NICMOS Proposal Instructions 2: Patterns and Associations

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ABSTRACT
In this ISR the optional parameters in the NICMOS Proposal Instructions which implement the automatic execution of patterns of observations are described. These patterns are essentially macro level instructions which result in the execution of one member of a pre-defined set of exposures interleaved with HST small angle maneuvers. These greatly simplify the acquisition of dithered or chopped observations. The HST ground system is in the process of being augmented to treat the set of exposures in a pattern as an “association”. These associations are processed together in the pipeline calibration permitting the automated measurement of the sky background illumination and the anti-coincidence reject of cosmic rays and defective pixels. The “products” from the calibration of an association are also stored in the Hubble Data Archive so that the association may be reference either as an entity or via its component exposures.

1. Introduction
The NICMOS proposal instructions define the primary interface between the NICMOS Scientific Instrument (hereafter, SI) and HST observers. These instructions, combined with observatory level instructions, are used on a proposal logsheet at the start of the process of obtaining a NICMOS science or calibration observation. As such, the proposal instructions are the user interface to NICMOS and present a conceptual model of the operation of the SI to observers.

The present state of the General NICMOS Proposal Instructions is discussed in ISR NICMOS-012 “NICMOS Proposal Instructions 1. General Instructions” by J.W. MacKenty and R. Kutina (1996). In this ISR we describe a two significant departures from past practice. The inclusion of a mechanism to execute sequences of predefined patterns of observations from a simple syntax on a single proposal logsheet line and the association of exposures from the proposal stage through to the data calibration and archiving stages. These represent new developments for the SM97 Science Instruments. Since these con-
cepts are strongly related, we will refer to them as *associations* except when it is necessary to draw a distinction between them. The broader consequences and overall design of the association capability is documented in the ISR NICMOS-010 (also STIS-016) “Associations of NICMOS and STIS Exposures: an extension of the HST data processing pipeline” (MacKenty, J.W. and Baum, S., 1996).

**Summary of the Association Subset of the NICMOS Proposal Instructions**

In Table 1 a summary of the Proposal Instructions which implement *associations* is provided. A complete listing of the NICMOS Proposal Instructions may be found in ISR NICMOS-012.

**Table 1. NICMOS Proposal Instruction Optional Parameters for Associations**

<table>
<thead>
<tr>
<th>Config</th>
<th>Mode</th>
<th>Optional Parameter</th>
<th>Allowed Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>NIC1,</td>
<td>ACCUM,</td>
<td>PATTERN</td>
<td>NONE (default), SPIRAL-DITH, SQUARE-WAVE-DITH, XSTRIP-DITH, YSTRIP-DITH, ONE-CHOP,</td>
</tr>
<tr>
<td>NIC2,</td>
<td>MULTIACCUM,</td>
<td></td>
<td>TWO-CHOP, FOUR-CHOP, EIGHT-CHOP, SPIRAL-DITH-CHOP, XSTRIP-DITH-CHOP, YSTRIP-DITH-CHOP</td>
</tr>
<tr>
<td>NIC3</td>
<td>RAMP</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>NUM-POS</td>
<td></td>
<td>2 - 40</td>
</tr>
<tr>
<td></td>
<td>DITH-SIZE</td>
<td></td>
<td>0.0 - 40.0 arc seconds</td>
</tr>
<tr>
<td></td>
<td>CHOP-SIZE</td>
<td></td>
<td>0.0 - 1800.0 arcseconds</td>
</tr>
<tr>
<td></td>
<td>PATTERN-ORIENT</td>
<td></td>
<td>DETECTOR (default), 0.0 - 360 degrees</td>
</tr>
<tr>
<td></td>
<td>OFFSET</td>
<td></td>
<td>SAM (default), SAM-NO-REACQ, SAM-NO-GYRO, FOM</td>
</tr>
</tbody>
</table>

**2. Chopping and Dithering**

**Goals and Definitions**

A sequence of exposures with offset pointings permits several improvements in the quality of the resulting observations: (1) the background level and illumination structure can be determined nearly contemporaneously with the observations of the target, (2) a mosaic covering a target larger in spatial extent than the field of view of an individual camera can be obtained, and (3) the flat field (uniformity in gain) of the final image may be improved by the combination of multiple slightly offset images. The proposal syntax defined in this ISR enables a simple and robust specification of sequences of offset exposures which we will refer to as *patterns*. The exposures in each pattern are taken to be members of an association of exposures as defined in NICMOS ISR-010.
We choose to define two distinct type of motions:

- **DITHER** motions are limited to 40 arcseconds each. These are intended to be used to accomplish sequences of overlapping exposures for the construction of mosaics. Such sequences will be assembled into a single final image by the calibration pipeline.
- **CHOP** motions up to 1800 arcseconds are permitted. These are intended for the measurement of the background at one or more locations significantly removed from the target pointing. Each background pointing will be assembled into its own final image in addition to the target pointing.

