4. Instrument Mode Description

4.1 Instrument TM Modes

The ASPERA-3 experiment contains four sensor units and the scanner. Each sensor unit measures different components of the near-Mars plasma and can be operated in different modes. To handle available power and telemetry resource requirements in the most efficient way and to inhibit too large number of individual modes, we introduce seven basic TM modes (macro modes):

- OFF mode
- Safe mode
- Housekeeping mode
- Calibration mode
- Low mode
- Normal mode
- High mode
- Burst mode

OFF mode. The instrument is off although the external heaters are on and controled by the instrument termistors.

Safe mode. At experiment power switch on, the instrument enters to a safe mode. In the safe mode the software is run in PROM although the software allows command execution, housekeeping TM generation, RAM dumping and jumping to the RAM code. The instrument also enters to the safe mode in the following cases:

- the checksum of the RAM code fails
- watch dog is not reset

The safe mode is a fully operational mode, and the instrument is listening for other commands.

Housekeeping mode. In this mode none of the ASPERA-3 sensors is taking scientific data and DPU deliveries housekeeping data to OBDH. This mode is to monitor the instrument status.

Calibration mode. In this mode each of the different sensors is switch on individually for check-out and in-flight calibration purposes.

Low, Normal, High, Burst modes. These modes are foreseen for the scientific data taking. The modes differ from each other in the total amount of data produced and the structure of TM packages although individual settings defining the sensor configurations might be the same for different modes.

The TM requirements for each mode are summarised in Table 4.1-1.

Table 4.1-1 – TM requirements for the ASPERA-3 operational modes

Mode	Acronom	Power, W	Bit rate, bits/s
OFF mode		6 (Heaters)	0
Safe mode	ASPsafe	7	0
Housekeeping mode	ASPHK	7 (TBC)	27
Calibration mode	ASPCal	15	2175
Low mode	ASPLow	15	621
Normal mode	ASPNorm	15	2175
High mode	ASPHigh	15	6214
Burst mode	ASPBurst	15	18204

Note that the operational modes of the individual sensors may vary for the same experiment operation mode (ASPCal, ASPLow, ASPNorm, ASPHigh, ASPBurst) which is defined by the data rate only. The sensor settings for each mode are defined in macro commands stored in on-board software.

The scanning platform has three operational modes: scanning mode, stepping mode, and fixed position mode. In the scanning mode, the platform performs scans with three pre-selected speeds 32, 64, and 128 sec in one 0° - 180° scan. In the stepping mode the platform moves in steps through the angle defined by a command. The time the platform rests in each position is also commanded. In the fixed position mode the platform moves to a commandable position from 0° to 180° and rests there until the scanner mode changes.

4.2 Raw Data and Pre-processing

The raw data in 16 bit words are accumulated from the NPD and NPI sensors during 62.5 ms and from the ELS, IMA during 31.25 ms. The raw bit rates are given in Table 4.2-1.

Table 4.2-1 The ASPERA-3 sensors raw data bit rates

Sensor	Raw data	Bit rate, kbits/s
NPD	$6A \times 16M \times 16E \times 16$bits (bin)	384
	$6A \times 512$events $\times 32$bits (raw)	1536
	$6A \times 16$M $\times 16$bits (phd)	24
NPI	$32A \times 16$bits	8
IMA	$16A \times 32M \times 16$bits	256
ELS	$16A \times 16$bits	8

A - azimuth directions, *M* - mass, *E* - energy

4.3 ASPERA-3 sensor modes

All four ASPERA-3 sensors, ELS, NPI, NPD1 and NPD2, IMA, can be run independently although the individual sensor bit rates will be set by a macro command defining a macro mode in such way to produce the amount of data specified in Table 4.1.1. The raw data are compressed by integration over time, energy, azimuth, mass as well as using log - compression of 16-bit words to 8-bit words, masking, and look-up tables (NPD). The processed and formatted data are loss-less compressed by the USES

algorithm (Universal Source Encoding for Space, CCSDS 111.0-W-2). **The loss-less compression factor is not included in the macro mode bit rates while all other compressions are included.** For each sensor the loss - less compression factor is evaluated either using previous similar measurements (ELS, NPI) or in-flight callibration. For the estimations of the data rate one can use the loss-less compression factor of 1:4.

4.4 ELS modes

The ELS raw bit rate is 8 kbps. The 16 bit samples will first be log - compressed to 8 bit samples. Two options are considered:

ELS formula (Log – compression)
The 8-bit output value is split in a 4-bit exponent (e) and a 4-bit mantissa (m) according to the formula

For e<2, counts=m (for counts <= 32, the output value is the same as the input value)
For e>=2, counts=(m+16)*2^(e-1)

The further reduction will be made through decreasing the time resolution or / and summation of 2 or 4 adjusted energy sweeps. The amount of energy step is thus 128, 64, or 32. The amount and pattern of sectors to be read-out to TM can be also reduced by a command. The amount varies from 1 to 16 resulting to the corresponding bit rate change on a factor from 1 to 16. Table 4.4-1 below gives the ELS data rates.

