SWS AOT Design Description

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Scope

The SWS AOT Design Description is supplementary to the various SWS inputs (the ICS definitions, the AOT descriptions, the uplink table definitions). It describes the relationships between these various elements in connection with the actual instrumental functions to be performed. The SWS AOT descriptions are listed as Referenced Documents.

The primary aim of the SWS AOT Design Description is to provide transparency so as to improve the maintainability of this set of inputs.

The AOT Design Description does not address the definition of calibration observations through the Calibration Uplink System, the Activation and Deactivation sequences or Permanent Command Sequences for real-time commanding.

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Applicable Documents

1. SWS Observers Manual (version 2.0, ISO-SWS 94-18)
2. Instrument Teams to Science Operations Team Interface Control Document for information related to Astronomical Observations Templates, Instrument Command Sequences, Permanent Command Sequences, Activation and Deactivation Sequences, Memory Patch Segments, Instrument Memory Files, Instrument Tables (ISO/SSD/ICD-01, issue 3.0, 7/10/94)
3. Interface Control Document between the AOT/CO-to-OCT Logic and the System (SAI/94-426/Dc, draft 0.9, 17/03/95)

Reference Documents

1. AOT description S01_nn.AOT (nn $\geq$ 16)
2. AOT description S02_nn.AOT (nn $\geq$ 25)
3. AOT description S06_nn.AOT (nn $\geq$ 24)
4. AOT description S07_nn.AOT (nn $\geq$ 40)
5. ICS file SS0002_n.ICS (n $\geq$ 5)
6. Table S_BANDS2
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1 Main Developments between Versions 1.1 and 1.2

SWS AOT Design Description version 1.2 is the first description issued after the ISO launch.

Most post-launch changes in the SWS AOTs are directly or indirectly linked to the experienced effects of cosmic radiation on the detectors. These effects are stronger than expected. The direct consequence of the higher radiation level is that the detectors produce more noise than they did during ground testing and that more data are lost than anticipated.

The first measures taken to counter these effects were to adapt the detector noise parameters in S_DETECT (see 12.5) and to limit the reset intervals to 1 or 2 seconds (except for the InSb detectors, where a maximum of 4 seconds is still used). In the second place, the durations of dark-current measurements have been increased and in AOTS 6 and 7 increased use is made of repeated spectral scans.

More emphasis on dark-current measurements resulted in changes in the ICSes used in AOTs 1 and 2 (doubled maximum dark length in the grating scan ICS, introduction of a dedicated ICS to measure dark currents at the proper settings of gains and reset intervals immediately after a grating scan).

The use of photometric checks in all AOTs has been reduced to minimize the deleterious after-effects of such measurements on sensitive spectral measurements or dark measurements.

AOT 7 still needed some corrections (the wavelength-dependent gap correction, through table S_FPDGAP, see 12.7, and more precise control of the LW grating during the FP scans) and has seen a number of changes to increase the observing efficiency.

The descriptions of AOTs 2 and 7 have been changed to improve their clarity. In AOT 7 this concerns the pseudo-code that defines the merging of SW grating scans with FP scans (procedure SW_ICS). The AOT 2 description, which had the longest and most awkward history of the four, now contains a full pseudo-code programme.

Finally, the tables S_FP35 (12.6) and S_GR6 (12.9) have been adapted to the in-orbit wavelength calibration results and the experienced system responsivities. For AOT 7 it has been necessary to define a fourth SWS aperture, replacing aperture 3 for the FP, to correct for an internal misalignment of 10 arc seconds.

2 Introduction

The intention of this AOT Design Document is to provide a single source of background information regarding the SWS Astronomical Observation Templates and the functioning of SWS during the execution of these AOTs. The document discusses hardware aspects as far as they play an explicit role in these observations, but focuses primarily on the inputs that the SWS instrument team is providing to define the translation of observers requirements into sequences of SWS commands.

At a high level, both the instrument and the Astronomical Observation Templates have been described in the SWS Observer's Manual. That document provides an adequate description of the ultimate purpose of the instrument and of the functions of the Astronomical Observation Templates defined for SWS. Here let it suffice to recapitulate that there exist the following 4 SWS Astronomical Observation Templates:

- AOT SWS01 observes the spectrum of an astronomical target at all the wavelengths accessible by SWS, i.e. from 2.38 μm to 45.2 μm. The observer specifies the rate at which the observation will be carried out. This rate determines the sensitivity of the observation and it may limit its spectral resolution.
- AOT SWS02 is simple in concept. It allows to observe spectral lines, together with the surrounding continuum over a range of typically 1500 km/s. The AOT logic will try to optimize the observing programme by simultaneous execution of spectral scans with the SW section ($\lambda < 12$ μm) and with the LW section ($\lambda > 12$ μm) of the spectrometer.
- AOT SWS06 is designed for longer grating scans. It uses reference scans at user-selected wavelengths to monitor any responsivity drifts occurring during an observation. These reference scans may interrupt long scans. Dark-currents are taken only at the start and the conclusion of a measurement. Like AOT SWS02, the AOT will simultaneously execute SW and LW measurements], when possible.
- AOT SWS07 takes care of the Fabry-Perot measurements. It decides whether it makes sense to keep the grating scanner stationary during the observation or whether it is better to try and keep the grating scanner tuned to the wavelength observed by the FP during the FP scan. In parallel to the FP measurements, AOT SWS07 also accepts SW grating measurements and tries to schedule those in parallel with the FP measurements.

In the past, AOTs SWS03, SWS04 and SWS05 have existed. They dealt with pure FP measurements and with raster observations. The functionality of the former FP AOT SWS03 has been fully incorporated in AOT SWS07. The raster AOTs SWS04 and SWS05 were deleted because the mechanism of concatenating AOTs would be more appropriate with SWS.

In chapter 2 of this document an overview is given of the SWS spectrometer functions that play a significant role in the operations during execution of AOTs. Chapter 3 is an introduction to the assembly of SWS uplink documents and tables. Then the uplink is discussed, starting at the command level (chapter 4), command sequences (chapter 5) and ending with the AOT descriptions (chapters 6 - 10). Chapter 11 discusses the various uplink tables defined by SWS. Finally, chapter 12 discusses the TDATA definition and chapter 13 provides cross-references between AOTs, ICSes and uplink tables.

3 SWS Hardware Functions Controlled Routinely

This chapter gives an overview of those SWS instrument functions that have to be controlled during the execution of SWS AOTs. SWS functions needed or exercised at the begin and end of a spacecraft revolution (activation and de-activation procedures) are not discussed here. The function overview follows more or less the light and signal paths through the instrument.

3.1 Aperture Selection

SWS has three separate apertures in the telescope focal plane. A shutter system can be switched to 4 different positions. With shutter position 0, all three apertures are closed and the instrument registers the detector dark currents. In the other 3 shutter positions, one of the apertures 1 to 3 is open. With each aperture, two distinct wavelength ranges are associated, one in the range 2.38-13.16μm, the other in the range 11.4-45.2μm. A dichroic beam splitter behind each aperture separates the two and directs them into either the "short-wavelength" (SW) or the "long-wavelength" (LW) section of the spectrometer.

If the spectrometer is switched to a different aperture, the telescope has to be rotated over a small angle to move the source image into the new aperture. For this reason, the number of aperture changes in an observation is limited to the minimum. In an SWS AOT, first any aperture-1 measurements are done, then any aperture-2 measurements and finally any aperture-3 measurements.

3.2 Grating Scanners

The incoming radiation is collimated and directed towards the grating via a scan mirror. The radiation is reflected, again passes the scan mirror and then continues towards the detectors. The wavelength selected depends on the angles of incidence and reflection on the grating, i.e. primarily on the position of the scan mirror, but also on the selected aperture or detector. All detector elements and the three entrance apertures are "seen" in different directions from the grating, which causes the wavelength to shift if one changes aperture or selects a different detector.

It is in the nature of a grating spectrometer to be sensitive to higher harmonics of the wavelength to which the grating is tuned primarily. A grating spectrometer therefore needs measures to suppress the unwanted spectral orders. SWS employs spectral orders ranging from 1 to 4 (see the Observers Manual for further details regarding the various spectral bands of SWS). Here it suffices to say that the separation of spectral orders in SWS is done by (1) filters in each of the $2 * 3$ spectrometer inputs, (2) filters in front of most of the detectors and (3) by the filtering through the wavelength-dependence of the detector responsivity (in principle, all detectors in SWS have a cut-off wavelength, beyond which IR quanta no longer have sufficient energy to free ch at the reference wavelengtharge carriers in the detectors).

In their operating range, the detectors tend to have a constant quantum efficiency, so that their responsivity (detector current per unit of incident power) tends to be proportional to wavelength.

The grating scanners are either directly put in a specified stationary position or they are commanded to perform a scanning pattern defined by a block of scan parameters. The scanner positions are defined by 13-bit numbers that roughly depend linearly on the selected wavelength. The timing of the scanning patterns is determined by step durations (measured in units of 1/16 second, i.e. one spacecraft telemetry frame) and by step counts and scan counts.

3.3 Fabry-Perot Etalons

In the LW section, four of the detectors are located behind a tunable Fabry-Perot interferometer, which increases the spectral resolving power from 1000-2000 to 20,000-35000. The Fabry-Perot etalon has a thickness of about 12.5 mm, which can be varied by about 25 microns. There are two etalons, one for wavelengths shorter than 26μm and one for longer wavelengths. The etalons are mounted on a single pair of parallel plates.

The FP position is specified by a 9-bit number that bears a linear relationship to the thickness adjustment. This linear number controls the currents through 3 electro-magnetic positioners that determine the gap width and maintain the parallelism of the etalons; the conversion to currents is performed on-board through calibration tables in the SWS computer memory. The 9-bit FP scanner control is arranged exactly like the control of the two grating scanners.

The FP requires pre-selection of a narrow wavelength range. This is done by means of the LW grating scanner. For short FP scans, the LW grating scanner is set into a fixed position. Longer at the reference wavelengthFP scans require the LW grating scanner to stay tuned through a slow scan (i.e. in minimal steps of long duration).

3.4 Detectors and Amplifiers

The SWS has 48 detectors, distributed over four 12-element arrays (the 4 grating detector bands) and two detector pairs (one pair behind each Fabry-Perot etalon, labeled band 5 band 6).

In the AOTs, the adjustable parameters for the detectors are the reset intervals and the electronic gains. The reset interval constitutes the longest uninterrupted integration interval and thereby limits the sensitivity, but it also limits the speed at which an observation can be carried out: in practice, the integration interval is selected to obtain the fastest observing mode compatible with the observer's sensitivity requirements. The electronic gains are needed to overcome the limitations of a 12-bit signal encoding where the dynamic range is expected to require some 16 bits.

The reset intervals can be set separately for the SW bands (detector arrays 1 and 2) and the LW bands (detector arrays 3, 4, 5 and 6). The reset intervals are measured in units of 1/16 second (1 spacecraft telemetry frame). The selected values are always either 16, 32, 64 or 128 (1, 2, 4 or 8 seconds). Shorter values are not sensible, considering that a reset costs about 0.3 seconds. Longer reset intervals do not make sense, because of the 2-sec time constant of the high-pass filter in the signal-handling electronics. Usually, the reset intervals are made equal to the step duration of the FP or grating scanners.

The electronic gains can be set separately for each of the 6 detector bands, at 3 levels (0, 1 and 2, corresponding to relative gains of 1, 4 and 16).

3.5 Calibration Sources

SWS has 4 sets of internal infrared radiation sources:

1. The "flusher sources". They are used in the activation procedure, not in the AOTs.
2. The "diffuse calibrators". These are incandescent sources that illuminate all SWS detectors directly, meant for regular checks of the detector responsivities. They can be operated at two power levels. Several sources are needed to reach all detectors; they are connected in series and operated as a single unit. The AOT logic and table structure allow to use these sources, but with the present settings the grating calibrator sources are used instead.
3. The "grating calibrators". These sources provide reference spectra, which are injected into the spectrometer close to the entrance apertures. They are incandescent sources equipped with fixed Fabry-Perot etalons that provide recognizable spectral detail for the entire SWS wavelength range. Originally, these sources were primarily meant to monitor regularly the quality of the wavelength calibration of the spectrometer. In view of the experienced instrument stability it was decided to reserve this use of the grating calibrators to dedicated calibration measurements and to use the grating calibrators in the AOTs only to monitor detector responsivity. The grating calibrator output can be tuned by moving the grating scanners, which makes it easier to stimulate the detectors at the desired levels than with the diffuse calibrators. There are two separate calibrators for the two spectrometer sections, connected in series and operated as a single unit. They can be operated at two power levels.
4. The Fabry-Perot calibrator, which is used in dedicated calibration procedures only.

4 Uplink Elements for SWS Operations

¿From bottom to top, we address the following Uplink Elements:

Instrument Commands

In the uplink software, they consist of a mnemonic, followed by an argument. The argument may be another mnemonic, used to specify a change to a single bit ("single commands"), or a 1-byte or 2-byte number ("magnitude commands"). A command with a two-byte argument is implemented as a pair of commands with one-byte arguments, and therefore counts as 2 commands in the length of an Instrument Command Sequence. Examples of all three kinds:

```
SHUT_CS_2    (CS_DIFFUS_ON)  switches on the diffuse calibrators.
SW_RST_INT_L (32)            sets the least significant byte of the
                             reset interval for the detectors in the
                             short-wavelength section to 32
                             (2 seconds).
SWSC_STPOS   (4095)          specifies the neutral position as the
                             start position for the next SW scan.
```

The latter command could have been explicitly split in two magnitude commands as follows:

```
SWSC_STPOS_L  (255)          sets the least significant byte of
                             the SW scanner start position.
SWSC_STPOS_H  (31 )          sets the most significant byte of
                             the SW scanner start position.
```

In general, the suffix _L or _H indicates a magnitude command modifying either the least significant or the most significant byte of a 16-bit word.

Instrument Command Seqences (ICSes)

In the logic defining an AOT, the ICS is the lowest-level procedure. The SWS AOTs use only 7 different generic ICSes (Most ICSes have many variable parameters).

An ICS is a sequence of commands that is uplinked in one go. There is a maximum length for an ICS, amounting to 56 commands (where commands with two-byte arguments count twice). In general, an SWS ICS starts off by putting the instrument in the right configuration and then commands a timed process to start. In most cases, the next ICS may not be uplinked until the timed process has finished. Some ICSes have internal timing by wait commands or by synchronization commands, e.g. to reserve time for a dark-current measurement prior to some other measurement. The commands in an ICS may have fixed arguments or arguments determined by the AOT-to-OCT logic.

The AOTs ICSes have been designed to keep the number of ICS uplinks to a reasonable minimum. This is because the uplink of an ICS needs time including an overhead that does not depend on the size of an ICS.

AOT Descriptions

Each of the SWS AOTs is defined by an "AOT description". The description specifies how the observer's requirements (AOT input parameters) have to be translated into a sequence of ICSes, with their variable parameters set properly and with the correct timing.

Uplink Tables

As many as possible of the instrument characteristics that have to be taken into account in the implementation of AOTs have been collected into tables, that are kept apart from the AOT descriptions. In essence, these tables contain the instrument calibration, although many of them contain data that are not direct calibration results (such as specifications of the time between internal calibrations or selection rules of internal calibrators).

