

June 30, 2000 T10/00-XXX revision 0

To: John Lohmeyer, chairperson, T10

From: Bob Snively Date: June 2, 2000

Subject: Draft of Annex D, FCP-2 revision 5

This document contains a draft of Annex D to be included in FCP-2, revision 5, based on T10/00-137r5.

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# 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
r   <b>▶</b> -	Time-out value exceeded, caused transmission of IU or ELS
	IU or ELS received is processed to transmit IU or ELS
X	Frame lost or dropped
Continue	Error detection complete. Operation continues with specified Error Recovery.

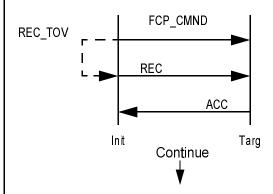
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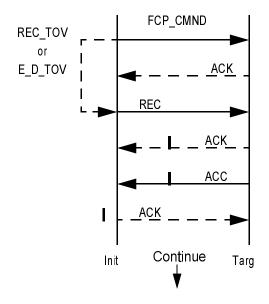
Figure D.1 - Lengthy FCP CMND or Lost ACK

#### **Status Detection**

### **Unacknowledged Classes**

### **Acknowledged Classes**





REC can be optionally used at any time to ascertain status of an Exchange. It can also be used in conjunction with ABTS(Sequence) to obtain additional information useful in the Error Recovery process.

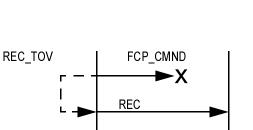
### **No Error Recovery**

None: The ACC for the REC indicates the Exchange is open and the Target holds Sequence Initiative. No error recovery is required.

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**Error Detection** 

#### I



Init

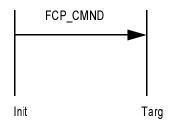
# **Error Recovery**

Continue

LS\_RJT

Targ

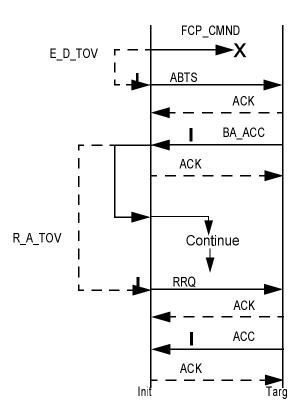
The LS\_RJT for the REC indicates the Exchange is unknown. The FCP\_CMND is retransmitted in a new Exchange using the same CRN and in the same class of service.



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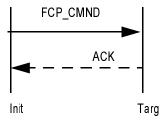
I



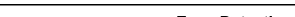


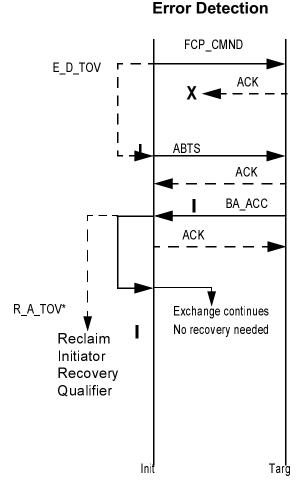
The BA\_ACC indicates that the FCP\_CMND was never received. (BA-ACC payload: SEQ\_ID Validity = invalid, Low SEQ\_CNT = 0, High SEQ\_CNT = SEQ\_CNT of ABTS frame). Both the initiator and target establish Recovery Qualifiers. The value of R\_A\_TOV for in-order delivery is zero. The use of REC to determine status for error recovery is optional.

### **Error Recovery**



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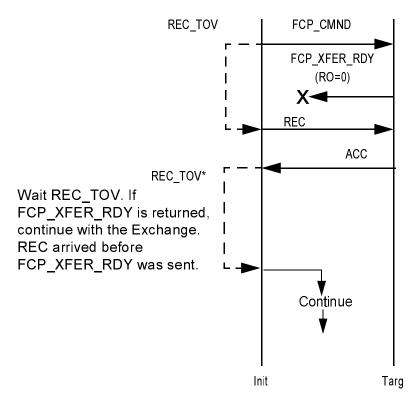




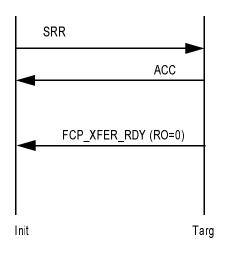
No error recovery required. The BA\_ACC Payload indicates that FCP\_CMND was received. The BA\_ACC payload is SEQ\_ID Valid, SEQ\_ID value of FCP\_CMND, low SEQ\_CNT = high SEQ\_CNT = SEQ\_CNT of FCP\_CMND. Note that the issuance of RRQ is not necessary in this case, since the target will not have established a Recovery Qualifier. However, the initiator cannot reclaim the resources associated with its Recovery Qualifier until R\_A\_TOV time-out expires. The value for R\_A\_TOV is 0 for in-order delivery. The use of REC to determine status for error recovery is optional.

