

# Annex D Error detection and recovery action examples

(Informative) [Draft, based on T10/00-137r5]

## D.1 Introduction

This annex diagrams various error detection and recovery procedures for SCSI devices conforming to this profile.

Table D.1 - Diagram Drawing Conventions

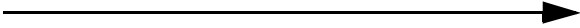
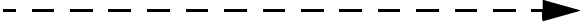
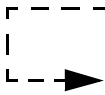
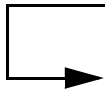

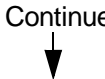
| Drawing Convention  | Meaning  |
|---|--|
|    | Acknowledged or Unacknowledged Frame   |
|    | Acknowledgement Frame  |
|    | Time-out value exceeded, caused transmission of IU or ELS                    |
|    | IU or ELS received is processed to transmit IU or ELS                        |
|   | Frame lost or dropped  |
|  | Error detection complete. Operation continues with specified Error Recovery. |

Figure D.1 - Lengthy FCP\_CMND

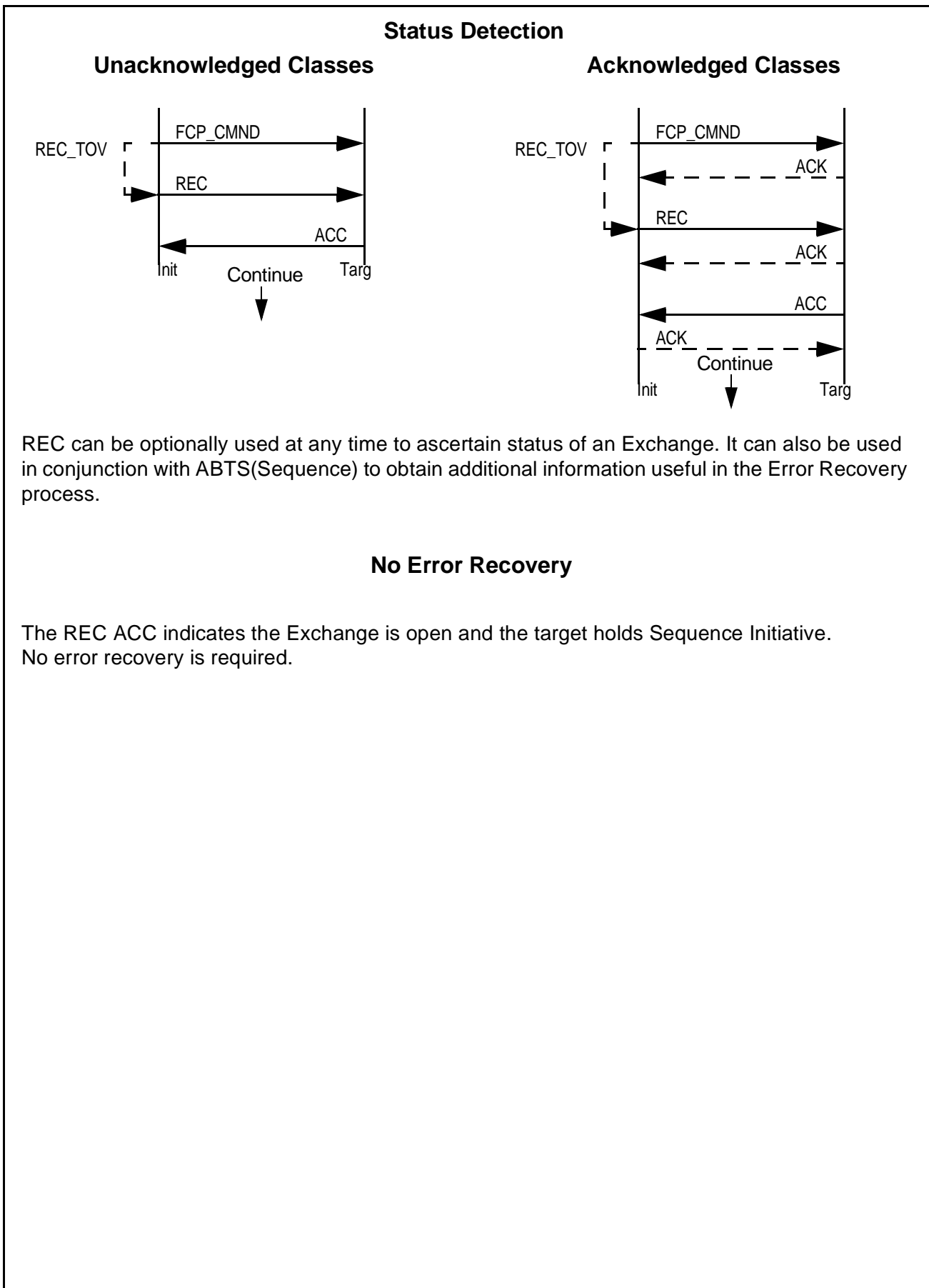
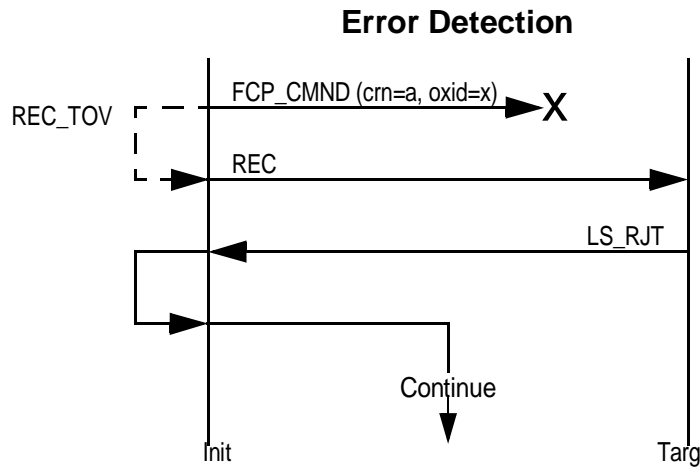
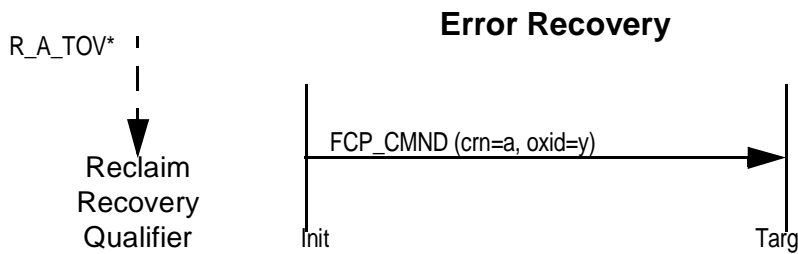


Figure D.2 - FCP\_CMND Lost, Unacknowledged Classes



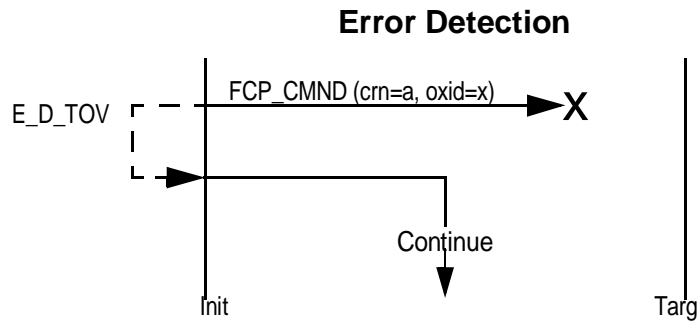
Upon receipt of the LS\_RJT for the REC (indicates the Exchange is unknown) the initiator performs error recovery.



The FCP\_CMND is retransmitted in a new Exchange using the same CRN.

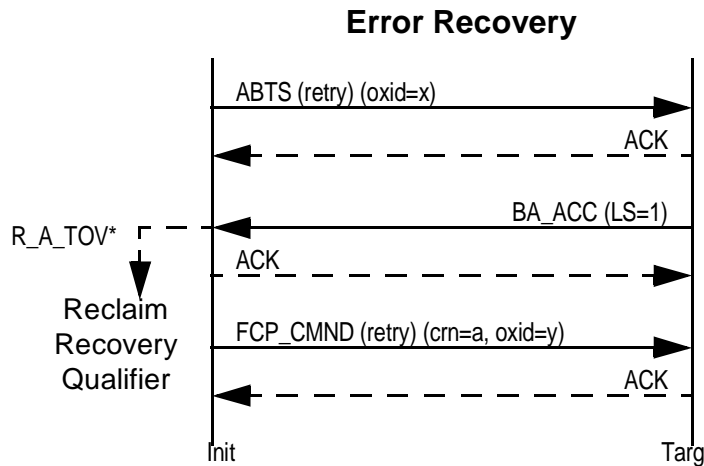
The initiator establishes a Recovery Qualifier. The value of R\_A\_TOV\* for in-order topologies is 0.

Figure D.3 - FCP\_CMND Lost, Acknowledged Classes



Upon expiration of E\_D\_TOV, the initiator performs error recovery.

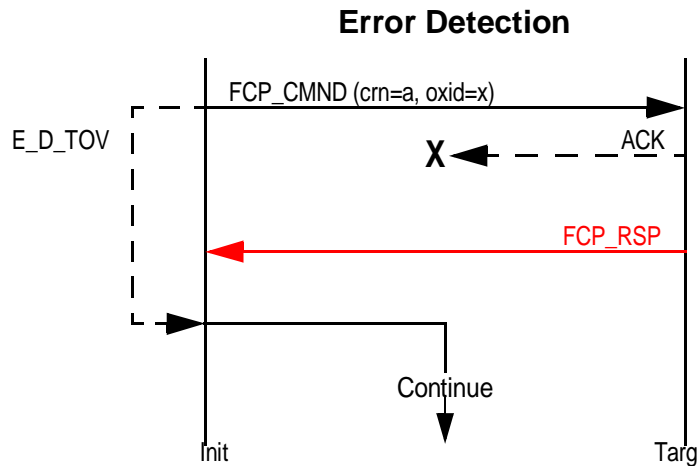
The use of REC to determine status for error recovery shall not be used.



The initiator sends an ABTS(retry) requesting the Exchange be retried. The FCP\_CMND is retransmitted in a new Exchange using the same CRN.

Both initiator and target establish Recovery Qualifiers. The value of R\_A\_TOV\* for in-order topologies is 0.

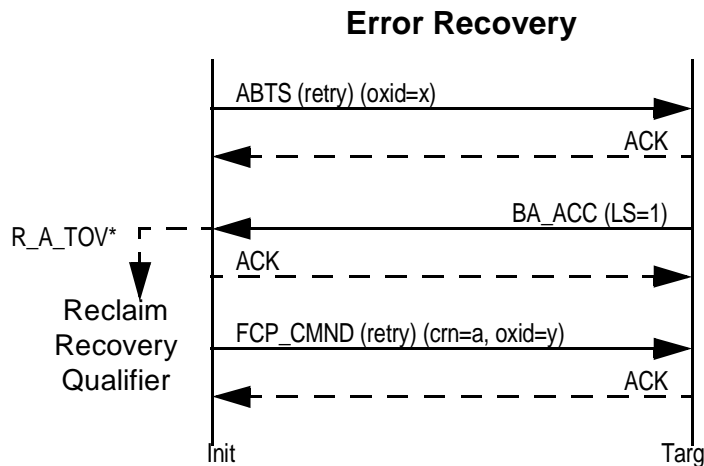
Figure D.4 - FCP\_CMND Acknowledgement Lost, Acknowledged Classes



Upon expiration of E\_D\_TOV, the initiator performs error recovery. Although it is possible for the Exchange to continue when the ACK is lost, in the interest of simplicity, error recovery is performed.

The use of REC to determine status for error recovery shall not be used.

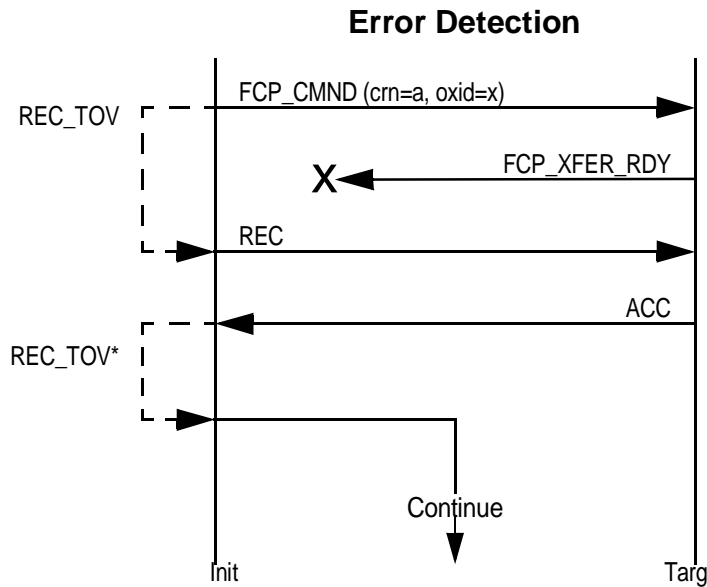
It was not decided how to proceed if the exchange “continues” or “completes” before the E\_D\_TOV expires.



The initiator sends an ABTS(retry) requesting the Exchange be retried. The FCP\_CMND is retransmitted in a new Exchange using the same CRN.

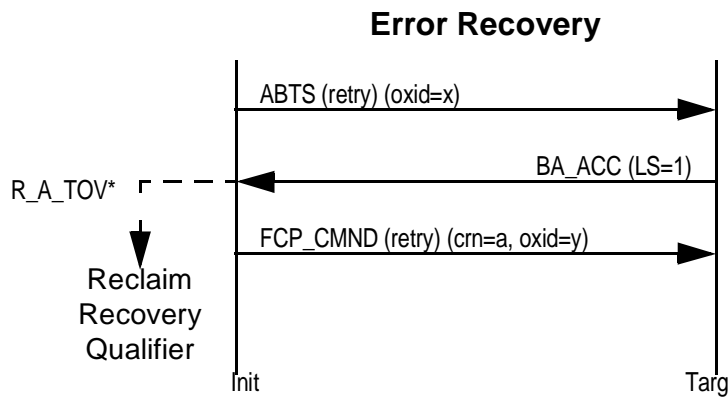
Both initiator and target establish Recovery Qualifiers. The value of R\_A\_TOV\* for in-order topologies is 0.

Figure D.5 - FCP\_XFER\_RDY Lost, Unacknowledged Classes



The REC ACC indicates the initiator holds Sequence Initiative and the Exchange is open.

