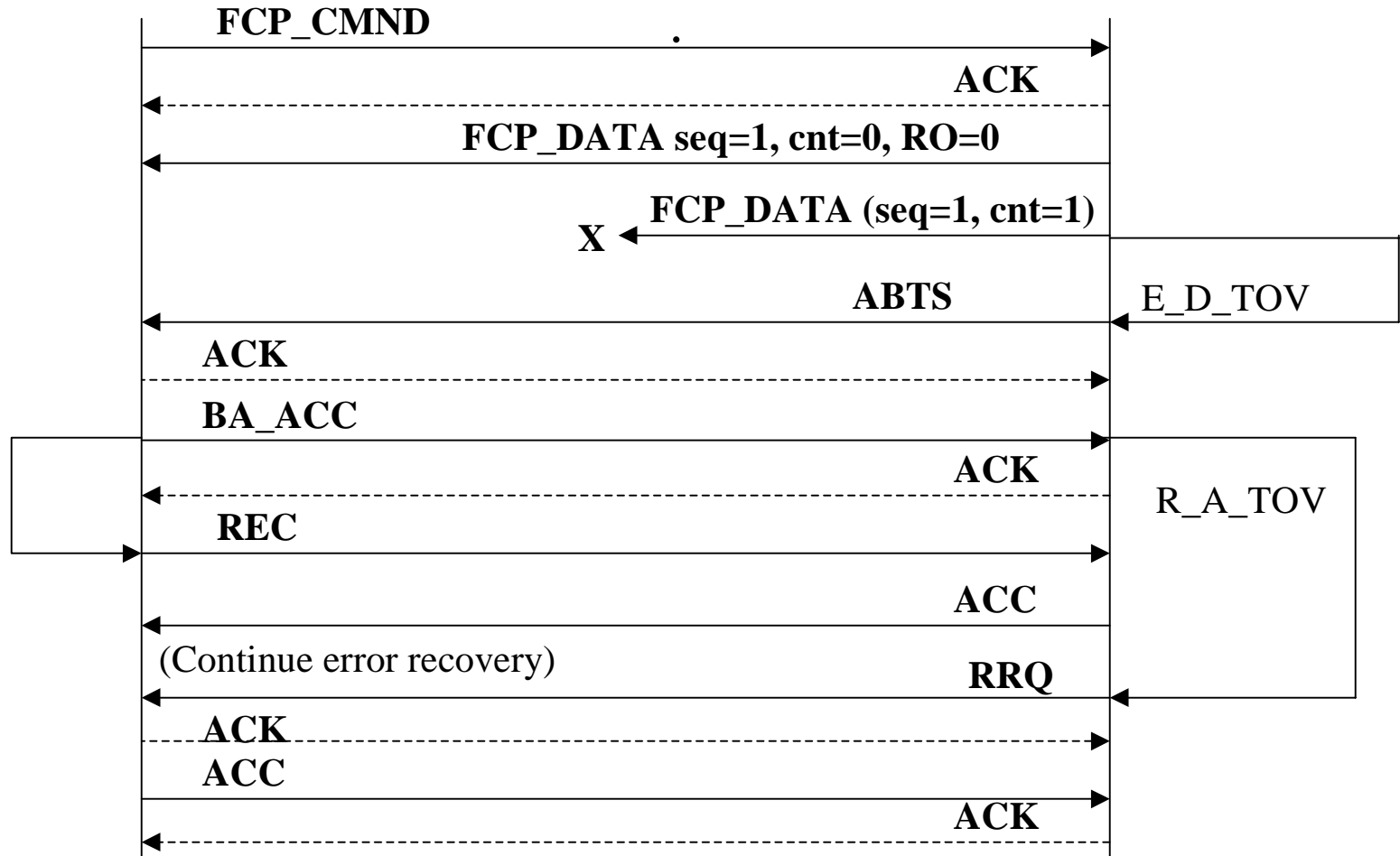


BA\_ACC indicates by its payload, that the FCP\_DATA Sequence was not completely received (Payload: SEQ\_ID valid, SEQ\_ID value = SEQ\_ID of FCP\_CMND, low SEQ\_CNT of 0 not equal to high SEQ\_CNT of 2). New SEQ\_IDs shall be used for retransmission of FCP\_XFER\_RDY and FCP\_DATA. For Class 2 the Sequence count value used with the retransmission of FCP\_DATA must be one greater than the value used in ABTS. Note that if all data frames arrive at the Target prior to the expiration of E\_D\_TOV (out-of-order), then there is no error and no recovery is necessary. ACKs for REC/ACC are not shown.

# D.9 Class 3 Lost Read Data, Last Frame of Seq.



# D.9 Class 2 Lost Read Data, Last Frame of Seq



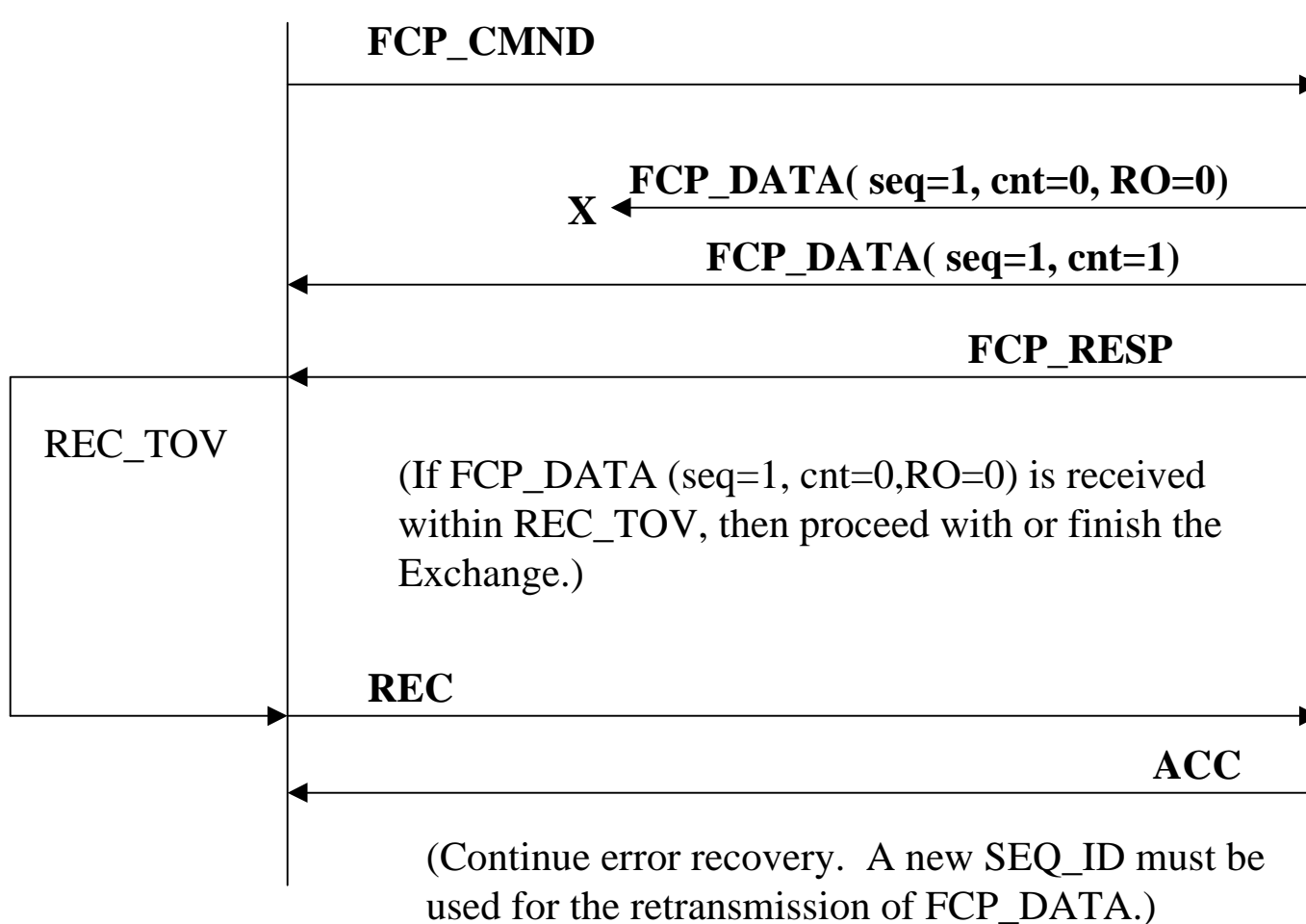
## Error Recovery Addition

BA\_ACC indicates by its payload, that the FCP\_DATA Sequence was not completely received (Payload: SEQ\_ID invalid, low SEQ\_CNT of 0 not equal to high SEQ\_CNT of the ABTS frame of 2).

