




PASTIS V2 INTEGRATION GUIDE

	Name and Acronym	Date and Signature
Written by	Frédéric BLON DSO/BL/OB	25/02/2020 
Approved by	Antoine VERGNAUD DSO/BL/OB	 31/03/2020
Application Authorised by	Stéphane LOUVEL DSO/BL/PR	 31/03/2020

Applicability to Aerostat Systems (tick the systems concerned):

BSO	BPS	BLD	MIR	BPCL	AEC	CAPTIFS
X						

Applicability to projects (tick the projects concerned):

NOSYCA	FIRBL	PILOT	EUSOBALLON	G3D	CIASI	BAMED	ATT	STR2	CHARMEX
X									

Is document configuration-managed? No	by:	as from:
--	-----	----------

KEY WORDS

PASTIS, BSO, NOSYCA

CHANGES

Version	Date	Subject
1.0	12/04/2019	Initial version
1.1	27/11/2019	Add of electric wiring for TOR §6.3, add of bandwidth limitation §8.5, add of appendix 1, add of radio questionnaire for scientists.

TABLE OF CONTENTS

1. SUBJECT.....	4
2. APPLICABLE DOCUMENTS AND REFERENCE DOCUMENTS.....	4
3. ABBREVIATIONS AND TBC/TBD LIST	4
4. PREAMBLE	5
4.1. Introduction to the PASTIS system.....	5
4.2. Limits	6
5. NCU (PAYLOAD GONDOLA) CONFIGURATION	6
5.1. Payload configuration	6
5.2. Mission Control Centre IP configuration	7
6. TOR (ON/OFF) CONFIGURATION.....	8
6.1. TOR (ON/OFF) module	8
6.2. TORs wiring.....	9
6.3. TORs ELECTRIC WIRING	9
6.4. USING THE TORS	10
7. SERIAL CONFIGURATION	12
7.1. Onboard serial configuration.....	12
7.2. Pin assignment of serial connectors	14
7.3. SOL (ground-based) serial configuration	14
8. NETWORK RECOMMENDATIONS	14
8.1. Reception of telemetry by the mission control centre	14
8.2. Transmission of telecommand frames	15
8.3. Address translation	15
8.4. Tests in a degraded environment and bandwidth limitation.....	15
9. APPENDIX 1: TOR USER GUIDE	15
DISTRIBUTION	17

1. SUBJECT

This guide provides the information needed for integrating scientific payloads into the PASTIS communication gateway.

2. APPLICABLE DOCUMENTS AND REFERENCE DOCUMENTS

Reference	Document title
BSO-MU-PASTIS-7681-CN	PASTIS V2 System User Manual

3. ABBREVIATIONS AND TBC/TBD LIST

Acronym	Definition
CU	Charge Utile [Payload]
GSR	Ground Segment Responsible
NCU	Nacelle Charge Utile [Payload Gondola]
NOSYCA	BSO Ground segment
NSO	Nacelle de Servitude Opérationnelle [Operational housekeeping gondola].
NTP	Network time protocol
OSB	Open Stratospheric Balloon
PASTIS	Passerelle Technologique d'interconnexion [Interconnection Technology Gateway]
SER	Serial
SSID	Wifi network identifier
SW	Switch
TM	Telemetry
TOR [ON/OFF]	On/Off signal (contact)

TBC/TBD	Section	Short title

4. PREAMBLE

4.1. INTRODUCTION TO THE PASTIS SYSTEM

PASTIS is an on-board/ground communication system designed to transmit scientific data streams between the mission control centre and the instruments on the payload during NOSYCA open stratospheric balloon (OSB) flights. The PASTIS system is divided into two subsystems: PASTIS-SOL [PASTIS - GROUND] and PASTIS-BORD [PASTIS-ONBOARD].

- The PASTIS-SOL system connects the science mission centre to the ground segment of the NOSYCA system, enabling communication with the payload of the OSB balloon flight chain.
- The PASTIS-BORD system connects the payload scientific instruments to the operational housekeeping gondola (NSO), allowing communication with the ground-based science mission centre.