TDATA Specifications

Although part of the AOT descriptions, the TDATA deserve mention here. TDATA are messages merged on the ground with the telemetry, more or less in synchronization with the uplink process. They provide additional information, for use either in Quick-Look Analysis or in Off-line Analysis. The TDATA are meant to transmit the **intentions** behind what happens in the instrument. The TDATA are in principle specified in Applicable Document Nrs. 3 and 4, but for SWS the implementation of the TDATA is completely defined in the AOT descriptions.

5 Instrument Commands

Below follows an overview of all commands used in the SWS AOTs, with very short explanations. Each command consists of a Command Mnemonic (or name), followed by an argument in parentheses. In the overview the arguments have been suppressed for most commands.

```
SYNC_FLAG    (SET)        synchronize with next TM format (each 2 sec)
END_SEQ_NOP               wait (in 1/16 s)
SHUTTER_L                 set shutter position (0, 1, 2 or 3)
SHUT_CS_1 (CS_GRATNG_OF)  switch grating source OFF
SHUT_CS_1 (CS_GRATNG_ON)  switch grating source ON
SHUT_CS_1 (CS_GRATNG_LO)  switch grating source LOW
SHUT_CS_1 (CS_GRATNG_HI)  switch grating source HIGH
SHUT_CS_1 (FLUSH_SRC_OF)  switch flusher source OFF
SHUT_CS_1 (FLUSH_SRC_LO)  switch flusher source LOW
SHUT_CS_2 (CS_FP_OFF)     switch FP cal. source OFF
SHUT_CS_2 (CS_FP_LO)      switch FP cal. source LOW
SHUT_CS_2 (CS_DIFFUS_OF)  switch diffuse source OFF
SHUT_CS_2 (CS_DIFFUS_ON)  switch diffuse source ON
SHUT_CS_2 (CS_DIFFUS_LO)  switch diffuse source LOW
SHUT_CS_2 (CS_DIFFUS_HI)  switch diffuse source HIGH
                          (ON/OFF and HIGH/LOW are separate functions)

Note: SHUT_CS_1 and SHUT_CS_2 address two independent shutter and
calibration source controllers, in arrangement that will leave
some functionality in case of an electronics failure. This was done
because the LW and SW sections share these functions. Otherwise the
two sections are mutually independent.

RUN_FLAGS_L        a combination of:
                   bit 2 : generate (4) or stop(0) SW resets
                   bit 3 : generate (8) or stop(0) LW resets
                   bit 4 : start   (16) or stop(0) cal source
                                                (INTERVAL-timed)
                   bit 5 : execute (32) or stop(0) SW scan
                   bit 6 : execute (64) or stop(0) LW scan
                   bit 7 : execute(128) or stop(0) FP scan
HEADER_0 (RESET_MECH)  reset scanners/FP

INTERVAL           proper use: set exposure interval (even, in 1/16 s)
INTERVAL_H         improper use: 240 + generic ICS number
INTERVAL_L         improper use: flag dark (1) or not (even)
```

```
GAIN_B1_L          gain band 1 (0, 1 or 2, for 1x, 4x, or 16x)
GAIN_B2_L          gain band 2 (0, 1 or 2, for 1x, 4x, or 16x)
GAIN_B3_L          gain band 3 (0, 1 or 2, for 1x, 4x, or 16x)
GAIN_B4_L          gain band 4 (0, 1 or 2, for 1x, 4x, or 16x)
GAIN_B5_L          gain band 5 (0, 1 or 2, for 1x, 4x, or 16x)
GAIN_B6_L          gain band 6 (0, 1 or 2, for 1x, 4x, or 16x)

SW_RST_INT         SW reset interval (in 1/16 s)
LW_RST_INT         LW reset interval (in 1/16 s)
LW_RST_INT_L       LW reset interval (in 1/16 s)

SWSC_DNPOS         position SW scanner directly
LWSC_DNPOS         position LW scanner directly
FP_DN_POSI         position FP scanner directly

SW scanner parameter block:

HEADER_5_L   (128) SW scanner mode: positive first
HEADER_5_L   (0)   SW scanner mode: negative first
                   Additional modes exist, not used in the present AOTs
SWSC_STPOS         SW scan, start position
SWSC_NSTPP         SW scan, nr of pos. steps
SWSC_NSTPP_L       SW scan, nr of pos. steps
SWSC_STSZP         SW scan, pos. step size
SWSC_STSZP_L       SW scan, pos. step size
SWSC_STINP         SW scan, pos. ste duration (in 1/16 s)
SWSC_NSTPN         SW scan, nr. of neg. steps
SWSC_NSTPN_L       SW scan, nr. of neg. steps
SWSC_STSZN         SW scan, neg. step size
SWSC_STSZN_L       SW scan, neg. step size
SWSC_STINN         SW scan, neg. step interval (in 1/16 s)
SWSC_NSCAN         nr of SW scans
SWSC_NSCAN_L (1)   1 SW scan

LW scanner parameter block:

HEADER_6_L   (128) LW scanner mode: positive first
HEADER_6_L   (0)   LW scanner mode: negative first
                   Additional modes exist, not used in the present AOTs
LWSC_STPOS         LW scan, start position
LWSC_NSTPP         LW scan, nr of pos. steps
LWSC_NSTPP_L       LW scan, nr of pos. steps
```

```
LWSC_STSZP           LW scan, pos. step size
LWSC_STSZP_L         LW scan, pos. step size
LWSC_STINP           LW scan, pos. step duration (in 1/16 s)
LWSC_NSTPN           LW scan, nr of neg. steps
LWSC_NSTPN_L         LW scan, nr of neg. steps
LWSC_STSZN           LW scan, neg. step size
LWSC_STSZN_L         LW scan, neg. step size
LWSC_STINN           LW scan, neg. step duration (in 1/16 s)
LWSC_NSCAN           nr of LW scans
LWSC_NSCAN_L  (1)    1 LW scan

FP scanner parameter block:

HEADER_7_L   (140) FP scanner mode: FP1 (band 5)
HEADER_7_L   (156) FP scanner mode: FP2 (band 6)
                   Additional modes exist, not used in the present AOTs
FP_START_P         FP scan, start position
FP_NSTEPSP         FP nr of pos. steps
FP_STSIZEP    (0)  FP scan, pos. step size = 0
FP_STSIZEP_L       FP scan, pos. step size
FP_STPINTP    (0)  FP scan,  pos. step duration = 0
FP_STPINTP_L       FP scan, pos. step duration (in 1/16 s)
FP_NSTEPSN    (0)  FP scan, 0 neg.steps
FP_NSTEPSN_L  (1)  1 FP negative step
FP_STSIZEN    (0)  FP scan, neg. step size = 0
FP_STSIZEN_L  (0)  FP scan, neg. step size = 0
FP_STPINTN    (0)  FP scan, neg. step duration = 0
FP_STPINTN_L       FP scan, neg. step duration (in 1/16 s)
FP_N_SCANS    (0)  0 FP scans
FP_N_SCANS_L  (1)  1 FP scan
```

5.1 Use of Run Flags

SWS uses 8 Run Flags to control semi-automatic processes. All 8 Run Flags can be set or reset simultaneously by the RUN_FLAGS_L magnitude command to ensure the synchronization of several actions. The following 6 Run Flags are used by the AOTs (their binary weights in the RUN_FLAGS_L argument are indicated between brackets):

- Run flag 2 (value 4): if set, enables the resets of the pre-amplifiers for detector bands 1 and 2. If set to 0, will stop those resets. The resets are stopped only if they have to be synchronized with another process, such as scanner stepping. This is necessary only for resets other than at 1-sec or 2-sec intervals, since these more frequent resets are already synchronized with the 2-sec telemetry format.

- Run flag 3 (value 8): if set, enables the resets of the pre-amplifiers for detector bands 3 through 6. If set to 0, will stop those resets. The resets are stopped only if they have to be synchronized with another process, such as scanner stepping. This is necessary only for resets other than at 1-sec or 2-sec intervals, since these more frequent resets are already synchronized with the 2-sec telemetry format.
- Run flag 4 (value 16) is used to time exposures by the internal calibrators. First the INTERVAL parameter has to be set, then the appropiate calibrator's output level must be set and the calibrator must be commanded "ON" and finally run flag 4 is raised. The exposure lasts during an interval of INTERVAL spacecraft telemetry frames (INTERVAL/16 seconds), after which interval the run flag 4 is set to 0 again. Note: the calibrators can also be switched on and off directly: if the INTERVAL parameter is 0, the commanded state of the calibrators takes effect immediately, for indefinite time.
- Run flags 5, 6 and 7 (values 32, 64 and 128) control the operation of the SW scanner, the LW scanner and the FP scanner. The flags remain raised until the scanner patterns have been performed as specified in the corresponding parameter blocks (see above) and then are reset to 0.

5.2 Scanner operation

The SW scanner, the LW scanner and the FP scanner are controlled in similar ways. They can be positioned directly, by the *DNPOS* commands and they can be programmed to execute a scan or even a repeated scan, by the combined use of the Run Flags and the scanner parameter blocks. The operations of the three scanners are in principle controlled independently, but often they are used simultaneously and mutually synchronized: the RUN_FLAGS_L command allows precise timing of the scan starts. The FP scanner is only used together with the LW scanner: in FP measurements, the LW grating section has to stay tuned with the FP. Even if a stationary LW position is selected for a FP scan, the LW scanner is enabled, in this case to perform steps of size 0.

The precise execution of a scan is demonstrated in the following pseudo code for a SW scan

```
HEADER_5_L = 128     { ''positive first'' }
set RUN_FLAG 5       { To 1 (2^5 = 32 in the RUN_FLAGS_L command).
                       This starts the scan execution.
                       This run flag remains set during the scans. }
SW_pos = SWSC_STPOS
ns = SWSC_NSCAN                      { always 1 in the AOTs }
repeat
```

```
        n = SWSC_NSTPP
        repeat
            wait (SWSC_STINP/16) seconds  { and measure, of course }
            SW_pos = SW_pos + SWSC_STSZP
            n = n - 1
        until  n <= 0
        n = SWSC_NSTPN
        repeat
            wait (SWSC_STINN/16) seconds  { and measure, of course }
            SW_pos = SW_pos - SWSC_STSZN
            n = n - 1
        until n <= 0
        ns = ns - 1
    until  ns <= 0
    reset RUN_FLAG 5                      { to 0 }
```

The SW scan is started by setting the run flag (bit 5) of the run flags word), e.g. by the command RUN_FLAGS_L (44), which enables the SW and LW resets (bits 2 and 3) and the SW scanner (bit 5 in the run flags word) Immediately after the last increment has been applied, the scanner run flag (bit 5) returns to 0 and the run flags word becomes equal to 12 (only the resets remain enabled).

Since the NSCAN, N_SCANS, NSTPP and NSTPN values are compared to the counters only after the first cycle of the loops they control, there will always be at least one scan and at least one step in both directions.

In a typical positive scan in one direction, both SWSC_STINP and SWSC_STINN would be equal to the SW reset interval, SWSC_STSZN would be 0, SWSC_NSTPN and SWSC_NSCAN would be 1.

This would result in (SWSC_NSTPP+1) integrations of equal duration and at equidistant scanner positions, with the run flag up for exactly the same period.

In a "negative first" scan the two inner loops occur in different order:

```
    HEADER_5_L = 0         { ''negative first'' }
    set RUN_FLAG 5
    SW_pos = SWSC_STPOS
    ns = SWSC_NSCAN
    repeat
        n = SWSC_NSTPN
        repeat
            wait (SWSC_STINN/16) seconds
```

```
        SW_pos = SW_pos - SWSC_STSZN
        n = n - 1
    until n <= 0
    n = SWSC_NSTPP
    repeat
        wait (SWSC_STINP/16) seconds
        SW_pos = SW_pos + SWSC_STSZP
        n = n - 1
    until n <= 0
    ns = ns - 1
until ns <= 0
reset RUN_FLAG 5
```

The INTERVAL parameter is used in the AOTs also to indicate that a valid dark-current measurement is being carried out. To flag dark-current measurements, the least significant bit of the INTERVAL parameter is used. If INTERVAL is used to time calibrator exposures, the least significant bit of INTERVAL will not be set (in those cases, INTERVAL is always a multiple of 1 sec, i.e. 16 frames). The high byte of INTERVAL is not needed except in calibrator exposures. This byte has been assigned to indicate the generic ICS being active: (240 + k) for ICS SS000k.

6 Instrument Command Sequences

6.1 Introduction

There are seven different Instrument Command Sequences (ICSes) used in the SWS AOTS. Each of them is reproduced here and discussed. The ICSes conform to a strict format convention specified in ISO/SSD/ICD-01.

The commands are specified by a command mnemonic, a formal ($*$) or actual argument in brackets and an explanatory comment. They end with a single letter (in column 62), required by the ICD, indicating the origin of the commanded value. The letter F indicates a fixed argument and the letter T (originally for "table") indicates a value defined by the AOT-to-OCT logic as specified in the AOT description. The values are almost never straight from tables.

Numbers in square brackets used in the SWS command comments refer to Instrument Variables in the AOT descriptions. These numbers are the most useful cross references to the AOT-to-OCT logic (and hence to the parameters stored in various tables).

6.2 ICS durations and timing

The formal definition of an ICS includes a parameter ICSDURTN, which is the execution time of the SWS in the instrument, i.e. the time needed to decode and execute the commands plus the time needed to execute timed calibration exposures, scanner operations or waits required for other purposes.

All ICS durations are specified in the AOT Descriptions. For the scanning ICSes SS0004, SS0005 and SS0009 the ICSDURTN parameter includes 6 seconds allocated to command execution and format synchronization. SWS has no mechanism to buffer an ICS before it is executed. This means that the execution of an ICS must be completed before the first command of the next ICS arrives at the command interface with the spacecraft.

The uplink process uses additional time between ICSes, consisting of a fixed overhead per ICS (at present 6 seconds) and a variable overhead, depending on the nunber of commands in the ICS (5-8 seconds).

The fixed overhead was introduced to cope with timing uncertainties (in particular in connection with handshakes between the two ground stations to be used for ISO). The variable overhead is needed because an ICS has to be uplinked entirely before it is transferred to SWS. These overhead parameters are kept in the SOC file s_uplink.sws and gene_ctl.cfg.