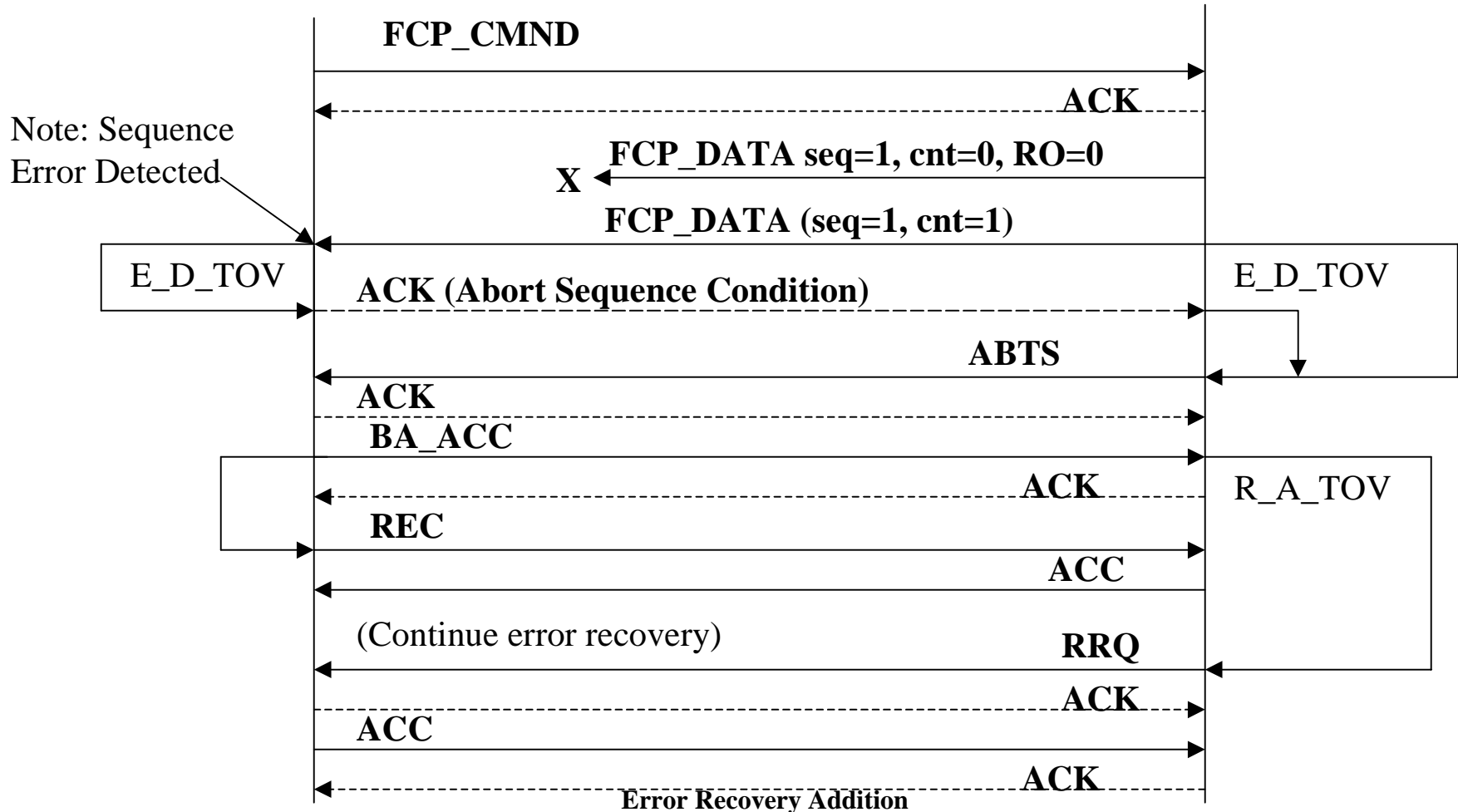
A new Sequence ID shall be used for retransmission of FCP\_DATA.

For Class 2, the Sequence count value used with the retransmission of FCP\_DATA shall be one greater than the value used in ABTS. The ACKs for REC/ACC are not shown.

# D.10 Class 3 Lost Read Data, Not Last Frame of Seq

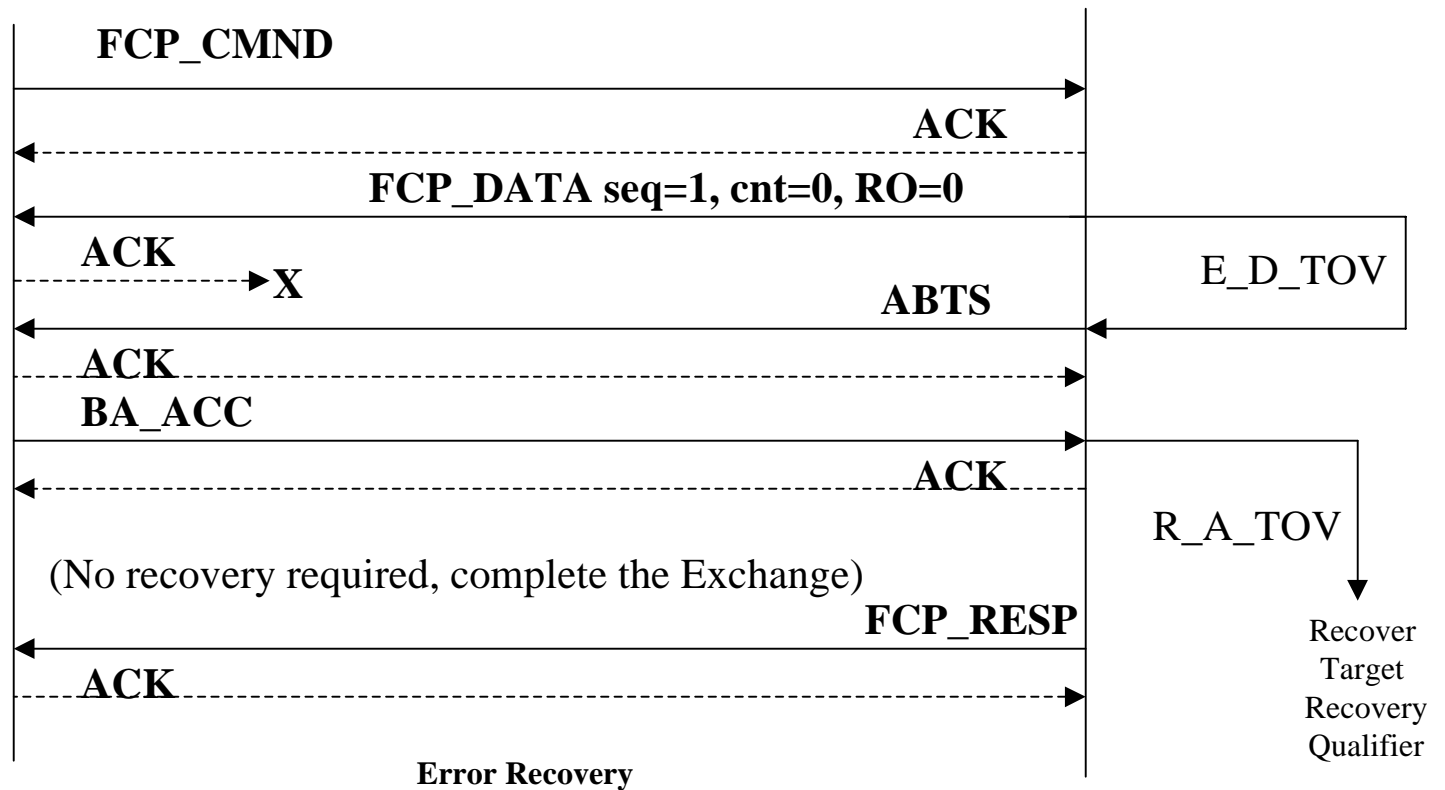


# D.10 Class 2 Lost Read Data, Not Last Frame of Seq



BA\_ACC indicates by its payload, that the FCP\_DATA Sequence was not completely received (Payload: SEQ\_ID invalid, low SEQ\_CNT of 0 not equal to high SEQ\_CNT of the ABTS frame of 2). A new Sequence ID shall be used for retransmission of FCP\_DATA. For Class 2, the SEQ\_CNT used with the retransmission of FCP\_DATA shall be one greater than the value used in ABTS. Note that if all data frames arrive at the initiator before E\_D\_TOV expires, then no recovery is required; a frame or frames arrived out-of-order. The ACKs for REC/ACC are not shown.

# D.11 Class 2 ACK Lost on Read



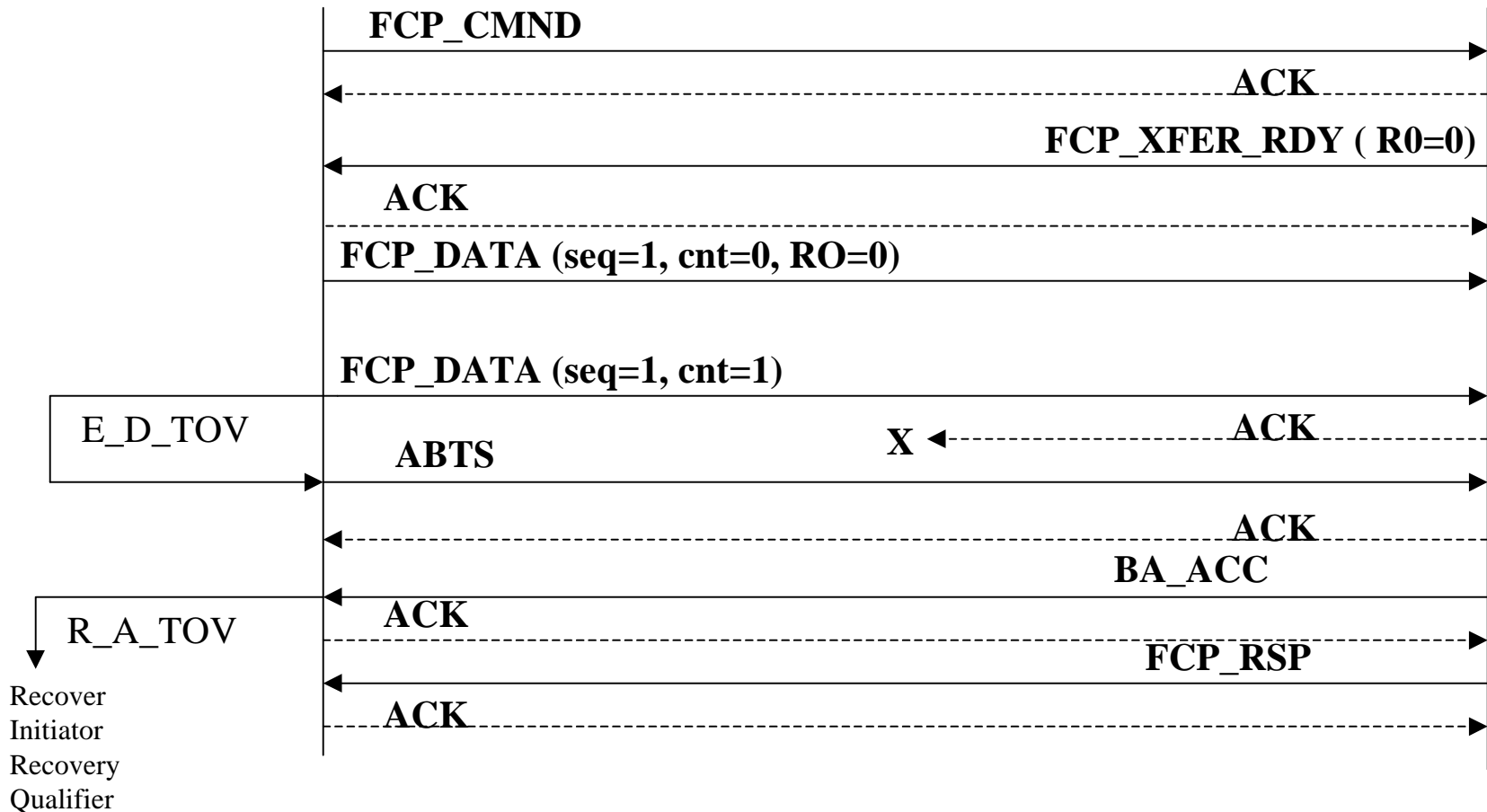
None:

The initiator has received the FCP\_DATA Sequence. No error recovery is required.

Note: The BA\_ACC indicates the FCP\_DATA sequence was received (Payload is SEQ\_ID valid, SEQ\_ID value =SEQ\_ID value of FCP\_DATA Sequence, low SEQ\_CNT=high SEQ\_CNT= SEQ\_CNT of ABTS frame).

Note: The Target must establish its Recovery Qualifier. The resources associated with the Recovery Qualifier can be reclaimed after R\_A\_TOV. The issuance of RRQ is optional as no Recovery Qualifier was established by the Initiator in this case. FCP\_RESP can be received anytime after the transmission of FCP\_CMD due to out-of-order delivery.

# D.12a Class 2 ACK Lost on Write



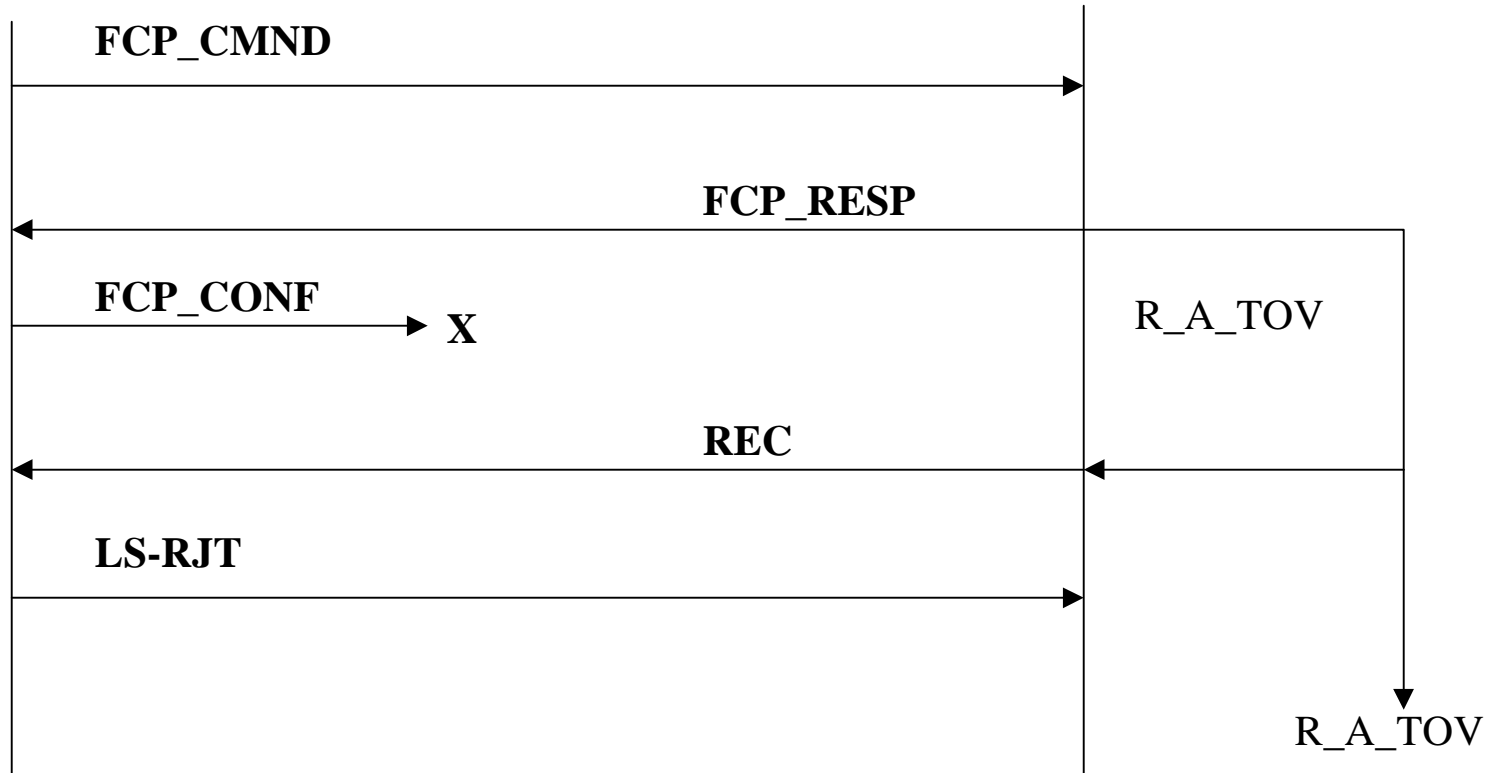
## Error Recovery

None: The Target received the FCP\_DATA sequence. No error recovery is required.

Note: The BA\_ACC indicates the data sequence was received (Payload is SEQ\_ID valid, SEQ\_ID value =SEQ\_ID value of the FCP\_DATA Sequence, low SEQ\_CNT=high SEQ\_CNT=SEQ\_CNT of ABTS frame). The Target and Initiator continue the Exchange. The Initiator must establish its Recovery Qualifier. The resources associated with the Recovery Qualifier can be reclaimed after R\_A\_TOV. The issuance of the RRQ is optional as no Recovery Qualifier was established by the Target. FCP\_RESP can be received at any time after the last FCP\_DATA frame has been transmitted.



# D.?1 Class 3 FCP\_CONF Lost



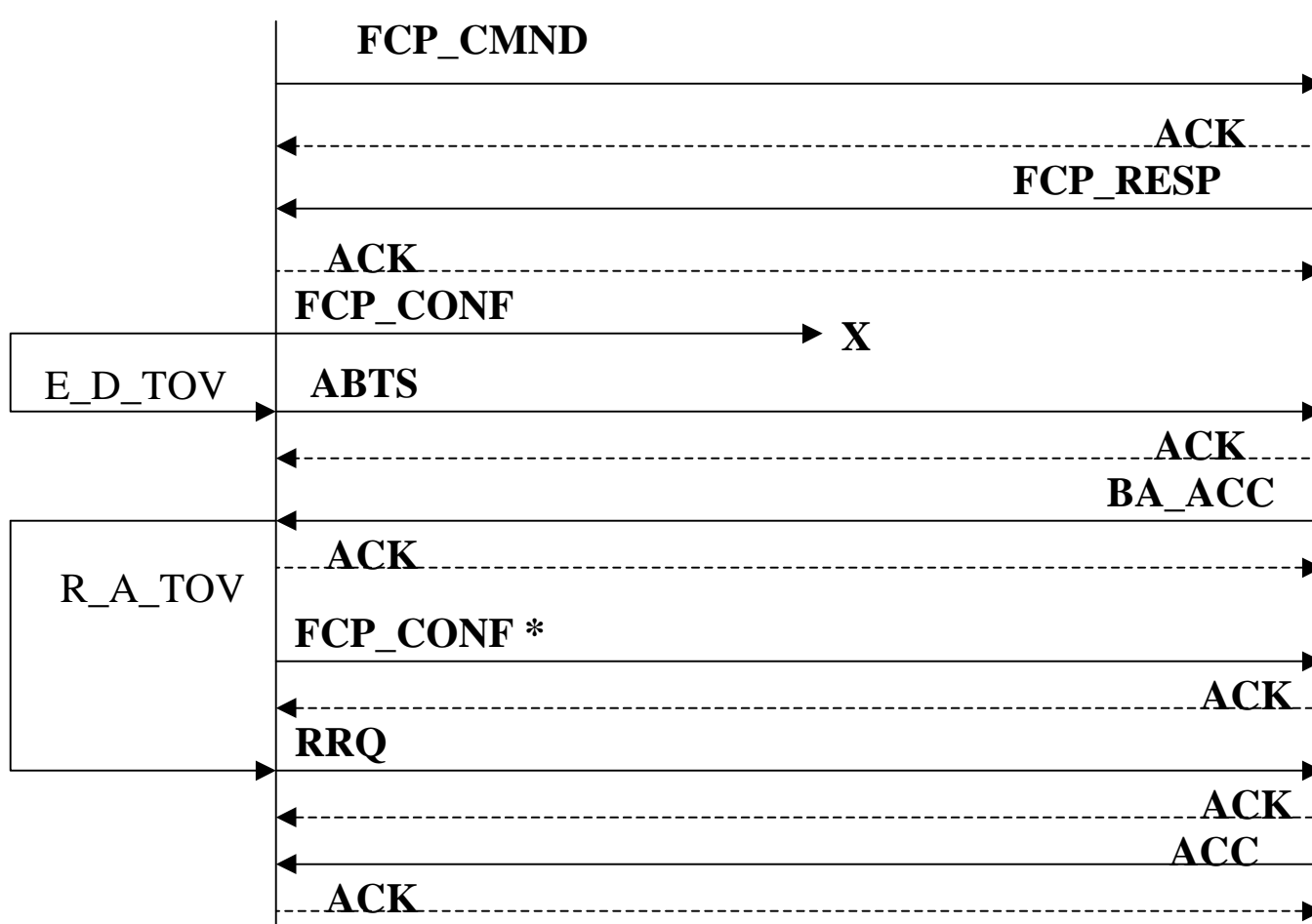
## Error Recovery

None.