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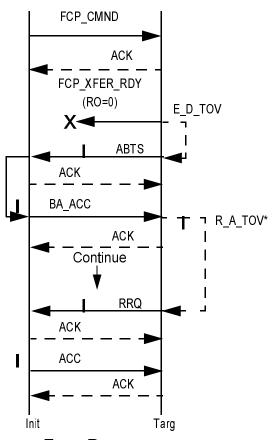
The ACC for the REC indicates the Initiator holds Sequence Initiative and the Exchange is open. The Initiator sends an SRR requesting the FCP\_XFER\_RDY be resent. The Target resends the FCP\_XFER\_RDY using the same Relative Offset. A new SEQ\_ID must be used for retransmission of the FCP\_XFER\_RDY. For in-order delivery, the value of REC\_TOV\* is 0.



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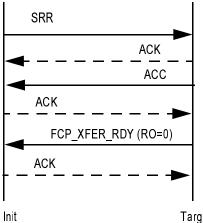
#### I





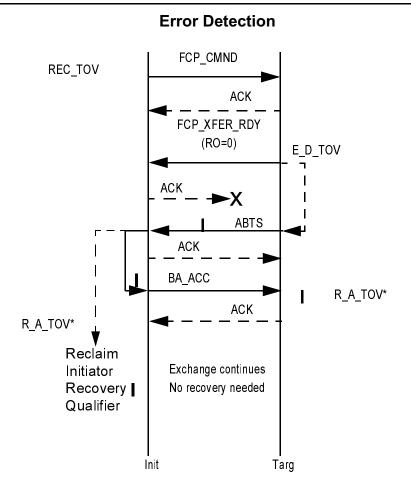
#### Error Recovery

For acknowledged classes, the BA\_ACC indicates that the FCP\_XFER\_RDY was never received by the initiator. The 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. The value for R\_A\_TOV\* for in-order delivery is 0. A new SEQ\_ID must be used in the retransmission of FCP\_XFER\_RDY. The use of REC to determine status for error recovery is optional.



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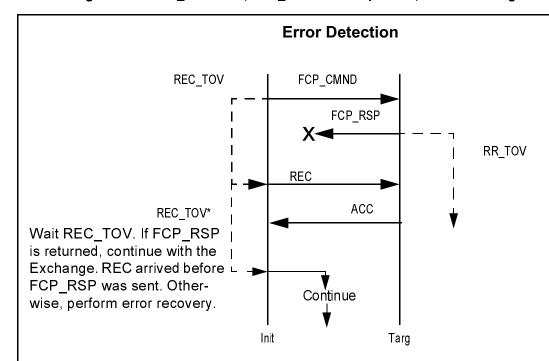




The BA\_ACC indicates that the FCP\_XFER\_RDY was received by the initiator. The BA\_ACC payload of SEQ\_ID valid, SEQ\_ID = SEQ\_ID of the FCP\_XFER\_RDY frame, low SEQ\_CNT = high SEQ\_CNT = SEQ\_CNT of the ABTS frame. No error recovery is required. There is no need for the target to issue the RRQ 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. The value of  $R_A_TOV^*$  for in-order delivery is 0, The use of REC to determine status for error recovery is optional.

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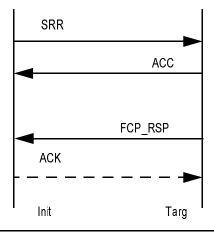
Figure D.8 - FCP RSP Lost, FCP CONF not requested, Unacknowledged Classes



The ACC for the REC indicates the Initiator holds Sequence Initiative and the Exchange is complete. The Initiator sends an SRR requesting the FCP\_RSP be resent. The Target retransmits the FCP\_RSP. For in-order delivery, the value of REC\_TOV\* is 0.

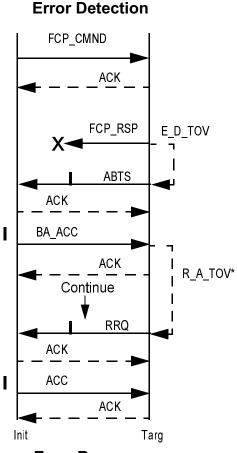
For sequence level recovery, the target must keep the context of this Exchange until the OX\_ID value is reused in a new command, implicitly validating the receipt of FCP\_RSP, or for at least RR\_TOV, in order to preserve the FCP\_RSP information. This long time-out can be avoided by using FCP\_CONF. The FCP\_RSP retransmission must use a new SEQ\_ID.

For exchange level recovery, the context of the Exchange can be purged by the target after FCP\_RSP is transmitted.

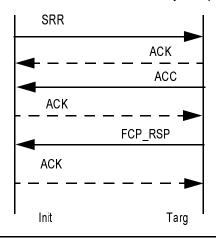


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Figure D.9 - FCP RSP Lost, FCP CONF not requested, Acknowledged Classes

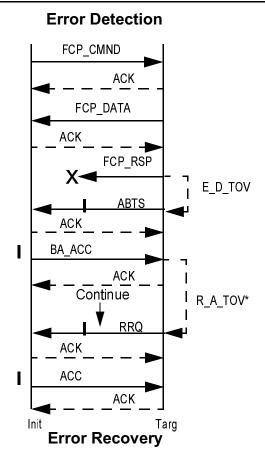


BA\_ACC to ABTS indicates that the FCP\_RSP was never received by the initiator. The payload is SEQ\_ID invalid, low SEQ\_CNT = 0, high SEQ\_CNT = SEQ\_CNT in ABTS frame = 1. Both initiator and target must establish Recovery Qualifiers. The value of R\_A\_TOV\* for inorder delivery is 0. A new SEQ\_ID must be used in the retransmission of FCP\_RSP. The use of REC to determine status for error recovery is optional.