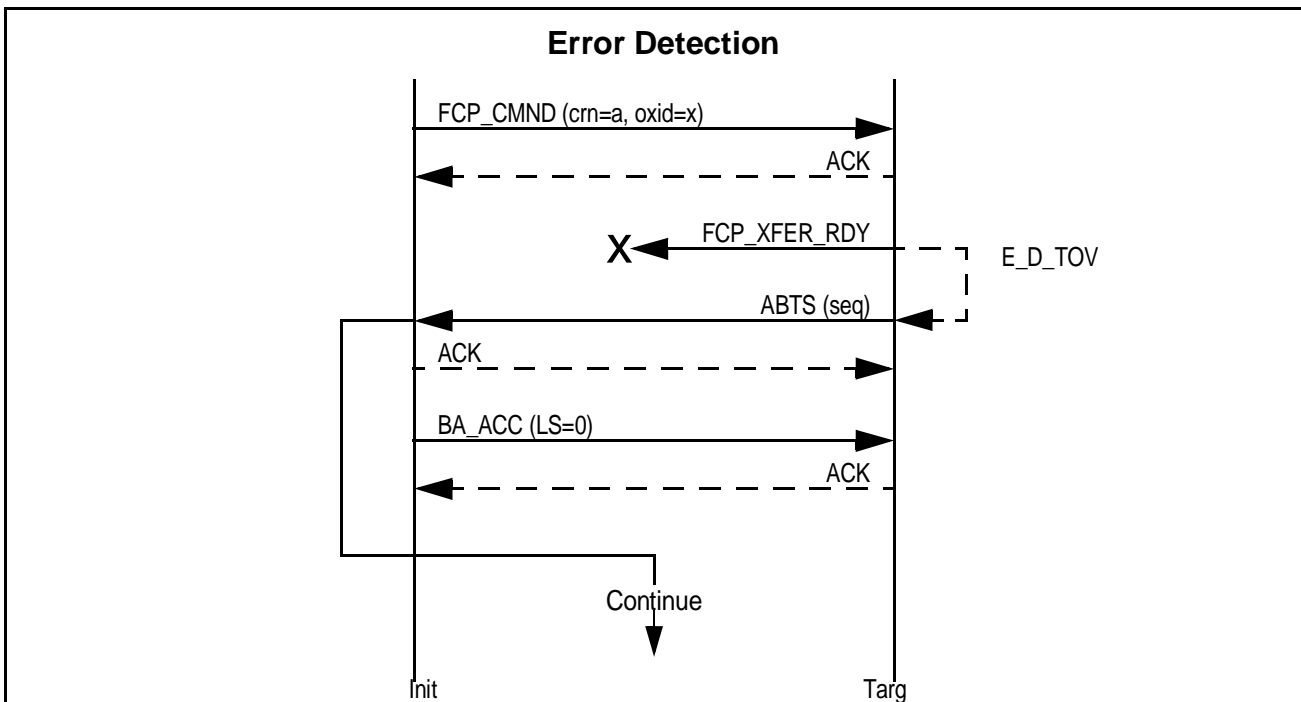
Wait REC\_TOV\* before performing error recovery. If FCP\_XFER\_RDY is received before REC\_TOV\* expires, continue with the Exchange (REC ACC arrived before FCP\_XFER\_RDY, out of order). Otherwise continue recovery. For in-order topologies, the value of REC\_TOV\* is 0.



The initiator sends an ABTS(retry) requesting the Exchange be retried. The FCP\_CMND is retransmitted in a new Exchange using the same CRN.

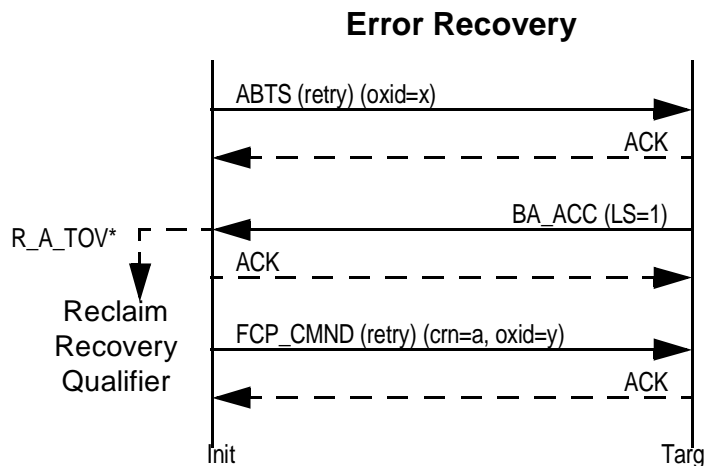
Both initiator and target establish Recovery Qualifiers. The value of R\_A\_TOV\* for in-order topologies is 0.

Figure D.6 - FCP\_XFER\_RDY Lost, Acknowledged Classes



After receiving the ABTS, the initiator performs error recovery. **Does the initiator send BA\_ACC or go directly to recovery and send ABTS(retry)?**

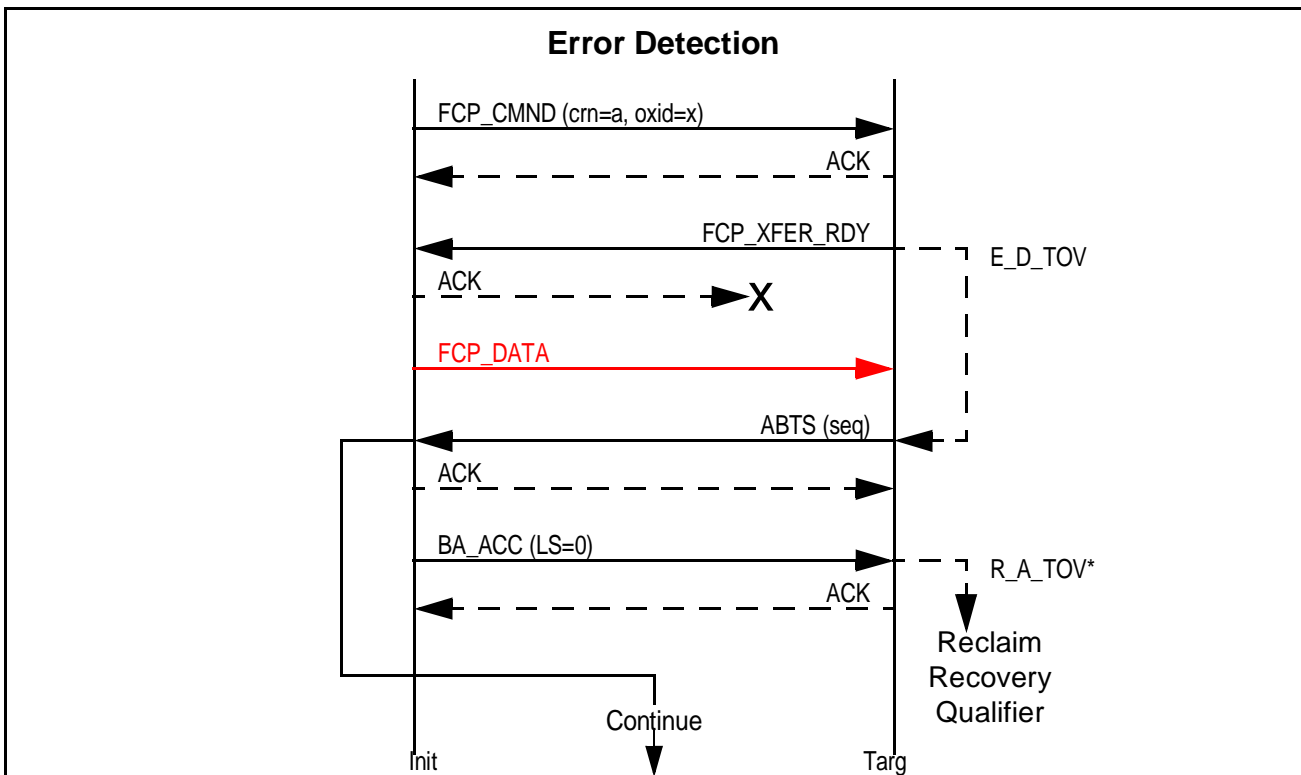
The use of REC to determine status for error recovery shall not be used.



The initiator sends an ABTS(retry) requesting the Exchange be retried. The FCP\_CMND is retransmitted in a new Exchange using the same CRN.

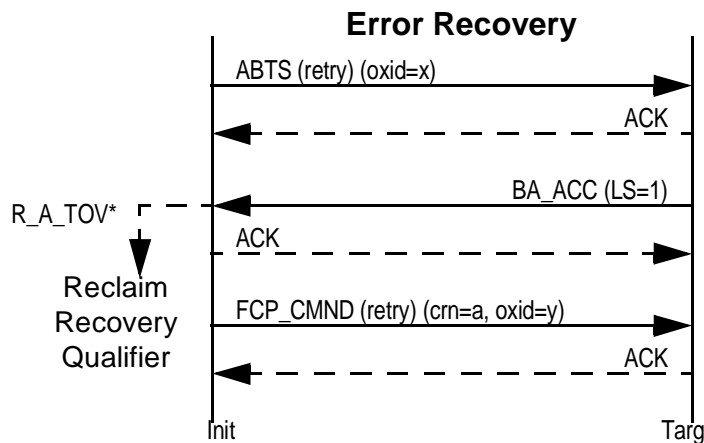
Both initiator and target establish Recovery Qualifiers. The value of R\_A\_TOV\* for in-order topologies is 0.

Figure D.7 - FCP\_XFER\_RDY Received, ACK Lost, Acknowledged Classes



Although it is possible for the Exchange to continue when the ACK is lost, in the interest of simplicity, error recovery is performed when the initiator receives the ABTS.

It was not decided how to proceed when the target receives the FCP\_DATA before the E\_D\_TOV expires (initiator does not know ACK was lost and sends the FCP\_DATA). Will the target send an ACK for the data? Will it send FCP\_RSP? Does the initiator send BA\_ACC or go directly to recovery and send ABTS(retry)? If BA\_ACC is sent, target might send FCP\_RSP.

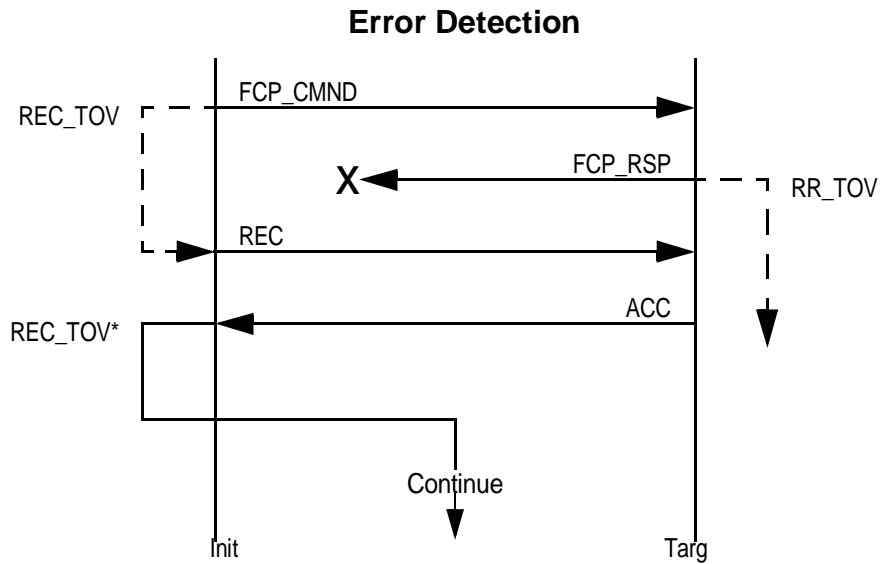


The initiator sends an ABTS(retry) requesting the Exchange be retried. The FCP\_CMND is retransmitted in a new Exchange using the same CRN.

Both initiator and target establish Recovery Qualifiers. The value of R\_A\_TOV\* for in-order topologies is 0.

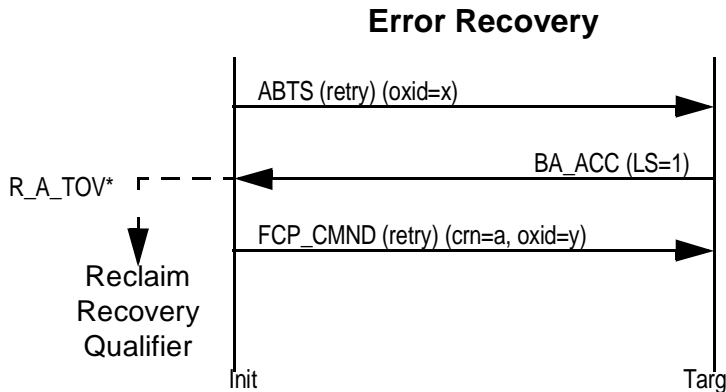


Figure D.8 - FCP\_RSP Lost, FCP\_CONF not requested, Unacknowledged Classes



The REC ACC indicates the initiator holds Sequence Initiative and the Exchange is complete. The target must keep the context of this Exchange until the OX\_ID value is reused in a new command (implicitly validating the receipt of FCP\_RSP), or for at least RR\_TOV in order to preserve the FCP\_RSP information. This long time-out can be avoided by using FCP\_CONF.

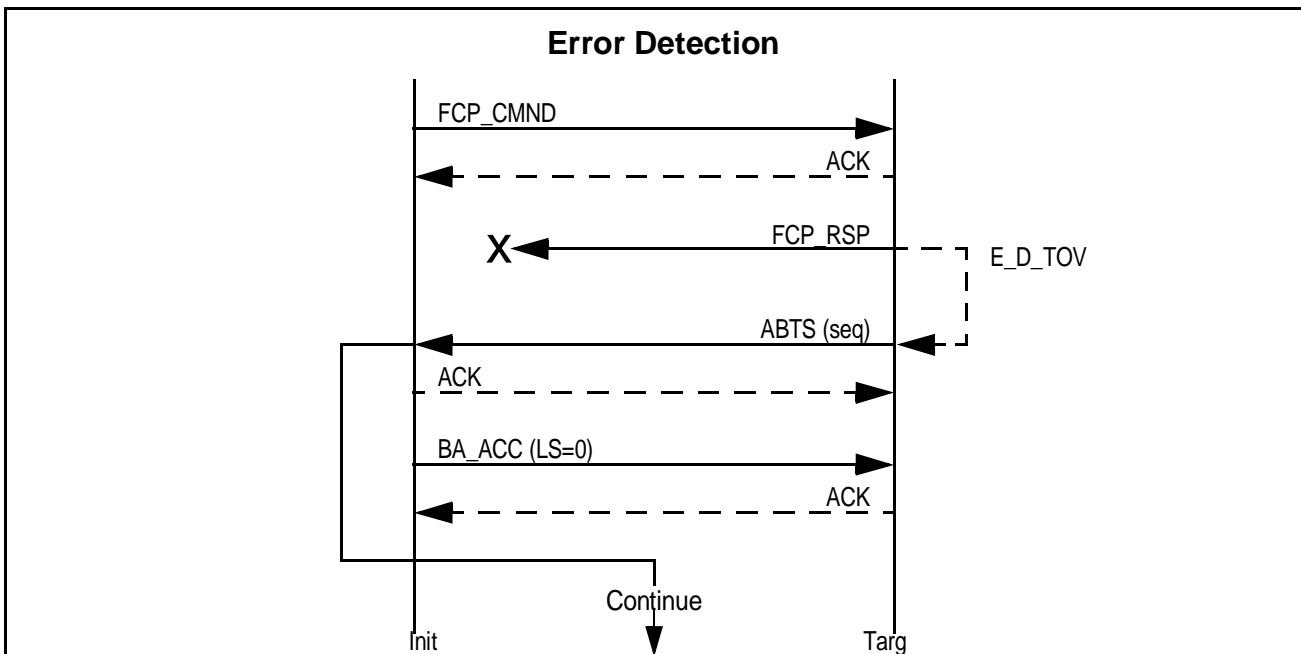
Wait REC\_TOV\* before performing error recovery. If FCP\_RSP is received before REC\_TOV\* expires, continue with the Exchange (REC ACC arrived before FCP\_RSP, out of order). Otherwise perform error recovery.