LS-RJT implicitly indicates that the Initiator received FCP\_RESP and sent FCP\_CONF, since no context exists for the Exchange.

The context for the Exchange in the Target must be preserved for another R\_A\_TOV to prevent possible aliasing. If FCP\_CONF is received after REC is transmitted, it is accepted and discarded and the context for the Exchange can be purged.

# D.?? Class 2 FCP\_CONF Lost

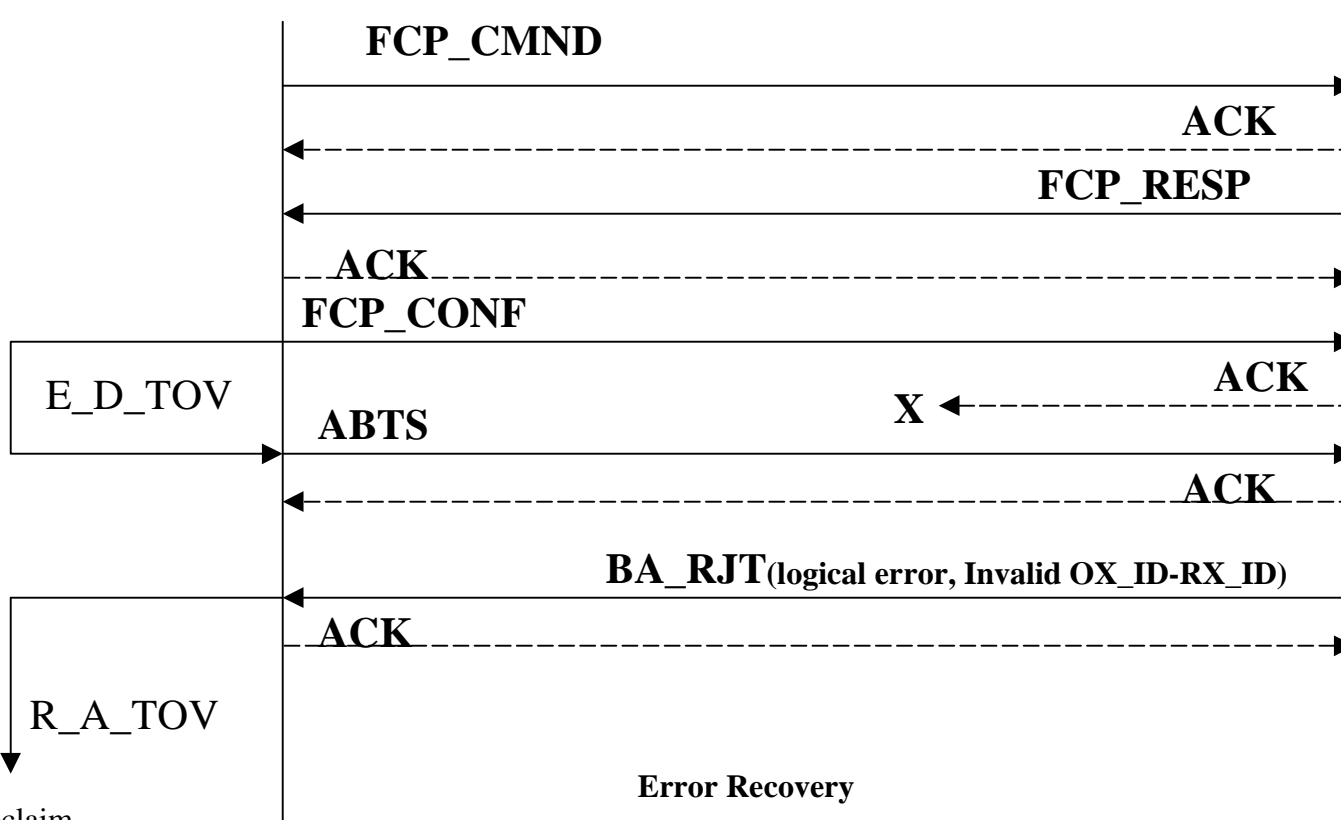


## Error Recovery

BA\_ACC payload indicates that FCP\_CONF was not received (low SEQ\_CNT=0, not equal to high SEQ\_CNT =1, SEQ\_ID valid, SEQ\_ID value =SEQ\_ID of FCP\_CMND)

\* Second FCP\_CONF must be sent with a different SEQ\_ID and the SEQ\_CNT value must be one greater than the value used in the ABTS frame.

# D.??? Class 2 ACK Lost on FCP\_CONF

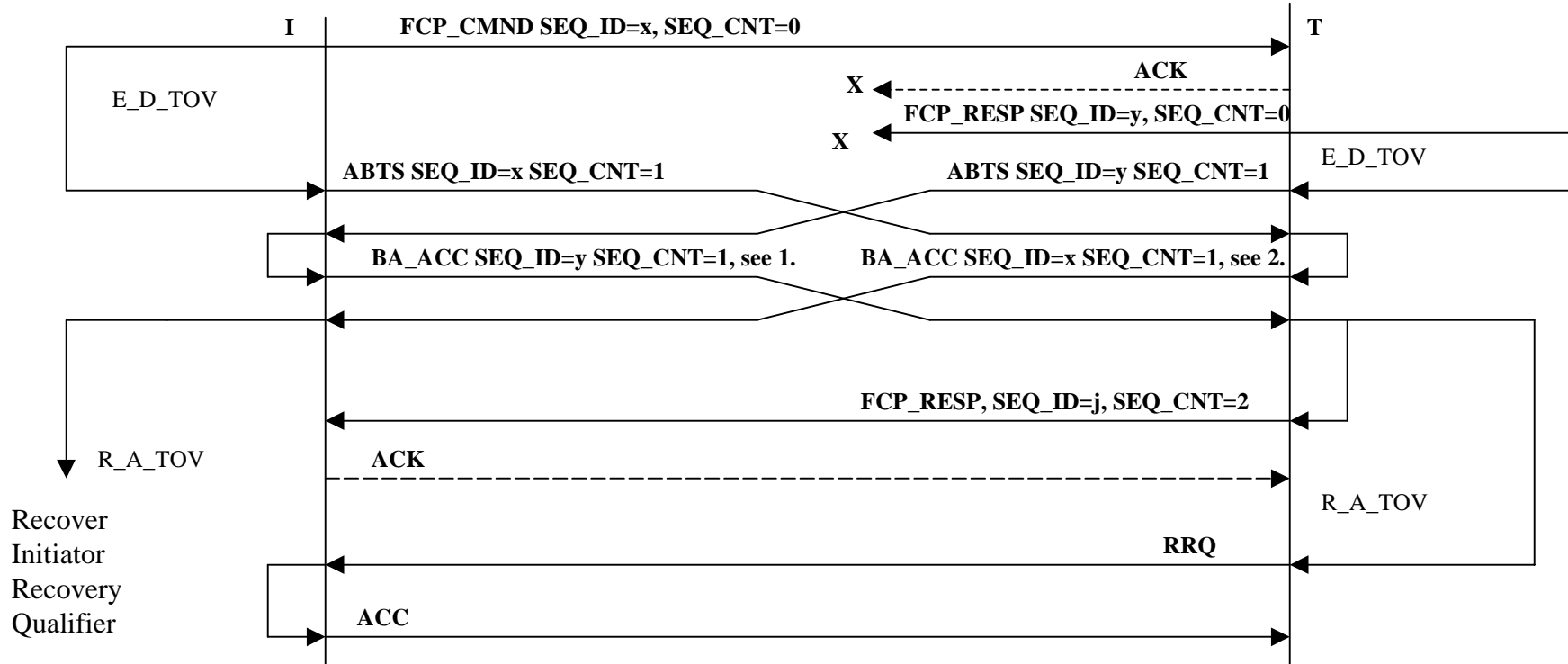


Reclaim  
Initiator  
Recovery  
Qualifier

None:

BA\_RJT is the response to the ABTS since no context exists for this Exchange and the ABTS was not issued on the first Sequence of a new Exchange. The Initiator must establish a Recovery Qualifier on receipt of the BA\_RJT. The resources associated with the Recovery Qualifier can be reclaimed when R\_A\_TOV expires. Note that the issuance of RRQ is optional as no Recovery Qualifier was established by the Target.

