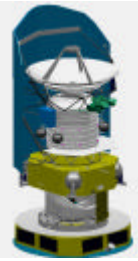


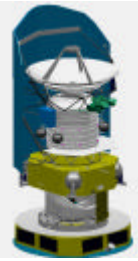
FIRST

AOCS - Instrument Meeting

FAO-1

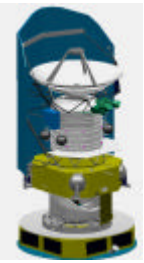
ESTEC, 11 April 2000

A. Elfving (SCI-PXS)



Presentation Structure

- Terminology
- Walk-through of Requirements
- Peaking-up
- Observation Modes
- On-Target Flag

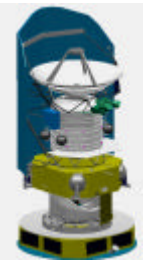


Pointing Terminology

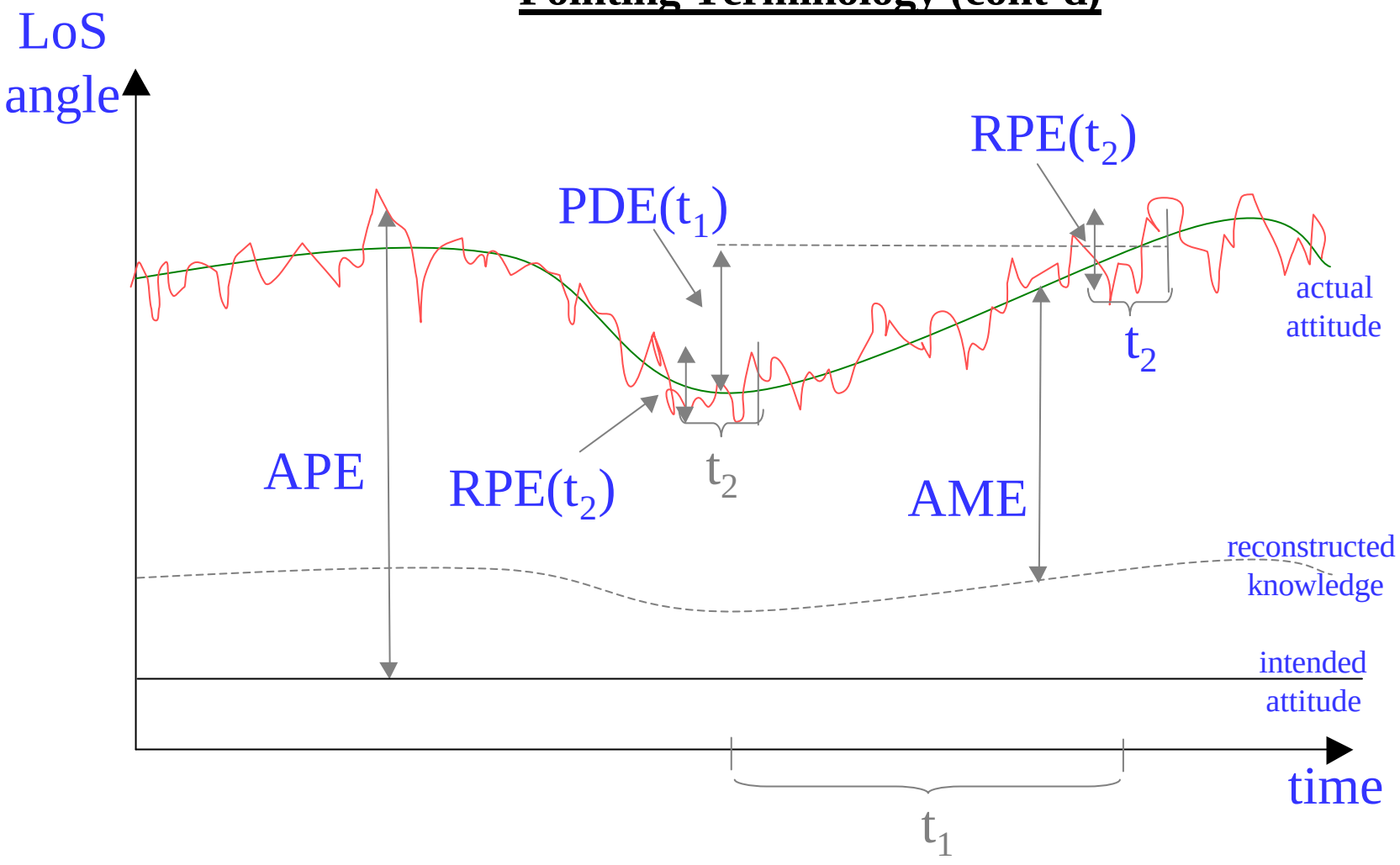
- **Absolute Pointing Error (APE):** is the angular separation between the desired direction and the instantaneous actual direction
- **Attitude Measurement Error (AME):** is the angular separation between the actual and the measured pointing direction. This performance requirement is referred to as ‘a posteriori knowledge’.
- **Pointing Drift Error (PDE):** is the angular separation between the short time average pointing direction during some time interval and a similar average pointing direction at a later time.