The initiator sends an ABTS(retry) requesting the Exchange be retried. The FCP\_CMND is retransmitted in a new Exchange using the same CRN.

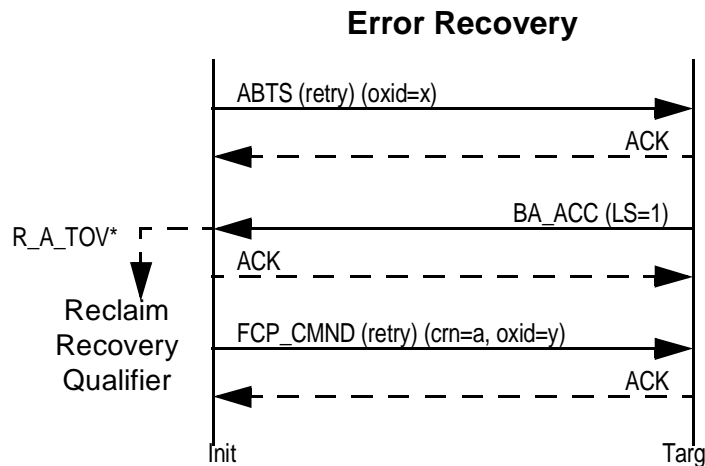
Both initiator and target establish Recovery Qualifiers. The value of R\_A\_TOV\* for in-order topologies is 0.

Figure D.9 - FCP\_RSP Lost, FCP\_CONF not requested, Acknowledged Classes



After receiving the ABTS, the initiator performs error recovery. Does the initiator send BA\_ACC or go directly to recovery and send ABTS(retry)?

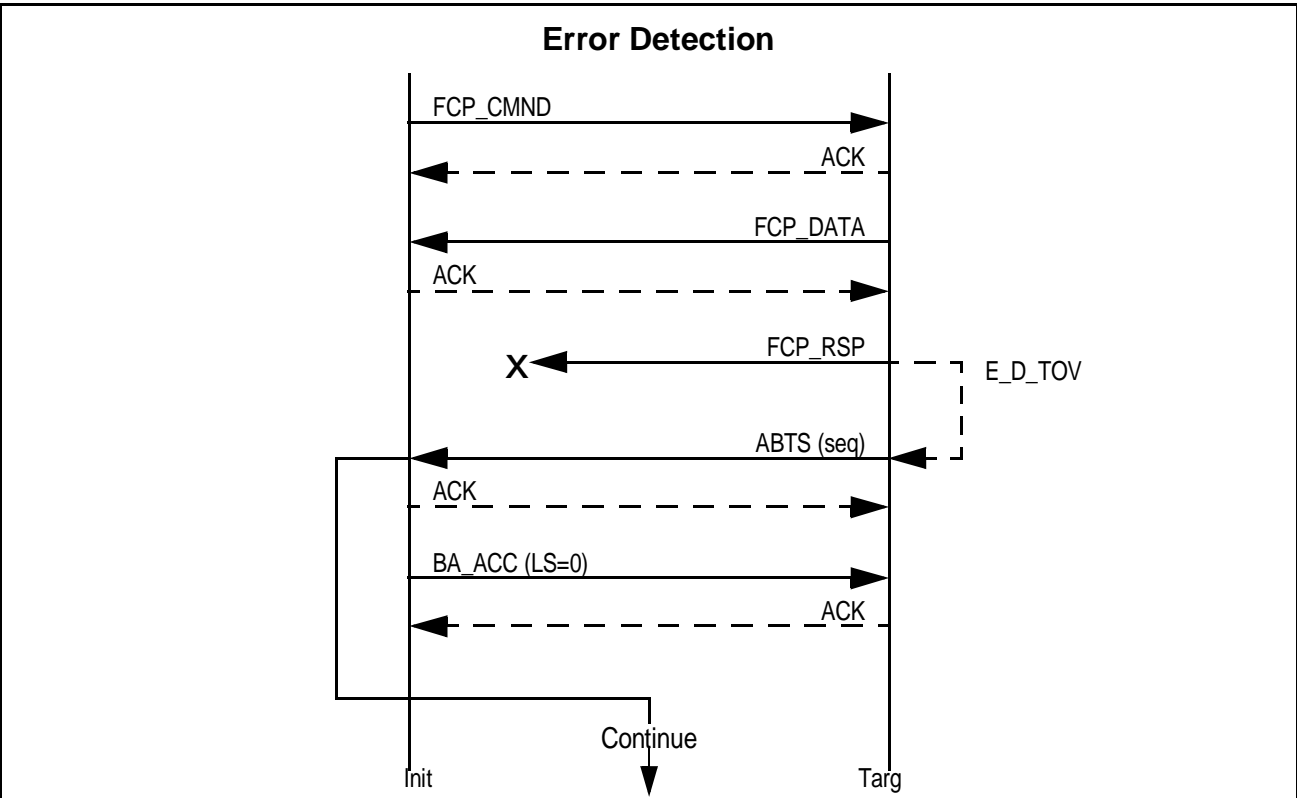
The use of REC to determine status for error recovery shall not be used.



The initiator sends an ABTS(retry) requesting the Exchange be retried. The FCP\_CMND is retransmitted in a new Exchange using the same CRN.

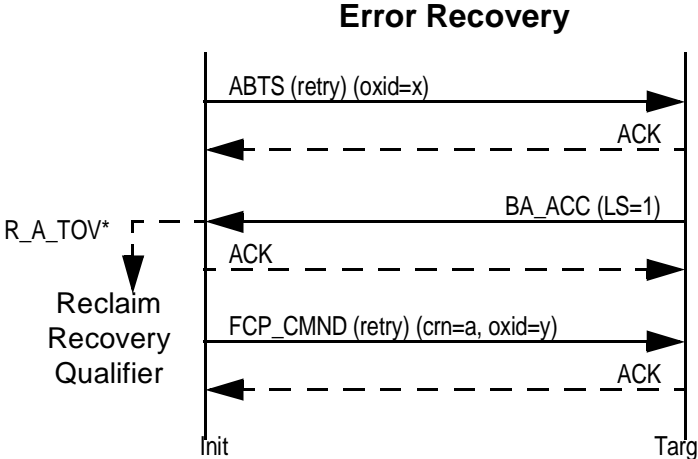
Both initiator and target establish Recovery Qualifiers. The value of R\_A\_TOV\* for in-order topologies is 0.

Figure D.10 - FCP\_RSP Lost after Read Command, FCP\_CONF not requested, Acknowledged Classes



After receiving the ABTS, the initiator performs error recovery. **Does the initiator send BA\_ACC or go directly to recovery and send ABTS(retry)?**

The use of REC to determine status for error recovery shall not be used.



The initiator sends an ABTS(retry) requesting the Exchange be retried. The FCP\_CMND is retransmitted in a new Exchange using the same CRN.

Both initiator and target establish Recovery Qualifiers. The value of R\_A\_TOV\* for in-order topologies is 0.

Figure D.11 - FCP\_RSP Received, ACK Lost, Acknowledged Classes, Example 1

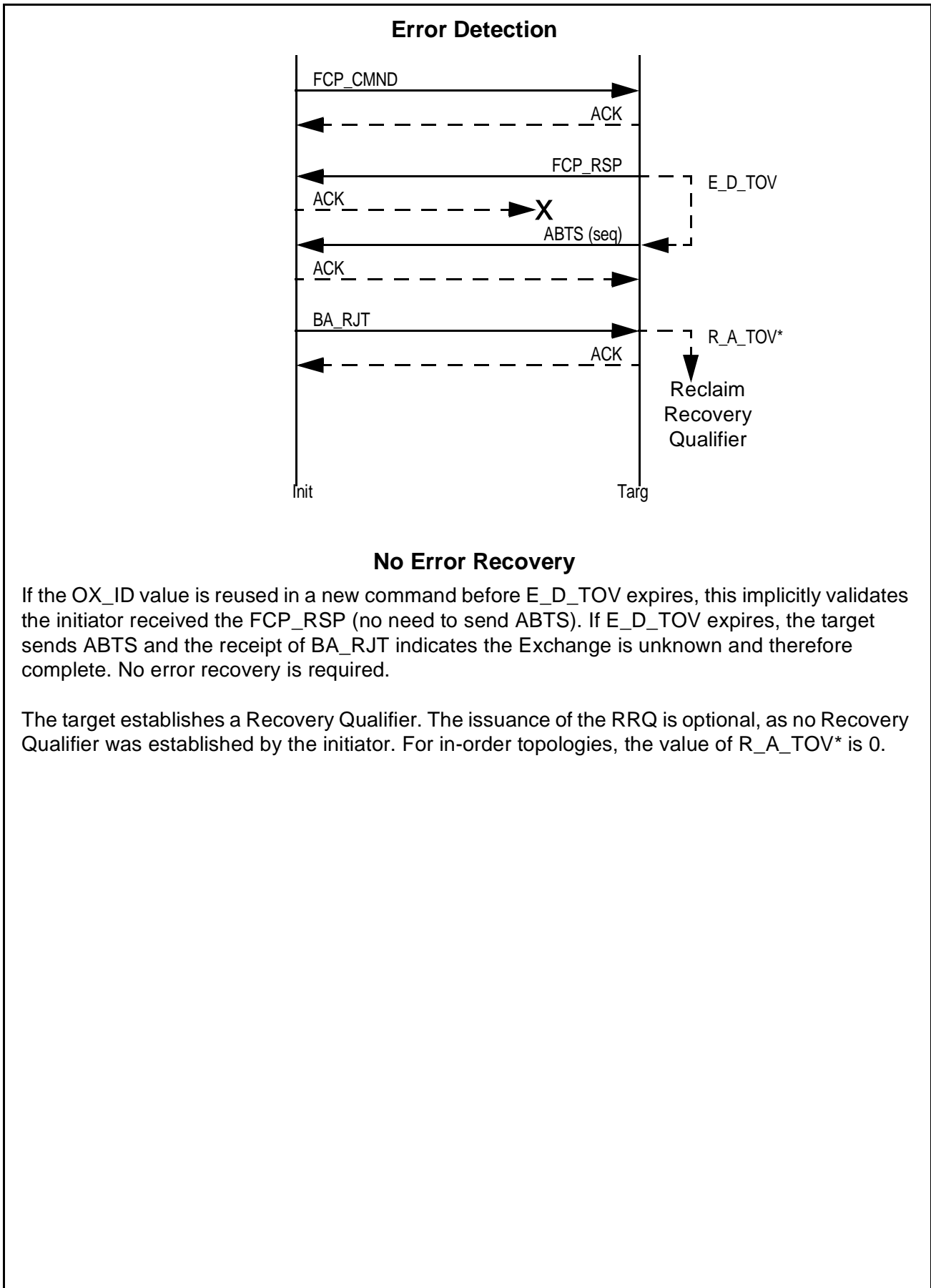
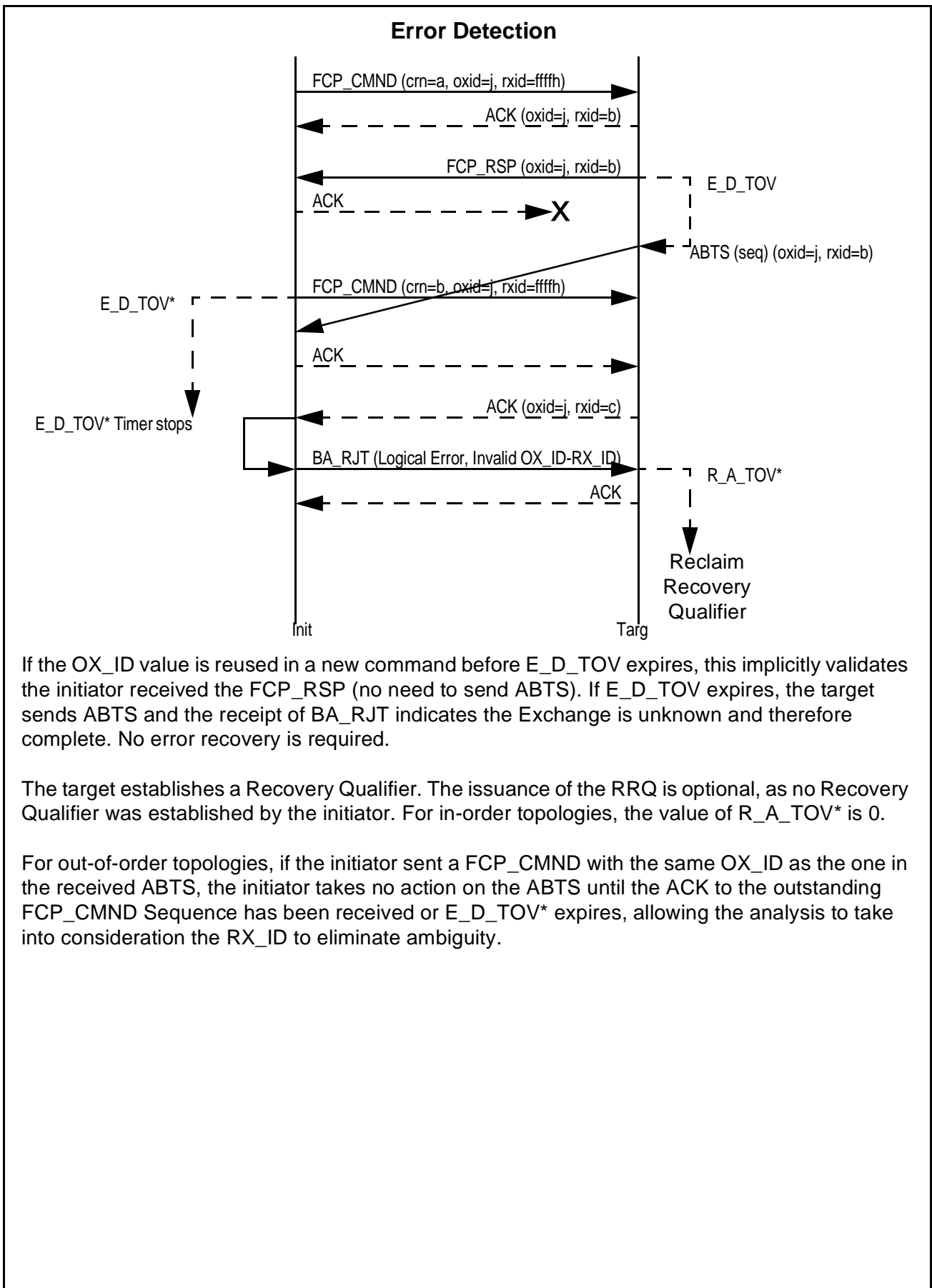