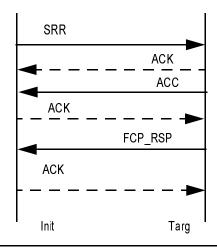
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Figure D.10 - FCP RSP Lost after Read Command, FCP CONF not requested, Acknowledged Classes



BA\_ACC to ABTS indicates that the FCP\_RSP was never received by the initiator. The payload is SEQ\_ID valid, SEQ\_ID = SEQ\_ID of FCP\_DATA Sequence, low SEQ\_CNT = x, high SEQ\_CNT = SEQ\_CNT in ABTS frame = 1. Both initiator and target must establish Recovery Qualifiers. The value of R\_A\_TOV\* for in-order delivery is 0. A new SEQ\_ID must be used in the retransmission of FCP\_RSP.

The use of REC to determine status for error recovery is optional.

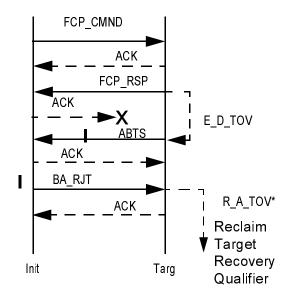


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Figure D.11 - FCP RSP Received, ACK Lost, Acknowledged Classes, Example 1

#### **Error Detection**

#### **Acknowledged Classes**



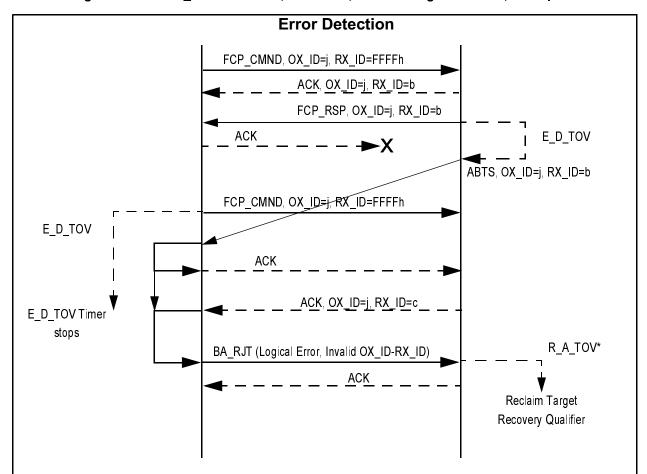
### **No Error Recovery**

No error recovery required.

The BA\_RJT for the ABTS indicates the Exchange is unknown and therefore complete. 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. For in-order delivery, the value of R\_A\_TOV\* is 0. The target does not need to issue RRQ as no Recovery Qualifier was established by the initiator.

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



No recovery performed.

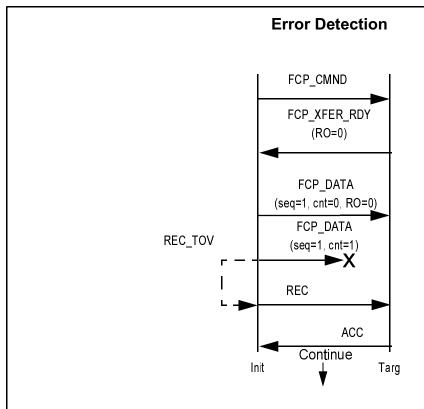
The BA\_RJT for the ABTS indicates that the Exchange is unknown and therefore complete and no error recovery is required. The target must establish a Recovery Qualifier. The associated resources cannot be reused for a period of R\_A\_TOV.

No action is taken on ABTS unto the ACK to the outstanding Sequence has been received, allowing the analysis to take into consideration the RX\_ID, to eliminate ambiguity. For in-order delivery, the value of  $R_A_TOV^*$  is 0.

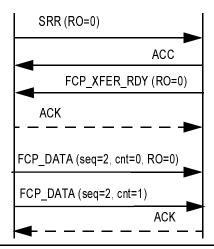
The target need not issue RRQ, as no Recovery Qualifier was established by the initiator.

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

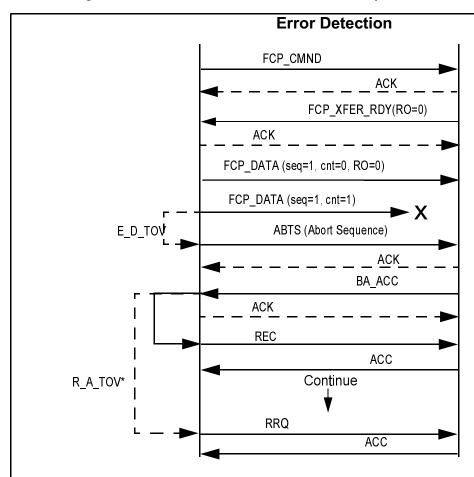


The ACC for the REC indicates the Target does not hold Sequence Initiative and the Exchange is open. The Initiator sends an SRR requesting a FCP\_XFER\_RDY be resent using the specified Relative Offset. The Target retransmits the FCP\_XFER\_RDY using the specified Relative Offset. New SEQ\_IDs are used for FCP\_XFER\_RDY and FCP\_DATA retransmission.