6.3 ICS SS0001 - Diffuse calibrators

ICS SS0001 is one of the two ICSes which can be used to perform a photometric check, in this case by means of the diffuse calibrators. Photometric checks expose the detectors to a reproducible source of IR radiation, to monitor the detector responsivity. SS0001 measures the responsivity employing reset intervals of 2 seconds and gains of 1. The illumination level can be set to two values. The ICS moves the grating scanners to their neutral positions, because tests showed that the grating scanner positions can have some effect on the illumination levels.

```
ICSNAME  = SS0001
ICSDESC  = Photometry check. INSTVAR references in []
        ICSNAME      SS0001
        LABEL        Photometry check
        INTERVAL_H   (241)          flag ICS 1                F
        INTERVAL_L   (1)            flag dark                 F
        RUN_FLAGS_L  (12)           resets only               F
        SHUTTER_L    (0)            shutter closed            F
        GAIN_B1_L    (0)            band 1 ampl. gain 1x      F
        GAIN_B2_L    (0)            band 2 ampl. gain 1x      F
        GAIN_B3_L    (0)            band 3 ampl. gain 1x      F
        GAIN_B4_L    (0)            band 4 ampl. gain 1x      F
        GAIN_B5_L    (0)            band 5 ampl. gain 1x      F
        GAIN_B6_L    (0)            band 6 ampl. gain 1x      F
        HEADER_5_L   (*)            [56] GC_SWSC_HEADER       T
        HEADER_6_L   (*)            [60] GC_LWSC_HEADER       T
        SWSC_DNPOS   (4095)         SW scanner to mid pos     F
        LWSC_DNPOS   (4095)         LW scanner to mid pos     F
        SW_RST_INT   (32)           SW det. reset intvl 2 s   F
        LW_RST_INT   (32)           LW det. reset intvl 2 s   F
        SYNC_FLAG    (SET)          sync next cmd with fmt    F
        SYNC_FLAG    (SET)          sync next cmd with fmt    F
        SYNC_FLAG    (SET)          sync next cmd with fmt    F
        SYNC_FLAG    (SET)          sync next cmd with fmt    F
        INTERVAL     (*)            [51] PC_INTERVAL          T
        SHUT_CS_2    (*)            [52] PC_DIFFUS_HILO       T
        SHUT_CS_2    (CS_DIFFUS_ON) diffuse source ON         F
        RUN_FLAGS_L  (28)           start exposure            F
        END_ICS
ICSDURTN = PC_DURATION = INSTVAR53
```

ICS SS0001 sets INTERVAL to indicate that SS0001 is active, dark currents being taken. It closes the shutters and sets the detector gains. The grating scanner headers are set and the grating scanners are moved to neutral positions. The reset intervals are set to 2 sec (no synchronizations needed). After 4 format synchronizations (8 seconds after the start of the ICS execution), the INTERVAL is redefined and the exposure starts by the RUN_FLAGS_L (28) command. The ICS duration specified in the AOT descriptions will allow for some dark recovery after the calibrator exposure.

6.4 ICS SS0002 - Grating calibrators

ICS SS0002 is one of the two ICSes which can be used to perform a photometric check, in this case by means of the grating calibrators. Photometric checks expose the detectors to a reproducible source of IR radiation, to monitor the detector responsivity. SS0002 measures the responsivity employing reset intervals of 1 second. The illumination level can be set to two values.

Originally, this ICS was defined to monitor the stability of the wavelength calibration of SWS. This function has been moved to dedicated calibration sequences and in the AOTs the grating calibrators are used as responsivity monitors. During the exposure the grating scanners are moved over a small range. These small scans are not absolutely required (reproducible scanner positions are required, of course). but they have the advantage that they offer the different detectors in a band overlapping wavelength regions.

```
ICSNAME  = SS0002
ICSDESC  = Grating scanners wavelength check INSTVAR references in []
        ICSNAME      SS0002
        LABEL        Grating scanners wavelength check
        INTERVAL_H   (242)          flag ICS 2               F
        INTERVAL_L   (1)            flag dark                F
        RUN_FLAGS_L  (12)           resets only              F
        SHUTTER_L    (0)            shutter closed           F
        GAIN_B1_L    (2)            band 1 ampl. gain 16x    F
        GAIN_B2_L    (0)            band 2 ampl. gain 1x     F
        GAIN_B3_L    (0)            band 3 ampl. gain 1x     F
        GAIN_B4_L    (0)            band 4 ampl. gain 1x     F
        GAIN_B5_L    (2)            band 5 ampl. gain 16x    F
        GAIN_B6_L    (2)            band 6 ampl. gain 16x    F
        SW_RST_INT   (16)           SW det. reset intvl 1 s  F
        LW_RST_INT   (16)           LW det. reset intvl 1 s  F
        HEADER_5_L   (*)            [56] GC_SWSC_HEADER      T
        SWSC_STPOS   (*)            [57] GC_SWSC_STPOS       T
        SWSC_NSTPP   (*)            [58] GC_SWSC_NSTPP       T
        SWSC_STSZP   (*)            [59] GC_SWSC_STSZP       T
        SWSC_STINP   (16)           SW step intvl pos 1 s    F
```

```
        SWSC_NSTPN   (0)            SW \                     F
        SWSC_STSZN   (0)            SW  > no stepping back   F
        SWSC_STINN   (16)           SW /                     F
        SWSC_NSCAN_L (1)            SW 1 scan only           F
        HEADER_6_L   (*)            [60] GC_LWSC_HEADER      T
        LWSC_STPOS   (*)            [61] GC_LWSC_STPOS       T
        LWSC_NSTPP   (*)            [62] GC_LWSC_NSTPP       T
        LWSC_STSZP   (*)            [63] GC_LWSC_STSZP       T
        LWSC_STINP   (16)           LW step intvl pos 1 s    F
        LWSC_NSTPN   (0)            LW \                     F
        LWSC_STSZN   (0)            LW  > no stepping back   F
        LWSC_STINN   (16)           LW /                     F
        LWSC_NSCAN_L (1)            LW 1 scan only           F
        HEADER_7_L   (140)          FP to defined position   F
        FP_DN_POSI   (0)                                     F
        END_SEQ_NOP  (96)           WAIT 6 SECONDS           F
        SYNC_FLAG    (SET)          sync next cmd with fmt   F
        INTERVAL     (*)            [64] GC_INTERVAL         T
        SHUT_CS_1    (*)            [65] GC_GRACAL_HILO      T
        SHUT_CS_1    (CS_GRATNG_ON) grating source ON        F
        RUN_FLAGS_L  (124)          src on/en.res/start scan F
        END_ICS
ICSDURTN = GC_DURATION = INSTVAR66
```

ICS SS0002 sets INTERVAL to indicate that SS0002 is active, dark currents being taken. It closes the shutters and sets the detector gains. The grating scanner headers and parameter blocks are set. The reset intervals are set to 1 sec (no synchronizations needed). After a 6-second wait and 1 format synchronization (8 seconds after the start of the ICS execution), the INTERVAL is redefined and the exposure starts by the RUN_FLAGS_L (124) command, enabling the resets, the interval timer and the two grating scanners simultaneously. The ICS duration specified in the AOT descriptions will allow for some dark recovery after the calibrator exposure.

6.5 ICS SS0004 - SW grating scan

ICS SS0004 is the ICS used to do the SW grating scans in AOT SWS07. That AOT primarily does FP observations, but can perform SW grating observations simultaneously or separately. ICS SS0004 was designed to do SW grating scans without affecting the operations of LW scanner and Fabry-Perot.

There are three commands in the ICS which affect the LW section, in principle: there are two RUN_FLAGS_L commands and one SHUTTER_L command. The SHUTTER_L command is needed because the ICS is used also to command SW measurements without simultaneous FP scans. The definition of the argument for the RUN_FLAGS_L commands has to be done carefully, because it must not change the state of any of the LW run flags, to avoid inadvertent stops or restarts of LW or FP scans.

The ICS is also used to do dark-current scans for SW measurements in AOT SWS07. Those dark-current scans are repetitions of reference scans, with the shutter closed and the dark-current flag raised. The SW measurements are never done simultaneously with FP measurements.

```
ICSNAME  = SS0004
ICSDESC  = SW grating scan. INSTVAR references in []
        ICSNAME      SS0004
        LABEL        SW grating scan
        INTERVAL_H   (244)         flag ICS 4               F
        INTERVAL_L   (0)           flag no dark             F
        RUN_FLAGS_L  (*)           [120] RUN_FL_INI         T
        GAIN_B1_L    (*)           [83] GAIN_B1             T
        GAIN_B2_L    (*)           [84] GAIN_B2             T
        SW_RST_INT   (*)           [90] SW_RST_INT          T
        HEADER_5_L   (*)           [93] SWSC_HEADER         T
        SWSC_STPOS   (*)           [94] SWSC_STPOS          T
        SWSC_NSTPP   (*)           [95] SWSC_NSTPP          T
        SWSC_STSZP   (*)           [96] SWSC_STSZP          T
        SWSC_STINP   (*)           [97] SWSC_STINP          T
        SWSC_NSTPN   (*)           [98] SWSC_NSTPN          T
        SWSC_STSZN   (*)           [99] SWSC_STSZN          T
        SWSC_STINN   (*)           [100] SWSC_STINN         T
        SWSC_NSCAN   (1)           one SW scan              F
        SYNC_FLAG    (SET)         sync next cmd with fmt   F
        SHUTTER_L    (*)           [92] SHUTTERPOS          T
        RUN_FLAGS_L  (*)           [119] RUN_FLAGS          T
        INTERVAL_L   (*)           [123] DARK_SCAN          T
        END_ICS
ICSDURTN = ICS_DURATION = INSTVAR80
```

SS0004 first sets the INTERVAL parameter to a value indicating no dark-current. The run flags are set to a value determined by the AOT logic, not changing the settings of run flags 3, 6 and 7 (LW and FP operations) and if necessary preparing a change to long SW resets. The gains and reset intervals for bands 1 and 2 are set, the SW scanner pattern is defined and then the run-flags command is given after a format synch, enabling SW resets and scan on top of any LW/FP actions.

The following run flag settings can appear:

Initial setting: (RUN_FL_INI parameter)

8 (bit 3) stop SW resets before starting an isolated SW scan or dark-current measurement,

12 (bits 2 and 3) continue SW resets while setting up an isolated SW scan or SW dark-current measurement

200 (bits 3, 5, 6, 7) stop SW resets, continue FP measurements, for a "merged" SW scan,

204 (bits 2, 3, 5, 6, 7) continue SW resets and FP measurement, for a "merged" SW scan.

Second run flags setting (RUN_FLAGS parameter):

44 (bits 2, 3, 5) start an isolated SW scan or dark current measurement,

236 (bits 2, 3, 5, 6, 7) start "merged" SW scan,

SW dark-current measurements are implemented as SW reference scans with the shutter closed. They differ from ordinary scans by the shutter setting and by the DARK_FLAG setting (INTERVAL_L is set to 1 instead of 0). Of course the dark-current measurement can not be done simultaneously with an FP scan.

6.6 ICS SS0005 - SW+LW grating scan

ICS SS0005 is used in three distinct modes:

1. Start with a dark-current measurement, then do a grating measurement with the shutter open, consisting of a positive scan immediately followed by a negative scan, back to the start position (the standard practice in AOTs SWS01 and SWS02). In SWS01 the reset intervals are multiples of the scanner step durations. In SWS02 the scanner step durations may be multiples of the reset intervals.

2. Only do a dark measurement, in the form of a reference grating scan with the shutter closed (the standard dark current measurements in AOT SWS06).

3. Perform a grating scan or a reference grating scan without preceding dark-current measurement (the standard grating scans in AOTs SWS06).

```
ICSNAME  = SS0005
ICSDESC  = Grating scan. INSTVAR references in []
        ICSNAME      SS0005
        LABEL        Grating scan
        INTERVAL_H   (245)          flag ICS 5                F
        INTERVAL_L   (0)            flag no dark              F
```

```
        RUN_FLAGS_L  (*)            [120] RUN_FL_INI         T
        SHUTTER_L    (*)            [121] SHUTTR_INI         T
        GAIN_B1_L    (*)            [83] GAIN_B1             T
        GAIN_B2_L    (*)            [84] GAIN_B2             T
        GAIN_B3_L    (*)            [85] GAIN_B3             T
        GAIN_B4_L    (*)            [86] GAIN_B4             T
        SW_RST_INT   (*)            [90] SW_RST_INT          T
        LW_RST_INT   (*)            [91] LW_RST_INT          T
        SYNC_FLAG    (SET)          sync next cmd with fmt   F
        RUN_FLAGS_L  (12)           enable resets            F
        INTERVAL_L   (*)            [122] DARK_WAIT          T
        HEADER_5_L   (*)            [93] SWSC_HEADER         T
        SWSC_STPOS   (*)            [94] SWSC_STPOS          T
        SWSC_NSTPP   (*)            [95] SWSC_NSTPP          T
        SWSC_STSZP   (*)            [96] SWSC_STSZP          T
        SWSC_STINP   (*)            [97] SWSC_STINP          T
        SWSC_NSTPN   (*)            [98] SWSC_NSTPN          T
        SWSC_STSZN   (*)            [99] SWSC_STSZN          T
        SWSC_STINN   (*)            [100] SWSC_STINN         T
        SWSC_NSCAN_L (1)            one SW scan              F
        HEADER_6_L   (*)            [102] LWSC_HEADER        T
        LWSC_STPOS   (*)            [103] LWSC_STPOS         T
        LWSC_NSTPP   (*)            [104] LWSC_NSTPP         T
        LWSC_STSZP   (*)            [105] LWSC_STSZP         T
        LWSC_STINP   (*)            [106] LWSC_STINP         T
        LWSC_NSTPN   (*)            [107] LWSC_NSTPN         T
        LWSC_STSZN   (*)            [108] LWSC_STSZN         T
        LWSC_STINN   (*)            [109] LWSC_STINN         T
        LWSC_NSCAN_L (1)            one LW scan              F
        END_SEQ_NOP  (*)            [89] WAIT                T
        END_SEQ_NOP  (*)            [89] WAIT                T
        RUN_FLAGS_L  (*)            [120] RUN_FL_INI         T
        SYNC_FLAG    (SET)          sync next cmd with fmt   F
        SHUTTER_L    (*)            [92] SHUTTERPOS          T
        RUN_FLAGS_L  (*)            [119] RUN_FLAGS          T
        INTERVAL_L   (*)            [123] DARK_SCAN          T
        END_ICS
ICSDURTN = ICS_DURATION = INSTVAR80
```

Actions:

1. For a combination dark-current and spectral scan (AOT1, AOT2):

- 1a) Sets the interval parameter (dark flag to 0), optionally disables the resets, closes the shutter, sets the gains for the grating arrays and the reset intervals, enables the resets after a format synch, sets the dark-current flag to 1, sets up the grating scanner parameter blocks.
- 1b) Waits, to perform the dark-current measurement. Two END_SEQ_NOP commands are used for this, because the maximum wait of 16 seconds form a single command proved too short.
- 1c) Again optionally disables the resets, again synchronizes with the telemetry format, moves the shutter to open the desired aperture, redefines the run flags to start the scans, sets the dark flag to 0.

2. For a dedicated dark-current measurement (dark reference scan in AOT6):

- 2a) Sets the interval parameter (dark flag to 0), optionally disables the resets, closes the shutter, sets the gains for the grating arrays and the reset intervals, enables the resets after a format synch, sets the dark-current flag to 1, sets up the grating scanner parameter blocks.
- 2b) No Wait before the scan starts
- 2c) Again optionally disables the resets, synchronizes with the telemetry format, leaves the shutter closed, redefines the run flags to start the scans, leaves the dark flag at value 1.

3. For a scan without preceding dark measurement (AOT6):

- a) Sets the interval parameter (dark flag to 0), optionally disables the resets, moves the shutter to open the desired aperture, sets the gains for the grating arrays and the reset intervals, enables the resets after a format synch, sets the dark-current flag to 0, sets up the grating scanner parameter blocks.
- b) No wait before the scan starts. grating scan.
- c) Again optionally disables the resets, synchronizes with the telemetry format, leaves the shutter open, redefines the run flags to start the scans, leaves the dark flag at value 1.

6.7 ICS SS0006 - Dark-current measurement

ICS SS0006 is used for a dark-current measurement after a grating scan (SS0005).