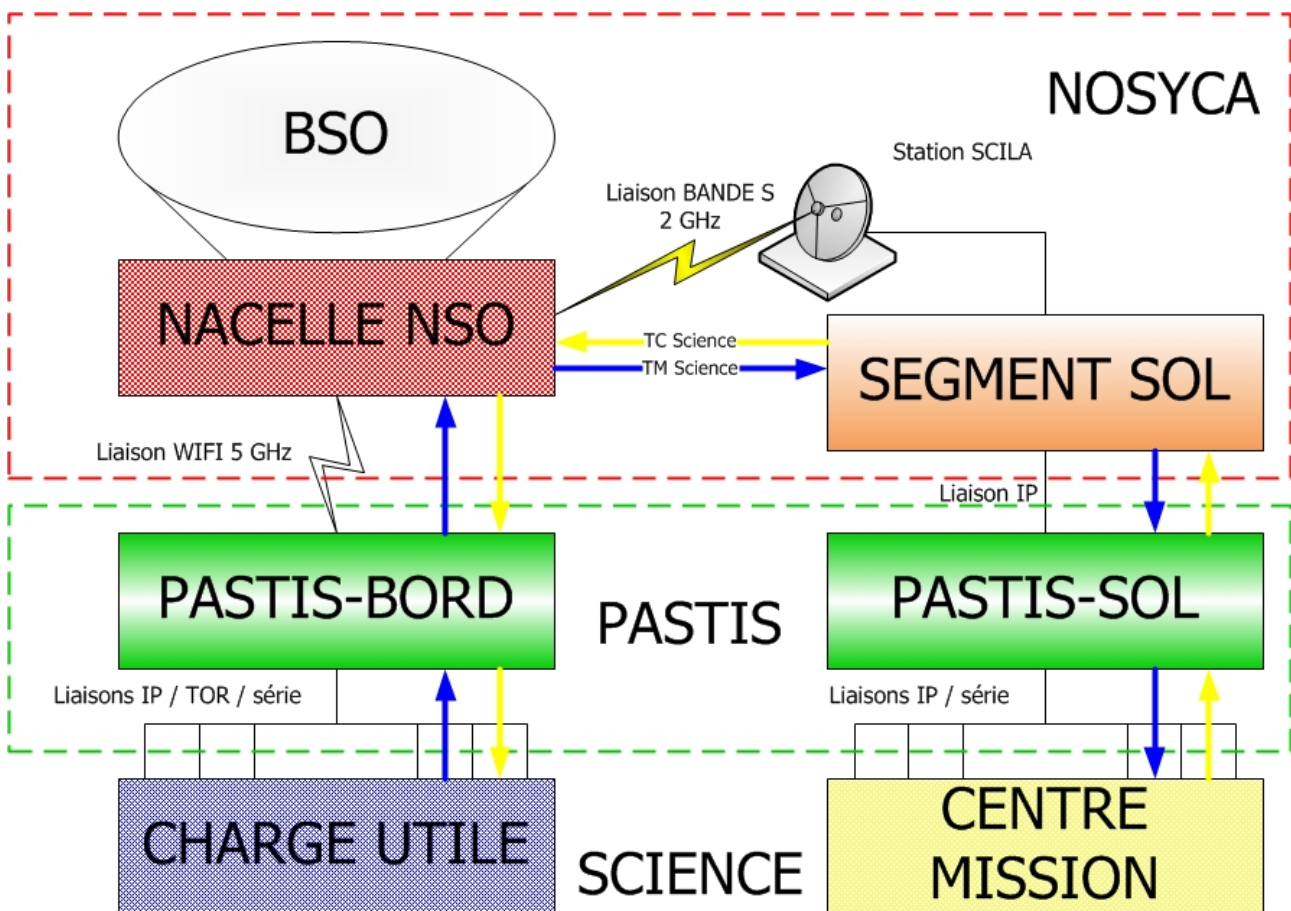


Figure 1 PASTIS system integration diagram

The PASTIS system is available with two different configurations:

- Main layout
 - Only the PASTIS-PRINCIPAL-BORD box installed in the payload
 - PASTIS-RT-SOL router as the only interface with the mission control centre
 - Communication links:
 - 6 Ethernet IP ports, 12 TOR (ON/OFF) outlets on board
 - 6 Ethernet IP ports on the ground
- Complete layout
 - PASTIS-PRINCIPAL-BORD boxes plus PASTIS-AUXILIAIRE-BORD installed in the payload
 - PASTIS-RT-SOL router plus PASTIS-SER-SOL IP/serial gateway as interface with the mission control centre
 - Communication links:
 - 10 Ethernet IP ports, 12 TOR (ON/OFF) outlets and 4 serial ports on board
 - 6 Ethernet IP ports on the ground

Whatever the configuration chosen for the equipment, the PASTIS system provides, per PASTIS-BORD/PASTIS-SOL pair, the following basic services:

- Internet access open to all protocols via the NOSYCA ground segment network for the mission control centre
- a direct wired link between PASTIS-BORD and PASTIS-SOL for use on the ground during pre-flight integration.
- one or two PASTIS-BAT-BORD on-board batteries for the flight
- time distribution accessible to all payload and mission control-centre equipment through the NOSYCA network's NTP time server

The data transmission speeds available on the PASTIS gateway are as follows: 1.5Mb/s downlink (gondola to ground) and 70kb/s uplink. These transmission speeds hold for the gondola as a whole, whereas if there are several experiments on board, the speeds will be divided accordingly. Exceeding these speeds, even on an occasional basis, can cause instabilities and interruptions in the Wifi link.

4.2. LIMITS

Payloads must not include a radio transmission device that has not been declared to CNES. If Wifi or radio devices are to be included on board, whether for 2.4 GHz or 5 GHz frequencies, their inclusion must be announced as soon as possible in order to find a channel that will not affect the science or TM links.

As the NSO/NCU link is provided over long-distance Wifi, packet losses are possible and may occur frequently. Address translation is not possible on the PASTIS gateway due to internal routing mechanisms. As a result, each device must have its own address in the addressing plan provided in the network section §3.1.

5. NCU (PAYLOAD GONDOLA) CONFIGURATION

5.1. PAYLOAD CONFIGURATION

The payload has a dedicated network, PASTIS-BORD-CU, within the PASTIS-BORD system. All payload instruments must configure their network board with the following parameters before connecting to the PASTIS-PRINCIPAL-BORD (and PASTIS-AUXILIARY-BORD) boxes and then be able to be controlled by the mission control centre.