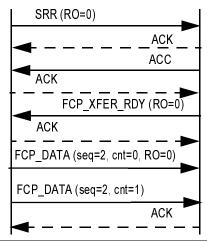
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Figure D.14 - Lost Write Data, Last Frame of Sequence, Acknowledged Classes



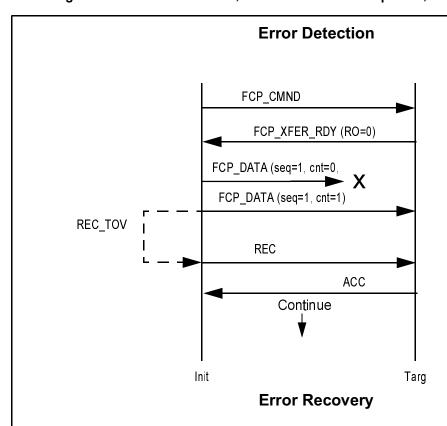
Using the information contained in the REC, the recovery may be performed as in figure D.13. The BA\_ACC may also be used. The payload is SEQ\_ID = valid, SEQ\_ID = SEQ\_ID of FCP\_CMND, low SEQ\_CNT of 0, high SEQ\_CNT of 2.

New SEQ\_IDs shall be used for retransmitting FCP\_XFER\_RDY and FCP\_DATA. ACKs for REC/ACC and RRQ/ACC are not shown. The value of R\_A\_TOV\* for in-order delivery is 0.



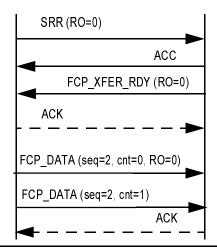
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Figure D.15 - Lost Write Data, Not Last Frame of Sequence, Unacknowledged Classes



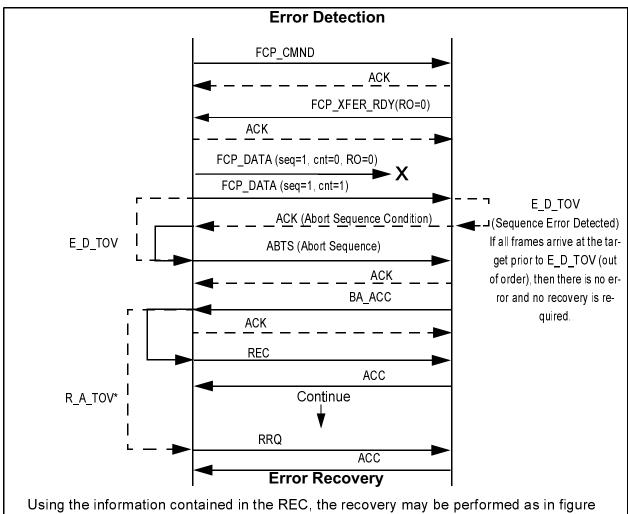
The ACC for the REC indicates the Target does not hold Sequence Initiative and the Exchange is open. The Initiator sends an SRR requesting a FCP\_XFER\_RDY be resent using the specified Relative Offset. The Target retransmits the FCP\_XFER\_RDY using the specified Relative Offset. New SEQ\_IDs are used for FCP\_XFER\_RDY and FCP\_DATA retransmission.

If the lost frame arrives at the target prior to the expiration of REC\_TOV, the exchange proceeds and no recovery is required.



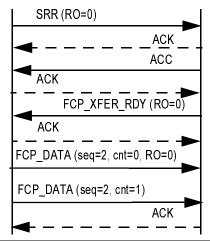
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Figure D.16 - Lost Write Data, Not Last Frame of Sequence, Acknowledged Classes



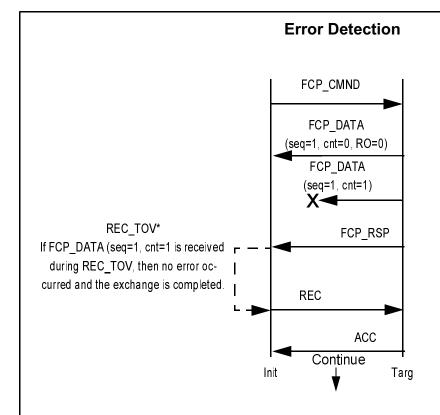
Using the information contained in the REC, the recovery may be performed as in figure D.15. The BA\_ACC may also be used. The payload is SEQ\_ID = valid, SEQ\_ID = SEQ\_ID of FCP\_CMND, low SEQ\_CNT of 0, high SEQ\_CNT of 2.

New SEQ\_IDs shall be used for retransmitting FCP\_XFER\_RDY and FCP\_DATA. ACKs for REC/ACC and RRQ/ACC are not shown. The value of R\_A\_TOV\* for in-order delivery is 0.