The ICS simply closes the shutter, and flags the dark-current and the ICS identification via the INTERVAL parameter. It does not change the gains or the reset interval length, so that the dark current is valid for the preceding measurement. The duration of the dark measurement is controlled by means of the ICS duration ICSDURTN.

```
ICSNAME  = SS0006
ICSDESC  = Dark measurement, to follow SS0005
        ICSNAME      SS0006
        LABEL        Dark measurement
        SHUTTER_L    (0)            shutter closed          F
        INTERVAL_H   (246)          flag ICS 6              F
        INTERVAL_L   (1)            flag dark               F
        END_ICS
ICSDURTN = DK_DURATION = INSTVAR127
```

```
ICSNAME  = SS0007
ICSDESC  = Reset
        ICSNAME      SS0007
        LABEL        Reset
        RUN_FLAGS_L  (0)            disable reset pulses    F
        SHUTTER_L    (0)            shutter closed          F
        GAIN_B1_L    (0)            band 1 ampl. gain 1x    F
        GAIN_B2_L    (0)            band 2 ampl. gain 1x    F
        GAIN_B3_L    (0)            band 3 ampl. gain 1x    F
        GAIN_B4_L    (0)            band 4 ampl. gain 1x    F
        GAIN_B5_L    (0)            band 5 ampl. gain 1x    F
        GAIN_B6_L    (0)            band 6 ampl. gain 1x    F
        SHUT_CS_1    (CS_GRATNG_OF) grating source OFF      F
        SHUT_CS_1    (CS_GRATNG_LO) grating source LOW      F
        SHUT_CS_1    (FLUSH_SRC_OF) flusher source OFF      F
        SHUT_CS_1    (FLUSH_SRC_LO) flusher source LOW      F
        SHUT_CS_2    (CS_FP_OFF)    FP cal. source OFF      F
        SHUT_CS_2    (CS_FP_LO)     FP cal. source LOW      F
        SHUT_CS_2    (CS_DIFFUS_OF) diffuse source OFF      F
        SHUT_CS_2    (CS_DIFFUS_LO) diffuse source LOW      F
        SW_RST_INT   (32)           SW det. reset intvl 2 s F
        LW_RST_INT   (32)           LW det. reset intvl 2 s F
        SYNC_FLAG    (SET)          sync next cmd with fmt  F
        RUN_FLAGS_L  (12)           enable reset pulses     F
        INTERVAL     (0)            cal.src. interval reset F
        HEADER_0     (RESET_MECH)   reset scanners/FP       F
        END_ICS
ICSDURTN = (3 * T_fmt)
```

6.8 ICS SS0008 - Reset scan parameter blocks

ICS SS0008 was introduced when AOT SWS07 was implemented. ICS SS0009 was too long to allow double (2-byte) commands for all settings of the parameter blocks. Low-order bytes are sufficient in most cases, but one must make sure that there is no garbage left in the high-order bytes. At that time it was decide to introduce an ICS that would zero all words in the scan parameters blocks.

```
ICSNAME  = SS0008
ICSDESC  = Reset scan parameter blocks
        ICSNAME      SS0008
        LABEL        Reset scan parameter blocks
        SWSC_STPOS   (0)                                  F
        SWSC_NSTPP   (0)                                  F
        SWSC_STSZP   (0)                                  F
        SWSC_STINP   (0)                                  F
        SWSC_NSTPN   (0)                                  F
        SWSC_STSZN   (0)                                  F
        SWSC_STINN   (0)                                  F
        SWSC_NSCAN   (0)                                  F
        LWSC_STPOS   (0)                                  F
        LWSC_NSTPP   (0)                                  F
        LWSC_STSZP   (0)                                  F
        LWSC_STINP   (0)                                  F
        LWSC_NSTPN   (0)                                  F
        LWSC_STSZN   (0)                                  F
        LWSC_STINN   (0)                                  F
        LWSC_NSCAN   (0)                                  F
        FP_START_P   (0)                                  F
        FP_NSTEPSP   (0)                                  F
        FP_STSIZEP   (0)                                  F
        FP_STPINTP   (0)                                  F
        FP_NSTEPSN   (0)                                  F
        FP_STSIZEN   (0)                                  F
        FP_STPINTN   (0)                                  F
        FP_N_SCANS   (0)                                  F
        END_ICS
ICSDURTN = (2 * T_fmt)
```

6.9 ICS SS0009 - FP/LW + SW scan

ICS SS0009 starts an FP scan and may simultaneously start an LW grating scan (to keep the LW grating tuned to the FP wavelength during the FP scan) and an SW grating scan (for additional scientific harvest). Because of the number of required commands, many commands only set the low-order byte of 2-byte parameters. The ICS either measures dark current only or no dark current at all.

The LW and FP scanners are moved physically as early as possible, to give the FP scanner time to settle and to achieve a tuned configuration with the detector receiving a representative signal.

To avoid hysteresis effects in the Fabry-Perot mechanism, the FP is first set to position 0 (maximum gap width).

The scan will always be done in the positive direction, i.e. from larger to smaller gap width.

```
ICSNAME  = SS0009
ICSDESC  = FP scan combined with short-wave grating scan.
ICSDESC  = For most scanner parameters only the low bytes are provided
ICSDESC  = (only the start positions, the step durations and the FP nr
ICSDESC  = of steps are treated as two-byte parameters).
ICSDESC  =
ICSDESC  = INSTVAR references in []
ICSDESC  =
        ICSNAME      SS0009
        LABEL        FP and SW grating scan
        INTERVAL_H   (249)        flag ICS 9            F
        INTERVAL_L   (0)          flag no dark          F
        RUN_FLAGS_L  (*)          [120] RUN_FL_INI      T
        HEADER_7_L   (*)          [111] FP_HEADER       T
        FP_DN_POSI   (0)          FP position           F
        HEADER_6_L   (*)          [102] LW scan mode    T
        LWSC_DNPOS   (*)          [103] LWSC_STPOS      T
        GAIN_B1_L    (*)          [83] GAIN_B1          T
        GAIN_B2_L    (*)          [84] GAIN_B2          T
        GAIN_B5_L    (*)          [87] GAIN_B5          T
        GAIN_B6_L    (*)          [88] GAIN_B6          T
        SW_RST_INT   (*)          [90] SW_RST_INT       T
        LW_RST_INT_L (*)          [91] LW_RST_INT       T
        HEADER_5_L   (*)          [93] SW scan mode     T
        SWSC_STPOS   (*)          [94] SWSC_STPOS       T
        SWSC_NSTPP_L (*)          [95] SWSC_NSTPP       T
        SWSC_STSZP_L (*)          [96] SW stepsize, pos.  T
```

```
        SWSC_STINP   (*)           [97] SWSC_STINP          T
        SWSC_NSTPN_L (*)           [98] SW nr of steps, neg T
        SWSC_STSZN_L (*)           [99] SWSC_STSZN          T
        SWSC_STINN   (*)           [100] SWSC_STINN         T
        SWSC_NSCAN_L (1)           one SW scan              F
        LWSC_STPOS   (*)           [103] LWSC_STPOS         T
        LWSC_NSTPP_L (*)           [104] LW nr of steps pos.T
        LWSC_STSZP_L (*)           [105] LW step size, pos. T
        LWSC_STINP   (*)           [106] LW step durat., posT
        LWSC_NSTPN_L (*)           [107] LWSC_NSTPN         T
        LWSC_STSZN_L (*)           [108] LW step size, neg. T
        LWSC_STINN   (*)           [109] LWSC_STINN         T
        LWSC_NSCAN_L (1)           one LW scan              F
        FP_DN_POSI   (*)           [112] FP_START_P         T
        FP_START_P   (*)           [112] FP_START_P         T
        FP_NSTEPSP   (*)           [113] FP nr of steps, posT
        FP_STSIZEP_L (*)           [114] FP step size, pos. T
        FP_STPINTP_L (*)           [115] FP step durat., posT
        FP_NSTEPSN_L (*)           [116] FP_NSTEPSN         T
        FP_STSIZEN_L (*)           [117] FP_STSIZEN         T
        FP_STPINTN_L (*)           [118] FP_STPINTN         T
        FP_N_SCANS_L (*)           [...] FP nr of scans     T
        RUN_FLAGS_L  (*)           [120] RUN_FL_INI         T
        SYNC_FLAG    (SET)         sync next cmd with fmt   F
        SHUTTER_L    (*)           [92] SHUTTRPOS           T
        RUN_FLAGS_L  (*)           [119] RUN_FLAGS          T
        INTERVAL_L   (*)           [123] DARK_SCAN          T
        END_ICS
ICSDURTN = ICS_DURATION = INSTVAR80
END_DATA
```

Actions:

a) Set the INTERVAL parameter (ICS SS0009, no dark), optionally stop resets (superfluous?), set FP scan mode and zero position, set LW scan mode and start position,

b) Set gains Bands 1, 2, 5 and 6, set reset intervals, set up SW and LW scan parameters.

c) Move FP to start position, set up FP scan parameters, optionally stop resets, synch with format, move the shutter to open the desired aperture, start the LW/FP scans, possibly simultaneously with a SW scan, leave the dark-current flag at value 0.

If the ICS is used for a dark-current measurement, the selected aperture is 0. The SW, LW and FP scanners are enabled, but they execute only a single step with step size 0. The duration of the dark-current measurement is determined only by the relative timing between this ICS and the next one to be uplinked. Using the FP scan ICS for the dark currents, with the same scanner positioning and reset definitions as in the true FP scans, will maximize the chance of obtaining representative dark currents.

7 SWS AOTs, Overview and Description Formats

7.1 Some History

Originally, a set of 5 SWS AOTs was foreseen:

- SWS01, a general grating scan AOT,
- SWS02, an AOT to scan individual spectral lines with the grating,
- SWS03, an AOT to scan individual spectral lines with the FP,
- SWS04, an AOT to scan lines with the grating in a celestial raster,
- SWS05, an AOT to scan lines with the FP in a celestial raster.

The second AOT was the simplest in concept and the first to be developed. It evolved into the present AOT SWS02. At that time, AOTs were supposed to be almost entirely table-driven, according to the predecessor of Applicable Document Nr. 2. A list of AOT Parameters, a list of Instrument Variables, a set of Tables and an ICS Set were the essential components of the AOT definitions.

A small set of generic ICSes was defined for SWS, and a single Instrument Variable List that mapped the variable parameters of all ICSes onto a single list of variables used in all AOT Descriptions.

Part of the logic needed for SWS02 was difficult to capture in these table structures. The observer's requirements, consisting of lists of required wavelengths and sensitivities, had to be translated into a time-ordered series of ICSes, making sure that all measurements to be done with a single aperture were grouped in time, and making sure that simultaneous measurements were done efficiently. Instructions to the implementor of the logic were needed that did not fit in easily with the original "Template" concept.

As AOT SWS02 was being implemented, SWS03 was the next AOT to be defined in detail. The interplay between LW grating scanner and FP scanner needed much more precise instructions than were used in the SWS02 definition. The only way to specify this unambiguously is to use computer language. It was decide to use pseudo code, in principle following the PASCAL conventions, to define the wavelength scanner operations. Out of this grew a hybrid AOT decription, relying on the combination of a half-sufficient list of Instrument Variables and some pieces of pseudo-code.

The functions foreseen for AOT 1 were divided over two AOTs: AOT SWS01 and a new AOT, SWS06. SWS01 was designed for complete wavelength coverage at reduced spectral resolution. The new AOT SWS06 was designed for long grating scans, with a new strategy to deal with the detector response problems experienced during instrument tests.

SWS06 was the next AOT to be built, AOT SWS01 being much more simple in concept than the others. AOT SWS06 still has the list of Instrument Variables, but was defined completely in terms of pseudo-code, in the form of a syntactically valid PASCAL program. This approach was very successful: the PASCAL pseudo code was easy to translate into a viable C programme and the AOT logic was implemented with fewer iterations than even the much more simple SWS02.

As the definition of SWS06 proceeded, it was decided to drop the raster AOTs SWS04 and SWS05. SWS, with its three apertures, was an awkward instrument to use in raster pointings, since it was not possible to combine pointing adjustments for aperture changes and pointing adjustments for raster operations into a single observation. The functionality of a raster pointing can be implemented by means of concatenated single pointings. Those carry some extra overheads, but the overheads are partly compensated by the freedom to use different apertures in a single observation.

AOT SWS01 was defined and implemented with relatively few problems, as the next AOT after SWS06. AOT SWS01 relies almost entirely on the Instrument Variable list. The Template concept is perfectly suited for this AOT, because it makes exactly three up-down grating scans, over pre-defined ranges.

As the implementation of SWS03 was being delayed, there was an opportunity to replace it by AOT SWS07. AOT SWS07 has the capabilities projected for SWS03, but it offers the additional possibility of SW grating observations in parallel to the FP scans. The description of SWS07 was assembled from existing SWS06 and SWS03 documentation. SWS07 is also described in the form of a PASCAL pseudo-code program, though not in the rigorous detail of the SWS06 description.

Finally, with all after-launch modifications, the SWS02 description was no longer maintainable and it was replaced by a complete pseudo-code version.

The story ends with the following list:

- SWS01: for low-resolution complete grating scans,
- SWS02: for line profile scans with the grating,
- SWS06: for general grating observations,
- SWS07: for FP observations combined with SW scans.

7.2 AOT Description Formats

AOT parameters

Each AOT description starts off with a list of AOT parameters, named "AOTPNM01" upto "AOTPNM33", in accordance with Applicable Document 2.

The variables are also given symbolic names, such as "SNR_REQ". These names are used in the AOT descriptions, but they also have external significance, in the definitions of the input panels in the proposal entry system PGA (for Proposal Generation Aid).

The AOT parameters are input parameters from the observer, measurement counters and output parameters (supposed to be) for immediate feed-back to the observer.

The AOTPNM numbers are a sparse set, with commonality (also for the symbolic names) between AOTs SWS02, SWS06 and SWS07.

The conventions agreed to for the SWS AOTs:

1. AOT parameters 1-9: AOT-level inputs. Used only for the radial-velocity parameter (parameter 1 in AOTS SWS02, SWS06 and SWS07).
2. AOT parameters 10-29: Measurement-level inputs (all other observer inputs, and measurement counters).
3. AOT parameters 30-40: Outputs to the observer (measurement durations, achieved signal-to-noise ratios and sensitivities).

   The AOT parameter listing includes for each parameter the unit in which it must be specified and the allowed range of its value.

Instrument Variables

The Instrument Variables have names running from "INSTVAR01" to "INSTVAR99" (as per Applicable Document Nr. 2) and then "INSTVAR100" to "INSTVAR123". Most INSTVARs correspond to variable ICS parameters; those INSTVARs are grouped per ICS (the scan ICSes SS0004, SS0005 and SS0009 share the same INSTVAR block). Every variable ICS parameter is consistently mapped onto a single INSTVAR.

The INSTVARs also have symbolic names, by which they are referred to in the AOT descriptions.

The INSTVAR specifications include a prescription for their evaluation. This can be a reference to a table, a fixed value, an expression referring to other INSTVARs or AOT parameters, or a reference to a pseudo-code procedure.

Most INSTVARs that are no ICS parameters are parameters that are direct links to the various Tables of uplink parameters.

The ICS Set Description

Most of the remaining volume of the AOT Descriptions are occupied by the logic specified in the "ICS set" definition "SETNAM01".

In the SWS AOT Descriptions the SETNAM01 section is used to define the sequencing of ICSes and to define any logic that could not be captured directly in the INSTVAR list. In the case of SWS02, SWS06 and SWS07, the SETNAM01 definition (or rather the SETLOG01 part of that) consists of the pseudo - PASCAL program prescribing the entire logic. With SWS01 there is a mix of pseudo code and other prescriptions in this section.

TDATA definitions

After SETLOG01, Transparent Data definitions are listed. Again, the format of the definitions is prescribed in Applicable Document nr. 2. These Transparent Data definitions define **how** the different TDATA fields (identified by byte numbers) have to be filled, to match Applicable Document nr. 3. **When** the TDATA fields have to be (re-)defined is determined by the preceding logic.