Pointing Terminology (cont'd)

- **Relative Pointing Error (RPE):** is the angular separation between the instantaneous pointing direction and the short time average pointing direction during some time interval. This is also known as the pointing stability.
- **Spatial Relative Pointing Error (SRPE):** is the angular separation between the short time average pointing direction and a desired pointing direction. The desired pointing direction being referenced relative to a previously achieved average pointing direction.



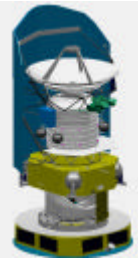
Pointing Terminology (cont'd)



Spacecraft Slew and Scan

Definitions:

- slew is a manoeuvre of the S/C from one pointing direction to another without specific requirements on the path
- scan is a manoeuvre of the S/C along a specified path with a specified rate along this path

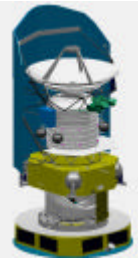


Requirements and Goals

The pointing requirements are applicable to the detectors Line of Sight (LoS) of the instruments. The error in determining the absolute attitude of a detector line of sight, using detector dedicated calibration source(s), shall be assumed to be less than 50% of the AME.

Requirements: performance to be satisfied under all applicable conditions and margins

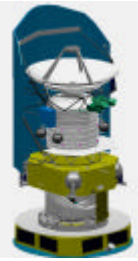
Goals: performance to be satisfied under restricted, but specified, conditions and without margins



Pointing Requirements and Goals

ERROR	*Optical Axis (arcsec)*	*Around Optical Axis (arcmin)*	*Goals (arcsec)*	*Goals around Optical Axis (arcmin)*
APE	*£ 3.7*	*3.0*	*£ 1.5*	*3.0*
PDE(24 hours)	*£ 1.2*	*3.0*	*n.a.*	*n.a.*
AME	*£ 3.1*	*3.0*	*£ 1.2*	*3.0*
RPE (1 min)	*£ 0.3*	*1.5*	*£ 0.3*	*1.5*
SRPE (4x4 deg)	*£ 1.0*	n.a.	n.a.	n.a.

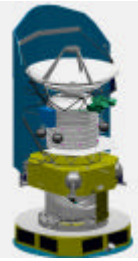
Values all 68% temporal probability



Scan Requirements and Goals

ERROR	*Optical Axis (arcsec)*	*Around Optical Axis (arcmin)*	*Goals (arcsec)*	*Goals around Optical Axis (arcmin)*
RPE (1 min) scan	*£ 1.2*	*£ 1.5*	*£ 0.8*	*n.a.*
AME scan	*£ 5.0*	*£ 3.0*	*£ 2.4*	*n.a.*
AME slew	*£ 10*	*3.0*	*£ 5.0*	*3.0*

Values all 68% temporal probability



Calibration

- Commissioning calibrations in order to establish the angles between stellar reference and the instruments lines of sight.

  > telemetry will be used to reach APE and AME

- During the routine operations phase, the spacecraft shall be able to support instrument dedicated calibrations, i.e. peaking-up.

  > telemetry will be used to improve APE up to SRPE performance

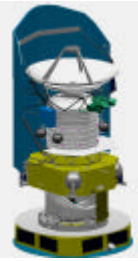
Pointing Requirements and Goals: Calibration

Peaking Up

During the observation of bright sources, a way of correcting the blind pointing error when the source is bright enough is envisaged. The spacecraft perform a five-point cross scan (left, right, centre, up, down) and a double gaussian is fitted to the two three point linear scans by the instruments.