Figure D.12 - FCP\_RSP Received, ACK Lost, Acknowledged Classes, Example 2

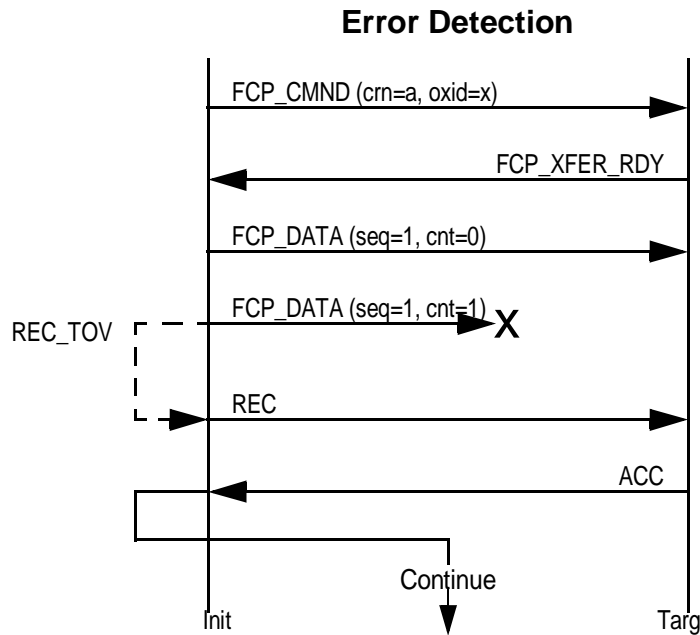


If the OX\_ID value is reused in a new command before E\_D\_TOV expires, this implicitly validates the initiator received the FCP\_RSP (no need to send ABTS). If E\_D\_TOV expires, the target sends ABTS and the receipt of BA\_RJT indicates the Exchange is unknown and therefore complete. No error recovery is required.

The target establishes a Recovery Qualifier. The issuance of the RRQ is optional, as no Recovery Qualifier was established by the initiator. For in-order topologies, the value of R\_A\_TOV\* is 0.

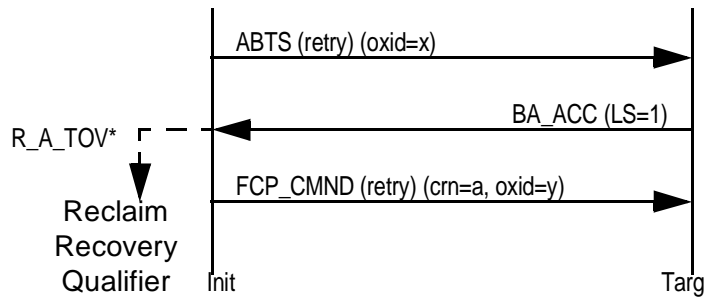
For out-of-order topologies, if the initiator sent a FCP\_CMND with the same OX\_ID as the one in the received ABTS, the initiator takes no action on the ABTS until the ACK to the outstanding FCP\_CMND Sequence has been received or E\_D\_TOV\* expires, allowing the analysis to take into consideration the RX\_ID to eliminate ambiguity.

Figure D.13 - Lost Write Data, Last Frame of Sequence, Unacknowledged Classes



The REC ACC indicates the target does not hold Sequence Initiative and the Exchange is open. The initiator performs error recovery.

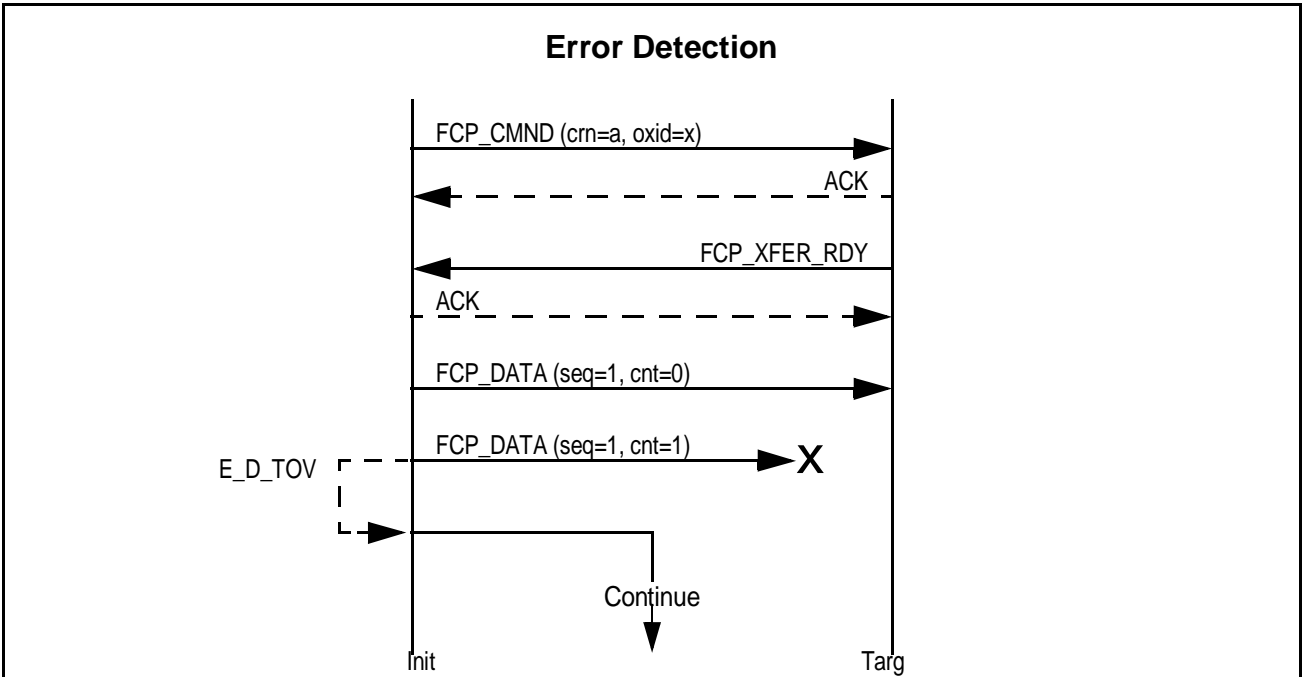
### Error Recovery



The initiator sends an ABTS(retry) requesting the Exchange be retried. The FCP\_CMND is retransmitted in a new Exchange using the same CRN.

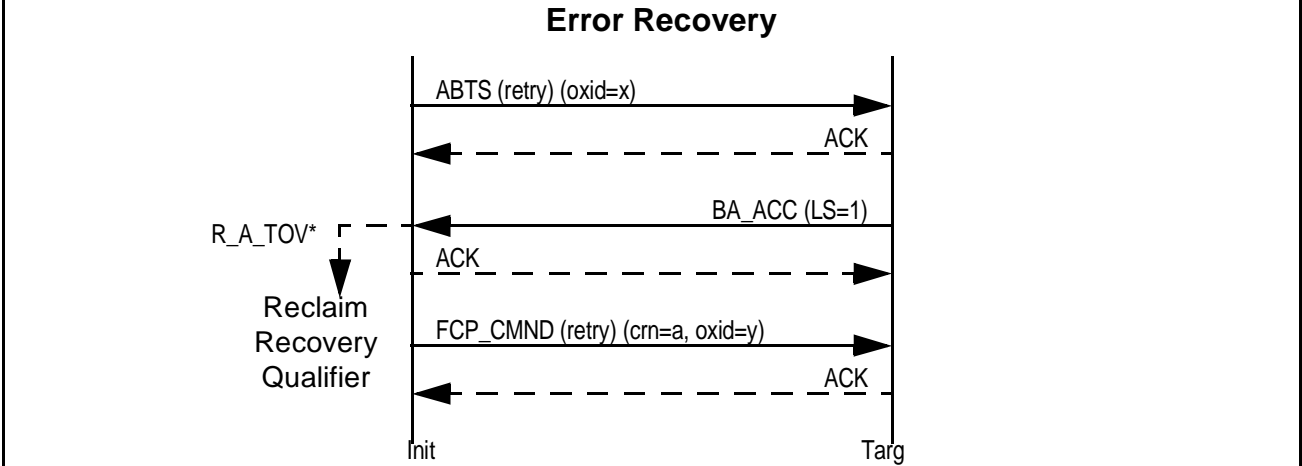
Both initiator and target establish Recovery Qualifiers. The value of R\_A\_TOV\* for in-order topologies is 0.

Figure D.14 - Lost Write Data, Last Frame of Sequence, Acknowledged Classes



Upon expiration of E\_D\_TOV, the initiator performs error recovery.

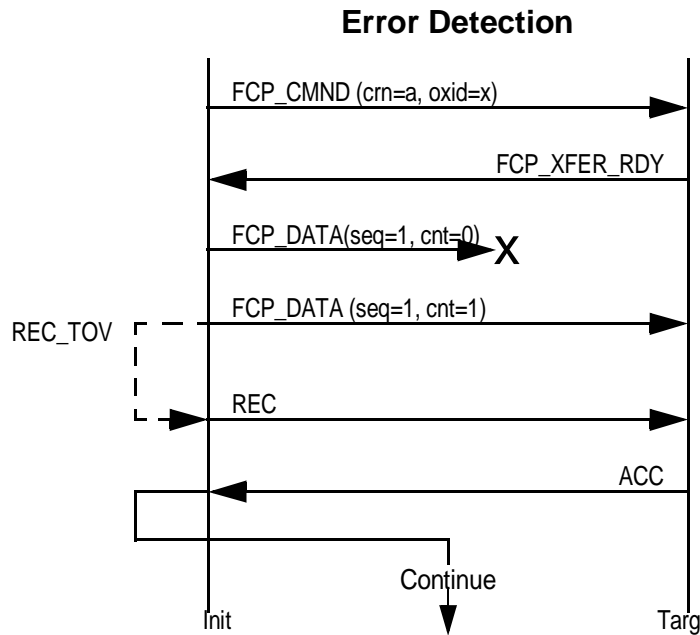
The use of REC to determine status for error recovery shall not be used.



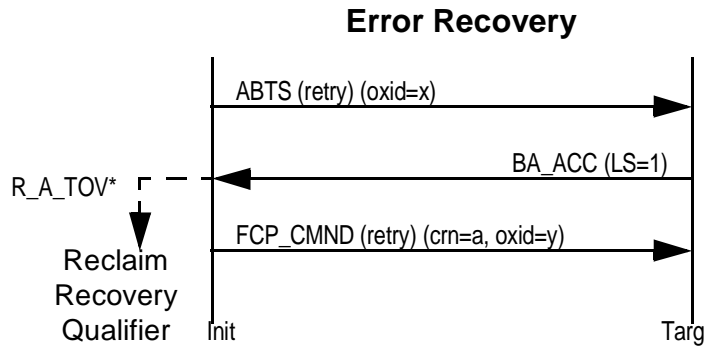
The initiator sends an ABTS(retry) requesting the Exchange be retried. The FCP\_CMND is retransmitted in a new Exchange using the same CRN.

Both initiator and target establish Recovery Qualifiers. The value of R\_A\_TOV\* for in-order topologies is 0.

Figure D.15 - Lost Write Data, Not Last Frame of Sequence, Unacknowledged Classes



The REC ACC indicates the target does not hold Sequence Initiative and the Exchange is open. The initiator performs error recovery.

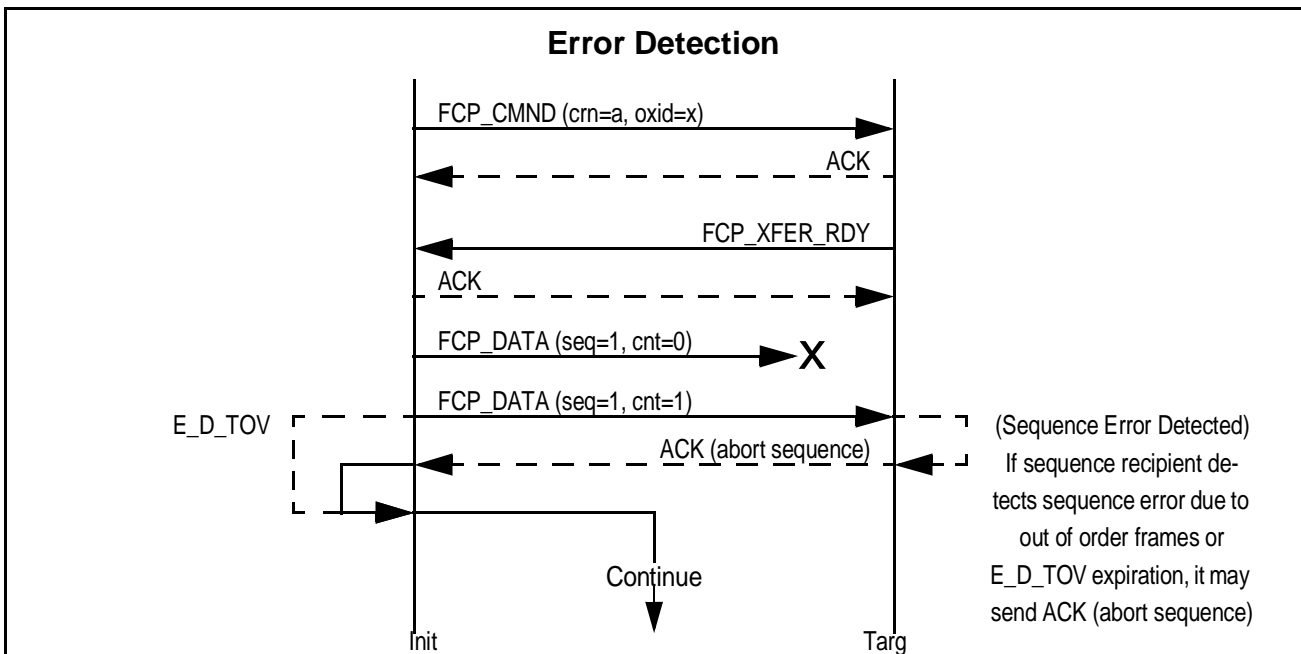


The initiator sends an ABTS(retry) requesting the Exchange be retried. The FCP\_CMND is retransmitted in a new Exchange using the same CRN.