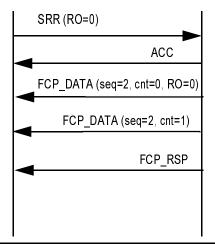


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Figure D.17 - Lost Read Data, Last Frame of Sequence, Unacknowledged Classes

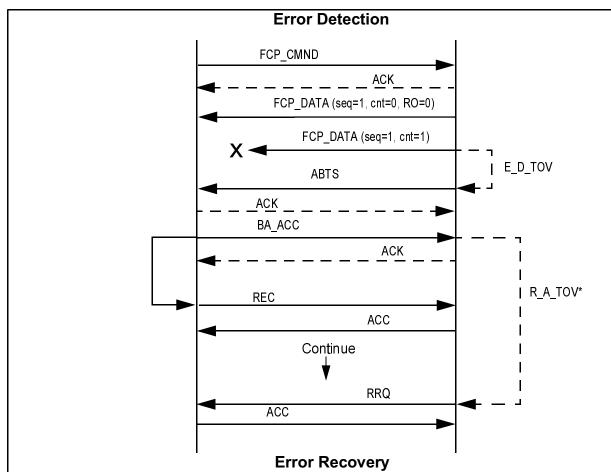


The ACC for the REC indicates the Target does not hold Sequence Initiative and the Exchange is open. The Initiator sends an SRR requesting a FCP\_DATA be resent using the specified Relative Offset. FCP\_DATA retransmission uses a new SEQ\_ID. For in-order delivery, the value of REC\_TOV\* is 0.



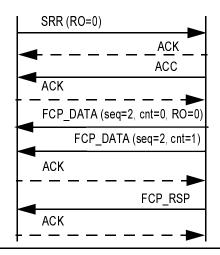
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Figure D.18 - Lost Read Data, Last Frame of Sequence, Acknowledged Classes



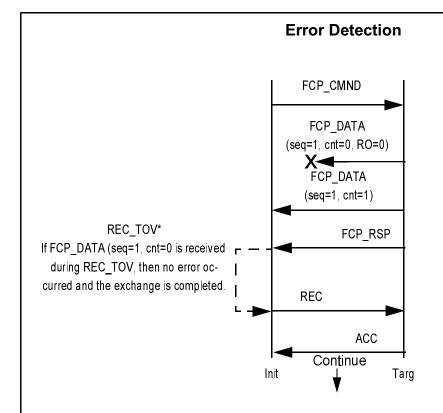
Using the information contained in the REC, the recovery may be performed as in figure D.17. The BA\_ACC may also be used because it indicates that the FCP\_DATA sequence was not completely received. The payload is SEQ\_ID = invalid, low SEQ\_CNT of 0, high SEQ\_CNT of ABTS frame.

New SEQ\_IDs shall be used for retransmitting FCP\_DATA. ACKs for REC/ACC and RRQ/ACC are not shown. The value of R\_A\_TOV\* for in-order delivery is 0.

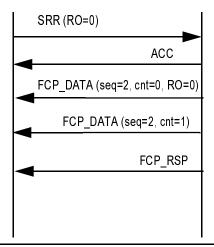


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Figure D.19 - Lost Read Data, Not Last Frame of Sequence, Unacknowledged Classes

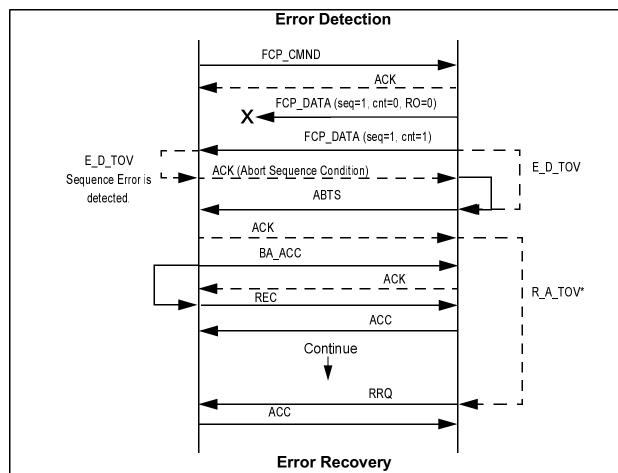


The ACC for the REC indicates the Target does not hold Sequence Initiative and the Exchange is open. The Initiator sends an SRR requesting a FCP\_DATA be resent using the specified Relative Offset. FCP\_DATA retransmission uses a new SEQ\_ID. For in-order delivery, the value of REC\_TOV\* is 0.



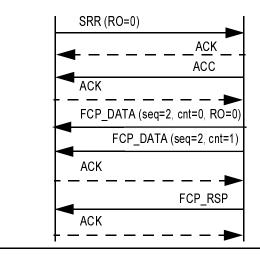
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Figure D.20 - Lost Read Data, Not Last Frame of Sequence, Acknowledged Classes



Using the information contained in the REC, the recovery may be performed as in figure D.17. The BA\_ACC may also be used because it indicates that the FCP\_DATA sequence was not completely received. The payload is SEQ\_ID = invalid, low SEQ\_CNT of 0, high SEQ\_CNT of ABTS frame.

New SEQ\_IDs shall be used for retransmitting FCP\_DATA. ACKs for REC/ACC and RRQ/ACC are not shown. The value of R\_A\_TOV\* for in-order delivery is 0.

