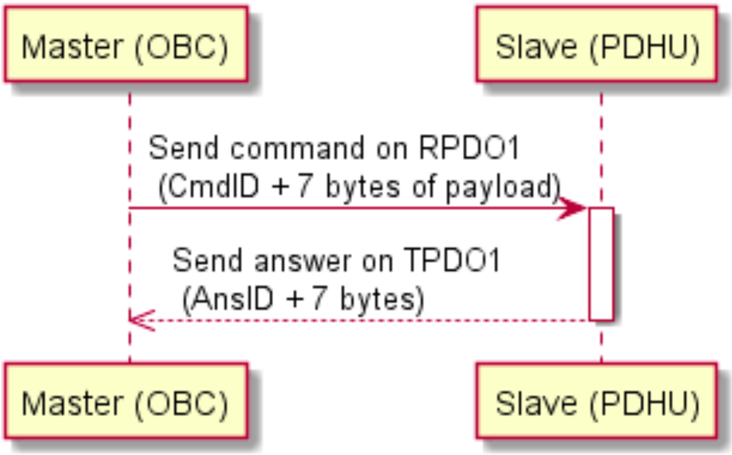
Appendix
Data-driven Mutation Testing:
LuxSpace
PHDU-PDO FAULT MODEL

This document describes the procedures to execute data-driven mutation testing on the LuxSpace Remote Commands over PDO (Process Data Object)) case study system.
In the Section 1 we will provide a brief overview of the case study. Then, in Section 2, we will describe the commands implemented in the command/response protocol and the data-driven mutation operators we plan on applying to the buffer that contains them.

1) Overview of the case study

The PDOs (TPDO1 and RPDO1) handle communication between the OnBoard Computer (OBC) and the PDHU (Payload Data Handling Unit).
The OBC initiates a remote access by sending a command (Cmd) on TPDO1 and the PDHU processes the command and send back its answer (Ans) on RPDO1.



The layouts of the commands and answers are described in the table below. Both are composed of a signal ID that must match between command and answer and a payload with size depending on the ID.

Field	Position	Size	Description
CmdID	Byte 0	UNSIGNED8	ID that defines the command
CmDData	Byte 1.7	7 Bytes	The command payload. The size and the meaning of the payload depend on the command ID
AnsID	Byte 0	UNSIGNED8	ID that matches with the CmdID
AnsData	Byte 1.7	Up to 7 Bytes	The Answer payload. The size and the meaning of the payload depend on the command ID

The first byte of the answer payload is always a status that reflect the command handling status and the 6 remaining answer payload bytes are meaningful only when the status is different from 00h (Command OK)

Status Code	Description
00h	Command OK
01h	Unknown command ID
02h	Bad command payload size: the received command payload size does not match with the expected one according to the command ID
03h	Bad parameter value
04h	Not allowed: the command is not allowed in the context
05h	Command aborted
06h	Command pending

2) COMMANDS DESCRIPTION

The CmID or AnsID occupies the first byte of the signal array. It is expressed as a Hexadecimal number of size UNSIGNED8. The highlighted ones are implemented in the SVF.

CmdID	Command Name	Command Description
0x01	STO_SND_FRM	Read from storage and send a range of frames to the PDD
0x02	STO_ACK_FRM	Acknowledge a range of frames
0x03	STO_RST_FRM	Reset all frames
0x04	STO_GET_HEAD	Retrieve the 5-bytes storage Head pointer
0x05	STO_GET_TAIL	Retrieve the 5-bytes storage tail pointer
0x10	SM_TST_CHIP	Storage Maintenance: Test Chip
0x11	SM_TST_BLOCK	Storage Maintenance: Test Block
0x12	SM_RESET	Storage Maintenance: Storage Reset
0x13	SM_SET_CB0_SIZE	Storage Maintenance: Set the frontier between both storage
0x1A	PDHU_RESET	Request a PDHU reset
0x1B	DBG_SELFTST	Debug/Monitoring: Perform a self-test
0x1C	CRC_COMPUTE	Compute the CCIT CRC

The payload varies according to the command.
Not all of these commands are being used by the OBSW. The implemented ones are STO_SND_FRM, STO_GET_HEAD, STO_GET_TAIL and CRC_COMPUTE.
Below we report the operators (Fault Class) to be used for each data item; however, red color is used to indicate data items that shall not be mutated.

RMTCMD(O1,01) STO_SND_FRM

Read from storage and send a range of frames to the PDD. The command is only available in ACTIVE mode.

ANS PAYLOAD

Byte	Name	Type	Description	Fault Class

BYTE [0] ID	AnsID=CmdID	HEX (UNSIGNED 8)	ID that defines the command: 0x01	IV(Value=0x02)
				IV(Value=0x03)
				IV(Value=0x04)
				IV(Value=0x05)
				IV(Value=0x10)
				IV(Value=0x11)
				IV(Value=0x12)
				IV(Value=0x13)
				IV(Value=0x1A)
				IV(Value=0x1B)
				IV(Value=0x01C)

BYTE [1]	Command Status	UINT8	Command status code	IV(Value=05h) to make it seem like the command was aborted
				IV(value=01h)
				IV(value=02h)
				IV(value=03h)
				IV(value=04h)
				IV(value=06h)
				IV(value=00h)

BYTE [2...5]	PendingRequest	UINT32	number of pending requests in the Storage Request FIFO	HV(Value=?)
				To show the same number of pending requests even when it changes
				SS(Delta=?)
				To add or subtract a fixed number to the number of pending requests

BYTE [6...7]	UNUSED	-	-	

RMTCMD(O1,04) STO_GET_HEAD

Retrieve the 5-bytes storage Head pointers.