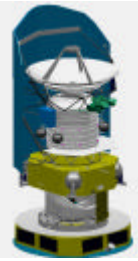
- The pointing offsets in the two orthogonal directions are computed by the instrument and the spacecraft pointing is adjusted accordingly before a much longer integration on the now correct position is carried out.

- On-board data exchange between instrument and spacecraft is required, off-set requests beyond a threshold are rejected.



Spacecraft Slew Requirements

- The maximum slew speed shall be at least 7°/min when the slew angle is large enough to permit full angular velocity
- For a slew smaller than 16 arcmin the total time between initiation of the slew and achievement of the pointing requirements on the new target is less than
  requirement: 10 + SQRT(2*phi) seconds
  goal: 5 + SQRT(phi) seconds
  where phi is slew angle in arcseconds
- The system is dimensioned for operational slews of at least 90 degrees, executed twice per day. Such slews shall be accomplished within 15 minutes including settling.



Spacecraft Scan Requirements

- A scan can be commanded in the range 0.1 arcsec/s to 1 arcmin/s with a resolution of 0.1 arcsec/s.

- Scan acceleration will be fixed by design, typically 0.05 arcmin/s2, i.e. 20 s and 10 arcmin to reach 1 arcmin/s

- The Absolute Rate Error about the scan axis shall be less than 1% of the scan rate but not less than 0.1 arcsec/s

Observation Modes

Fine Pointing Mode

The fine pointing mode is the basic operation mode and consists of observation pointings, followed/preceded by slew(s).

During science observations, the pointing requirements corresponding to the selected observation mode are met.

It is possible to maintain the fine pointing for periods of up to 20 hours, during which momentum unloading and wheel speed reversal shall not occur.

Observation Modes (cont'd)

- Raster Pointing

Raster pointing is a series of fine pointing observations of equal duration (t), separated by slews, in order that the pointing of the telescope axis moves in a raster pattern.

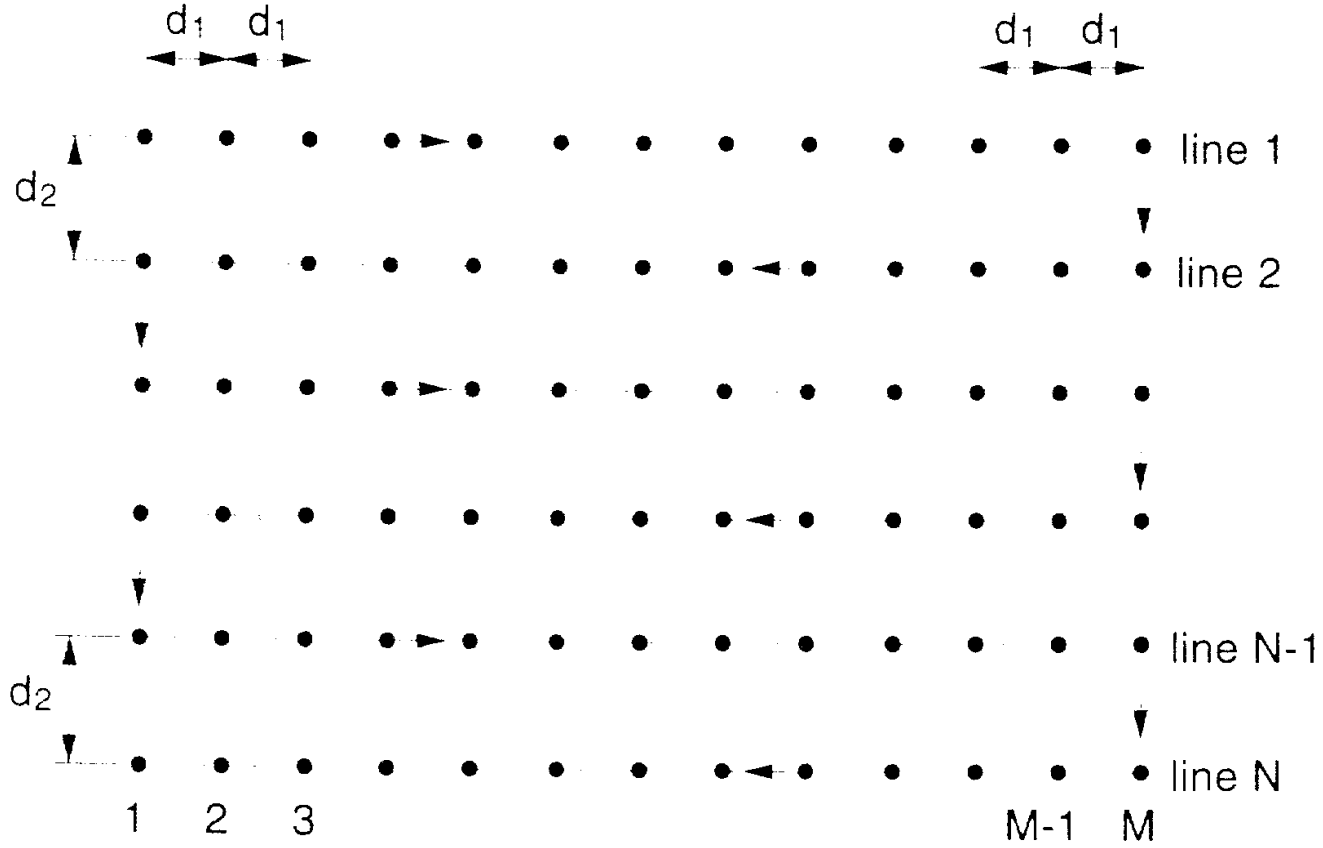
The inertial attitude of the pattern is defined by the quaternion Q1 of the 1st raster point and an angle phi representing the rotation of the pattern axes w.r.t. local instrument axes.