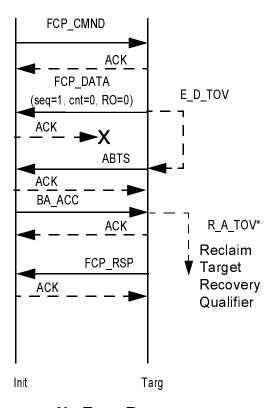


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Figure D.21 - ACK Lost on Read (Acknowledged Classes)

#### **Error Detection**

#### **Acknowledged Classes**



#### **No Error Recovery**

#### None:

The Initiator has received the FCP\_DATA frame or sequence. No error recovery is required.

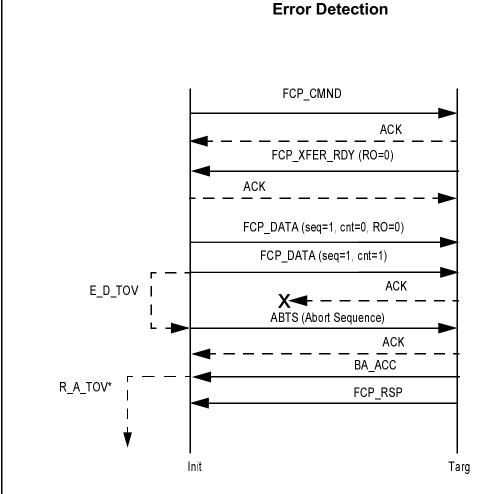
The BA\_ACC indicates the FCP\_DATA sequence was received (Payload is SEQ\_ID valid, SEQ\_ID value = SEQ\_ID value of FCP\_DATA sequence, low SEQ\_CNT = high SEQ\_CNT = SEQ\_CNT of ABTS frame).

The target must establish its Recovery Qualifier. The resources associated with the Recovery Qualifier can be reclaimed after R A TOV. For in-order delivery, the value of R A TOV\* is 0.

The issuance of RRQ is optional as no Recovery Qualifier was established by the initiator in this case. FCP\_RSP can be received anytime after the transmission of FCP\_CMND due to out of order delivery.

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



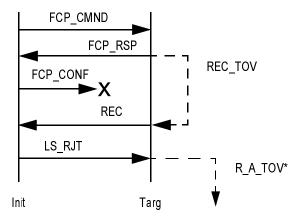
#### None:

The Target has received the FCP\_DATA sequence. No error recovery is required. The BA\_ACC indicates the data sequence was received. The payload is set to 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. For in-order delivery, the value of R\_A\_TOV\* = 0. The issuance of the RRQ is optional, as no Recovery Qualifier was established by the target. FCP\_RSP can be received at any time after the last FCP\_DATA frame has been transmitted.

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#### I

#### **Error Detection**



### **No Error Recovery**

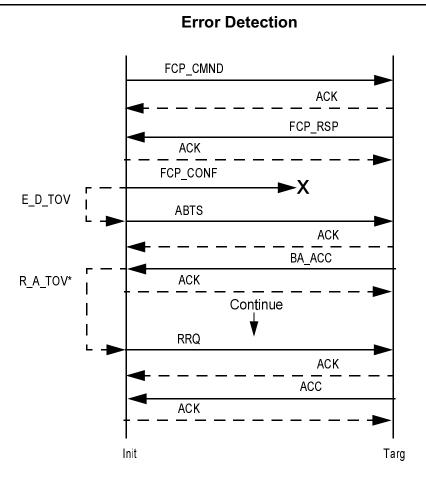
#### None.

The LS\_RJT for the REC indicates the Exchange is unknown. That implicitly indicates that the initiator received FCP\_RSP and sent FCP\_CONF.

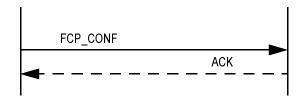
The context for the Exchange in the Target must be preserved for another  $R_A_TOV$  to prevent possible aliasing. If FCP\_CONF is received after REC is transmitted, it is accepted and discarded and the context for the Exchange can be purged. For in-order delivery, the value of  $R_A_TOV^* = 0$ .

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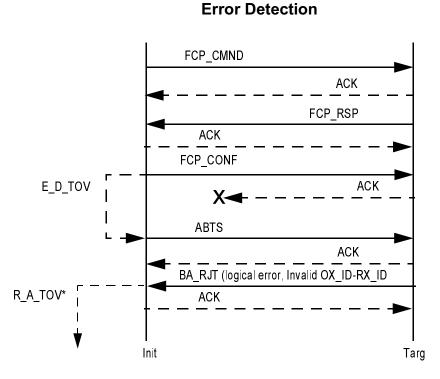


The BA\_ACC indicates that the FCP\_CONF was not received. The BA\_ACC payload is SEQ\_ID valid, SEQ\_ID value = SEQ\_ID of FCP\_CMND, Low SEQ\_CNT = 0, High SEQ\_CNT = 1). The value of R\_A\_TOV\* for in-order delivery is zero. FCP\_CONF must be retransmitted with a different SEQ\_ID.