Both initiator and target establish Recovery Qualifiers. The value of R\_A\_TOV\* for in-order topologies is 0.

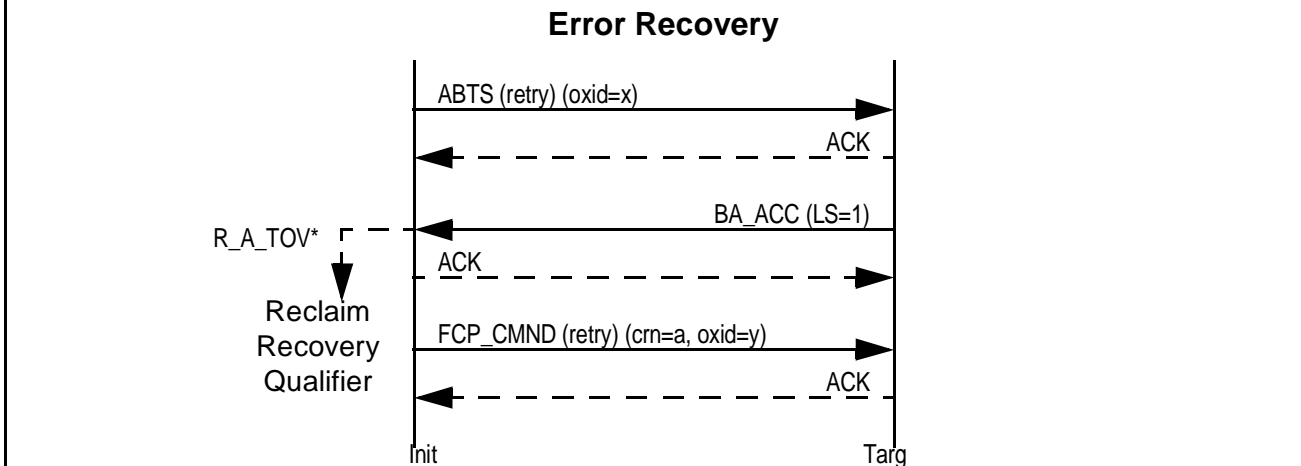


Figure D.16 - Lost Write Data, Not Last Frame of Sequence, Acknowledged Classes



Upon expiration of E\_D\_TOV or the receipt of ABTS, the initiator performs error recovery. **If ABTS is received, does the initiator send BA\_ACC or go directly to recovery and send ABTS(retry)?**

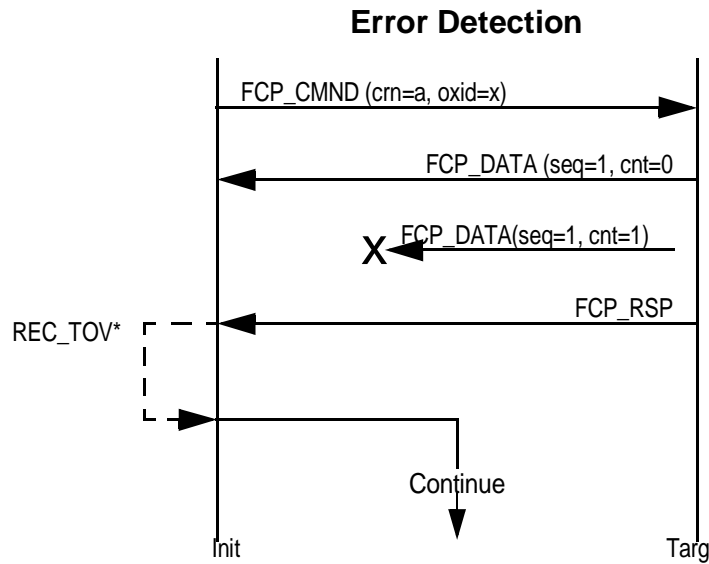
The use of REC to determine status for error recovery shall not be used.



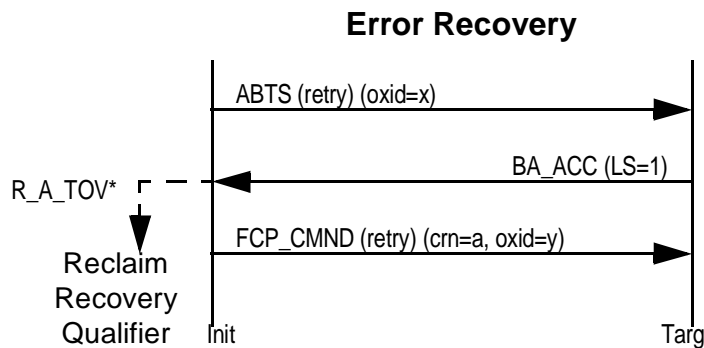
The initiator sends an ABTS(retry) requesting the Exchange be retried. The FCP\_CMND is retransmitted in a new Exchange using the same CRN.

Both initiator and target establish Recovery Qualifiers. The value of R\_A\_TOV\* for in-order topologies is 0.

Figure D.17 - Lost Read Data, Last Frame of Sequence, Unacknowledged Classes



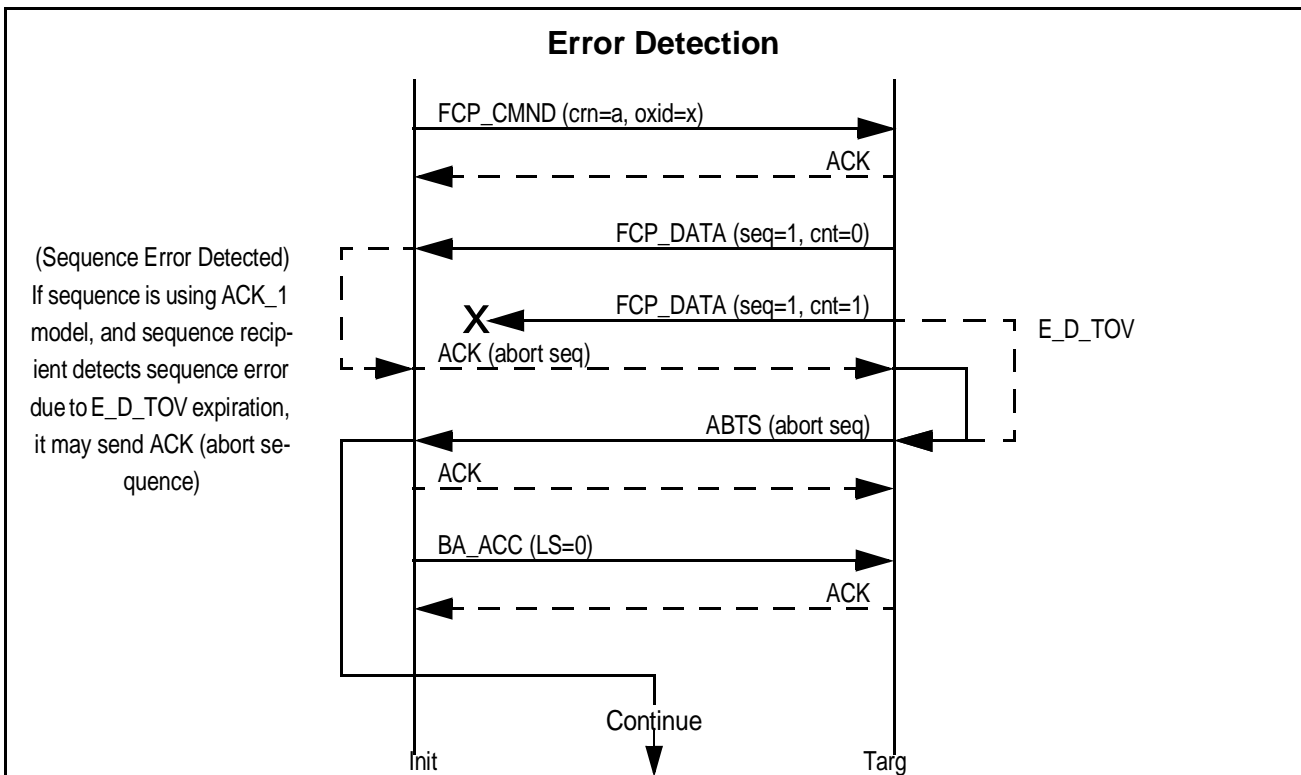
After receiving the FCP\_RSP, the initiator waits REC\_TOV\* before performing error recovery to wait for possible out of order FCP\_DATA frames. For in-order topologies, the value of REC\_TOV\* is 0.



The initiator sends an ABTS(retry) requesting the Exchange be retried. The FCP\_CMND is retransmitted in a new Exchange using the same CRN.

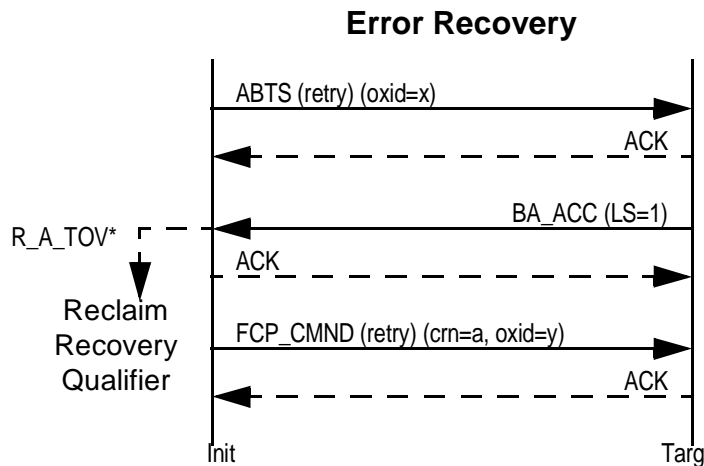
Both initiator and target establish Recovery Qualifiers. The value of R\_A\_TOV\* for in-order topologies is 0.

Figure D.18 - Lost Read Data, Last Frame of Sequence, Acknowledged Classes



After receiving the ABTS, the initiator performs error recovery. **Does the initiator send BA\_ACC or go directly to recovery and send ABTS(retry)?**

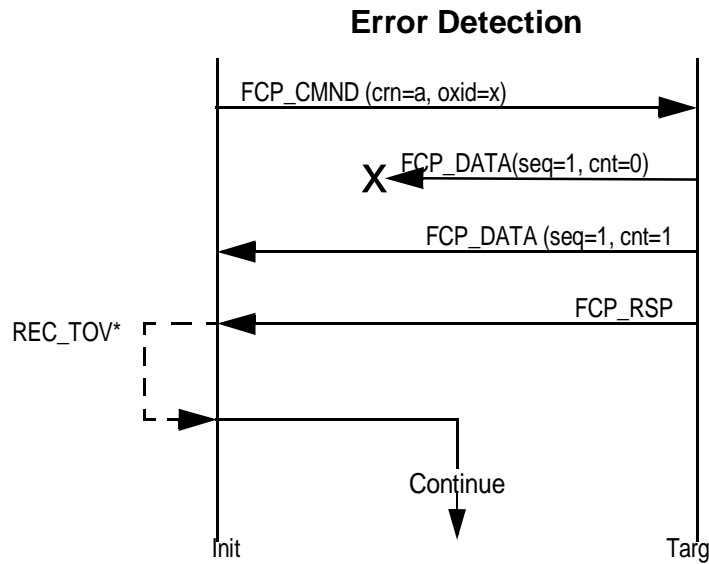
The use of REC to determine status for error recovery shall not be used.



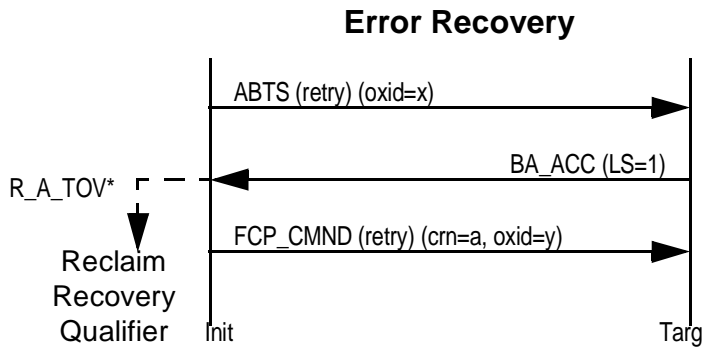
The initiator sends an ABTS(retry) requesting the Exchange be retried. The FCP\_CMND is retransmitted in a new Exchange using the same CRN.

Both initiator and target establish Recovery Qualifiers. The value of R\_A\_TOV\* for in-order topologies is 0.