The raster parameters, M, N, d_1 and d_2 are within the following range and resolution:

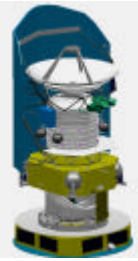
- M: 2 - 32
- N: 1 - 32
- d_1: 2 arcsec - 4 arcmin; resolution: 0.5 arcsec
- d_2: 2 arcsec - 4 arcmin or 0; resolution: 0.5 arcsec

Note1: d1 and d2 are sperical angles
Note 2: d_2 being zero, means that it is possible to scan N times the points of a single line.
The duration of stable pointing at any position, t, will be between 10s and 30 minutes.

Observation Modes (cont'd)



Normal Raster Pointing



Observation Modes (cont'd)

- Raster Pointing with OFF position

Raster pointing with OFF-position is a special form of raster pointing where, after a specified number of raster points (ON positions), the spacecraft slews to a predefined point (the OFF position), after which it resumes its raster pointing where it left the raster before going to the OFF position. The number of raster pointings (K) before going to the OFF position is determined by the timing characteristics of the raster pointing such that the time between each subsequent OFF position is less than some characteristic stability time of the instrument.

Observation Modes (cont'd)

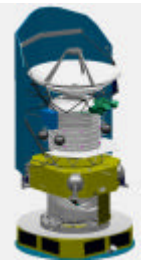
- Raster Pointing with OFF position (cont'd)

The raster parameters, M, N, K, d_1 and d_2 are within the following range and resolution:

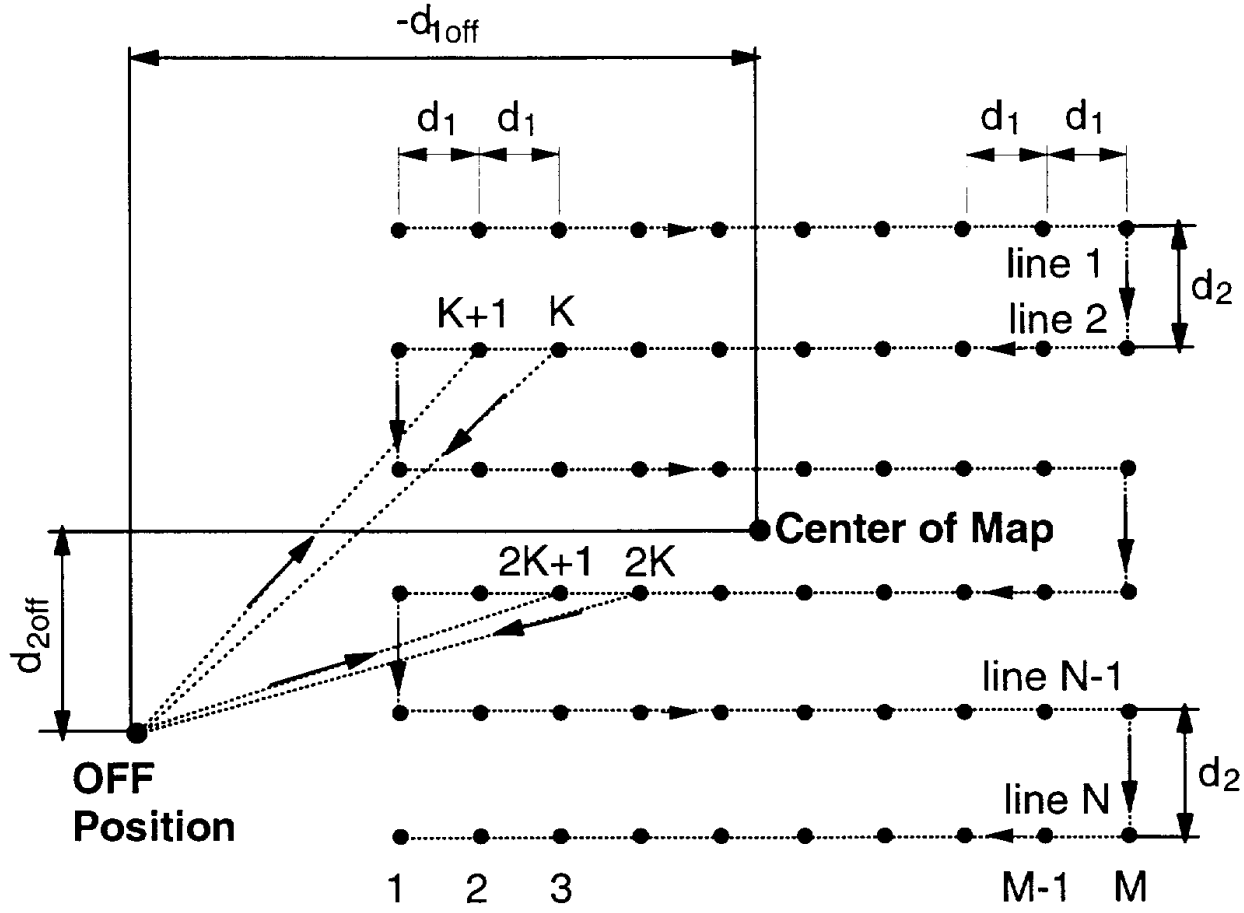
- M: 2 - 32
- N: 1 - 32
- K: 2 - M H N
- d_1: 2 arcsec - 1 arcmin; resolution: 0.5 arcsec
- d_2: 2 arcsec - 1 arcmin or 0; resolution: 0.5 arcsec

The maximum value of K being equal to the total number of ON positions implies normal raster pointing with only a single OFF position pointing at completion of the raster. The duration of stable pointing at any position, t, will be between 10s and 30 minutes.

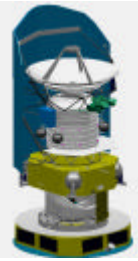
The attitude of the OFF position is defined by the quaternion Qoff:



Observation Modes (cont'd)



Raster Pointing with OFF-Position

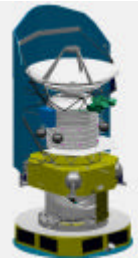


Observation Modes (cont'd)