## D.5? Class 2 ACK to FCP\_CMND and FCP\_RESP Lost, no FCP\_CONF Req.

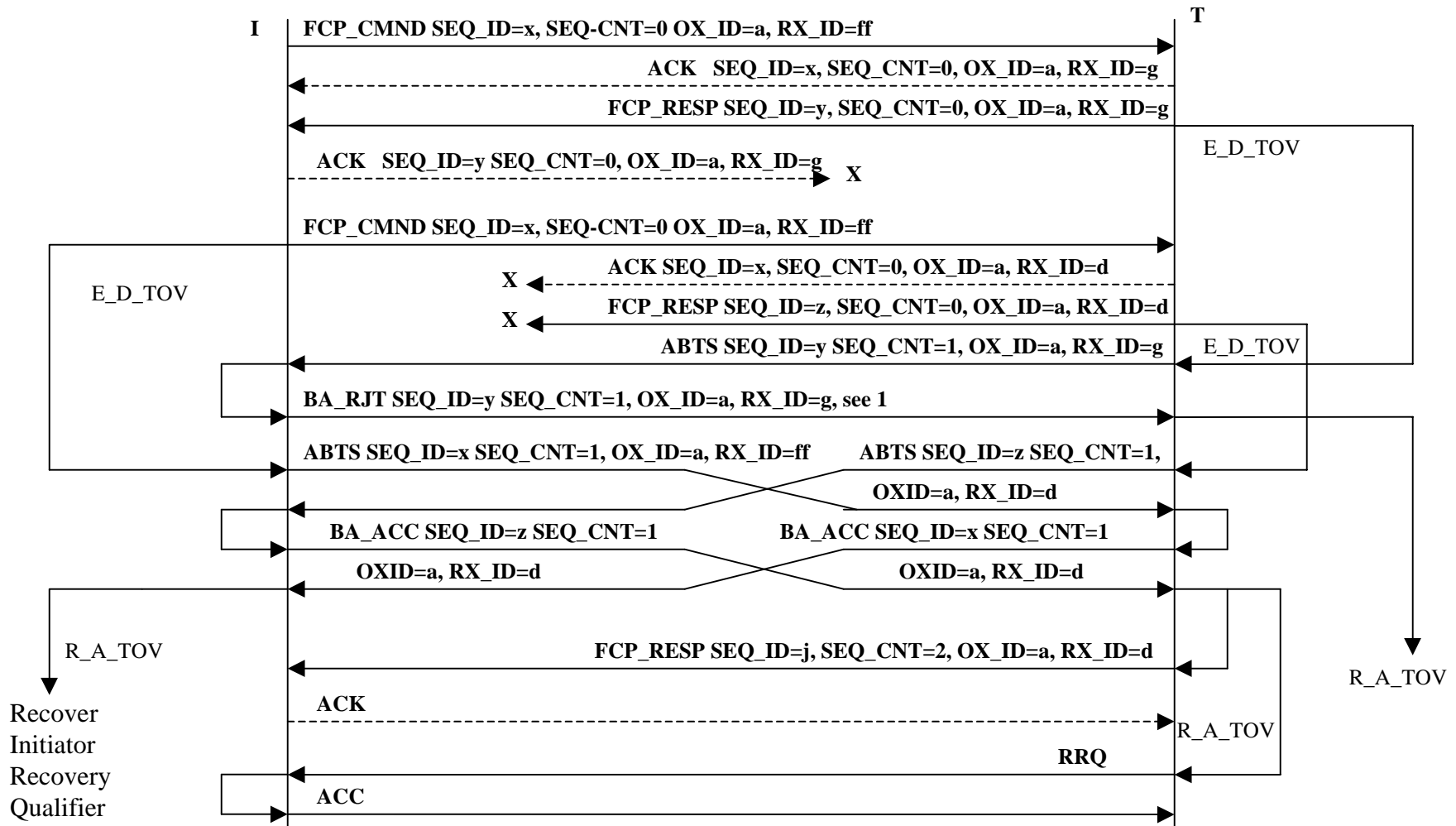


### Error Recovery

**TWO** Recovery Qualifiers are established on the Initiator side. One based on the ABTS sent by the Initiator to discard the ACK/Link Response frame to the FCP\_CMND and the other, as a Sequence recipient, to discard the FCP\_RESP, based on the ABTS issued by the Target. Only one Recovery Qualifier is established by the Target based on the ABTS that it sends to the Initiator. Since the FCP\_CMND was received, the Sequence is complete from the Target perspective and no Recovery Qualifier is needed. Thus the issuance of RRQ by the Initiator is optional and the response would be LS\_RJT.

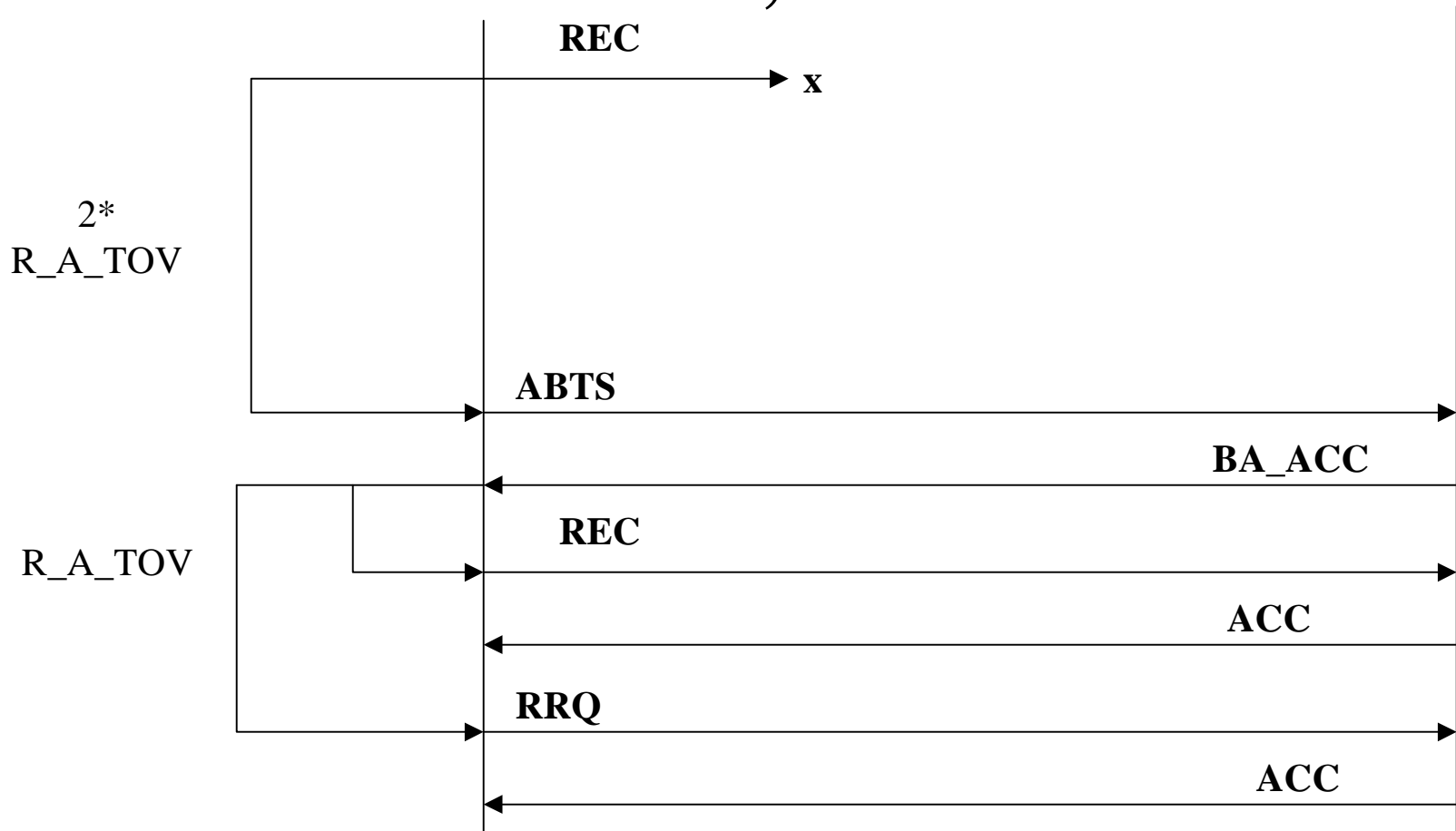
1. The payload is SEQ\_ID invalid, low SEQ\_CNT = 0, high SEQ\_CNT = 1.
2. The payload is valid SEQ\_ID, SEQ\_ID value = x, low SEQ\_CNT = high SEQ\_CNT = SEQ\_CNT of ABTS = 1. A new SEQ\_ID must be used in the retransmission of FCP\_RESP and the SEQ\_CNT value used must be one greater than the value used in the Target ABTS frame. Note that SEQ\_IDs used by the Initiator and Target are completely independent of each other, x could be the same value as y in the above example.

# D.5?? Class 2 ACK to FCP\_CMND and FCP\_RESP Lost, no FCP\_CONF Req. Plus ACK lost to previous FCP\_RESP



1. BA\_RJT is the response since no context exists for the old Exchange. Note that the old ESB, if it existed, would look very similar to the current ESB, except for the RX\_ID valid value of g and E\_STAT indicating a Completion indication of complete and an Ending Condition of Normal. Note that the Target must wait R\_A\_TOV before releasing the Recovery Qualifier (waiting for missing ACK) for the first Exchange, to free up RX\_ID=a. Note that SEQ\_ID values x and y can be different values or the SAME value, but z must be different than y and j must be different than z.