Figure D.19 - Lost Read Data, Not Last Frame of Sequence, Unacknowledged Classes



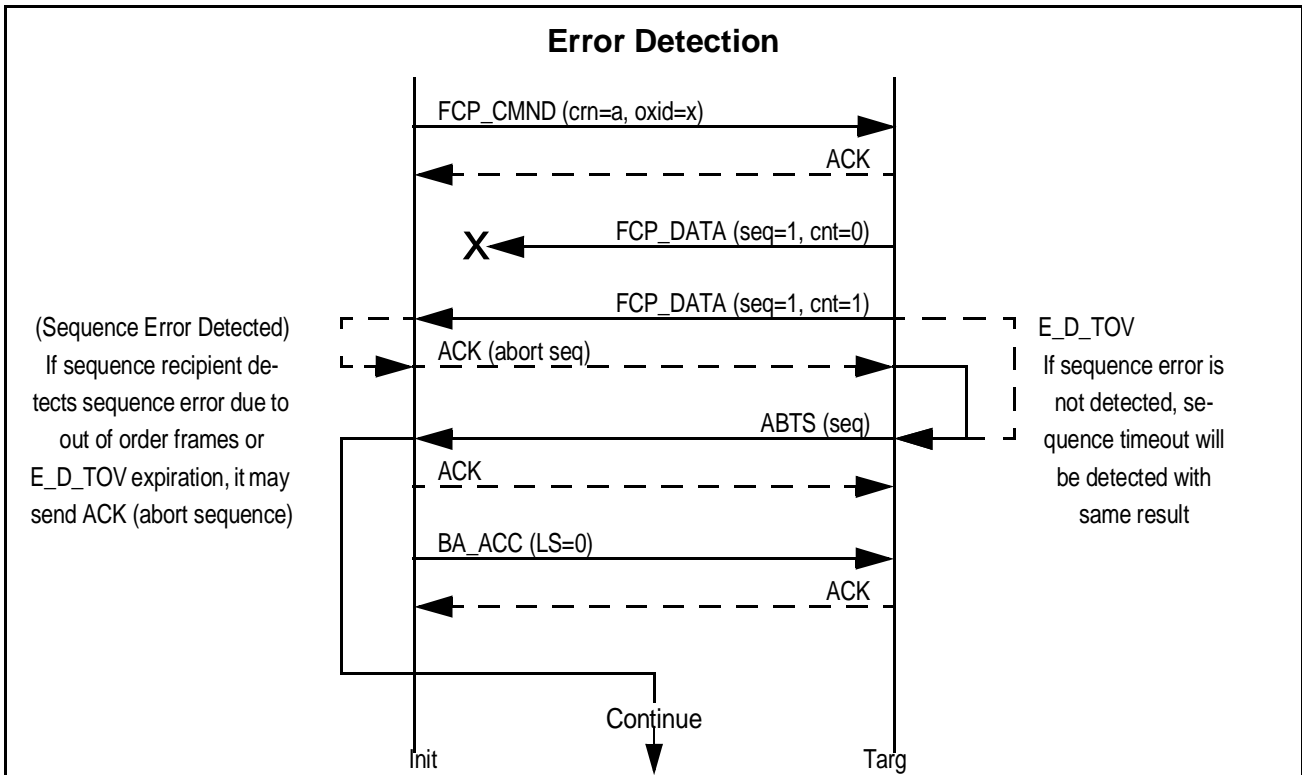
After receiving the FCP\_RSP, the initiator waits REC\_TOV\* before performing error recovery to wait for possible out of order FCP\_DATA frames. For in-order topologies, the value of REC\_TOV\* is 0.



The initiator sends an ABTS(retry) requesting the Exchange be retried. The FCP\_CMND is retransmitted in a new Exchange using the same CRN.

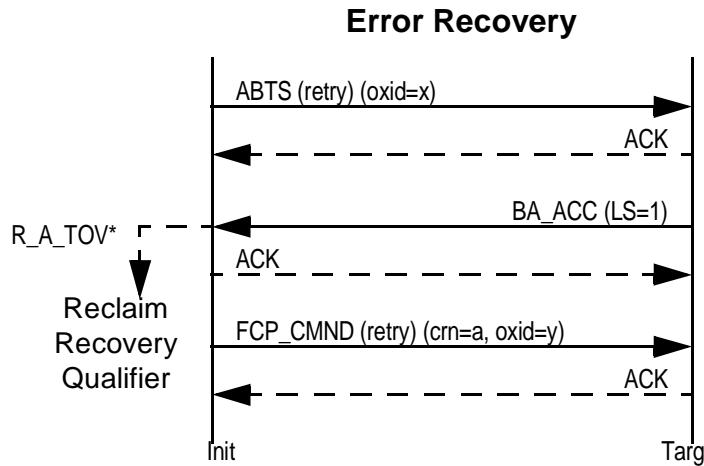
Both initiator and target establish Recovery Qualifiers. The value of R\_A\_TOV\* for in-order topologies is 0.

Figure D.20 - Lost Read Data, Not Last Frame of Sequence, Acknowledged Classes



After receiving the ABTS, the initiator performs error recovery. **Does the initiator send BA\_ACC or go directly to recovery and send ABTS(retry)?**

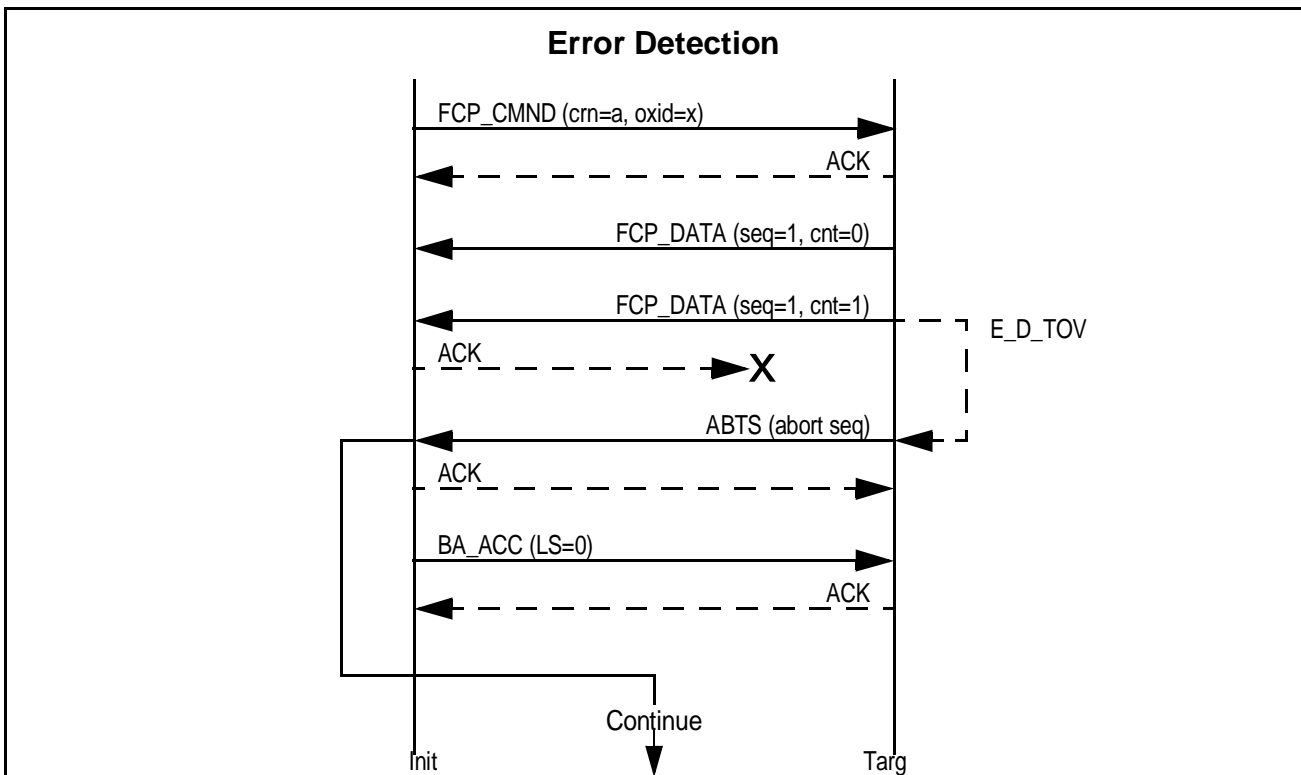
The use of REC to determine status for error recovery shall not be used.



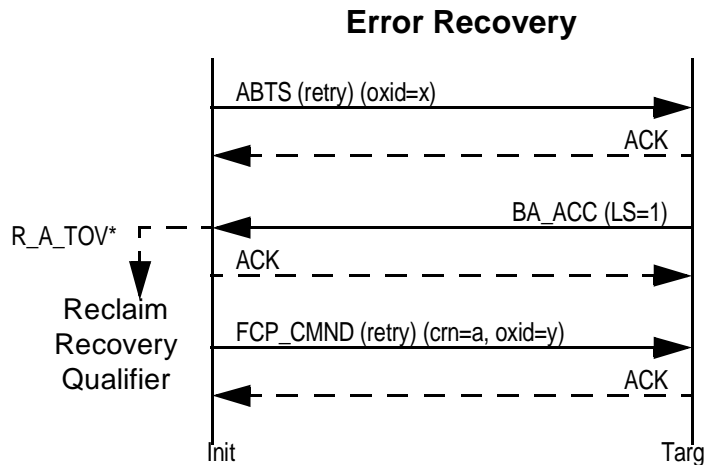
The initiator sends an ABTS(retry) requesting the Exchange be retried. The FCP\_CMND is retransmitted in a new Exchange using the same CRN.

Both initiator and target establish Recovery Qualifiers. The value of R\_A\_TOV\* for in-order topologies is 0.

Figure D.21 - ACK Lost on Read (Acknowledged Classes)



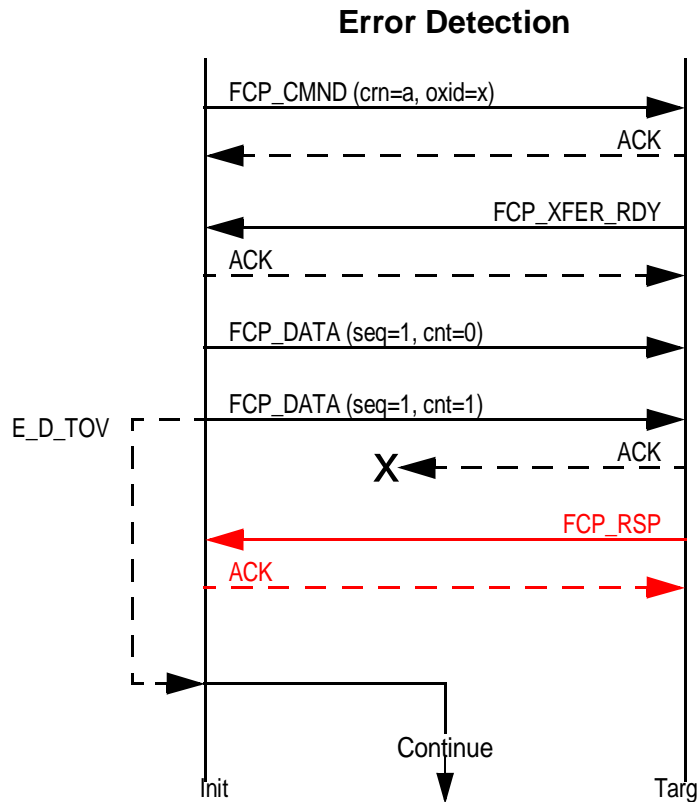
Although it is possible for the exchange to continue when the ACK is lost, in the interest of simplicity, error recovery is performed when the initiator receives the ABTS. **Does the initiator send BA\_ACC or go directly to recovery and send ABTS(retry)? If BA\_ACC is sent, target might send FCP\_RSP.**



The initiator sends an ABTS(retry) requesting the Exchange be retried. The FCP\_CMND is retransmitted in a new Exchange using the same CRN.

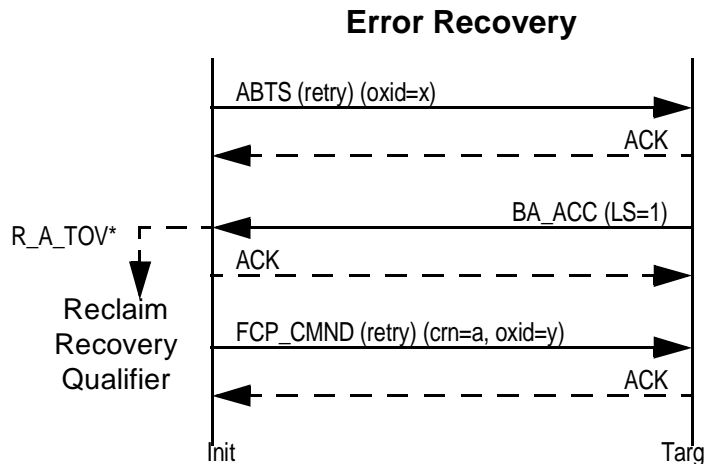
Both initiator and target establish Recovery Qualifiers. The value of R\_A\_TOV\* for in-order topologies is 0.

Figure D.22 - ACK Lost on Write (Acknowledged Classes)



Upon expiration of E\_D\_TOV, the initiator performs error recovery. **It was not decided how to proceed if FCP\_RSP is received before the E\_D\_TOV expires.**

The use of REC to determine status for error recovery shall not be used.



The initiator sends an ABTS(retry) requesting the Exchange be retried. The FCP\_CMND is retransmitted in a new Exchange using the same CRN.

Both initiator and target establish Recovery Qualifiers. The value of R\_A\_TOV\* for in-order topologies is 0.