Characteristics of the PASTIS-BORD-CU network

- Network 172.20.4.0/24
- Mask: 255.255.255.0
- Gateway (PASTIS-RT-BORD): 172.20.4.254
- IP addresses available: 172.20.4.1 to 172.20.4.253
- IP address reserved for CNES: 172.20.4.64
- no DNS

- DHCP active over the entire range of available IP addresses
- **Fixed IP addressing is highly recommended for in-flight operations**

Warning: it is important to properly coordinate the IP addressing of the payload to avoid any IP address conflict during operations! In case of a gondola shared between several experiments, the ground segment responsible will ask you to fill in an IP address assignment table.

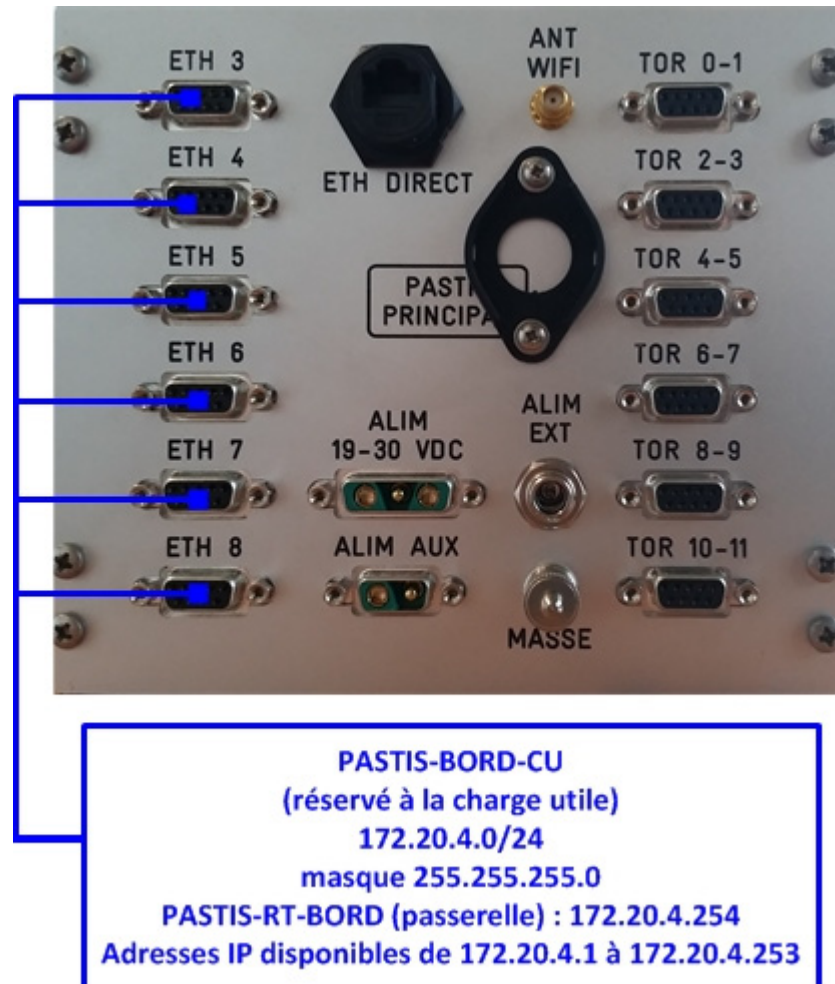


Figure 2: Payload IP configuration

During integration on the launch site, and if there are several different experiments, you should contact the CNES RSOL who will assign an IP range to each team to avoid any IP duplication.

5.2. MISSION CONTROL CENTRE IP CONFIGURATION

The mission control centre has a dedicated network, PASTIS-SOL-CM, which is part of the PASTIS-SOL system. All mission control centre PCs must configure their network boards with the following parameters before connecting to the PASTIS-RT-SOL router and then be able to control their instruments.

Characteristics of the PASTIS-SOL-CM network

- Network 172.20.3.0/24
- Mask: 255.255.255.0
- Gateway (PASTIS-RT-SOL): 172.20.3.254
- IP addresses available: 172.20.3.1 to 172.20.3.253
- Google DNS: primary 8.8.8.8 and secondary 8.8.4.4
- **Fixed IP addressing is highly recommended for in-flight operations**

- DHCP active for the entire range of available IP addresses

During integration on the launch site, and if there are several different experiments, you should contact the CNES RSOL who will assign an IP range to each team to avoid any IP duplication.