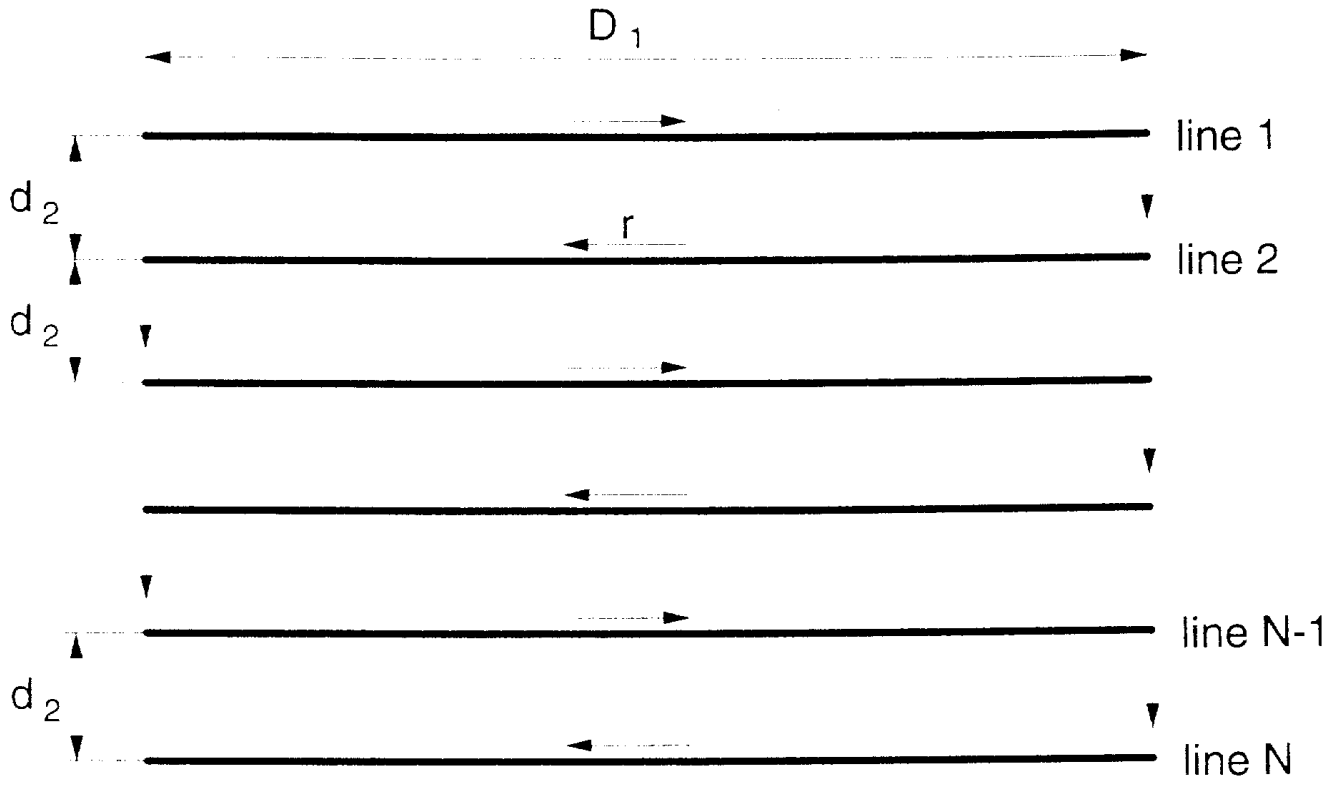
- Line Scanning

  This is a scanning mode along short parallel lines, such that the telescope axis moves. The scan parameters, N, D_1 and d_2 are within the following range and resolution:

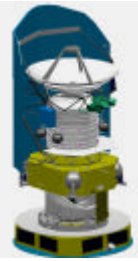
  - N : 1 - 32
  - D_1 : 1 arcmin - 110 deg; resolution: 1 arcmin
  - d_2 : 2 arcsec - 4 arcmin or 0; resolution: 0.5 arcsec



Observation Modes (cont'd)



Normal Line Scanning



Observation Modes (cont'd)