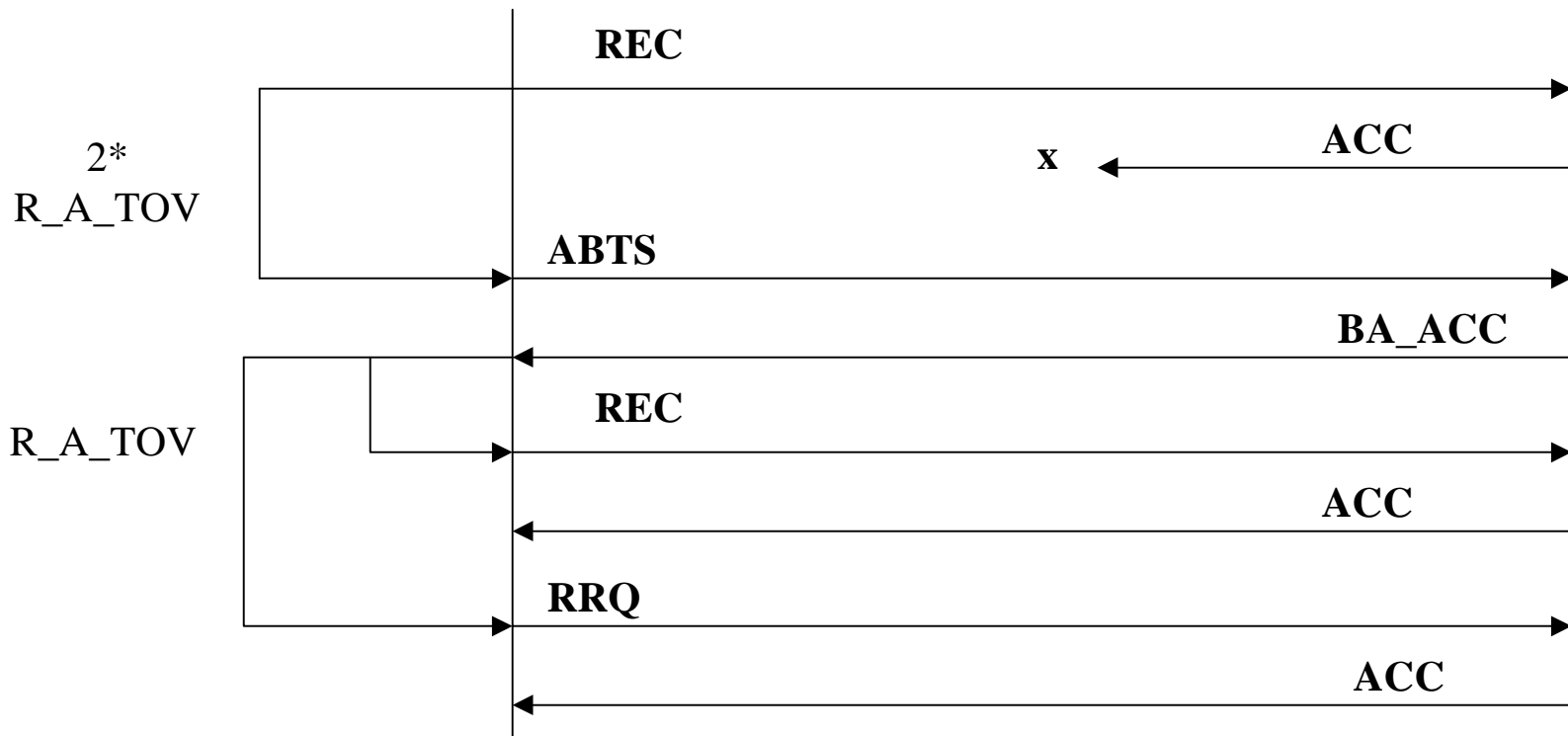
# D.13 C1 3, REC Lost



Since the REC was never received by the Target, the BA\_ACC payload is SEQ\_ID invalid, low SEQ\_CNT =0, high SEQ\_CNT= SEQ\_CNT of ABTS=1. Recovery qualifiers are established on both sides. The second REC must be issued in a new Exchange.

Change E\_D\_TOV in the test to  $2 * R\_A\_TOV$  to agree with the text in 12.6.2

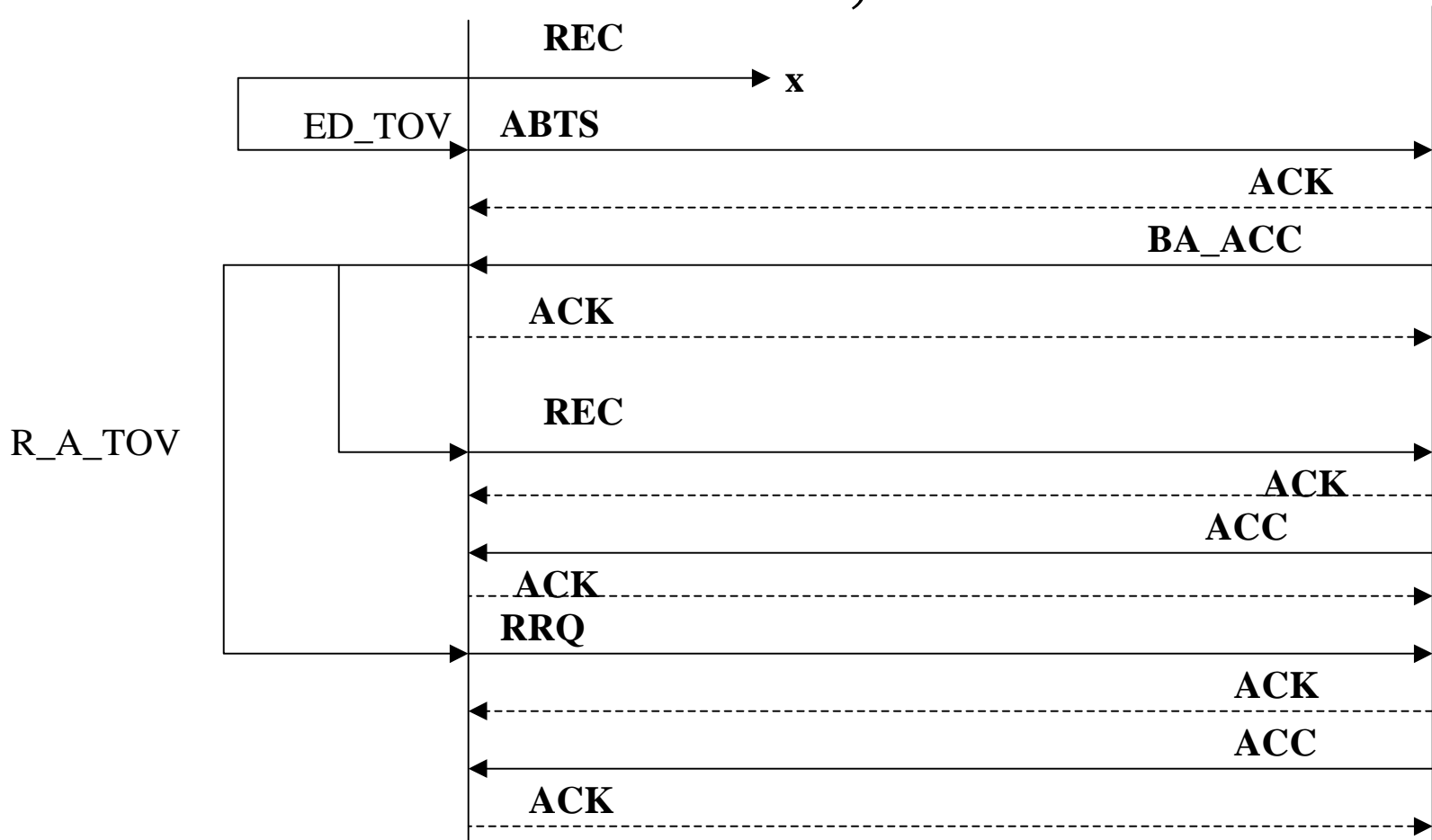
# D.13a C1 3, REC Response Lost



Since the Target has already responded with ACC then no context exists for the Exchange. The Target would view the ABTS as being issued on a new Exchange, establish a Recovery Qualifier and respond with BA\_ACC (Payload is SEQ\_ID invalid, low SEQ\_CNT=high SEQ\_CNT= SEQ\_CNT of ABTS). Since REC does not change any state, it can be reissued unconditionally. The second REC must be issued in a new Exchange.

Change E\_D\_TOV in the test to  $2^*R\_A\_TOV$  to agree with the text in 12.6.2