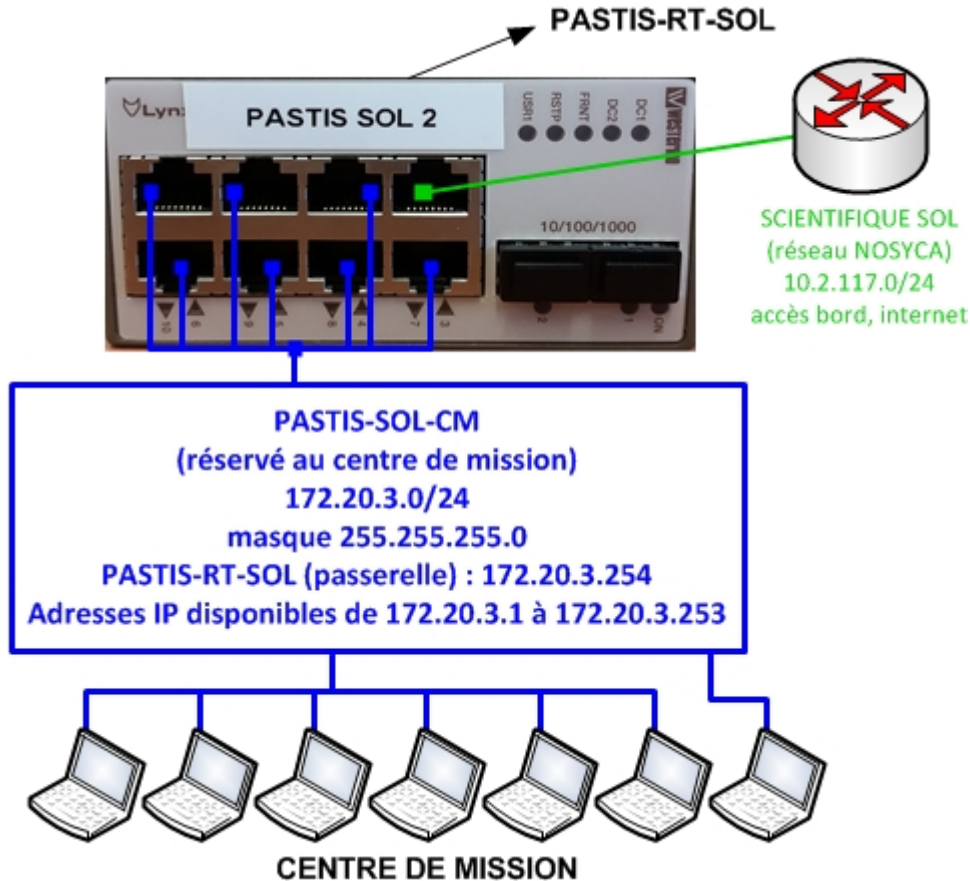


Figure 3: Mission Control Centre IP configuration

Figure 4: IP configuration for the mission control centre (with PASTIS-SER-SOL)

6. TOR (ON/OFF) CONFIGURATION

6.1. TOR (ON/OFF) MODULE

The TOR (ON/OFF) links are provided by an ACROMAG 982EN6012 gateway which is part of the PASTIS-BORD system.

The Acromag 982EN6012 TOR gateway is configured via the practical and easily accessible html interface at <http://172.20.1.253>.



Figure 5: PASTIS-TOR-BORD gateway

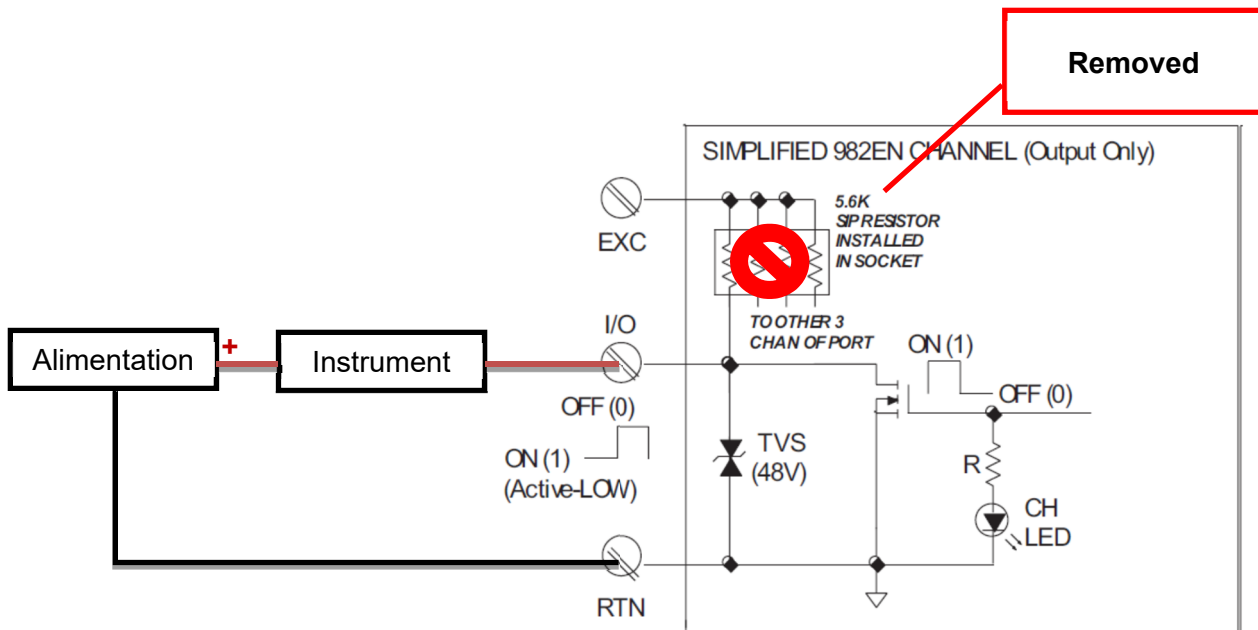
6.2. TORS WIRING

Connector	ETH n	TOR x-y
Type	SUBD9 female	SUBD9 female
Kind	Ethernet	Electric
Pin 1	RX (+)	(+) TOR x
Pin 2	n/c	(-) TOR x
Pin 3	TX (+)	n/c
Pin 4	n/c	(-) TOR y
Pin 5	n/c	(+) TOR y
Pin 6	RX (-)	n/c
Pin 7	n/c	n/c
Pin 8	TX (-)	n/c
Pin 9	n/c	n/c

Warning: the electrical current for each TOR circuit must be limited to a maximum of 500 mA, i.e. a maximum of 1 A per TOR of the PASTIS-PRINCIPAL-BORD box.