Figure D.23 - FCP\_CONF Lost, Unacknowledged Classes

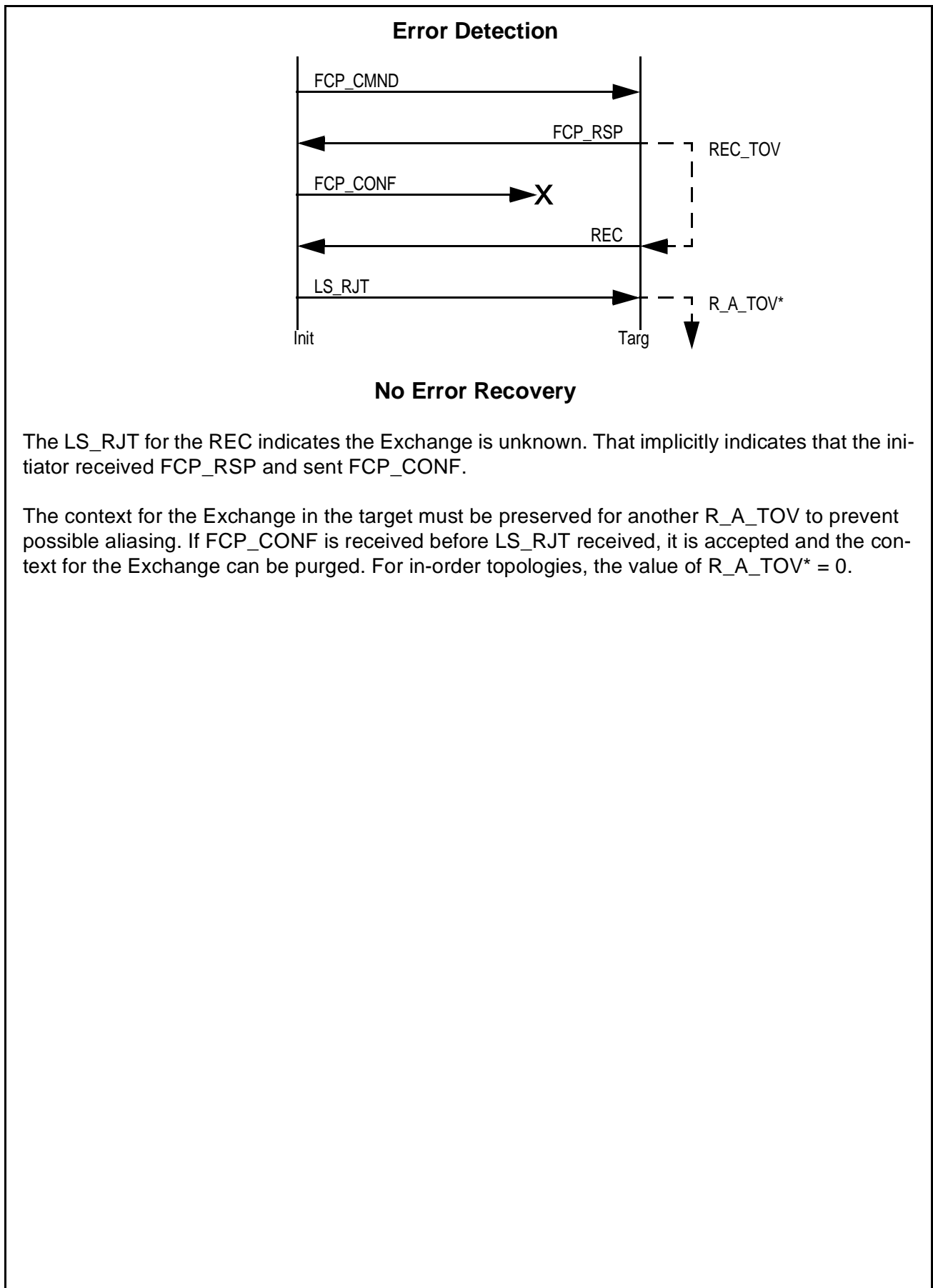
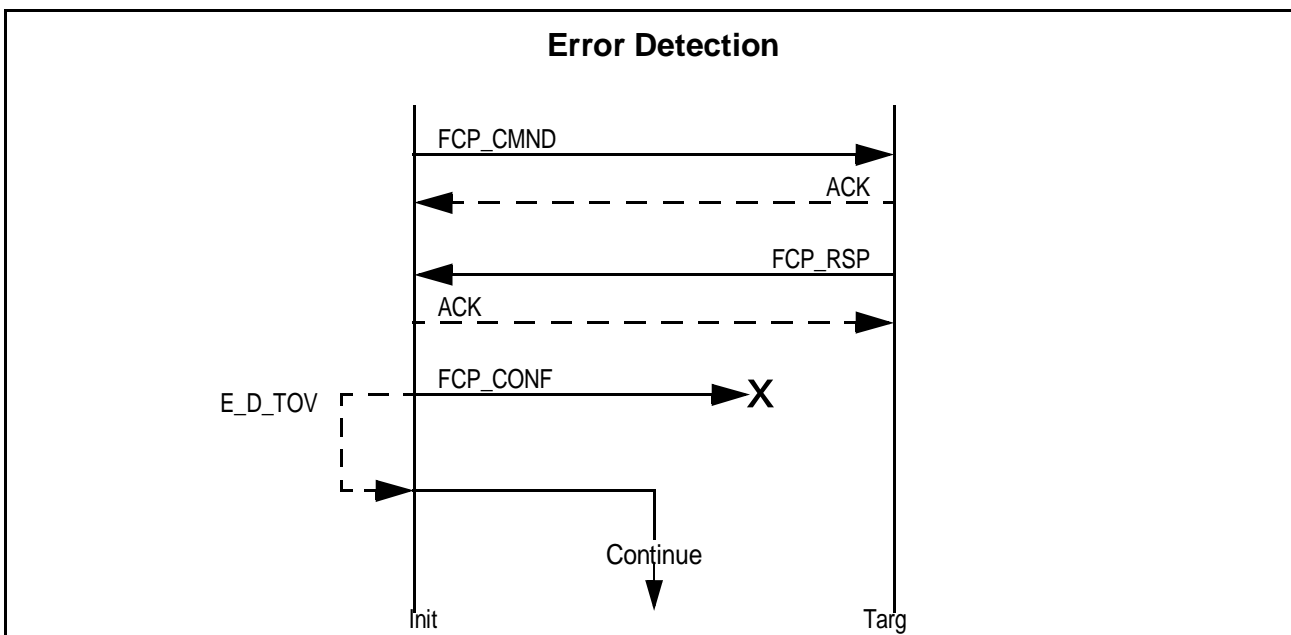


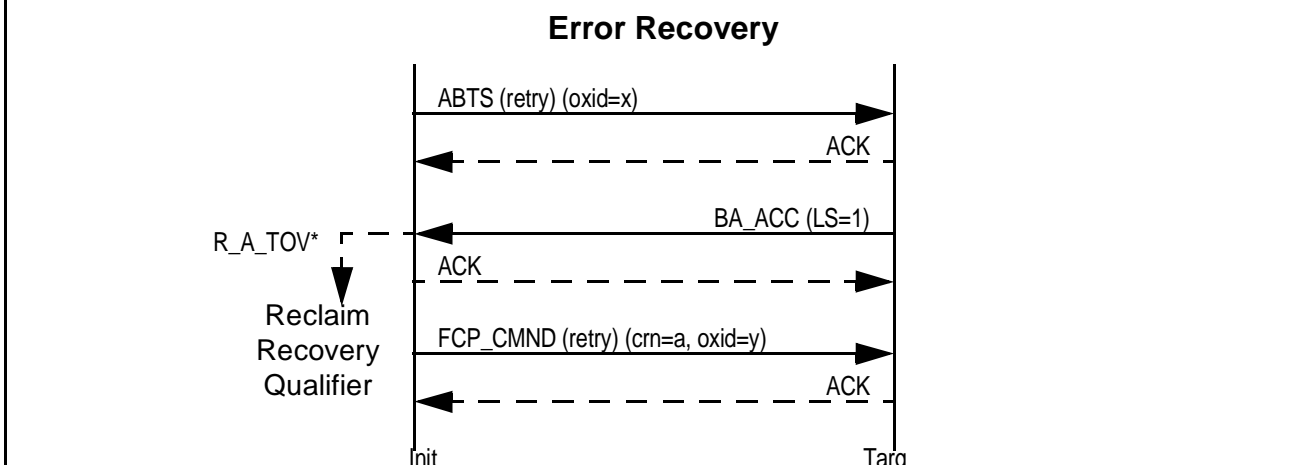


Figure D.24 - FCP\_CONF Lost, Acknowledged Classes



Upon expiration of E\_D\_TOV, the initiator performs error recovery.

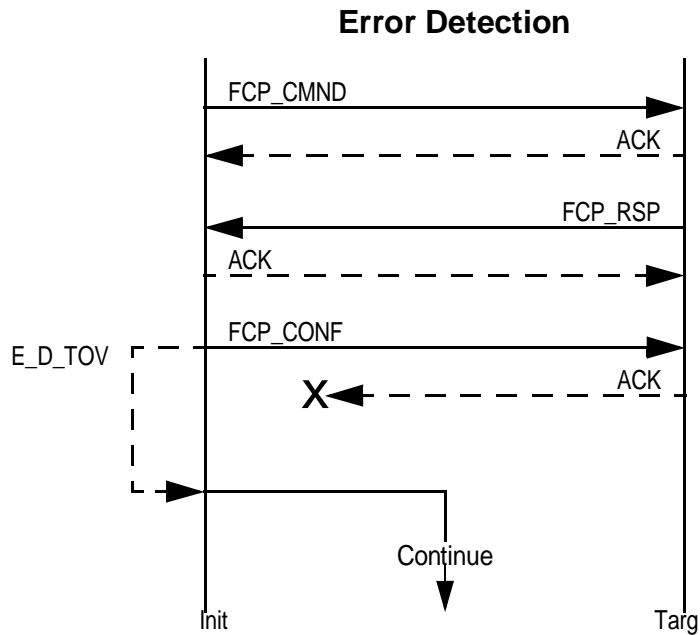
The use of REC to determine status for error recovery shall not be used.



The initiator sends an ABTS(retry) requesting the Exchange be retried. The FCP\_CMND is retransmitted in a new Exchange using the same CRN.

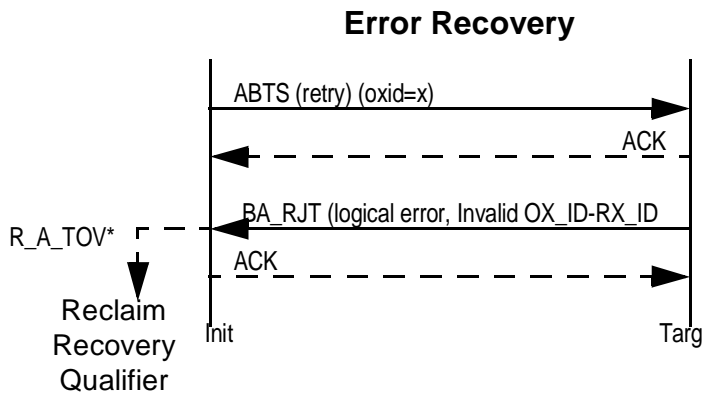
Both initiator and target establish Recovery Qualifiers. The value of R\_A\_TOV\* for in-order topologies is 0.

Figure D.25 - ACK lost on FCP\_CONF, Acknowledged Classes



Upon expiration of E\_D\_TOV, the initiator performs error recovery.

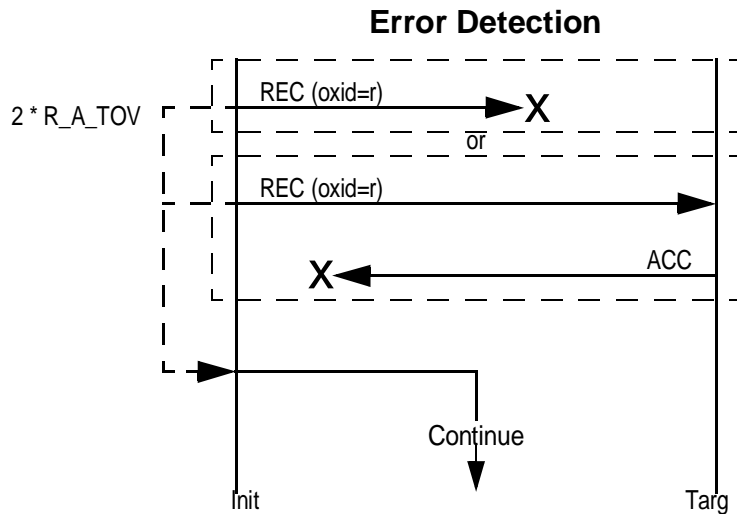
The use of REC to determine status for error recovery shall not be used.



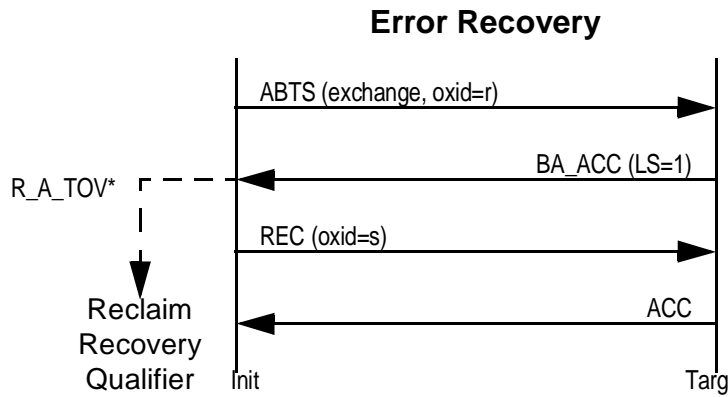
BA\_RJT is the response to the ABTS, since no context exists for this Exchange and the ABTS was not issued on the first sequence of a new Exchange.

The initiator establishes a Recovery Qualifier. The issuance of the RRQ is optional, as no Recovery Qualifier was established by the target. For in-order topologies, the value of R\_A\_TOV\* = 0.

Figure D.26 - REC or REC Response Lost, Unacknowledged Classes



Upon expiration of 2 times R\_A\_TOV, the initiator performs error recovery.



Initiator and target establish Recovery Qualifiers. For in-order topologies, the value of R\_A\_TOV\* is 0.

The initiator re-issues the REC in a new Exchange.