# D.13b Class 2, REC Lost

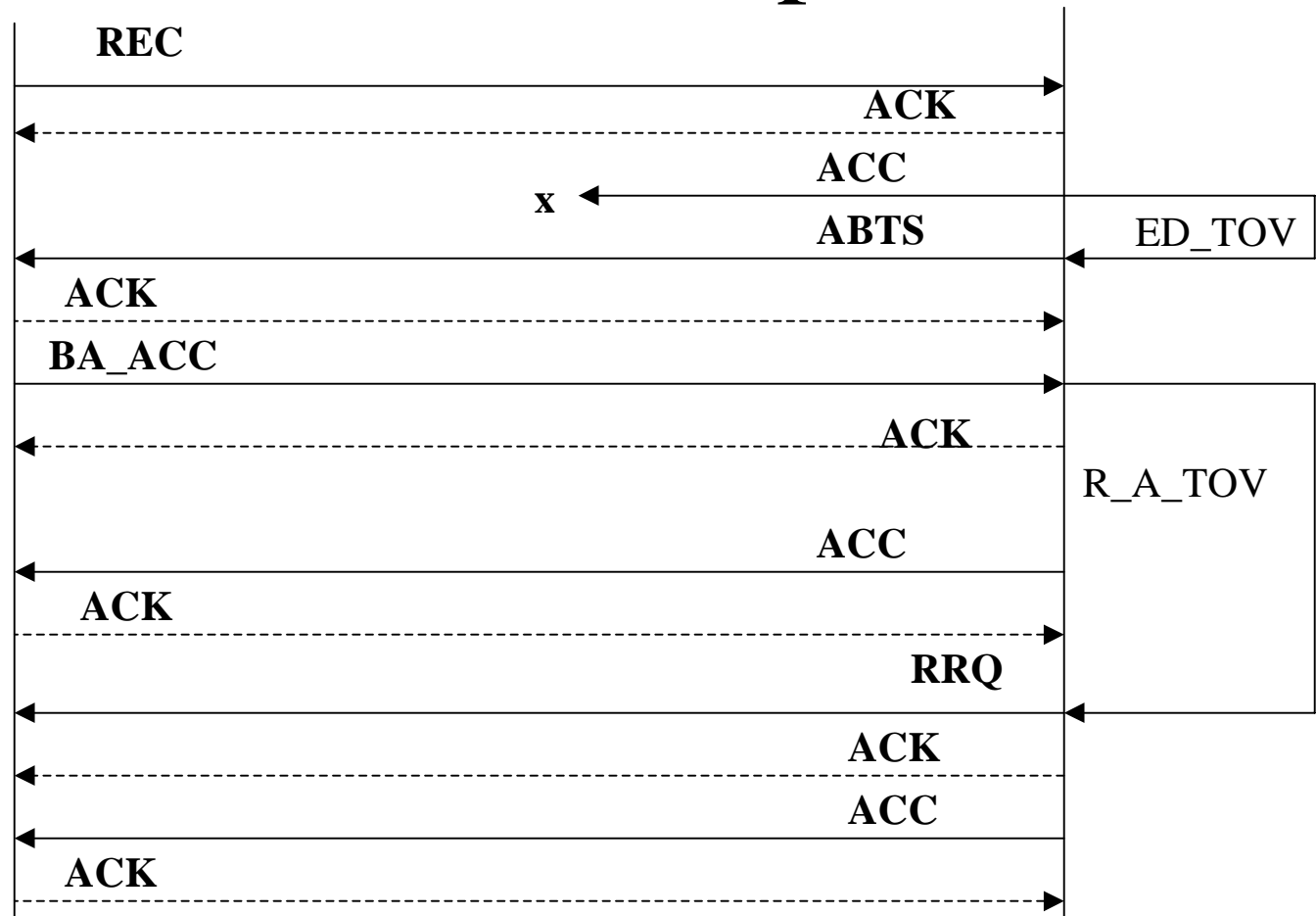


The BA\_ACC payload indicates that the REC was never received by the Target (Payload is SEQ\_ID invalid, low SEQ\_CNT=0, high SEQ\_CNT=SEQ\_CNT in ABTS frame) Recovery Qualifiers are established on each side.

The second REC is issued using a new Exchange.

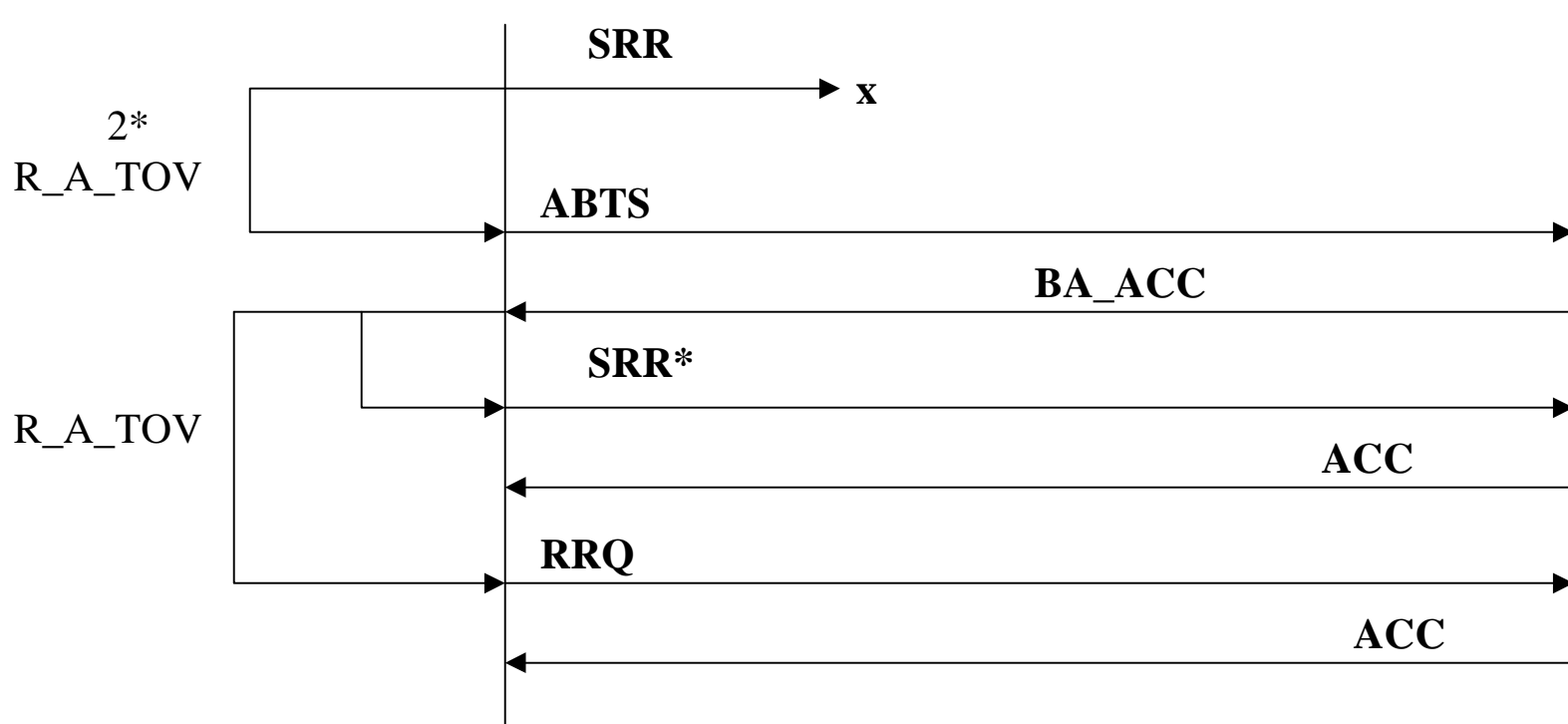


# D.13c Class 2, REC Response Lost



Note: The Target determines that the ACC was never received by the Initiator; BA\_ACC payload is SEQ\_ID invalid, Low SEQ\_CNT=0, High SEQ\_CNT=SEQ\_CNT of ABTS. Target reissues ACC.

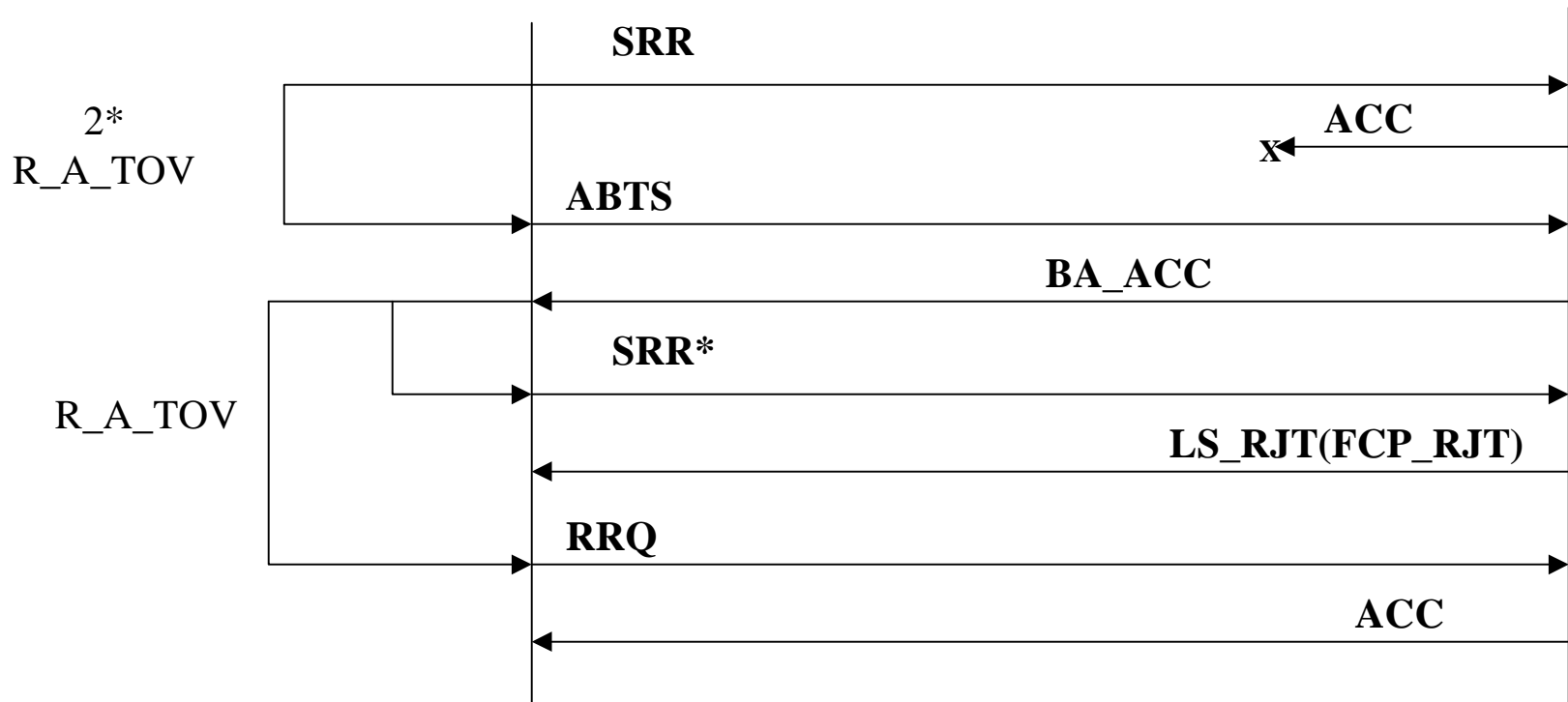
# D.14a Class 3, SRR Lost



Note: BA\_ACC Payload: SEQ\_ID Validity = invalid, low SEQ\_CNT=0, high SEQ\_CNT =SEQ\_CNT of ABTS frame. Recovery Qualifiers are established on both sides. SRR\* is issued in a new Exchange. The Target restarts the original Exchange per the SRR\* Payload.