In order to check that the PASTIS TORs are functioning correctly, the RSOL has dedicated equipment that can be used if there is any doubt.

6.3. TORS ELECTRIC WIRING



The board TOR PASTIS has 3 default embedded components, called SIP resistors. Of 5.6 k Ω . Each of these is removed because outputs don't use EXC channel ; EXC channel provides the wiring of a common driving voltage for the 4 outputs which is not expected for PASTIS.

This removal allows giving a different voltage on each output and avoiding adjacent currents that could disturb the operating of the other TOR outputs.

6.4. USING THE TORS

The TOR outlets are controlled via the PASTIS-TOR-BORD module integrated in the PASTIS-PRINCIPAL-BORD box.

The TOR outlets may be likened to a switch which is normally open and then either closed or opened by an operator:

- An outlet is said to be closed or *ON* when an electrical current can flow;
- An outlet is said to be open or *OFF* when no electrical current is flowing.

NB: a TOR outlet is always open (i.e. *OFF*) when PASTIS-PRINCIPAL-BORD is started.

Procedure for controlling the TOR outlets:

- From the PC's web browser, open the html interface of the PASTIS-TOR-BORD module by typing the address <http://172.20.1.253>
- Click on the *Test page* button
- in the authentication window and identify yourself as *admin/pastis*

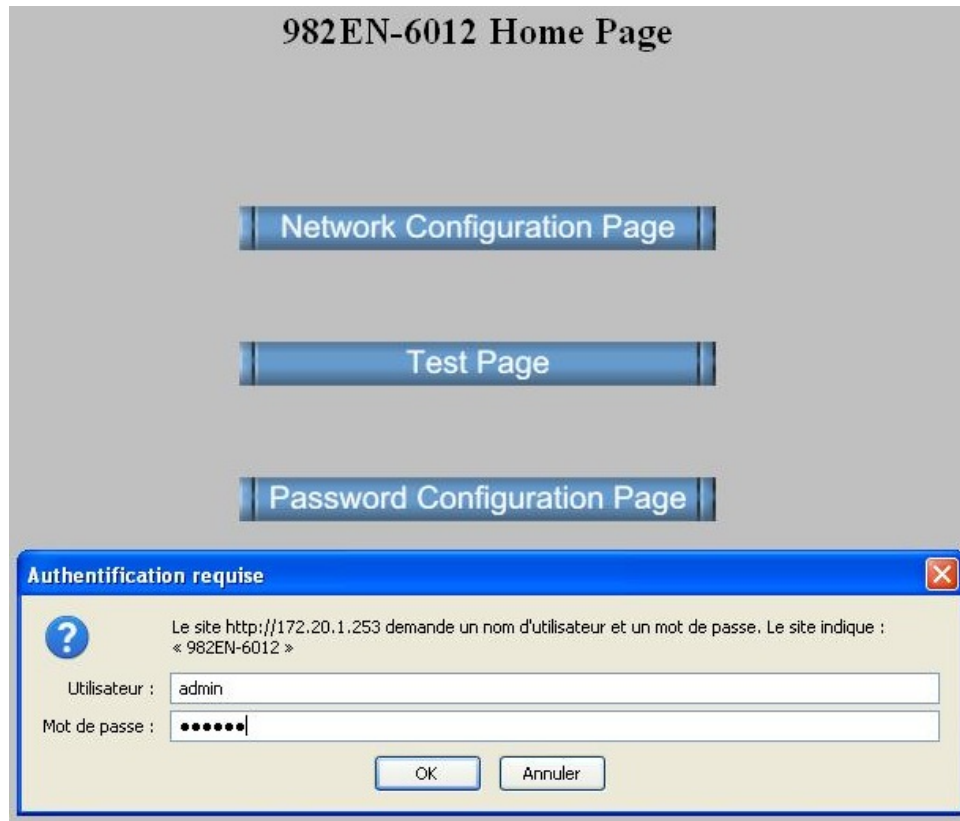


Figure6: Log-in

- To switch a TOR outlet (channel) *ON*, click on the corresponding *On/Off* button
- wait for the reloading of the html page that indicates *the* TOR outlet has been switched to *ON*
- To turn a TOR outlet (channel) *OFF* click on the corresponding *On/Off* button
- wait for the reloading of the html page that indicates the TOR outlet has been switched to *ON*

NB:only control one TOR outlet at a time and wait for the page to reload before opening another channel.