**Types of Motions and Spacecraft Limitations**

One, and only one, pattern may be defined on an individual exposure logsheet line. A pattern may only be specific on the “prime” NICMOS camera. The motions between each exposure are carried out by expanding the pattern into a sequence of individual exposures separated by POSTARG operations.

Telescope motions fall into three categories:

- **Small angle maneuvers (SAMS)** where FGS Fine Lock guiding is maintained. Such SAMS are typically limited to < 2 arcminutes from the point of the initial guide star acquisition. That is, this is the practical limit of the radial extent of the pattern. Often it will be smaller due to guide star availability.
- **SAMS without FGS guiding** (*i.e.* GYRO HOLD pointing control). These are necessary for larger motions (> 2 arcminutes). The telescope will drift at a rate of 1 to 2 milli-arcseconds per second of time (elapsed time -- *not* exposure time). For Camera 3 observations which significant thermal backgrounds this is the suggested observing practice.
- **SAMS with RE-ACQuisitions at each return to the target position.** This can be used to “chop” between a target and an offset background measurement pointing (which would be observed with GRYO HOLD pointing control).

The available options for “OFFSET” are:

- **SAM**, the default, will use guide stars whenever possible. If a motion, or the sequence of motions, moves the telescope sufficiently from the original position that guide stars are no longer available then exposures will be obtained using GRYO HOLD. If a subsequent motion returns the telescope to a point where the original guide stars become available then it will RE-ACQuire the guide stars. This incurs an overhead of ~3 minutes for each RE-ACQuisition.
- **SAM-NO-REACQ** will use guide stars (FGS Fine Lock) until the *first* instance in the pattern when guide stars become unavailable. The remainder of the pattern will be executed using GYRO HOLD pointing control.
- **SAM-NO-GYRO** will use guide stars for all exposures. If guide stars are not available, the observation cannot be scheduled.
• FOM does not require telescope pointing control. Rather the internal Field Offset Mirror (FOM) is used. This is the only available method when NICMOS is not the prime science instrument (i.e., it is being used in parallel with another SI) since these motions do not move the HST itself. The motion of the FOM is limited to a radius of no more than 26 arcseconds from the FOM’s center position.

Controlling the Number and Spacing of Points

The defined pattern sequences are all open ended. The observer must specify how many positions from the pattern are to be executed using the optional parameter “NUM-POS”. The first exposure is taken at position 1, the second at position 2, etc. for the dither patterns. For the chop and combined patterns (see Section 3), the first exposure is taken at position 1, the second at position 2, the third (and all subsequent odd-numbered exposures) at position 1, the forth at position 4, etc.

The spacing in arcseconds between each exposure is specified by the “DITH-SIZE” and “CHOP-SIZE” optional parameters for the dither and chop patterns, respectively. The combined patterns require the specification of both parameters.

3. Pattern and Array Orientations on the Sky

The orientation of the patterns on the sky is accomplished by the “PATTERN-ORIENT” optional parameter. This can be used either by itself or in conjunction with the observatory level special requirement “ORIENT”. If PATTERN-ORIENT is set to “DETECTOR”, the default, then the patterns motions are in the NICMOS (X-Y) focal plane orientation (i.e., rotated 225 degrees from the U2 axis). The orientation of the patterns on the sky is then determined by the orientation of the telescope with the “ORIENT” special requirement.

Since the use of the “ORIENT” special requirement usually constrains the scheduling opportunities for a target (and may result in the unavailability of suitable guide stars), NICMOS implements a further capability. The position angle on the sky (measured as the position of the NICMOS +y axis east from north) of the pattern’s (X-Y) frame may be specified with the “PATTERN-ORIENT” optional parameter. For example, the XSTRIP-DITH pattern with PATTERN-ORIENT=0 will track from East to West on the sky and with PATTERN-ORIENT=45 from SouthEast to NorthWest. Note that the orientation of each camera’s square field of view will be determined by the orientation of the spacecraft (which is not being constrained by the observer in this example).

4. Available Patterns

Dither Patterns

The dither patterns are recommended for the reduction of flat field uncertainties and the construction of mosaics (maps) of regions of the sky.
Figure 1: Dither Patterns

Chop Patterns

The Chop patterns are recommended for the measurement of the background adjacent to the target of interest. For each chop patterns, half of the exposures are taken on the target (position 1).
**Figure 2:** Chop Patterns

*ONE-CHOP*

```
1 ←→ 2
```

*TWO-CHOP*

```
4 ←→ 1 ←→ 2
```

*FOUR-CHOP*

```
4 ←→ 1 ←→ 2
```

*EIGHT-CHOP*

```
12 ←→ 8 ←→ 16
```

**Combined Patterns**

The combined patterns permits dithering interleaved with chops to measure the background.
5. Acknowledgments

The controlling documents for the capabilities of the NICMOS are (will be) the Cycle 7 Call for Proposals (CP), the Cycle 7 Phase 2 Proposal Instructions (Phase2 PI), and the NICMOS Instrument Handbook. These proposal instructions have been previously described in a series of memos by Ray Kutina. David Axon and Daniela Calzetti provided valuable input to the design of these patterns.