ANS PAYLOAD

Byte	Name	Type	Description	Fault Class

BYTE [0] ID	AnsID=CmdID	HEX (UNSIGNED8)	ID that defines the command: 0x04	IV(Value=0x01)
				IV(Value=0x02)
				IV(Value=0x03)

				IV(Value=0x05)
				IV(Value=0x010)
				IV(Value=0x011)
				IV(Value=0x012)
				IV(Value=0x013)
				IV(Value=0x01A)
				IV(Value=0x01B)
				IV(Value=0x01C)

BYTE [1] Payload	Command Status	UINT8	Command status code	IV(Value=05h) to make it seem like the command was aborted.
				IV(value=01h)
				IV(value=02h)
				IV(value=03h)
				IV(value=04h)
				IV(value=06h)
				IV(value=00h)
				VAT(T=06h, D=1)
				FVAT(T=06h, D=1)

BYTE [2...6] Payload	SequenceID	UINT40	Sequence ID corresponding to the head of the storage Byte #1 is the LSByte Byte #5 is the MSByte	BF(LSBit) for each byte?
BYTE [7] Payload	UNUSED	-	-	

RMTCMD(O1,05) STO_GET_TAIL

Retrieve the 5-bytes storage Tail pointer.

Ans Payload

Byte	Name	Type	Description	Fault Class

BYTE [0] ID	AnsID=CmdID	HEX (UNSIGNED8)	ID that defines the command: 0x05	IV(Value=0x01)
				IV(Value=0x02)
				IV(Value=0x03)
				IV(Value=0x04)
				IV(Value=0x010)
				IV(Value=0x011)
				IV(Value=0x012)
				IV(Value=0x013)
				IV(Value=0x01A)
				IV(Value=0x01B)
				IV(Value=0x01C)

BYTE [1] Payload	Command Status	UINT8	Command status code	IV(Value=05h) to make it seem like

				the command was aborted.
				IV(value=01h)
				IV(value=02h)
				IV(value=03h)
				IV(value=04h)
				IV(value=06h)
				IV(value=00h)
				VAT(T=06h, D=1)
				FVAT(T=06h, D=1)

BYTE [2...6] Payload	SequenceID	UINT40	Sequence ID corresponding to the tail of the storage Byte #1 is the LSByte Byte #5 is the MSByte	
BYTE [7] Payload	UNUSED	-	-	

RMTCMD(O1,1C) CRC_COMPUTE

Compute the CRC CCITT of MRAM data.
The command is only available when the PDHU is in PASSIVE mode.

ANS PAYLOAD

Byte	Name	Type	Description	Fault Class

BYTE [0] ID	AnsID=CmdID	HEX (UNSIGNED8)	ID that defines the command: 0x01C	IV(Value=0x01)
				IV(Value=0x02)
				IV(Value=0x03)
				IV(Value=0x04)
				IV(Value=0x05)
				IV(Value=0x010)
				IV(Value=0x011)
				IV(Value=0x012)
				IV(Value=0x013)
				IV(Value=0x01A)
				IV(Value=0x01B)

BYTE [1] Payload	Command Status	UINT8	Command status code	IV(Value=05h) to make it seem like the command was aborted. IV(Value=00h) to activate the syndrome part even if the command status was not 00h

				IV(Value=04h) to simulate a different PHDU mode
				IV(Value=05h) to make it seem like the command was aborted.
				IV(value=01h)
				IV(value=02h)
				IV(value=03h)
				IV(value=06h)

BYTE [2] Payload	Syndrom		MS Byte processed syndrom, only valid when returned status code is 00h	BF
BYTE [3] Payload	Syndrom		MS Byte processed syndrom, only valid when returned status code is 00h	BF
BYTE [4.7] Payload	UNUSED	-	-	

Status Code	Description
00h	Command OK
03h	if the CRC parameters coherency is bad
04h	if the PDHU mode is ACTIVE

3) PROBE INSERTION

The probes were inserted in the method *PdhuPdoService::IndicationReceived,* which handles the RMTCMD.
The method is defined in the file *PdhuPdoService.cpp,* contained in the folder Svf/Models/CAN/src/Pdhu/.
Each message type is handled by a different switch case and was targeted by a different fault model as shown below.

```
case 0x04: //RMTCMD(01,04) STO_GET_HEAD
{
    ::Smp::UInt64 sequenceId;
    auto statusCode = Pdhu->StorageReadBack->GetHeadPointer(data[1], sequenceId);

    if(statusCode == RCSC_CmdOk)
    {
        Generic::Utils::SerializeLe(sequenceId, newData.begin() + 2, 5);

        // MANUALLY INSERTED PROBE
        mutate_FM_STO_GET_HEAD( &newData );
        // END OF THE PROBE

        }
    else
    {
        newData[1] = statusCode;
        }
}
```