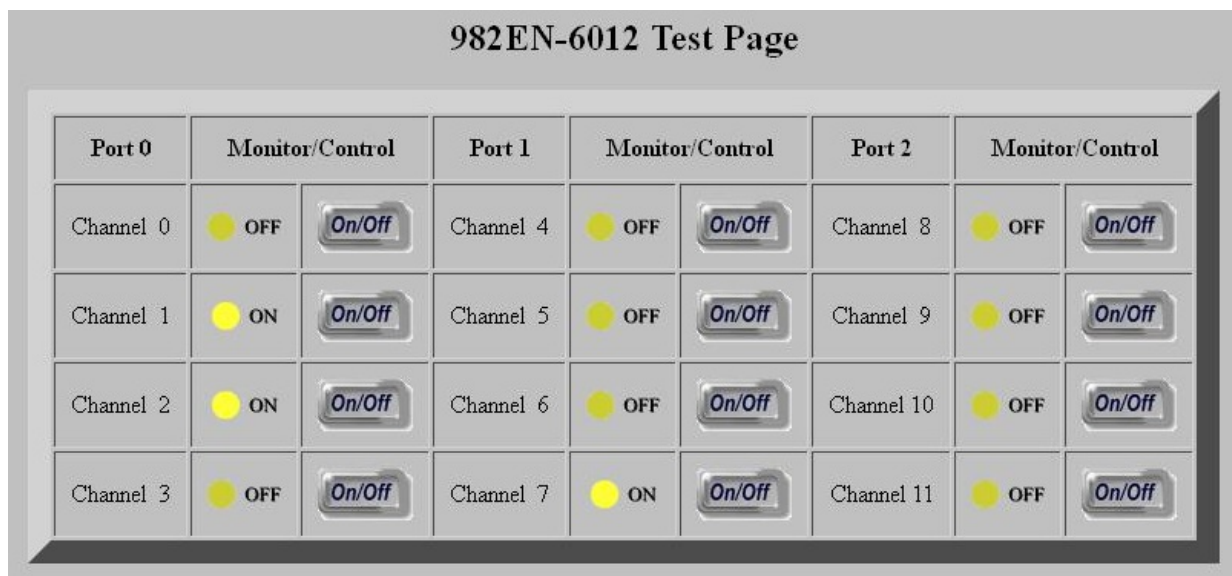


Figure 7: HMI for controlling the TOR outlets

7. SERIAL CONFIGURATION

The link between the mission control centre and an experiment that can be reached through a serial port is made through an SOL (ground-based) serial interface which transmits IP packets converted into serial data to the on-board serial gateway that performs the opposite conversion operation.

Using the PASTIS-SER-SOL and the PASTIS-AUXILIAIRE-BORD box, the system provides 4 configurable serial ports: the 4 serial ports of the PASTIS-AUXILIAIRE-BORD box are associated with the 4 serial ports of the PASTIS-SER-SOL gateway.

The default PASTIS configuration sets the serial ports as shown in the following table.

	PASTIS-SER-SOL	PASTIS-AUX-BORD
Association	Port 1 →	← Port SER-1
	Port 2 →	← Port SER-2
	Port 3 →	← Port SER-3
	Port 4 →	← Port SER-4
Protocole	RS-232	RS-232
Vitesse (baud)	115200	115200
Parité	Non	Non
Bits de données	8	8
Bits de stop	1	1
Contrôle de flux	Non	Non

Figure 8: default serial configuration

All the serial ports are configurable to be able to adapt to the needs and capabilities of scientific equipment. The following table shows all available parameter values that can be set for the serial ports.

Protocole	RS-232, RS-422, RS-485
Vitesse (baud)	300, 600, 1200, 2400, 4800, 9600, 14400, 19200, 28800, 38400, 57600, 76800, 115200, 230400
Parité	Non, impair (odd), pair (even)
Bits de données	5, 6, 7, 8
Bits de stop	1, 2
Contrôle de flux	Non, RTS/CTS, Xon/Xoff, Half duplex

7.1. ONBOARD SERIAL CONFIGURATION

The SER-1 to 4 ports are serial ports connected pin to pin with the serial ports of the two PASTIS-SER-BORD-1 & 2 gateways of the PASTIS-AUXILIAIRE-BORD box. They connect to the serial ports of the payload instruments with NULL MODEM cables.

The SER-1 port of the PASTIS-AUXILIAIRE-BORD box is the serial port that is associated, by configuration, with port 1 of the PASTIS-SER-SOL gateway.

The SER-2 port of the PASTIS-AUXILIAIRE-BORD box is the serial port that is associated, by configuration,

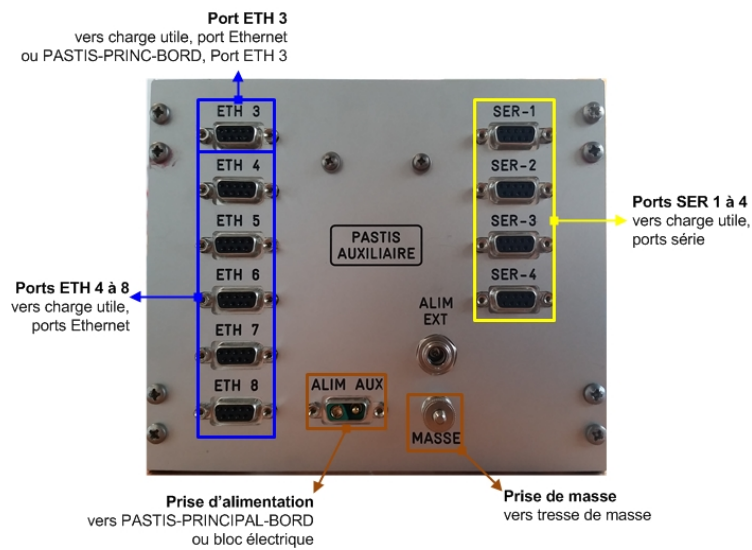
with port 2 of the PASTIS-SER-SOL gateway.