SETICS01

This is the final non-trivial information in the AOT Descriptions. It lists the ICSes applied in the AOT. For AOTs SWS02, SWS06 and SWS07 this section gives an overview of the sequence of events in the AOT.

8 AOT SWS01

AOT SWS01 is described by Reference Document Nr. 1. The functionality of AOT SWS01 is defined in Applicable Document Nr. 1, the SWS Observer's Manual.

8.1 SWS01 Observing Parameters

There are 5 parameters to be provided by the observer: one speed parameter (SPEED, AOTPNM10), to decide between 4 different scanning rates, and 4 estimates of peak flux densities for each of the 4 grating detector bands (FD_PEAK_B1 - FD_PEAK_B4, AOTPNM11 - AOTPNM14). The flux density estimates are used only for setting the gains.

8.2 SWS01 Wavelength Scanning Strategy

With each aperture, SWS01 makes a single scan "up" and "down", covering all the scanner positions occurring in the band definitions table S_BANDS6 and S_GR6 of AOT SWS06 (see 12.2 and 12.8). The ranges for AOT1 are stored in table S_LRSCAN (see 12.12).

Scanner step sizes and dwell times are defined for the four different scan rates in table S_LRRATE (see 12.11). The shortest dwell time is 2 telemetry frames (1/8 second). This is the shortest time that will allow complete command verification in the downlink. A longer dwell time of 4 telemetry frames is currently only applied for the slowest speed (SPEED 4). The reset interval is 1 second for SPEED 1 and 2 seconds for SPEED 2-4. The reset interval is much longer than the dwell time. Integrating over the reset interval will cause some spectral blurring. This is intentional, to prevent aliasing (in this case incomplete registration of spectral detail).

The scan lengths are arranged so that the resets in the "up" and "down" scans are aligned wavelength-wise. This facilitates the data processing.

8.3 SWS01 Simultaneous Measurements

In SWS01 simultaneous measurements are arranged by the scan range definitions in table S_LRSCAN (see 12.12). The SW and LW scan parameters are identical, except for the scanner start positions.

8.4 Reference Measurements

Reference measurements are not used in SWS01.

8.5 SWS01 Internal Calibrations

Two internal photometric check sequences are carried out, one after the aperture-1 measurements have been concluded and one at the end of the AOT. These checks currently are done by means of the grating calibrator. The checks have their own dark-current measurement built-in as a wait in the grating calibrator ICS.

The check sequences are determined by S_IDSDB parameters and tables S_PCTAB1 and S_SCTAB1 (see 12.10, 12.14 and 12.17). An extra check high-level check to stimulate band-1 detectors at the end can be arranged by modifying an S_IDSDB parameter.

8.6 SWS01 Dark-current Measurements

Each of the three "up-down" scans is preceded and followed by a dark-current measurement. The preceding measurement is arranged by a wait in the scan ICS, defined by the WAIT parameter in S_IDSDB. The WAIT parameter currently amounts to 20 seconds. The following measurement is made by performing the dark-current ICS SS0006.

8.7 SWS01 Areas of Concern

The table S_IDSDB contains a parameter PHOTIM_1, meant to control the frequency of photometric checks in AOT SWS01. At present, the logic ignores that parameter.

9 AOT SWS02

AOT SWS02 is described by Reference Document Nr. 2. The functionality of AOT SWS02 is defined in Applicable Document Nr. 1, the SWS Observer's Manual.

9.1 Observing Parameters

Observing parameters are: the heliocentric radial velocity of the object, and for each line to be observed a central wavelength, an expected flux density and a required signal-to-noise ratio. The wavelength is corrected for the radial velocity, using the non-relativistic formula. Estimates of the required measurement time and the achieved SNR are reported back to the observer (ignoring the savings and gains of simultaneous measurements).

9.2 SWS02 Wavelength Scanning Strategy

The scanner settings are determined from the input wavelengths by means of the band definitions of S_BANDS2 and the calibration file S_GR6 (see 12.1 and 12.9). The sensitivity for the selected wavelength is determined by responsivity data from S_GR6 and detector data from S_DETECT (see 12.5).

At each requested wavelength an "up-down" scan is performed. The number of steps in either direction is 50 and the step sizes are minimal: 2 for detector band 4, 1 for the other bands. The step counts and the step sizes for SWS02 are defined in the S_IDSDB table (see 12.10). The step duration is made equal to the reset time and is the smallest out of the sequence 1, 2, 4 seconds (4 is the maximum set in S_IDSDB for band 1, 2 is the maximum for detector bands 2, 3 and 4) that will provide sufficient sensivity. If the largest allowed reset interval does not yet give enough sensitivity, the scan with the maximum reset interval is repeated until enough sensitivity is expected.

9.3 SWS02 Simultaneous Measurements

For an efficient merging, the measurements for the LW and SW section to be done with a given aperture are first sorted in order of decreasing duration. Measurements that require repetition of scans are split into individual scans.

Then the measurements are combined, one LW scan with one SW scan, starting with the longest measurements. The faster of the two scans is slowed down by giving it the same scanner step interval as its counterpart. The reset interval is not adjusted, to prevent merged measurements from being spoilt by amplifier saturation.

If the two lists are of unequal length, the remaining measurements of the longer list will be merged with repeated measurements from the shorter list, provided that this merging will not increase the observing time.

If measurements can not be merged, the idle section of the spectrometer will not be activated.

9.4 SWS02 Reference Measurements

Reference measurements are not used in SWS02.

9.5 SWS02 Internal Calibrations

An internal photometric check sequence is carried out, first after roughly PHOTIM_2 seconds and then again roughly every PHOTIM_2 (see S_IDSDB, 12.10) seconds. For a short AOT, one check is done at the end. These checks have their own dark-current measurement built-in as a wait in the grating calibrator ICS.

The check sequences are determined by S_IDSDB parameters and tables S_PCTAB1 and S_SCTAB1 (see 12.14 and 12.17). An extra check high-level check to stimulate band-1 detectors at the end can be arranged by modifying an S_IDSDB parameter.

9.6 SWS02 Dark-current Measurements

Each scan ICS has its own dark-current scan measurement built in, of a duration of 20 seconds. This is arranged by a wait in the scan ICS, defined by the WAIT parameter in S_IDSDB. The WAIT parameter currently amounts to 20 seconds. If a grating scan is not followed by another grating scan with the same reset intervals and detector gains, ICS SS0006 is used to insert a dark-current measurement at the proper settings.

9.7 SWS02 Areas of Concern

The merging of SW and LW measurements could be further optimized by investigating case by case whether more scans at shorter reset intervals can lead to a faster execution.

10 AOT SWS06

AOT SWS06 is described by Reference Document Nr. 3. The functionality of AOT SWS06 is defined in Applicable Document Nr. 1, the SWS Observer's Manual.

10.1 Observing Parameters

Observing parameters are: the heliocentric radial velocity of the object, and for each measurement (wavelength range to be observed) a start wavelength, an end wavelength and a reference wavelength, an expected flux density and a required signal-to-noise ratio, and finally a peak flux density estimate. The flux densities and the signal-to-noise ratio are taken to apply at the reference wavelength. The wavelengths are corrected for the radial velocity, using the non-relativistic formula.

The three wavelengths for a measurement must fall in a single AOT band as defined by table S_BANDS6 (see 12.2). The wavelength bands in these tables overlap significantly. The ordering of the bands in the table indicate which bands are preferred: the first band from the table containing all three wavelengths will be used in the AOT.

The distinction between peak and expected flux density is made because the wavelength range of a measurement may be quite large, with much variation of the flux density. The expected flux density and required SNR are used to select scan rates and gain settings; the peak flux estimates are needed to decide on gain settings.

The reference wavelength is used to for reference scans that start, conclude and possibly interrupt the measurement. The scan implementation assumes that the flux density estimates and the required SNR may be taken to apply at the reference wavelength (even if that is not included in the required wavelength range).

Estimates of the required measurement time and the achieved SNR are reported back to the observer (ignoring the savings and gains of simultaneous measurements), together with estimates of the noise-equivalent flux densities at the start and end of the range.

10.2 SWS06 Wavelength Scanning Strategy

The scan ranges are determined from the input wavelengths by means of the band definitions of S_BANDS6 and the calibration file S_GR6 (see 12.2 and 12.9).

The fastest (least sensitive) SWS06 scans employ a dwell time of 1 second and a scanner steps defined by the detector-dependent parameter MAX_STEP defined in table S_DETDEP (see 12.4).

The sensitivities are determined with the aid of calibration data in S_GR6 and S_DETECT.

A scan is executed at least twice, once "up" and once "down" ("up" is in the direction of decreasing wavelength). If the fastest scan does not give enough sensitivity, then it is slowed down. First the integration time is increased to 2 seconds, then the step size is decreased until it is as small as 2 units, then the integration time is increased as far as allowed (MAX_RESET from S_DETECT), finally the step size is reduced to 1. So the most sensitive AOT scan has a step size of 1 and a step duration equal to MAX_RESET. If such an "up-down" scan does not give the required sensitivity, the sensitivity is increased by repeating the scan. This whole process is described in procedure DEFINE_SCAN in the pseudo-code in the AOT Description.

The "up" and "down" scans are performed in two different ICS's. They will be divided into smaller scans if their duration is longer than the REF_INT parameter from table S_DETDEP (see 12.5).

10.3 SWS06 Simultaneous Measurements

The selection of mergible scan pairs is the same as in SWS02: the longest scans will be merged first and scans may be re-scheduled only if they are not longer than their prospective counterparts. The shorter of the two scans my be slowed down by reducing the step size, as long as this does not make it last longer than the counterpart scan. Then its scan length is extended to make the two durations match. For merged scans, the interval between reference scans is determined by the scan that needs the more frequent reference scans.

If no merging partner scan can be found, a scan is merged with a default scan on the other side. That this scan was not requested can be concluded only from the TDATA (see section 12).

10.4 SWS06 Reference Measurements

Reference measurements are done with intervals roughly equal to REF_INT criterion from table S_DETDEP (see 12.5). Scans shorter than REF_INT are not accompanied by reference scans. Longer scans get at least 2 reference scans, before the "up" scan and after the "down" scan. In between there may be as many refernce scans as needed to satisfy the REF_INT criterion.

The durations of the reference scans, as a function of the reset interval, are given by table S_REFDUR. For merged scans, the duration of the refernce scan is set to the maximum of the durations required for the two scans.

The reference scans are done only in the "up" direction. They use a step size equal to the reset interval. The scan length is then the ratio between duration and reset interval. They are centered on the reference wavelengths as given by the AOTs. S_BANDS6 and S_GR6 together determine the required scanner settings.

10.5 SWS06 Internal Calibrations

An internal photometric check sequence is carried out, first after roughly PHOTIM_6 seconds and then again roughly every PHOTIM_6 (see S_IDSDB, 12.10) seconds. For a short AOT, one check is done at the end. These checks have their own dark-current measurement built-in as a wait in the grating calibrator ICS.

The check sequences are determined by S_IDSDB parameters and tables S_PCTAB1 and S_SCTAB1 (see 12.14 and 12.17). An extra check high-level check to stimulate band-1 detectors at the end can be arranged by modifying an S_IDSDB parameter.

10.6 SWS06 Dark-current Measurements

The strategy in SWS06 is not to interrupt measurements for dark-current determinations. The only dark currents are taken prior to the "up" scan, or before the first reference scan, and following the "down" scan, or the concluding reference scan. The dark-currents are programmed by issuing the reference scan ICS with the same parameters as normal references scans, except that the shutter is closed and the dark-current flag raised.

10.7 SWS06 Areas of Concern

11 AOT SWS07

AOT SWS07 is described by Reference Document Nr. 4. The functionality of AOT SWS07 is defined in Applicable Document Nr. 1, the SWS Observer's Manual.

11.1 SWS07 Observing Parameters

SWS07 uses a more precise velocity correction than AOTs SWS02 and SWS06, including a correction for the orbital motion of the earth around the sun. This time- and target-dependent correction is specified in the logic. The time-dependence is such that observing times or an individual target have to be re-calculated on a monthly basis (procedure EARTH_COR in the pseudo code).

The FP measurements require a central wavelength, an expected flux density and a required SNR, like the measurements in AOT SWS02, plus a velocity range that is translated into a scan length. The output parameters are measurement duration and achieved SNR, like those of SWS02.

The SW measurements have the same input and output parameters as the measurements in SWS06; SWS07 is not designed for LW line measurements. However, the AOT bands are sligthly different from those in AOT SWS06 (compare S_BANDS6 and S_BANDS7, 12.2 and 12.3).

11.2 SWS07 Wavelength Scanning Strategy

FP scans are made in the "up" direction only, i.e. in the direction of decreasing wavelength. The reason to scan in only one direction is that the Fabry-Perot mechanism shows hysteresis, i.e. the FP gap calibration would be different for one scan direction than for the other. Each scan now starts off by moving the FP to the far end of its range, to the maximum possible gap width, then to move to the required start position and only then to start the scan. A minimum number of 3 FP scans is executed for every FP measurement (the number 3 is from S_IDSDB, 12.10)

The translation from precise wavelength to gap width requires to compute in which order the FP should work for the measurement. In many cases it is required to change the FP order during the scan, so that the FP scans have to be broken up into smaller scans, each limited to one FP order. The calibration of the FP gap width is recorded in table S_FPDRIV (see 12.8). The gap widths are corrected by a small wavelength-dependent amount, specified in table S_FPDGAP (12.7).

The strategy is always to perform at least two identical scans for a measurement, to guarantee some redundancy in the data. The step size is fixed (read from table S_FP35); the dwell time is set equal to the reset interval and set either to the value that will yield the required SNR in three scans or to the maximum (MAX_RESET from S_DETECT (12.5)). If necessary, scans are repeated to increase the SNR beyond what three scans with maximum dwell time can produce. The sensitivity depends on the responsivities as recorded in S_FP35 (see 12.6). and the detector noise as defined in S_DETECT.

The LW scanner has to preselect the right wavelength for the FP. For short FP scans, the scanner might be put in a stationary position, but in practice it is always necessary to adjust the LW scanner position during the FP scan. The approach taken is to have the LW scanner always active during the FP scan. If a stationary scanner position is desirable, the LW grating scanner step size is set to 0 and the step duration equal to the FP step duration. If the scanner has to be moved, the step size is 1 and the step duration much longer than the FP step duration. In the latter case, care is taken that the match between preselected wavelength by the grating and resonance wavelength of the FP is optimal halfway between the LW scanner steps. The LW scanner calibration is contained in S_FP35.

To achieve synchronization in scans with more than 2 grating positions, it is necessary to start the scan with the grating "ahead" by exactly 0.5 grating steps. To minimize interruptions to achieve synchronization after the scan start, the following strategies are used:

FP scans requiring only one grating step can be done without problems, the two intervals are the step durations for a one-step "up" scan and a one-step "down" scan (the latter with step size 0).

FP scans requiring more than one grating step are started earlier than needed, in a position of perfect synchronization, if the cost of the earlier start is acceptable (usually the case).

FP scans requiring more than one step and too costly to start at a point of synchronization are broken into two, a part-step and a fully synchronizied step sequence.

The SW scans are programmed as close as possible to the strategy of SWS06. Their band limits are defined in S_BANDS7 (which has an extended SW range compared to S_BANDS6 and has no LW ranges). The calibration data come from S_GR6 and S_DETECT.