Table 4.4-1. ELS modes and data rates

Mode	Sweeps summation / time resolution	Sector pattern	Data rate, kbps
ELSB0	No sum. / 4s	[1, 1, 1, 1,.., 1]	4
ELSH0	2 sweeps / 8 s	[1, 1, 1, 1,.., 1]	2
ELSN0	4 sweeps / 16 s	[1, 1, 1, 1,.., 1]	1
ELSL0	8 sweeps / 32 s	[1, 1, 1, 1,.., 1]	0.5
ELSB1	No sum. / 4s	[0, 1, 0, 1,.., 1]	2
ELSH1	2 sweeps / 8 s	[0, 1, 0, 1,.., 1]	1
ELSN1	4 sweeps / 32 s	[0, 1, 0, 1,.., 1]	0.5
ELSL1	8 sweeps / 32 s	[0, 1, 0, 1,.., 1]	0.25
ELSBx	No sum. / 4s	Arbitrary	-
ELSHx	2 sweeps / 8 s	Arbitrary	-
ELSNx	4 sweeps / 32 s	Arbitrary	-
ELSLx	8 sweeps / 32 s	Arbitrary	

4.5 NPI modes

The NPI raw bit rate based on the fundamental sampling time 62.5 ms is 8 kbps. The reduction is made via increasing integration time by a factor of 1, 2, 4, 8,…, 32, 64, 128. Three integration times 500, 1000, and 2000 ms correspond to the three basic scanner periods 32, 64, 128 sec. Change in the scanner period normally results in the change in the NPI mode to keep the largest acceptable pixel size. Similar to ELS, the pattern of sectors to be read-out to TM is commandable and can be arbitrary. Table 4.5-1 below gives the NPI data rates and mode identifications. The 16-bit counters are log-compressed according to the "ELS formula" down to 8-bits. The compression can be turn-on/off by a command.

Table 4.5-1. NPI modes and data rates

Mode	Integration time in the 62.5	Data rate, kbps

	ms	
NPIH	8	0.5
NPIN	16	0.25
NPIL	32	0.125
NPIx	Any from 1, 2, 4, .., 128, 1024 (=64 sec)	4 bps – 8 kbps

4.6 NPD modes

NPD sensor electronics is run in two fundamental modes - binned matrix mode (B) and raw event mode (R). In both modes each of the NPD sensors (NPD1 or NPD2) can be disable (masked out). In the binned matrix mode (B- mode) the set-ups for both NPD sensors are always identical. In the B - mode the addressing of the data array is as follows (see Appendix 6 DigTOF in ASPERA/NPD, version 0.3, 17.01.02).

Direction	2 bits	4 directions, one not used!
PH STOP	4 bits	16 mass (M) bins
TOF	4 bits	16 velocity (V) bins
Total	10 bits (1024 16-bit counters)	

In the R - mode the bit allocation per each 32-bit event is as follows.

Spare	7 bits[31…25]
Coincidence flags	3 bits[24…22]
Direction	2 bits[21..20]
PH STOP	8 bits[19…12]
TOF	12 bits[11…0]
Total	32 bits

The integration times 500, 1000, 2000 ms (8, 16, 32 sampling periods of 62.5 ms) correspond to the three scanner periods 32, 64, 128 s. These are the basic ones but the integration factor is made commandable, so the integration time can vary as 1, 2, 4, 8,…., 64, 128 times the fundamental sampling period 62.5 ms. If the NPD electronics is run in the raw event mode no further reduction will be made. The R - mode will be used only for calibrations. In the binned data mode 16M x 16V matrix for each direction can be further reduced to a *x*M x *y*V matrix according to the table 4.6-1 below. The default matrix No.=1, corresponding *x*=2, *y*=16. The 16-bit counters are log-compressed to 8 bits.