The SER-3 port of the PASTIS-AUXILIAIRE-BORD box is the serial port that is associated, by configuration, with port 3 of the PASTIS-SER-SOL gateway. It corresponds to SERIAL port 1 of the internal PASTIS-SER-BORD-2 gateway.

The SER-4 port of the PASTIS-AUXILIAIRE-BORD box is the serial port that is associated, by configuration, with port 4 of the PASTIS-SER-SOL gateway.

Characteristics of the serial interfaces of the PASTIS-AUXILIAIRE-BORD box, by default:

- Connection with NULL MODEM cables
- the four serial ports are SUB-D9 female connectors



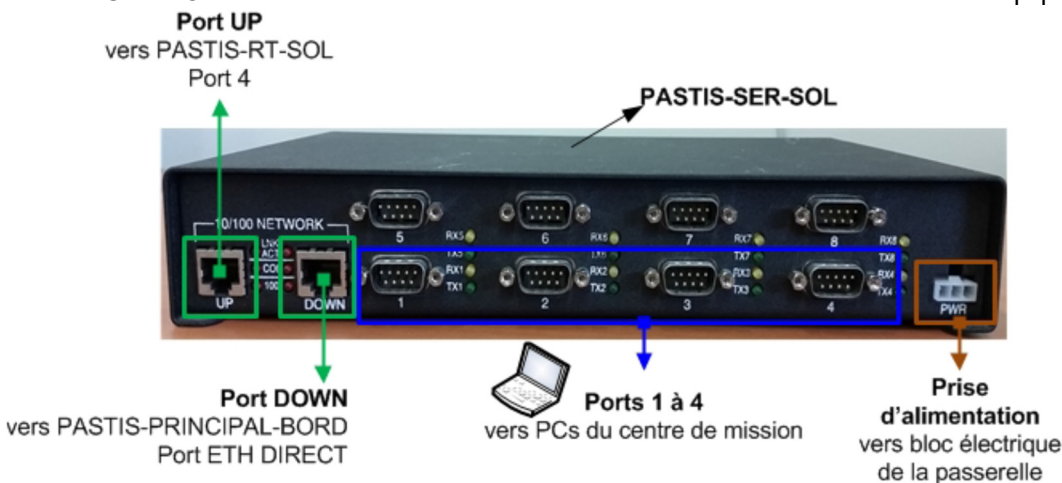
7.2. PIN ASSIGNMENT OF SERIAL CONNECTORS

Connector	ETH n	SER-n			
Type	SUBD9 female	SUBD9 female			
Nature	Ethernet	RS-232 (*)	RS-422 (*)	RS-485 /2 wires (*)	RS-485 /4 wires (*)
Pin 1	RX (+)	CD	n/c	n/c	n/c
Pin 2	n/c	RX D	RX D(-)	n/c	RX D(-)
Pin 3	TX (+)	TX D	TX D(-)	TX D / RX D(-)	TX D(-)
Pin 4	n/c	DTR	n/c	n/c	n/c
Pin 5	n/c	GND	GND	GND	GND
Pin 6	RX (-)	SRF	n/c	n/c	n/c
Pin 7	n/c	RTS	TX D(+)	TX D / RX D(-)	TX D(+)
Pin 8	TX (-)	CTS	RX D(+)	n/c	RX D(+)
Pin 9	n/c	RI	n/c	n/c	n/c

(*) This depends on the protocol configured on each port of the PASTIS-SER-BORD gateways. The RS-232 protocol is the default protocol configuration.

7.3. SOL (GROUND-BASED) SERIAL CONFIGURATION

Once the two SOL and BORD gateways have been configured, simply connect to the allocated SOL serial port with a NULL MODEM cable to obtain a link similar to a direct link with the on-board equipment.



8. NETWORK RECOMMENDATIONS

The link between the NSO and the NCU via the wifi link is subject to perturbations that can be significant in flight (interruptions ranging from a few seconds to several minutes, packet losses, latency time).

8.1. RECEPTION OF TELEMETRY BY THE MISSION CONTROL CENTRE

In order to achieve as much of the mission as possible, the User Datagram Protocol (UDP) should be preferred. This is because the UDP protocol is not connection oriented (send and forget) and the loss of a packet will not affect the rest of the communication, provided the applications are coded accordingly. If the packet is lost, there will be no automatic retransmission but the next packet, once the perturbation has ended, will be routed correctly.

It is also recommended not to construct ground-based data with a set of received packets. Since packets can

be lost, if only one packet of a set is missing, the ground data will be lost or unusable.

8.2. TRANSMISSION OF TELECOMMAND FRAMES

Again, you should preferably use the UDP protocol to transmit telecommands to the payload. In case of loss of the packet, simply send the telecommand again. It is better to have to resend a telecommand because of packet loss than to have a TCP session that is never established because of too many losses.

8.3. ADDRESS TRANSLATION

Address translation is not possible on the PASTIS gateway due to internal routing and encapsulation mechanisms. Each piece of on-board equipment must have an on-board address and each piece of ground-based equipment must have an SOL (ground) network address.