As much as possible, the SW scans are programmed during FP scans. During such a scan, they always start at least with a reference scan. (SWS07 differs from other SWS AOTs in that it uplinks SW scans while the FP scan is still being executed. In all other cases ICSes are only uplinked after the previous ICS has completed all its actions.) If there is sufficient time in the FP scans, the SW measurements may be repeated so that the SW section need not remain idle.

After all FP scans that use the same aperture have been finished, the SW programme for that aperture is concluded without attempting further FP measurements. First all executed SW reference scans are repeated to match them with dark-current measurements (SW dark current measurements are not allowed during the FP measurements). Then the remaining unscheduled SW scans are programmed as they would have been in AOT SWS06, without the LW section being active.

11.3 SWS07 Simultaneous Measurements

As already indicated above, there is no real merging of SW scans and FP scans. The SW scans are programmed as far as possible during the execution of the FP programme and finished afterwards.

11.4 SWS07 Reference Measurements

For the FP scans, reference measurements are not done. For the SW scans reference measurements are done, in the first place at the start of an SW sequence generated during a set of subsequent FP scans, in the second place together with dark-current measurements after the FP measurements for the same aperture have been done. The definition of reference measurements occurs exactly as for unmerged measurements in SWS06.

11.5 SWS07 Internal Calibrations

An internal photometric check sequence is carried out, first after roughly PHOTIM_6 seconds and then again roughly every PHOTIM_6 (see S_IDSDB, 12.10) seconds. For a short AOT, one check is done at the end. These checks have their own dark-current measurement built-in as a wait in the grating calibrator ICS.

The check sequences are determined by S_IDSDB parameters and tables S_PCTAB1 and S_SCTAB1 (see 12.14 and 12.17).

An extra check high-level check to stimulate band-1 detectors at the end can be arranged by modifying an S_IDSDB parameter.

11.6 SWS07 Dark-current Measurements

FP dark-currents measurements are carried twice for each measurement: once before the first FP scan of the measurement, and once after the last FP scan of the measurement. These dark currents are taken by uplinking a separate FP-scan ICS, which closes the shutter and then executes a single step from the same start position as the neighbouring FP scan. The duration of a dark-current measurement, as determined by the ICS_DURATION is 32 seconds for the present choice of reset intervals (1 or 2 seconds).

Dark-current measurements for single SW measurements are taken as they would in AOT6, i.e. as reference scans with the shutter closed, directly preceding or following a scan or normal reference scan.

Dark-current measurements for SW measurements merged with FP measurements are postponed until all FP observations for the same aperture have been concluded. Postponed dark scans are paired with repeated reference scans.

11.7 SWS07 Areas of Concern

The measurement counters are missing in the AOT parameters listing. This is a formality.

12 AOT Tables

Each AOT table is more or less self-explanatory. The ISO/SSD/ICD-01 prescribes headers for each table with room for comments.

The tables are all fully listed, in alphabethical order. Only the very long S_GR6 and S_FP35 tables have been stripped of almost all of their entries.

For some tables, update procedures exist within the SWS Interactive Analysis environment:

UPDATE_DETECT updates the detector noise values in S_DETECT, using the SWS calibration file CAL07.

UPDATE_FP35 updates the grating wavelength calibration and related data in the table S_FP35.

UPDATE_FPDRIV updates the data in the FP drive characteristics table S_FPDRIV, using the SWS calibration file CAL12.

UPDATE_GR6 updates the grating wavelength calibration and related data in the table S_GR6.

UPDATE_LRSCAN updates the scan ranges for AOT SWS01 in the table S_LRSCAN, using the AOT tables S_GR6, S_BANDS2 and S_BANDS6 and the SWS calibration file CAL40.

UPDATE_LRSENS computes the responsitivity figures for SWS01 in the table S_LRSENS, using the AOT tables S_GR6 and S_BANDS6.

The contents of table S_FPDGAP have been copied from SWS calibration file CAL18.

12.1 S_BANDS2

This table contains the band definitions for AOT SWS02. The bands are listed in order of increasing wavelength. The wavelength ranges are defined by the start wavelength START_LAMBDA of every band, which simultaneously is the end wavelength of the previous band. The remaining three parameters define how the band must be observed: the detector array DETARRAY = 1, 2, 3, 4 for the InSb, Si:Ga, Si:As and Ge:Be array, the APERTURE = 1, 2, 3 and the grating order GR_ORDER = 1, 2, 3 or 4.

```
START_INST_TAB = S_BANDS2
VERSION        = V02.02
DATE           = 22/04/96
AUTHOR         = D.A. Beintema
COMMENT
COMMENT            AOT band definition for AOT 2
COMMENT
COMMENT          Changes in V02.00 (26/07/95):
COMMENT
COMMENT          Band 3E inserted (starting at 28.0 microns)
COMMENT
COMMENT          Changes in V02.01 (15/02/96):
COMMENT
COMMENT          Start of band 3E moved to 27.5 microns
COMMENT
COMMENT          Changes in V02.04 (22/04/96):
COMMENT
COMMENT          Start of band 2A moved from 4.05 to 4.08 microns
COMMENT
NUM_OF_KEYS    = 4
NUM_OF_ROWS    = 12
KEY_NAME01     = DETARRAY
COMMENT            The detector array (1, 2, 3, or 4)
KEY_FORM01     = I
KEY_NAME02     = APERTURE
COMMENT            SWS Aperture (1, 2 or 3)
KEY_FORM02     = I
KEY_NAME03     = GR_ORDER
COMMENT            Grating order (1, 2, 3 or 4)
KEY_FORM03     = I
KEY_NAME04     = START_LAMBDA
COMMENT            Start of the wavelength band
KEY_FORM04     = F
  1  1  4   2.38
```

```
  1  1  3   2.60
  1  2  3   3.02
  1  2  2   3.52
  2  2  2   4.08
  2  2  1   5.30
  2  3  1   7.00
  3  1  2  12.0
  3  2  2  16.5
  3  2  1  19.5
  3  3  1  27.5
  4  3  1  29.0
END_INST_TAB
```

12.2 S_BANDS6

This table contains the band definitions for AOT SWS06. The bands are listed in order of increasing wavelength. Adjacent bands have a finite wavelength overlap. START_LAMBDA and END_LAMBDA specify the start and end wavelength of a band. How the band must be observed is defined in the first three columns: the detector array DETARRAY = 1, 2, 3, 4 for the InSb, Si:Ga, Si:As and Ge:Be array, the APERTURE = 1, 2, 3 and the grating order GR_ORDER = 1, 2, 3 or 4.

```
START_INST_TAB = S_BANDS6
VERSION        = V02.02
DATE           = 22/04/96
AUTHOR         = D.A. Beintema
COMMENT
COMMENT            AOT band definition for AOT6
COMMENT
COMMENT          Changes in V2.00 (26/07/95):
COMMENT
COMMENT          Band 3E inserted (28.0-29.0 microns)
COMMENT          Band 3D (19.5-29.6) moved to end of table, to ensure that it
COMMENT          is selected only for scans that will not fit in band 3E
COMMENT          or band 4 (now 28.0 to 45.2 microns)
COMMENT
COMMENT          Changes in V2.01 (15/01/96):
COMMENT
COMMENT          Bands 3D, 3E and 4 back in order of wavelength,
COMMENT          Transition to 3E maoved rom 28.0 to 27.5 microns,
COMMENT          Overlaps between bands 3D, 3E and 4 removed
COMMENT
COMMENT          Changes in V2.02 (22/04/96):
COMMENT
COMMENT          End of band 1E moved from 4.06 to 4.08 microns,
COMMENT
NUM_OF_KEYS    = 5
NUM_OF_ROWS    = 12
KEY_NAME01     = DETARRAY
COMMENT            The detector array (1, 2, 3, or 4)
KEY_FORM01     = I
KEY_NAME02     = APERTURE
COMMENT            SWS Aperture (1, 2 or 3)
KEY_FORM02     = I
KEY_NAME03     = GR_ORDER
COMMENT            Grating order (1, 2, 3 or 4)
```

```
KEY_FORM03      = I
KEY_NAME04      = START_LAMBDA
COMMENT             Start of the wavelength band
KEY_FORM04      = F
KEY_NAME05      = END_LAMBDA
COMMENT             End of the wavelength band
KEY_FORM05      = F
  1  1  4   2.38   2.61
  1  1  3   2.60   3.03
  1  2  3   3.02   3.53
  1  2  2   3.52   4.08
  2  2  2   4.05   5.31
  2  2  1   5.30   7.01
  2  3  1   7.00  12.1
  3  1  2  12.0   16.6
  3  2  2  16.5   19.6
  3  2  1  19.5   27.6
  3  3  1  27.5   29.0
  4  3  1  28.9   45.2
END_INST_TAB
```

12.3 S_BANDS7

This table contains the band definitions for SW grating observations in AOT SWS07. The bands are listed in order of increasing wavelength. Adjacent bands have a finite wavelength overlap. START_LAMBDA and END_LAMBDA specify the start and end wavelength of a band. How the band must be observed is defined in the first three columns: the detector array DETARRAY = 1, 2, 3, 4 for the InSb, Si:Ga, Si:As and Ge:Be array, the APERTURE = 1, 2, 3 and the grating order GR_ORDER = 1, 2, 3 or 4.

```
START_INST_TAB = S_BANDS7
VERSION        = V00.08
DATE           = 22/04/96
AUTHOR         = D.A. Beintema
COMMENT
COMMENT            AOT band definition for AOT7
COMMENT
NUM_OF_KEYS    = 5
NUM_OF_ROWS    = 7
KEY_NAME01     = DETARRAY
COMMENT            The detector array (1, 2, 3, or 4)
KEY_FORM01     = I
KEY_NAME02     = APERTURE
COMMENT            SWS Aperture (1, 2 or 3)
KEY_FORM02     = I
KEY_NAME03     = GR_ORDER
COMMENT            Grating order (1, 2, 3 or 4)
KEY_FORM03     = I
KEY_NAME04     = START_LAMBDA
COMMENT            Start of the wavelength band
KEY_FORM04     = F
KEY_NAME05     = END_LAMBDA
COMMENT            End of the wavelength band
KEY_FORM05     = F
COMMENT
COMMENT          Changes in V0.08 (22/04/96):
COMMENT
COMMENT          End of band 1E moved from 4.06 to 4.08 microns,
COMMENT
  1  1  4   2.38   2.61
  1  1  3   2.60   3.03
  1  2  3   3.02   3.53
  1  2  2   3.52   4.08
  2  2  2   4.05   5.31
```

```
  2  2  1   5.30   7.01
  2  3  1   7.00  13.16
END_INST_TAB
```

12.4 S_DETDEP

This table contains some instrument constants that indirectly depend on the detector array being used: the grating resolution in scanner position counts, needed to compute signal-to-noise, the maximum step size (again in scanner position counts) and the maximum time interval between reference scans. The latter two parameters are needed to define grating scan scenarios in AOTs SWS06 and SWS07.

```
START_INST_TAB = S_DETDEP
VERSION        = V01.00
DATE           = 14/03/96
AUTHOR         = D.A. Beintema
COMMENT
COMMENT            Indirect detector dependencies
COMMENT
NUM_OF_KEYS    = 4
NUM_OF_ROWS    = 4
KEY_NAME01     = DETARRAY
COMMENT            DETARRAY identifies the detector band
COMMENT            DETARRAY equals either 1, 2, 3, 4
KEY_FORM01     = I
KEY_NAME02     = RES_EL
COMMENT            spectral resolution element, expressed in scanner units
KEY_FORM02     = F
KEY_NAME03     = MAX_STEP
COMMENT            coarsest allowable step in a scan,
COMMENT            expressed in scanner units
KEY_FORM03     = I
KEY_NAME04     = REF_INT
COMMENT            Recommended interval between reference measurements,
COMMENT            expressed in seconds
KEY_FORM04     = F
  1  4.5 4 8000
  2  4.5 4 1000
  3  4.5 4 1000
  4  7.5 6 1000
END_INST_TAB
```

12.5 S_DETECT

Noise characteristics per detector array (cf. SWS Observers Manual) and maximum sensible reset interval

IA procedure UPDATE_DETECT will replace the noise values in the table by values derived from data analaysis (CAL07).

```
START_INST_TAB = s_detect
VERSION        = V01.00
DATE           = 96/01/18
AUTHOR         = D.A. Beintema
COMMENT
COMMENT            Detector noise characteristics
COMMENT            The expected noise with an integration time T seconds
COMMENT            and a signal of S microvolts per second equals the
COMMENT            square root of the sum of the squares of the following
COMMENT            3 noise terms:
COMMENT
COMMENT                READ_NOISE / T,
COMMENT                DARK_NOISE / sqrt (T),
COMMENT                SHOT_NOISE * sqrt (S / T)
COMMENT
COMMENT         15/01/96: DARK_NOISE values increased to conform
COMMENT                   to in-flight observed nouse at reset 2 secs
COMMENT
COMMENT         18/01/96: column MAX_RESET added
COMMENT
NUM_OF_KEYS    = 5
NUM_OF_ROWS    = 6
KEY_NAME01     = DETARRAY
COMMENT            DETARRAY identifies the detector band
COMMENT            DETARRAY equals either 1, 2, 3, 4, 5 or 6
KEY_FORM01     = I
KEY_NAME02     = READ_NOISE
COMMENT            microvolts
KEY_FORM02     = F
KEY_NAME03     = DARK_NOISE
COMMENT            Current noise (microvolt/s at 1 sec integer time)
KEY_FORM03     = F
KEY_NAME04     = SHOT_NOISE
COMMENT            Signal-dependent current noise (microvolts/s at 1 sec
COMMENT            integr.time and 1 microvolt/s signal)
```

```
KEY_FORM04     = F
KEY_NAME05     = MAX_RESET
COMMENT            maximum reset interval (seconds)
KEY_FORM05     = I
  1  0.75  0.74  0.10   4
  2  0.75  1.90  0.13   2
  3  1.00  3.90  0.14   2
  4  1.56  5.20  0.32   2
  5  0.63  1.24  0.18   2
  6  0.89  1.15  0.13   2
END_INST_TAB
```

12.6 S_FP35

Main table for FP observations: Contains the grating calibration, band definition and wavelength-dependent properties of the Fabry-Perots, over-all responsivity as a function of wavelength. Constraints: the scanner positions are expected to be integers; the wavelengths must be ascending, the increments can be freely chosen.