Change E\_D\_TOV in the test to  $2^*R\_A\_TOV$  to agree with the text in 12.6.3

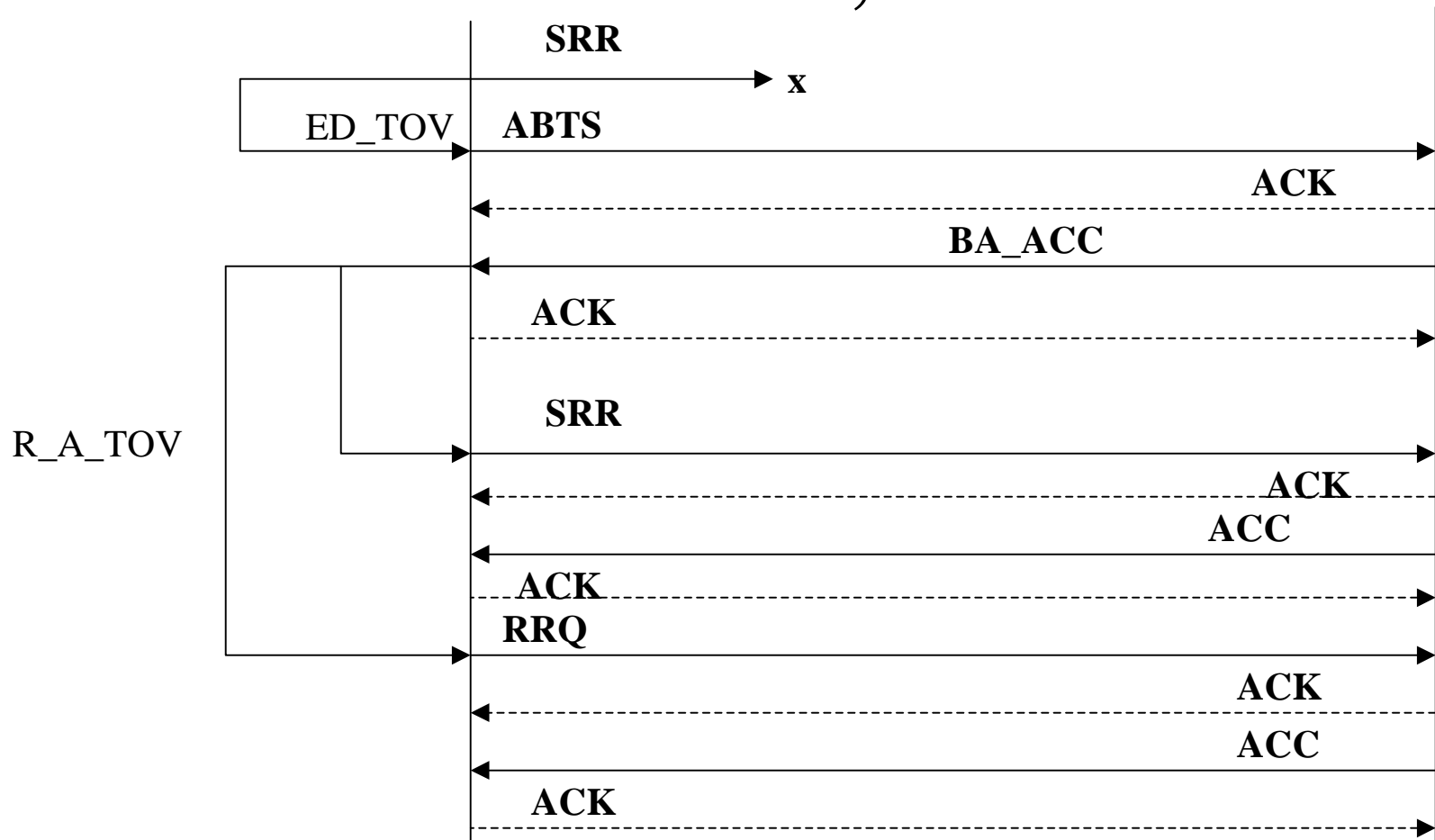
# D.14b Class 3, SRR Response Lost



Note: The Exchange for the SRR completed. Since to the Target this looks like an ABTS on a new Exchange, the BA\_ACC Payload is SEQ\_ID Validity = invalid, low SEQ\_CNT=0, high SEQ\_CNT = SEQ\_CNT of ABTS. FCP\_RJT is returned since the the original Exchange has been restarted by the Target per the Payload of the SRR. The original Exchange is in process, or it has completed and no context for it (OX\_ID-RX\_ID) remains.

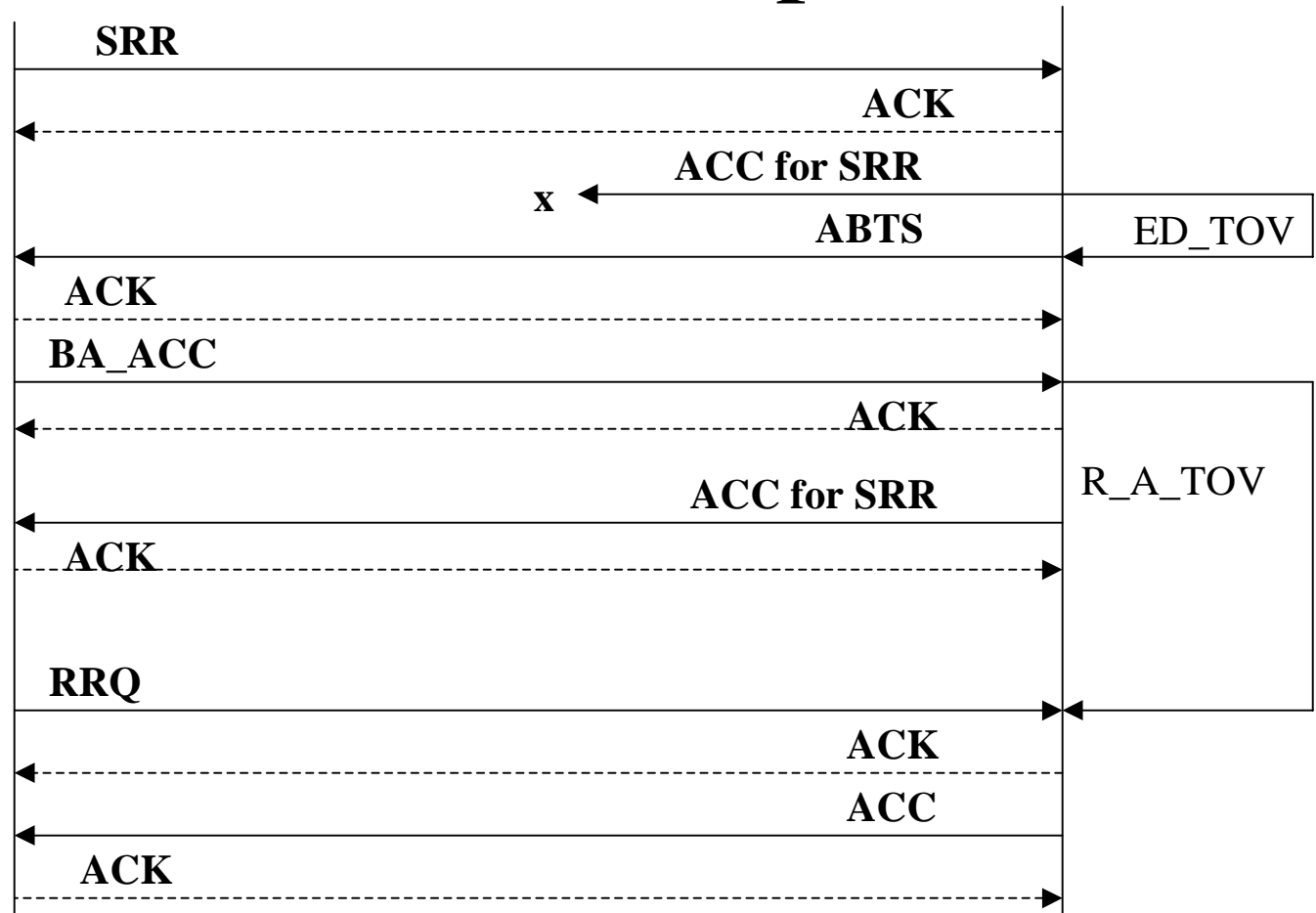
Change E\_D\_TOV in the test to  $2^*R\_A\_TOV$  to agree with the text in 12.6.3

# D.14c Class 2, SRR Lost



Since this is an ABTS on a new Exchange, Recovery Qualifiers must be established. BA-ACC indicates Invalid SEQ\_ID, low SEQ\_CNT= 0 and high SEQ\_CNT = SEQ\_CNT of the ABTS. The second SRR is issued using a new Exchange.

# D.14d Class 2, SRR Response Lost



Note: The BA\_ACC payload indicates SEQ\_ID invalid, low SEQ\_CNT=0 and high SEQ\_CNT=SEQ\_CNT of the ABTS, which indicates that the ACC for SRR was not received and will be discarded if it is received. Recovery Qualifiers are established on both sides. The ACC for SRR is issued with a new SEQ\_ID and a SEQ\_CNT one greater than used in the ABTS.