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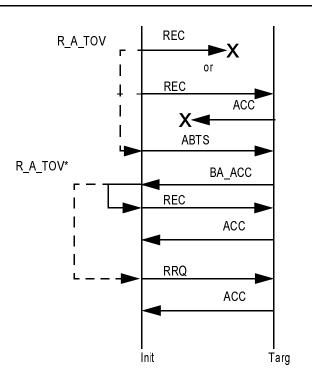
#### None:

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.

Issuance of the RRQ is optional, as no Recovery Qualifier was established by the target. For in-order delivery, the value of R A  $TOV^* = 0$ .

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



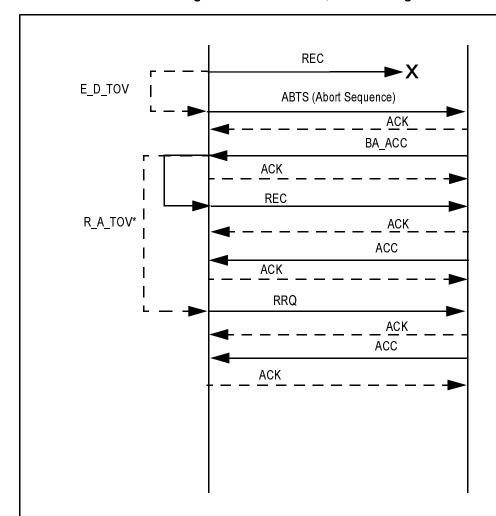
For the case of the REC never having been received, the BA\_ACC payload will be SEQ\_ID invalid, low SEQ\_CNT = 0, high SEQ\_CNT = SEQ\_CNT of ABTS = 1.

For the case of the ACC response to REC never having been received, the target would view the ABTS as having been issued on a new Exchange. The BA\_ACC payload will be SEQ\_ID invalid, low SEQ\_CNT = high SEQ\_CNT = SEQ\_CNT of ABTS.

In both cases, a Recovery Qualifier will be established. The second REC is issued in a new Exchange. For in-order delivery, the value of R\_A\_TOV\* is 0

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Figure D.27 - REC Lost, Acknowledged Classes



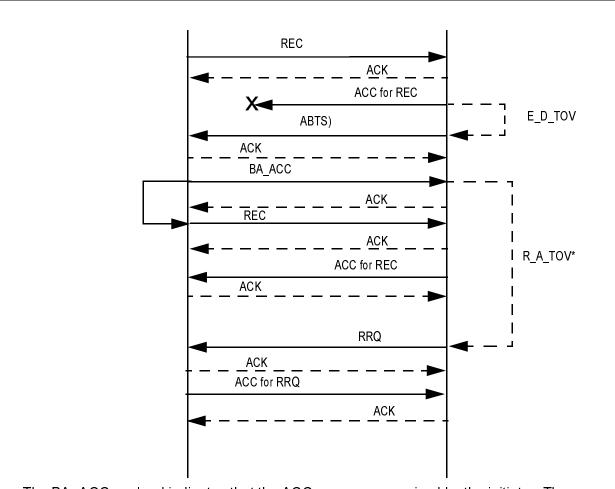
The BA\_ACC payload indicates that the REC was never received by the target. The payload is SEQ\_ID invalid, low SEQ\_CNT = 0, high SEQ\_CNT = SEQ\_CNT in ABTS frame. Recovery Qualifiers are established on each side.

For in-order delivery, the value of R\_A\_TOV\* is 0.

The second REC is issued using a new Exchange.

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Figure D.28 - REC Response Lost, Acknowledged Classes

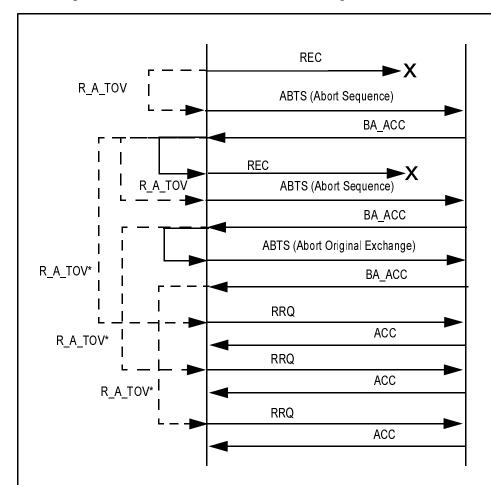


The BA\_ACC payload indicates that the ACC was never received by the initiator. The payload is SEQ\_ID invalid, low SEQ\_CNT = 0, high SEQ\_CNT = SEQ\_CNT in ABTS frame. After responding to the ABTS, the initiator reissues the REC in a new Exchange. Recovery Qualifiers are established on each side.

For in-order delivery, the value of R\_A\_TOV\* is 0.

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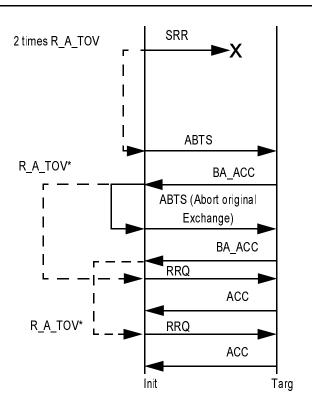
Figure D.29 - Two RECs Lost, Unacknowledged Classes, Abort the original exchange



The failure of two RECs issued against the same Exchange causes all associated Exchanges to be aborted. The ABTS for the original Exchange uses the previous SEQ\_ID and a SEQ\_CNT one greater than the count used in the previous sequence and Bit 0 = 0 set in the Parameter field. The payload for the BA\_ACC is SEQ\_ID valid, SEQ\_ID = SEQ\_ID of last deliverable sequence received, low SEQ\_CNT = 0 and high SEQ\_CNT = FFFFh. Recovery qualifiers are established on both sides for each Exchange. For in-order delivery, the value of  $R_A_TOV^*$  is 0.