IA procedure UPDATE_FP35 will replace the wavelength calibration in this table.

```
START_INST_TAB = s_fp35
VERSION        = V10.00
DATE           = 21-May-1996
AUTHOR         = D.A. Beintema, E. Valentijn, D. Kunze
COMMENT
COMMENT            A single table describing the properties of the FP-grating
COMMENT            combination, with the wavelength as the main entry
COMMENT
COMMENT            Responsivity column updated, as specified in the SWS PV
COMMENT            performance report, dd. 12-01-96, presented at the
COMMENT            Revolution 56 milestone meeting.
COMMENT
COMMENT            29-Feb: aperture 3 changed to 4, pseudo aperture
COMMENT                    to correct for internal misalignment SWS
COMMENT
COMMENT            14-Mar: aperture 4 changed back to 3,
COMMENT                    precision of LAMBDA_1, LAMBDA_2 and SCAN_RATIO
COMMENT                    increased.
COMMENT
COMMENT            01-Apr: aperture 3 changed to 4, pseudo aperture
COMMENT                    to correct for internal misalignment SWS
COMMENT
COMMENT            21-May: band-6 responsivities increased 25%,
COMMENT                    because of change to aperture 4
COMMENT
NUM_OF_KEYS    = 11
NUM_OF_ROWS    = 1405
KEY_NAME01     = LAMBDA_1
KEY_FORM01     = F
KEY_NAME02     = LAMBDA_2
KEY_FORM02     = F
COMMENT            LAMBDA_1 and LAMBDA_2 are the begin and end points
COMMENT            of a short wavelength range for which the other
COMMENT            variables are applicable (units: micrometers).
```

```
KEY_NAME03     = APERTURE
KEY_FORM03     = I
COMMENT          APERTURE denotes the aperture through which these
COMMENT          wavelengths should be observed.
KEY_NAME04     = DETARRAY
KEY_FORM04     = I
COMMENT          DETARRAY denotes the detector with which these wavelengths
COMMENT          should be observed.
KEY_NAME05     = GR_SCANPOS_A
KEY_FORM05     = I
COMMENT          GR_SCANPOS_A is the long-wavelength grating scanner
COMMENT          position at wavelength LAMBDA_A.
KEY_NAME06     = GR_D_LAMBDA
KEY_FORM06     = F
COMMENT          GR_D_LAMBDA is the change in wavelength due to a grating
COMMENT          scanner step of one unit.
KEY_NAME07     = FP_POS_STEP
KEY_FORM07     = I
COMMENT          FP_POS_STEP is the change in FP scanner position between two
COMMENT          integrations.
KEY_NAME08     = SCAN_RATIO
KEY_FORM08     = F
COMMENT          SCAN_RATIO is the change in FP scanner position required to
COMMENT          keep up with a unit change in the grating scanner position.
KEY_NAME09     = TRACK_LIM
KEY_FORM09     = F
COMMENT          TRACK_LIM  is the maximum FP scan range that does not need
COMMENT          tracking with the grating.
KEY_NAME10     = FP_RESOLUTION
KEY_FORM10     = F
COMMENT          FP_RESOLUTION is the resolving power of the FP
KEY_NAME11     = RESPONSIVITY
KEY_FORM11     = F
COMMENT          The instrument responsivity (microvolts / Jansky)
COMMENT
 11.398938  11.409036  1  5  3479 -0.0012617  2  28.80  1  20615 1.80330E-02
 11.409036  11.416606  1  5  3471 -0.0012627  2  28.79  1  20615 1.80330E-02
   .          .        .  .   .    .          .    .    .          .
 44.441338  44.471573  4  6   603 -0.0033607  2  18.79  1  30933 5.81842E-04
 44.471573  44.501801  4  6   594 -0.0033607  2  18.78  1  30933 5.42130E-04
END_INST_TAB
```

12.7 S_FPDGAP

Lists the gap corrections for the FP as a function of wavelength.

The contents of this table have been copied from SWS calibration file CAL18.

```
START_INST_TAB = s_fpdgap
VERSION        = V01.00
DATE           = 96/01/21
AUTHOR         = D.A. Beintema
COMMENT
COMMENT            Wavelength-dependence of Fabry-Perot gap width
COMMENT
COMMENT            For the short-wave FP (detector band 5):
COMMENT            (Double gap width) = nominal (double gap width)
COMMENT                                 + 2 * D_GAP_1
COMMENT
COMMENT            For the long-wave FP (detector band 6): use D_GAP_2
COMMENT
COMMENT            21/01/96: V01.00 created,  D.A. Beintema
COMMENT
NUM_OF_KEYS    = 4
NUM_OF_ROWS    = 40
KEY_NAME01     = DGAP_COUNT
COMMENT            counts table entries
KEY_FORM01     = I
KEY_NAME02     = DGAP_LAMBDA
COMMENT            microns
KEY_FORM02     = F
KEY_NAME03     = DGAP_1
COMMENT            Gap correction for FP1 (detector band 5), microns
KEY_FORM03     = F
KEY_NAME04     = DGAP_2
COMMENT            Gap correction for FP2 (detector band 6), microns
KEY_FORM04     = F
      1        10.0       1.200     0.000
      2        11.0       1.061     0.000
      3        12.0       0.807     0.000
      4        13.0       0.618     0.000
      5        14.0       0.475     0.000
      6        15.0       0.366     0.000
      7        16.0       0.281     0.000
      8        17.0       0.215     0.000
```

```
     9         18.0         0.162      0.296
    10         19.0         0.121      0.230
    11         20.0         0.088      0.174
    12         21.0         0.062      0.127
    13         22.0         0.041      0.088
    14         23.0         0.024      0.054
    15         24.0         0.010      0.025
    16         25.0         0.000      0.000
    17         26.0        -0.009     -0.021
    18         27.0        -0.015     -0.040
    19         28.0        -0.020     -0.056
    20         29.0        -0.024     -0.070
    21         30.0        -0.026     -0.082
    22         31.0        -0.028     -0.093
    23         32.0        -0.029     -0.103
    24         33.0        -0.030     -0.111
    25         34.0         0.000     -0.118
    26         35.0         0.000     -0.125
    27         36.0         0.000     -0.131
    28         37.0         0.000     -0.136
    29         38.0         0.000     -0.141
    30         39.0         0.000     -0.145
    31         40.0         0.000     -0.148
    32         41.0         0.000     -0.152
    33         42.0         0.000     -0.154
    34         43.0         0.000     -0.157
    35         44.0         0.000     -0.159
    36         45.0         0.000     -0.161
    37         46.0         0.000     -0.163
    38         47.0         0.000     -0.165
    39         48.0         0.000     -0.166
    40         49.0         0.000     -0.167
END_INST_TAB
```

12.8 S_FPDRIV

Contains calibration data of the adjustable FP etalon.

IA procedure UPDATE_FPDRIV updates the data in this table, using the SWS calibration file CAL12.

```
START_INST_TAB = s_fpdriv
VERSION        = V03.00
DATE           = 25-Jan-1996
AUTHOR         = D.A. Beintema, H.Feuchtgruber
COMMENT
COMMENT            FP drive calibration data for both FP bands.
COMMENT            The table avoids the extreme ends of the scan range.
COMMENT
NUM_OF_KEYS    = 5
NUM_OF_ROWS    = 2
KEY_NAME01     = DETARRAY
COMMENT            DETARRAY identifies the detectors to be used.
COMMENT            DETARRAY equals either 5 or 6
KEY_FORM01     = I
KEY_NAME02     = MIN_FPD
COMMENT            Twice the minimum gap width, in microns
KEY_FORM02     = F
KEY_NAME03     = MAX_FPD
COMMENT            Twice the maximum gap width, in microns
KEY_FORM03     = F
KEY_NAME04     = MIN_POS
COMMENT            MIN_POS is the digital scan position corresponding to
COMMENT            double gap width MIN_FPD
KEY_FORM04     = I
KEY_NAME05     = D_FPD
COMMENT            D_FPD is the change in the double gap width due to
COMMENT            one positive step in scan position
KEY_FORM05     = F
  5   24999.84   25032.07  340  -0.096211
  6   24980.28   25029.24  490  -0.100741
END_INST_TAB
```

12.9 S_GR6

Contains the wavelength and responsivity calibration of the grating spectrometer. The table contains effectively a sub-table for each AOT and, as defined by the combination of aperture, grating order and detector array. Within each sub-table the wavelengths are ascending. The bands are defined with maximal overlap. Constraints: the scanner positions are always integers, the increments in the table are free to choose and may vary.

IA procedure UPDATE_GR6 updates the grating wavelength calibration and related data in this table.

```
START_INST_TAB = s_gr6
VERSION        = V08.00
DATE           = 15-Jan-1996
AUTHOR         = D.A. Beintema, E. Valentijn
COMMENT
COMMENT          A single table describing the wavelength and responsivity
COMMENT          calibration of the grating section of SWS.
COMMENT
COMMENT
COMMENT          Responsivity column updated, as specified in the SWS PV
COMMENT          performance report, dd. 12-01-96, presented at the
COMMENT          Revolution 56 milestone meeting.
COMMENT
NUM_OF_KEYS    = 8
NUM_OF_ROWS    = 731
KEY_NAME01     = LAMBDA_1
KEY_FORM01     = F
KEY_NAME02     = LAMBDA_2
KEY_FORM02     = F
COMMENT            LAMBDA_1 and LAMBDA_2 are the begin and end points
COMMENT            of a short wavelength range for which all data in the line
COMMENT            apply (units: micrometers).
KEY_NAME03     = APERTURE
KEY_FORM03     = I
COMMENT            APERTURE denotes the aperture through which this range
COMMENT            should be observed.
KEY_NAME04     = DETARRAY
KEY_FORM04     = I
COMMENT            DETARRAY denotes the detector array with which this
COMMENT            range should be observed.
KEY_NAME05     = GR_ORDER
KEY_FORM05     = I
```

```
COMMENT              Grating order
KEY_NAME06     = SCANPOS
KEY_FORM06     = I
COMMENT              SCANPOS is the grating scanner setting that puts LAMBDA_1
COMMENT              in the middle of detector array DETARRAY
KEY_NAME07     = GR_D_LAMBDA
KEY_FORM07     = F
COMMENT              GR_D_LAMBDA is the change in wavelength due to a grating
COMMENT              scanner step of one unit.
KEY_NAME08     = RESPONSIVITY
KEY_FORM08     = F
COMMENT              The instrument responsivity (microvolts / Jansky)
    2.360    2.371    1    1    4   3647   -0.000298    1.080
    2.371    2.382    1    1    4   3610   -0.000297    1.054
      .        .      .    .    .     .        .           .
   44.821   45.007    3    4    1    612   -0.003342    0.539
   45.007   45.200    3    4    1    556   -0.003330    0.493
END_INST_TAB
```

12.10 S_IDSDB

The Instrument Default Settings Data Base contains loose instrument parameters and constants. In particular, the frequencies of internal calibrations and some dark-current measurements are controlled through S_IDSDB parameters.

```
START_INST_TAB  = s_idsdb
VERSION         = V00.15
DATE            = 96/01/23
AUTHOR          = D.A. Beintema
NUM_ENTRIES     = 54
COMMENT        SWS Instrument Default Settings DB
COMMENT
COMMENT        95/11/06, V00.11:
COMMENT                  A. Plug Added SAFETY_BUF used when calculating the
COMMENT                  AOT clock for the next ICS to be issued.
COMMENT
COMMENT        15/01/96, V00.12:
COMMENT                   Photocheck parameters, WAIT and MAX_INT
COMMENT
COMMENT        18/01/96, V00.13:
COMMENT                   SWSC_STINP_24 increased
COMMENT
COMMENT        19/01/96, V00.14:
COMMENT                   MIN_FP_SCANS added, FP_BREAK_LIM added,
COMMENT                   WAIT reduced (for double wait),MIN_STEPS increased
COMMENT
COMMENT        23/01/96, V00.15:
COMMENT                   typos removed
N_GC_GR         =  1
N_PC_GR         =  0
N_GC_FP         =  1
N_PC_FP         =  0
N_GC_7          =  1
N_PC_7          =  0
COMMENT
COMMENT        Photometry check - minimum interval (seconds) between
COMMENT        responsivity checks - separate values for all AOTs
PHOTIM_1        = 3600
PHOTIM_2        = 3600
PHOTIM_6        = 3600
PHOTIM_7        = 3600
COMMENT
```

```
COMMENT         Grating scanner check ICS parameters (SS0002)
COMMENT         All AOTs
GC_SWSC_HEADER   = 128
GC_LWSC_HEADER   = 128
COMMENT
COMMENT         Maximum integration interval, in seconds
MAX_INT          = 2
COMMENT
COMMENT         Maximum allowed expected pre-amplifier ramp-heights
COMMENT         (expected signal (Jansky's)
COMMENT             * responsivity (microvolts/second/Jansky)
COMMENT             * integration interval (seconds)
COMMENT             * gain (1, 4 or 16))
COMMENT         For AOTs 6 and 7 (SW grating):
MAX_RAMP         = 20000
COMMENT         For AOT 1:
MAX_RAMP_1       = 8000
COMMENT         FOR AOT 2:
MAX_RAMP_2       = 8000
COMMENT         For AOT 7 (FP):
MAX_RAMP_7       = 40000
COMMENT
COMMENT         Minimum number of steps in an AOT 6 or 7 grating scan
MIN_STEPS        = 50
COMMENT
COMMENT         Scan ICS parameters (SS0005-SS0006)
COMMENT         Common to all AOTs
WAIT             = 160
FLAGS_S          = 44
FLAGS_L          = 76
FLAGS_F          = 204
FLAGS_SL         = 108
FLAGS_SF         = 236
RUN_FL_INI_1     = 0
RUN_FL_INI_2     = 12
SHUTTR_INI       = 0
COMMENT
COMMENT         Grating scan ICS parameters (SS0005)
COMMENT         AOTs 2&4
SWSC_HEADER_24   = 128
SWSC_NSTPP_24    = 50
SWSC_STSZP_24    = 1
LWSC_HEADER_24   = 128
```

```
LWSC_STSZP_24_1 = 2
LWSC_STSZP_24_2 = 1
COMMENT
COMMENT        FP scan ICS parameters (SS0009)
COMMENT        AOT 7
OVERLAP         = 1
T_DARK          = 800
LWSC_HEADER_35  = 128
LWSC_STSZP_35   = 1
LWSC_STSZN_35   = 1
LWSC_STINN_35   = 0
LWSC_NSCAN_35   = 1
FP_HEADER_35_1  = 140
FP_HEADER_35_2  = 156
FP_NSTEPSN_35   = 0
FP_STSIZEN_35   = 0
FP_STPINTN_35   = 0
DARK_WAIT       = 1
DARK_SCAN       = 0
COMMENT        Execution flags for the high-level photometric check
COMMENT        at the conclusion of an AOT.
HI_LEVEL_CHECK_1       = 0
HI_LEVEL_CHECK_2       = 0
HI_LEVEL_CHECK_6       = 0
HI_LEVEL_CHECK_7       = 0
COMMENT        Safety buffer or margin used when calculating the
COMMENT        AOT clock for the next ICS to be issued.
SAFETY_BUF      = 4
COMMENT        Minimum number of FP scans in an AOT 7 measurement
MIN_FP_SCANS    = 3
COMMENT        Maximum duration allowed to change first fractional grating
COMMENT        step in FP scan to a full one.
FP_BREAK_LIM    = 45
END_INST_TAB
```

12.11 S_LRRATE

Defines the scan strategies for the four various SPEEDs of AOT SWS01. SWSC_STSZP is the step size of a single grating scanner step in digital scanner units. SWSC_STINP defines the dwell time at a specific SW grating scanner position in telemetry frames (1/16 seconds).

```
START_INST_TAB = S_LRRATE
VERSION        = V00.01
DATE           = 05/10/93
AUTHOR         = D.A. Beintema
COMMENT
COMMENT            Grating scan rates for AOT1
COMMENT
NUM_OF_KEYS    = 3
NUM_OF_ROWS    = 4
KEY_NAME01     = SPEED
COMMENT            AOT parameter (1, 2, 3 or 4)
KEY_FORM01     = I
KEY_NAME02     = SWSC_STSZP
COMMENT            SW grating scanner step size
KEY_FORM02     = I
KEY_NAME03     = SWSC_STINP
COMMENT            SW grating scanner step duration
KEY_FORM03     = I
  1    4    2
  2    2    2
  3    1    2
  4    1    4
END_INST_TAB
```

12.12 S_LRSCAN

Defines the scan ranges in AOT SWS01 for every of the three APERTUREs. SWSC_STPOS and LWSC_STPOS are the start positions for the SW and LW scanner, respectively. The SCANLENGTH applies to both the SW and the LW scan.