Figure D.27 - REC Lost, Acknowledged Classes

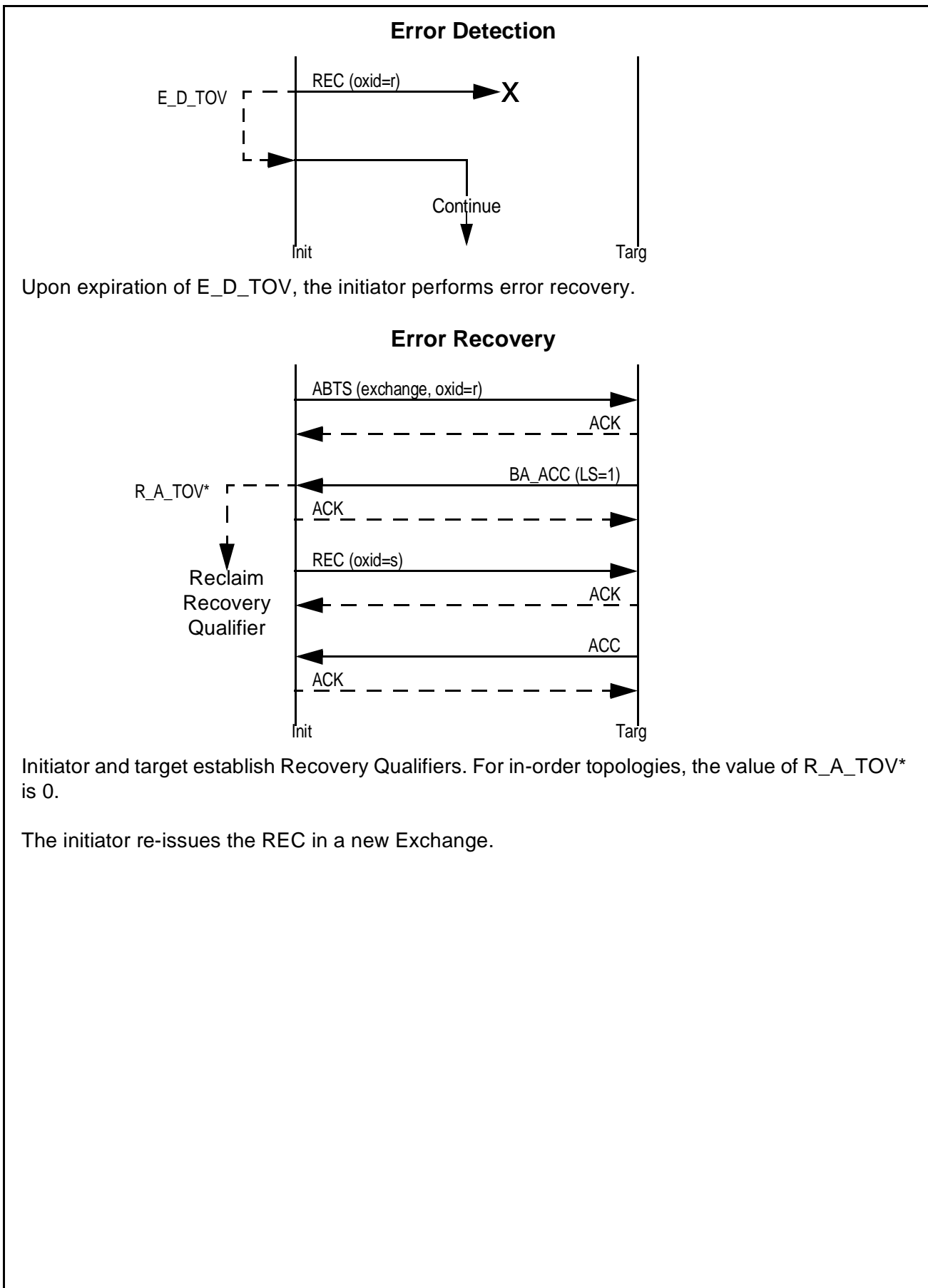
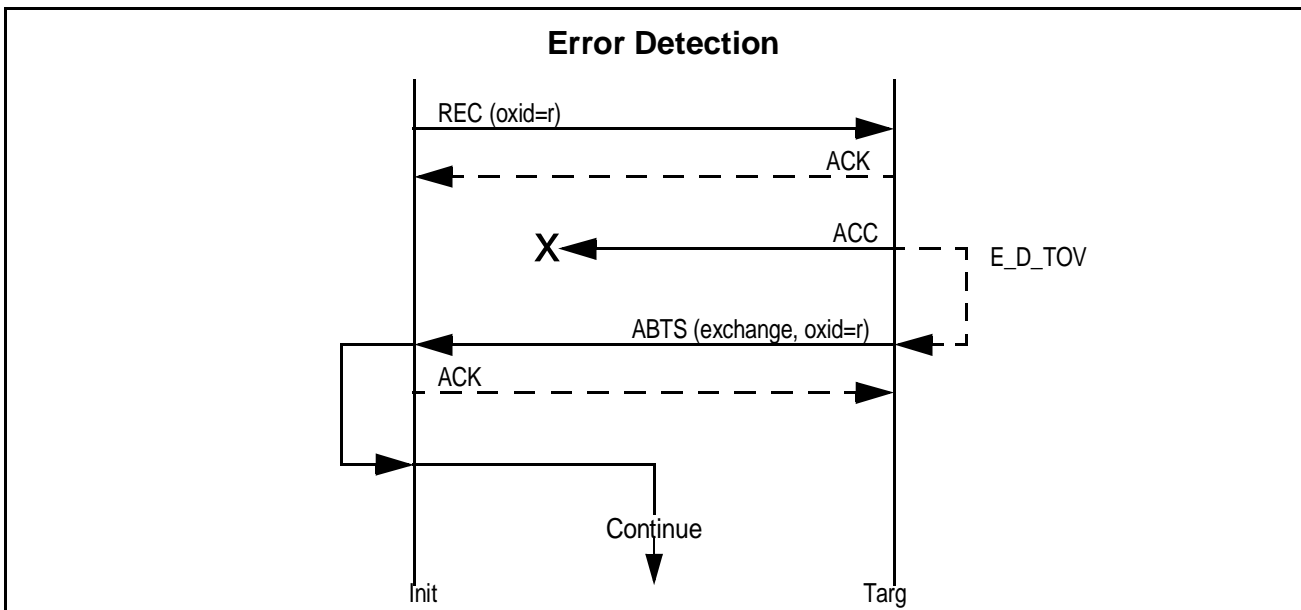
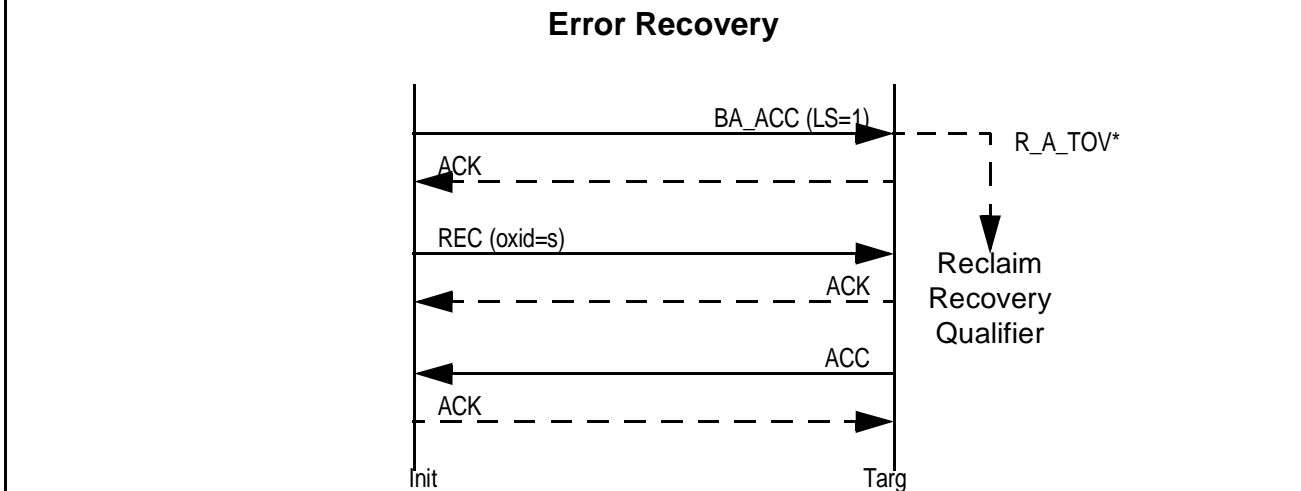


Figure D.28 - REC ACC Lost, Acknowledged Classes



Upon receipt of ABTS, the initiator performs error recovery.



Initiator and target establish Recovery Qualifiers. For in-order topologies, the value of R\_A\_TOV\* is 0.

The initiator re-issues the REC in a new Exchange.

Figure D.29 - Two RECs Lost, Unacknowledged Classes, Abort the original exchange

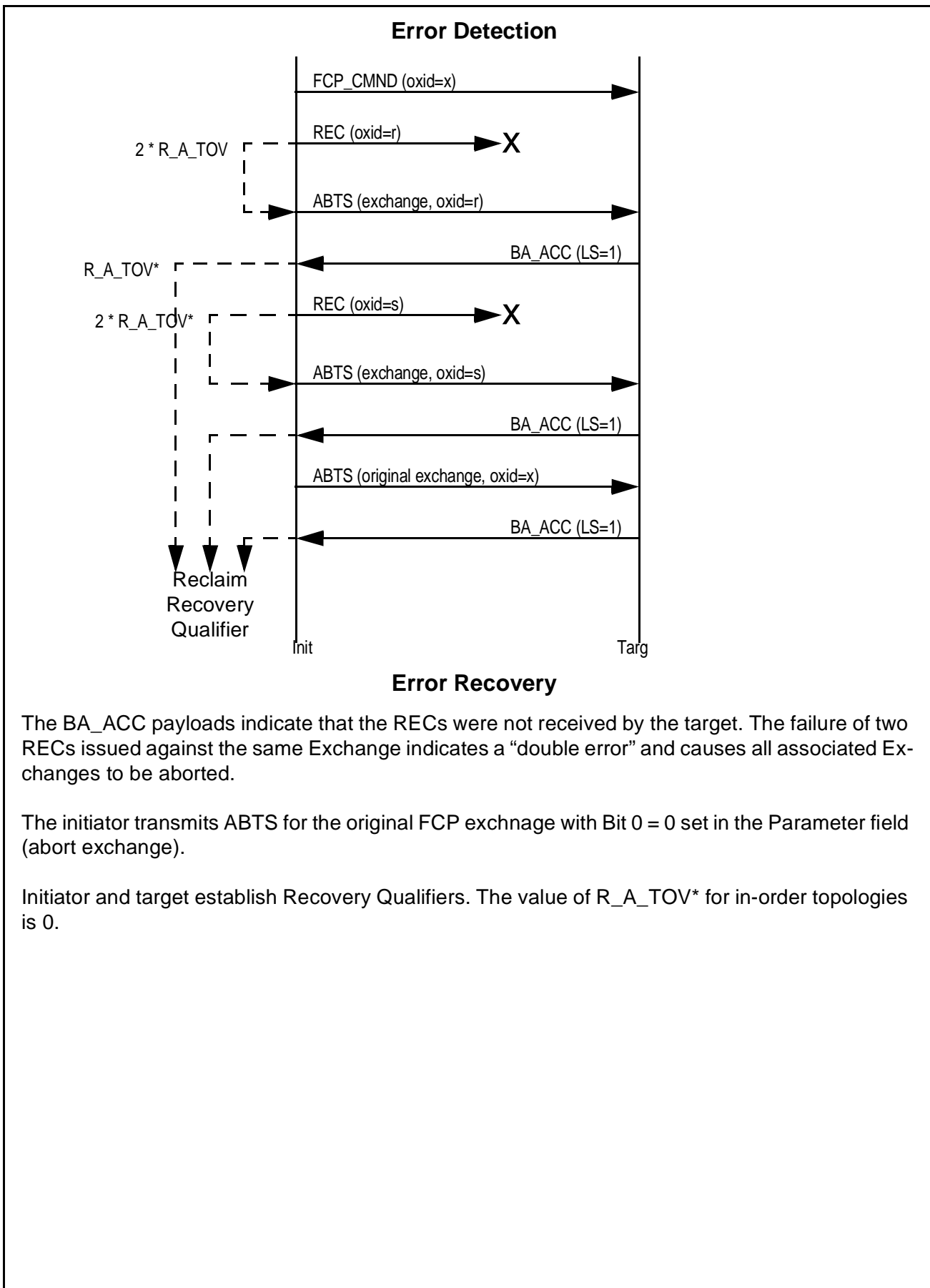
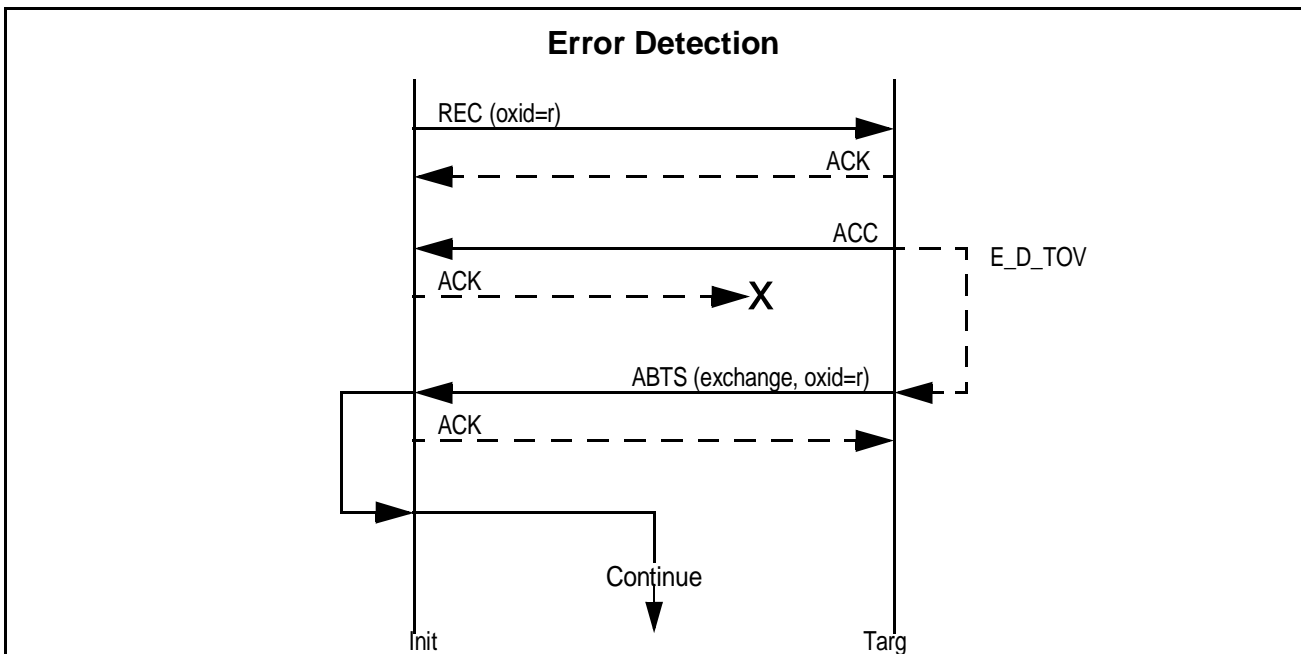
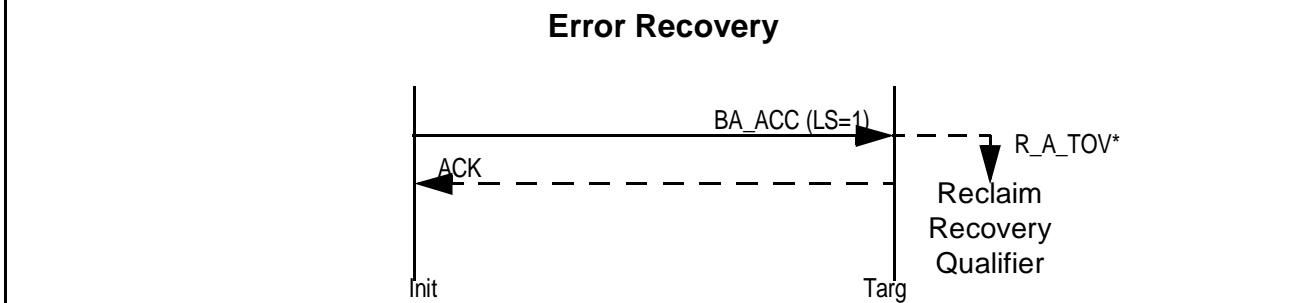


Figure D.30 - ACK to REC ACC Lost, Acknowledged Classes



Upon receipt of ABTS, the initiator performs error recovery.



Initiator and target establish Recovery Qualifiers. For in-order topologies, the value of R\_A\_TOV\* is 0.

**ISSUE:** If after the ACC to the original REC is received, the initiator sends another REC using the same OX\_ID (it does not know that the ACK was lost), the E\_D\_TOV timer on the target could expire and send the ABTS against the new REC Exchange.