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Figure D.30 - SRR Lost, Unacknowledged Classes, Abort original exchange



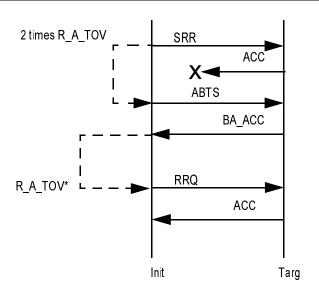
The payload for the BA\_ACC associated with the ABTS of the SRR is SEQ\_ID valid, low SEQ\_CNT = 0, high SEQ\_CNT = SEQ\_CNT of the ABTS frame.

The ABTS for the original Exchange uses the previous SEQ\_ID and a SEQ\_CNT one greater than the count used in the previous Sequence and Bit 0 = 0 in the Parameter field. The payload for the BA\_ACC associated with the ABTS for the original Exchange is SEQ\_ID valid, the SEQ\_ID = SEQ\_ID of the last deliverable Sequence of the original Exchange received, low SEQ\_CNT = 0, and high SEQ\_CNT = FFFFh.

Recovery Qualifiers are established on both sides for each Exchange. For in-order delivery, the value of R\_A\_TOV\* is 0.

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Figure D.31 - SRR Response Lost, Unacknowledged Classes



If the SRR Exchange is unknown to the Recipient, the Exchange was completed and the context purged. The payload for the BA\_ACC is SEQ\_ID invalid, low SEQ\_CNT = 0, high SEQ\_CNT = FFFFh. Recovery Qualifiers are established on both sides.

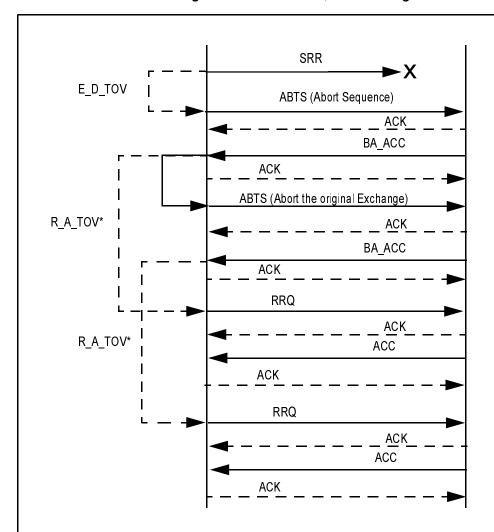
If the SRR Exchange is still known to the Recipient, the payload for the BA\_ACC is  $SEQ_ID$  valid,  $SEQ_ID = SEQ_ID$  of the SRR, low  $SEQ_CNT = high SEQ_CNT = SEQ_CNT$  of the ABTS frame. Since no Recovery Qualifier is established, RRQ need not be issued. The Recovery Qualifier is established on the initiator side and must be timed out for  $R_ATOV$ .

For in-order delivery, the value of R\_A\_TOV\* is 0.

In either case, the original Exchange need not be aborted.

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Figure D.32 - SRR Lost, Acknowledged Classes



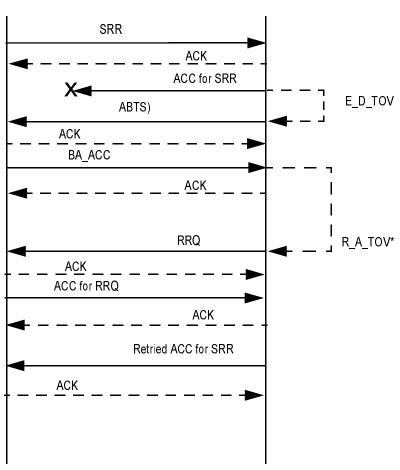
Since the ABTS on the SRR is on a new Exchange, Recovery Qualifiers must be established. The BA\_ACC payload indicates SEQ\_ID invalid, low SEQ\_CNT = 0, and high SEQ\_CNT = SEQ\_CNT of the ABTS.

An error on an SRR is a second error and the original Exchange is also aborted. SRR is not retried.

For in-order delivery, the value of R\_A\_TOV\* is 0.

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Figure D.33 - SRR Response Lost, Acknowledged Classes



The BA\_ACC of the ABTS associated with the SRR indicates that the ACC for the SRR was not received and will be discarded if it is later received. The BA\_ACC payload indicates SEQ\_ID invalid, low SEQ\_CNT = 0, and high SEQ\_CNT = SEQ\_CNT of the ABTS. The retry of the ACC for SRR is issued with a new SEQ\_ID.

Recovery Qualifiers are established on each side.

For in-order delivery, the value of R A TOV\* is 0.

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