Table 4.6-1. NPD reduction matrixes for binned data mode

Matrix No.	***x***	***y***
0	16	16
1	2	16
2	1	16

The reduction of 16 masses (PHD) to 2 is done according to the algorithm as below. Figure 4.6-1 shows it graphically. The threshold is commandable and depends on direction (STOP MCP number).

```
if (velocity_index <= 4) {than new_mass_index = 0};
if (velocity_index >= 8), {than new_mass_index = 1};
if ((velocity_index > 4) & (velocity_index < 8))
        if (mass_index <= threshold) {new_mass_index = 0);
        else {new_mass_index = 1};
```

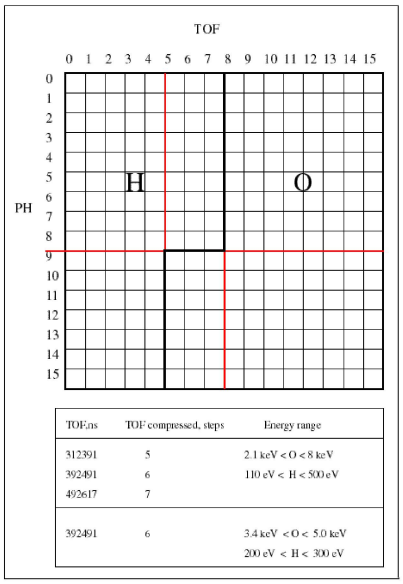

Figure 4.6-1. Reduction of the 16M x 16V bin matrix to 2M x 16V matrix.

Table 4.6-2 gives the thresholds for the flight model NPD1 and NPD2.

Table 4.6-2. Thresholds for the flight model NPD1 and NPD2.

STOP direction	NPD1 threshold index	NPD2 threshold index
Dir0	8	TBD
Dir1	5	TBD
Dir2	7	TBD

Beside two basic hardware modes NPD can be run in two other modes, phd-mode and tof-mode. In tof-mode NPD is run in raw mode and is sampled once per 0.5 sec (8 x 62.5 ms). From 32-bit data places[31…0] of the raw data array TOF[11…0] and Direction[21..20] corresponding to Coincidence[24..22] = 0 are extracted. The 12-bit TOF is converted to a 8-bit TOF by 4-bit right shift. A 16-bit counter of the 3x256 array addressed by the 8-bit TOF and Direction is incremented by 1. After the integration time the 16 - bit counters are log-compressed to 8-bit ones. The data volume 3x256x8=6144 bits/integartion time.

In phd-mode, the array containing 48 bins each with a depth of 65536 (16 - bit) is read-out once per integration time from the register STOPARRAY. The data volume per integration time 48x16 = 768 bits/integration time.

Table 4.6-3. NPD modes and data rates.

NPD mode	Integration time in 62.5 ms	Matrix No.	Data rate / one NPD kbps
NPDHR	8	N/A	32
NPDNR	16	N/A	16
NPDLR	32	N/A	8
NPDxR	Any from 1,2, …64, 128	N/A	-
NPDHB0	8	0(x=16, y=16)	12
NPDNB0	16	0(x=16, y=16)	6

NPDLB0	32	0(x=16, y=16)	3
NPDHB1	8	1(x=2, y=16)	1.5
NPDNB1	16	1(x=2, y=16)	0.75
NPDLB1	32	1(x=2, y=16)	0.375
NPDHB2	8	2(x=1, y=16)	0.75
NPDNB2	16	2(x=1, y=16)	0.375
NPDLB2	32	2(x=1, y=16)	192 bps
NPDxBn	Any from 1,2, …64, 128, 2048 (64 sec)	n = 0,1,2	-
NPDHT	8	N/A	12
NPDNT	16	N/A	6
NPDLT	32	N/A	3
NPDxT	Any from 1,2, …64, 128, 2048 (64 sec)	N/A	-
NPDHP	8	N/A	1.5
NPDNP	16	N/A	0.75
NPDLP	32	N/A	0.375
NPDxP	Any from 1,2, …64, 128, 2048 (64 sec)	N/A	-

4.7 IMA modes

IMA TM mode description is given in Appendix 6 (ICA-IMA TC/TM data formats and related software aspect, Issue 1.2, 2002-04-20). Table 4.7-1 gives summary of the IMA mode bit rates.

Table 4.7-1. ICA - IMA bit rates

Sid	Mnemonic	Exp. Pkt. size in bytes	ICA rate	IMA rate
0	Min (Minimum)	618	5.15 bps	10.3 bps
1	Nrm (Normal)	2478	103.25 bps	206.5 bps
2	Bst (Burst)	4092	1023 bps	2046 bps
3	Cal (Calibration)	1074	268.5 bps	537 bps
4	Spc (Special)	3198	799.5 bps	1599 bps
5	Tst (Test)	600	75 bps	150 bps
6	Ima (Ima)	3996 *	NA	3996 bps
HK	Housekeeping	24	6 bps	12 bps

*) For IMA 2 such packets are sent every acquisition period.

4.8 Mode Transition Diagram

There are no constraints on operation mode transitions.

5. Instrument Telemetry

For the instrument TM description see Appendix 5 (ASPERA-3 Main Unit Software User's Guide. Issue 1.0.0 of 2002-05-17). IMA TM is described in Appendix 6 (ICA-IMA TC/TM data formats and related software aspect, Issue 1.2 of 2002-04-20).