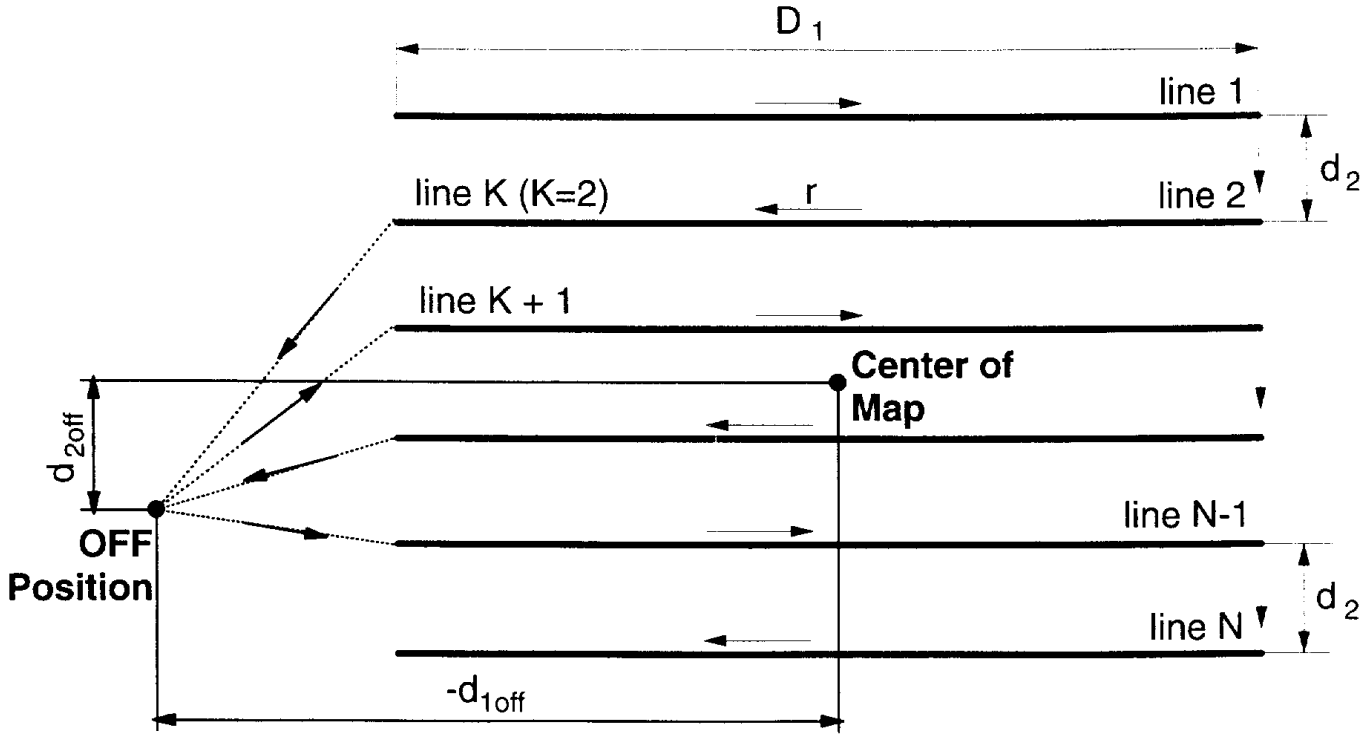
- Line Scanning with OFF Position

  Line scanning with OFF-position is a special form of line scanning where, after a specified number of lines, the spacecraft slews to a predefined point (the OFF position), after which it resumes its line scanning where it left the pattern before going to the OFF position.

  The scan parameters, N, D_1 and d_2 are command within the following range and resolution:

  - N : 1 - 32
  - K : 1 - N
  - D_1 : 1 arcmin - 2 deg; resolution: 1 arcmin
  - d_2 : 2 arcsec - 4 arcmin or 0; resolution: 0.5 arcsec

Observation Modes (cont'd)



Line Scanning with OFF-Position

Observation Modes (cont'd)

- Tracking of solar system objects

  The satellite is able to follow, by ground commanded attitude polynomials, objects such as planets, comets, etc. having a maximum speed relative to the tracking star of 10 arcsec/min.

  The attitude defining the raster or line scan pattern , Q1, may also be referenced to a solar system object.

  The pointing requirements whilst tracking solar system objects are met.

Observation Modes (cont'd)

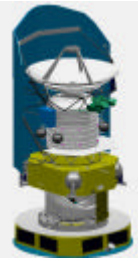
- Position Switching

  Position switching is an observing mode in which the instrument line of sight is periodically changed between a target source and a position off the source.

  This is a special case of raster pointing with the following raster parameters:

M:	2
N:	1-n
d1:	2 arcsec - 2 deg, resolution 0.5 arcsec
d2:	0

  The integration time in both positions are equal and are within the range of 10 sec to 20 min (depending on the throw)



Observation Modes (cont'd)

- Nodding

  Nodding is an observing mode in which the target source is moved from one instrument chop position to the other chop position. In this case the pointing direction will change in the direction of the instrument chopper throw.

  This is a special case of raster pointing with the following raster parameters:

phi:	0
M:	2
N:	1-n
d1:	2 arcsec - 16 arcmin, resolution 0.5 arcsec
d2:	0

  The integration time in both positions are equal and are within the range of 10 sec to 20 min (depending on the throw)

Need for On-Target Flag On-Board?

AOCS to Instruments: “On-Target Flag”

- can improve time efficiency of individual observations but no overall benefit expected since follow-on observations will be initiated by on-board schedule using absolute time.
- can improve commanding efficiency: no need for explicit P/L commands within an observation.