IA procedure UPDATE_LRSCAN updates the scan ranges for AOT SWS01 in this table, using the AOT tables S_GR6, S_BANDS2 and S_BANDS6 and the SWS calibration file CAL40.

```
START_INST_TAB = S_LRSCAN
VERSION        = V1.7
DATE           = 15-Jan-1996
AUTHOR         = D.A. Beintema, D. Kunze
COMMENT
COMMENT            Grating scan definitions for AOT1 (FM)
COMMENT
NUM_OF_KEYS    = 4
NUM_OF_ROWS    = 3
KEY_NAME01     = APERTURE
COMMENT            One of the three SWS apertures
COMMENT            APERTURE  equals either 1, 2, 3
KEY_FORM01     = I
KEY_NAME02     = SWSC_STPOS
COMMENT            Start position for the SW grating scanner
KEY_FORM02     = I
KEY_NAME03     = LWSC_STPOS
COMMENT            Start position for the LW grating scanner
KEY_FORM03     = I
KEY_NAME04     = SCANLENGTH
COMMENT            Length of scanner range
KEY_FORM04     = I
  1  2719 3858 2381
  2  1995 2216 5116
  3   862  460 4839
END_INST_TAB
```

12.13 S_LRSENS

Contains the RESPONSIVITY numbers, needed to determine reasonable gain settings for the 4 grating detector bands DETARRAY 1 to 4 in AOT SWS01. A gain of 0, 1 or 2 with an amplification of 1x, 4x or 16x is selected for a band, if two times the user-specified peak flux in [Jy] times the responsivity of the band in [uV/s per Jy] is greater than 2000, inbetween 500 and 2000, or lower than 500 [uV/s].

IA procedure UPDATE_LRSENS computes the responsitivity figures for SWS01 in this table, using the AOT tables S_GR6 and S_BANDS6.

```
START_INST_TAB = s_lrsens
VERSION        = V00.09
DATE           = 15/01/96
AUTHOR         = D.A. Beintema
COMMENT
COMMENT            Peak responsivities for AOT1
COMMENT            Used only to determine GAINs
COMMENT
NUM_OF_KEYS    = 2
NUM_OF_ROWS    = 4
KEY_NAME01     = DETARRAY
COMMENT            DETARRAY identifies the detector band
COMMENT            DETARRAY equals either 1, 2, 3, 4
KEY_FORM01     = I
KEY_NAME02     = RESPONSIVITY
COMMENT            microvolts/second per Jansky
KEY_FORM02     = F
  1  1.3
  2  1.6
  3  4.1
  4  1.4
END_INST_TAB
```

12.14 S_PCTAB1

Note: this table is presently not used

Parameters for diffuse calibrator checks in the grating AOTs SWS01, SWS02 and SWS06.

PC_INTERVAL is the length of the time the diffuse calibrator is switched on in units of 1 format length divided by 32. The current length is two times the length of a format of 1/16 seconds. PC_DIFFUS_HILO is the intensity level of the diffuse calibrator and PC_COUNT a counter in the set of diffuse calibrator checks.

```
START_INST_TAB  = S_PCTAB1
VERSION         = V00.02
DATE            = 01/07/94
AUTHOR          = Beintema
COMMENT             Table for diffuse calibrator checks for grating-only
COMMENT             AOTs (i.e. AOTs 1, 2 and 6)
NUM_OF_KEYS     = 3
NUM_OF_ROWS     = 2
KEY_NAME01      = PC_INTERVAL
KEY_FORM01      = I
KEY_NAME02      = PC_DIFFUS_HILO
KEY_FORM02      = C
KEY_NAME03      = PC_COUNT
KEY_FORM03      = I
  64   CS_DIFFUS_LO   1
  64   CS_DIFFUS_HI   2
END_INST_TAB
```

12.15 S_PCTAB2

Note: this table is presently not used

Parameters for diffuse calibrator checks in the FP AOT SWS07.

PC_INTERVAL is the length of the time the diffuse calibrator is switched on in units of 1 format length divided by 32. The current length is two times the length of a format of 1/16 seconds. PC_DIFFUS_HILO is the intensity level of the diffuse calibrator and PC_COUNT a counter in the set of diffuse calibrator checks.

```
START_INST_TAB  = S_PCTAB2
VERSION         = V00.02
DATE            = 01/07/94
AUTHOR          = Beintema
COMMENT             Table for diffuse calibrator checks for AOT 7
NUM_OF_KEYS     = 3
NUM_OF_ROWS     = 2
KEY_NAME01      = PC_INTERVAL
KEY_FORM01      = I
KEY_NAME02      = PC_DIFFUS_HILO
KEY_FORM02      = C
KEY_NAME03      = PC_COUNT
KEY_FORM03      = I
  64   CS_DIFFUS_LO   1
  64   CS_DIFFUS_HI   2
END_INST_TAB
```

12.16 S_REFDUR

Specifies the relationship between reset interval STEP_DUR of 1, 2, 4, or 8 seconds and the reference scan duration REF_DUR for AOTS SWS06 and SWS07 (SW).

```
START_INST_TAB = S_REFDUR
VERSION        = V00.01
DATE           = 25/07/93
AUTHOR         = D.A. Beintema
COMMENT
COMMENT            Dependence of the duration of a reference scan on
COMMENT            the length of a reset interval
COMMENT
NUM_OF_KEYS    = 2
NUM_OF_ROWS    = 4
KEY_NAME01     = STEP_DUR
COMMENT            reset interval length (seconds)
KEY_FORM01     = I
KEY_NAME02     = REF_DUR
COMMENT            reference scan duration
KEY_FORM02     = I
1   8
2   8
4  16
8  32
END_INST_TAB
```

12.17 S_SCTAB1

Grating calibrator scan parameters for the grating AOTs SWS01, SWS02 and SWS06.

GC_SWSC_STPOS defines the start position for the SW grating scanner check, GC_SWSC_NSTPP the number of steps to be executed and GC_SWSC_STSZP the step size in digital scanner units. GC_LWSC_STPOS, GC_LWSC_NSTPP and GC_LWSC_STSZP are the values for the LW scanner, respectively. GC_INTERVAL is the duration of the grating scan in a grating scanner check in units of 1 format length divided by 32. GC_INTERVAL = (1+GC_SWSC_NSTPP)∗16 = (1+GC_LWSC_NSTPP)∗16. GC_GRACAL_HILO is the intensity level of the diffuse calibrator and PC_COUNT a counter in the set of diffuse calibrator checks.

```
START_INST_TAB  = s_sctab1
VERSION         = V00.07
DATE            = 94/11/28
AUTHOR          = Beintema
COMMENT        Grating scanner table for AOTs 1, 2, 6
COMMENT           row 1 for the regular photometeric check,
COMMENT           row 2 to stimulate band 1 detectors
NUM_OF_KEYS     = 9
NUM_OF_ROWS     = 2
KEY_NAME01      = GC_SWSC_STPOS
KEY_FORM01      = I
KEY_NAME02      = GC_SWSC_NSTPP
KEY_FORM02      = I
KEY_NAME03      = GC_SWSC_STSZP
KEY_FORM03      = I
KEY_NAME04      = GC_LWSC_STPOS
KEY_FORM04      = I
KEY_NAME05      = GC_LWSC_NSTPP
KEY_FORM05      = I
KEY_NAME06      = GC_LWSC_STSZP
KEY_FORM06      = I
KEY_NAME07      = GC_INTERVAL
KEY_FORM07      = I
KEY_NAME08      = GC_GRACAL_HILO
KEY_FORM08      = C
KEY_NAME09      = GC_COUNT
KEY_FORM09      = I
   1500  20    2     1200  20    3     336   CS_GRATNG_LO   1
   1500  20    2     1200  20    3     336   CS_GRATNG_HI   2
END_INST_TAB
```

12.18 S_SCTAB2

Grating calibrator scan parameters for the Fabry-Perot AOT SWS07.

GC_SWSC_STPOS defines the start position for the SW grating scanner check, GC_SWSC_NSTPP the number of steps to be executed and GC_SWSC_STSZP the step size in digital scanner units. GC_LWSC_STPOS, GC_LWSC_NSTPP and GC_LWSC_STSZP are the values for the LW scanner, respectively. GC_INTERVAL is the duration of the grating scan in a grating scanner check in units of 1 format length divided by 32. GC_INTERVAL = (1+GC_SWSC_NSTPP)∗16 = (1+GC_LWSC_NSTPP)∗16. GC_GRACAL_HILO is the intensity level of the diffuse calibrator and PC_COUNT a counter in the set of diffuse calibrator checks.

```
START_INST_TAB  = s_sctab2
VERSION         = V00.07
DATE            = 94/11/28
AUTHOR          = Beintema
COMMENT         Grating scanner table for AOT 7
COMMENT            row 1 for the regular photometeric check,
COMMENT            row 2 to stimulate band 1 detectors
NUM_OF_KEYS     = 9
NUM_OF_ROWS     = 2
KEY_NAME01      = GC_SWSC_STPOS
KEY_FORM01      = I
KEY_NAME02      = GC_SWSC_NSTPP
KEY_FORM02      = I
KEY_NAME03      = GC_SWSC_STSZP
KEY_FORM03      = I
KEY_NAME04      = GC_LWSC_STPOS
KEY_FORM04      = I
KEY_NAME05      = GC_LWSC_NSTPP
KEY_FORM05      = I
KEY_NAME06      = GC_LWSC_STSZP
KEY_FORM06      = I
KEY_NAME07      = GC_INTERVAL
KEY_FORM07      = I
KEY_NAME08      = GC_GRACAL_HILO
KEY_FORM08      = C
KEY_NAME09      = GC_COUNT
KEY_FORM09      = I
   1500  20    2     4690  20    3     336   CS_GRATNG_LO   1
   1500  20    2     1200  20    3     336   CS_GRATNG_HI   2
END_INST_TAB
```

13 TDATA

The TDATA (short for Transparent Data) constitute a stream of message texts that are generated in the uplink process. These messages are merged with the satellite telemetry and serve to support Quick-Look and Off-Line Data Analysis. A limitation of the TDATA is that they can be only loosely synchronized with the telemetry.

The TDATA area is a field of 368 bytes. TDATA messages are updates of individual elements in the TDATA area. Much of the TDATA reflects administration outside the realm of the AOT implementation. Information addressed in the AOT description concerns the following TDATA items:

13.1 AOT-level TDATA

This information is defined at the start of the AOT and remains valid during the execution of the AOT.

- AOT (bytes 8-11). Identifies the AOT, e.g. "S02␣" for AOT SWS02.
- TDT_C (bytes 40-42). Assigned the value "OBS", indicating that the AOT does normal observations.
- AOTVAR, bytes 304-307, raster dimensions. Always "␣1␣1" with SWS, because the SWS AOTs do not use raster scans.
- AOTVAR, bytes 308-312, observation duration, expressed in seconds.
- AOTVAR, bytes 334-340, radial velocity. Used to echo the radial velocity entered by the observer. E.g "␣␣␣␣127" for 127 km/s (blank in AOT 1).

13.2 TDATA per aperture

The aperture is coded into bytes 16 and 17 of the TDATA area. Possible values: "S1", "S2", "S3" and "S4", associated with the start of measurements through aperture 1, aperture 2, aperture 3 or pseudo-aperture 4.

13.3 TDATA per ICS

The following data are updated at the start of an ICS:

- QLA_SIG (bytes 0-5). This is a group of 6 bytes reserved for messages directed at the user of Quick-Look Analysis. The SWS AOTs use this field to echo the generic ICS number (e.g. “5” for ICS SS0005) and to indicate the duration of the ICS, expressed in minutes. Example: QLA_SIG “␣512 ␣ ␣” would be issued close to the start of a grating scan (ICS SS0005) lasting 11.6 minutes. For merged FP and SW scans in AOT SWS07, the QLA_SIGs with apply only till the uplink of the next SW scan.

- Scan Type (byte 28). This byte is set to the values “␣”, “L”,“N” or “R”. “L” is used to mark grating scans at reduced resolution (i.e. grating scans executed in AOT SWS01). “R” denotes a reference grating scan, with the shutter either open or closed (AOTs SWS06 and SWS07). ”N” denotes a ”normal” grating or FP scan or dark-current measurement. A blank will indicate a calibration measurement or a reset ICS. In AOT SWS07, TDATA updates for SW reference scans executed during an FP scan will change the scan type temporarily to “R”.
- Measurement numbers (bytes 129-130 and bytes 131-132, not used in AOT SWS01). These measurement numbers can link ICSs to specific measurements requested by the observer. The measurement numbers simply count the measurements of spectral lines or spectral ranges, in the order in which the observer provided them, starting at 0. AOTs SWS02 and SWS06 have a single measurement counter; SWS07 has separate counters for the SW and the FP measurements. For any measurement to do with a specific observation or with a specific pair of observations, the measurement numbers are inserted in the TDATA. Measurement numbers for SW grating observations are stored in bytes 129-130, LW or FP scans are marked in bytes 131-132. In case of single (non-merged) measurements, the unused field is filled with blanks. The fields are also filled with blanks for ICSes not associated with particular measurements (photometric checks, reset ICSes).
- DETARRAY (bytes 133 and 134, not for SWS01). For each filled Measurement field (see above) a DETARRAY field is filled as well. Byte 133 can contain ’1’ or ’2’, for a grating measurement with detector array 1 (InSb) or 2 (Si:Ga). Byte 134 can contain ’3’ thru ’6’, for arrays 3 and 4 (Si:As or Ge:Be) or 5 and 6 (Si:Sb or Ge:Be FP detectors).
- Expected flux densities (bytes 135-142 and 143-150, not for SWS01). For each filled Measurement field (see above) an expected flux density is filled in as well. Bytes 135-142 are reserved for flux densities expected for SW grating measurements, bytes 143-150 are reserved for LW grating or FP measurements.

14 Cross-Reference Matrices, ICSes and Tables vs. AOTs

ICS file	Description	AOT Number			
		1	2	6	7
ICS SS0001	diffuse calibrators	X	X	X	X
ICS SS0002	grating calibrators	X	X	X	X
ICS SS0004	SW scan				X
ICS SS0005	SW + LW scan	X	X	X	
ICS SS0006	dark current	X	X		
ICS SS0007	reset	X	X	X	X
ICS SS0008	reset parameters	X	X	X	X
ICS SS0009	FP/LW + SW scan				X

Uplink Table	Description	AOT Number			
		1	2	6	7
S_BANDS2	AOT band limits		X		
S_BANDS6	AOT band limits			X	
S_BANDS7	AOT band limits				X
S_DETDEP	detector dependency			X	X
S_DETECT	detector noise		X	X	X
S_FP35	lambda and resp cal				X
S_FPDGAP	FP gap corections				X
S_FPDRIV	FP drive parameters				X
S_GR6	lambda and resp cal		X	X	
S_IDSDB	diverse constants	X	X	X	X
S_LRRATE	scan rates	X			
S_LRSCAN	scan limits	X			
S_LRSENS	responsivities	X			
S_PCTAB1	diffuse cal control	X	X	X	
S_PCTAB2	diffuse cal control				X
S_REFDUR	ref scan durations			X	X
S_SCTAB1	grating cal control	X	X	X	
S_SCTAB2	grating cal control				X