Since in-flight communication can be severely perturbed, it is recommended to perform robustness tests of client/server communications with loss rates ranging from 0 to 50% and latency times of up to 500 ms.

There are several software programs that can perform these tests:

- Netlimiter
- WonderShaper
- Wanem

8.4. TESTS IN A DEGRADED ENVIRONMENT AND BANDWIDTH LIMITATION

Each experiment has an allowed bandwidth to respect. Thus, it is very important that each experiment don't use more bandwidth than allowed as it can lead to communication loss for all experiments. This is important during all integration tests and flight.

Most of the file transfer protocols (FTP, SCP, ...) tend to realize big bandwidth peaks at the beginning of transfers.. The bigger the file to transfer is, the bigger is the peak (and the communication loss also).

Under Linux, bandwidth limiters exist and are based on TC and easy to deploy.

Here is an example of traffic shapping under Linux (not tested with file transfer protocol):

```
tc qdisc add dev enp0s25 root handle 1 : htb default 30
tc class add dev enp0s25 parent 1: classid 1:1 htb rate 0.05mbit
tc class add dev enp0s25 parent 1: classid 1:2 htb rate 0.05mbit
tc filter add dev enp0s25 protocol ip parent 1:0 prio 1 u32 match ip dst 172.20.3.xxx/32 flowid 1:1
tc filter add dev enp0s25 protocol ip parent 1:0 prio 1 u32 match ip src 172.20.3.xxx/32 flowid 1:1
```

Traffic shapping must be effective as soon as the computer boots (board and ground). A good thing to transfer data is to cut it in small chunks and send them over UDP (beware, no retransmissions in UDP).

9. APPENDIX 1: USER RADIO FORM

It is important that all radio enabled equipments are listed here., even if radio is limited to onboard needs (Wifi, bluetooth, zigbee, ...) with low power sources.

If Wifi is used by one of your equipment, it must use the 5 GHz band and channel 36. If more than one Wifi equipments are present, a change in the channel number will be asked. Thus, channel must be configurable.

Equipment /Instrument	Radio frequency	Wifi Channel	Power
Telescope	5 GHz	36	1mW

- Are you sure that your hardware always uses the same frequency channel, even during boot, reset or other cases ?
- Do you have inhibited / checked Wifi or other radio functions on COTS hardware on board (GoPro cameras, routers, ...) ?
If it is impossible to inhibit or to assign a specific channel, it will be asked to turn the equipment down for the flight.

10. APPENDIX 1: TOR USER GUIDE

DISTRIBUTION

NOM	SIGLE/SOCIETE	NB	NOM	SIGLE/SOCIÉTÉ	NB
DUBOURG Vincent	BL/D		RUBIO Jean-Claude	BL/OB	
BEZ Pascale	BL/D	1	JOUHANNET Nathalie	BL/OB	1
VARGAS André	BL/DA		BERGOS Pierre	BL/OB	
TECHER Pascal	BL		BESSES Francis	BL/OB	
COCQUEREZ Philippe	BL/PR		BLON Frédéric	BL/OB	1
LOUVEL Stéphane	BL/PR	1	BOTTIER Grégory	BL/OB	
MIRC Frederi	BL/NB		CAZALET Mathieu	BL/OB	
NICOLLE Eliane	BL/NB	1	CRUZEL Serge	BL/OB	
BAUSCH Denis	BL/NB		DOULIEZ Alain	BL/OB	1
BRAY Nicolas	BL/NB		JURQUET Bastien	BL/OB	
CLEMENT Grégory	BL/NB		LACOURTY Michel	BL/OB	
COGHE Thomas	BL/NB		LAMARQUE Christian	BL/OB	
EVRRARD Jean	BL/NB		LAVIGNE Gauthier	BL/OB	
GAUSSERES Serge	BL/NB		LOPEZ Jean-Marc	BL/OB	
GUILBON René	BL/NB		LUZE Patrick	BL/OB	
NICOT Jean-Marc	BL/NB		REBIERE Patrick	BL/OB	
PEUS Alain	BL/NB		SABLON Igor	BL/OB	
RICHARD Julie	BL/NB		THOUMIEUX Frédéric	BL/OB	
SOORS Xavier	BL/NB		VERGNAUD Antoine	BL/OB	1
VALDIVIA Jean-Noël	BL/NB		QUEVAREC Erwan	BL/VP	
VALERO Colette	BL/NB		LE DINH Loan	BL/VP	1
ZENONE Isabelle	BL/NB	1	BEHAR Jean-Baptiste	BL/VP	
ESTAQUE Philippe	DA/LOS		CONESSA Huguette	BL/VP	
LAULHERET Roland	AQ/SF		FOURCADE Jean	BL/VP	
POREZ-NADAL Florence	AQ/BA		GUIGUE Pascale	BL/VP	
GHAFFAR Mellony	EQUERT pr AQ/BA		LECTEZ Anne-Sophie	BL/VP	
DAUBAN Gilles	EQUERT pr AQ/BA		PLANES Mikael	BL/VP	
FORTAS Emmanuelle	MI-GSO pr AQ/IM		TROY Gabriel	BL/VP	
CARRE Olivier	CAPGEMINI		VENEL Stéphanie	BL/VP	