TECHNICAL REPORT

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Title: Title: An Observing Proposal for Segment Search during Commissioning of JWST	Doc #: JWST-STScI-000955, SM-12 Date: 29 August 2006 Rev:
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1.0 Abstract

We present a Phase 1 Observing Proposal for performing the JWST missing segment search, using one of NIRCam's short wavelength arms. The program can be performed without real-time contact.

2.0 Introduction

We attempt to capture advances in our plans for Commissioning JWST, as outlined the WFS&S Requirements Allocation Document, (Reference 1). Authoritative descriptions of these processes will eventually be collated in OTE-24, but enough detail is currently known about the process to enable a draft Phase 1 proposal for Segment Search to be presented here. The use of proposals will enable the S&OC-developed Observation Plan Executive (OPE), designed for routine Science Operations, along with all its communications and error checking and verification infrastructure, to be used for Commissioning operations.

3.0 Scope

The scope of this memorandum is to develop a credible Observing Proposal to execute a Segment Search during JWST WFS&C Commissioning. We rely on prior descriptions of Commissioning operations and NIRCam data flow, namely

1. JWST.2006.170.0024 "WFS&C Requirements Allocation Document"
2. JWST-STScI-000512: "Wavefront Sensing and Control on JWST: embedding the Executive at the Science & Operations Center"
3. STScI-JWST-TM-2003-0011 A: "Routine JWST Wavefront Sensing and Control"

4. NIRCam DRD-OPS-11-JWST-OPS-002843 2003: "NIRCam Operations Concept"
5. STSCI-JWST-TM-2004-0022: "NIRCam Science Data Pipeline Description"
6. STSCI-JWST-TM-2004-0023: "NIRCam Calibration Reference Files"
7. JWST-IRD-002996: "WFS&C Exec-to-S&OC IRD"

4.0 Subsystems and stakeholders

Segment Identification algorithms developed by Ball are described in OTE-14a. WFS&C operations involve NIRCam on JWST, the S&OC's Data Management Subystem (DMS), Proposal Planning Subystem (PPS), Flight Operations Subystem (FOS), the WFS&C Scientist and/or the JWST Project-wide WFS&C Team under Prime Contractor leadership, the WFS&C Executive Software Subsystem (the "Exec"), and the JWST Line-of-Sight Control system. The Fine Guidance Sensors are not used at this stage of Commissioning.

5.0 Segment Search in the WFS&C Commissioning sequence

Commissioning is currently described in a detailed process flowchart maintained by Acton (Ball) for the different phases of commissioning (see Figure 1 in JWST-STScI-000-512, Sivaramakrishnan et al.). These commissioning stages are summarized at the highest level by the following steps:

Focus Sweep
Segment Identification
if any segments are missing:
    Segment Search
Segment Array
if segment PSFs are confused:
    go back to **Segment Identification**
Global Alignment
Image Stacking
Coarse Phasing
Fine Phasing
Multi-Field Fine Phasing
if PM segment updates are too large:
    go back to **Coarse Phasing**

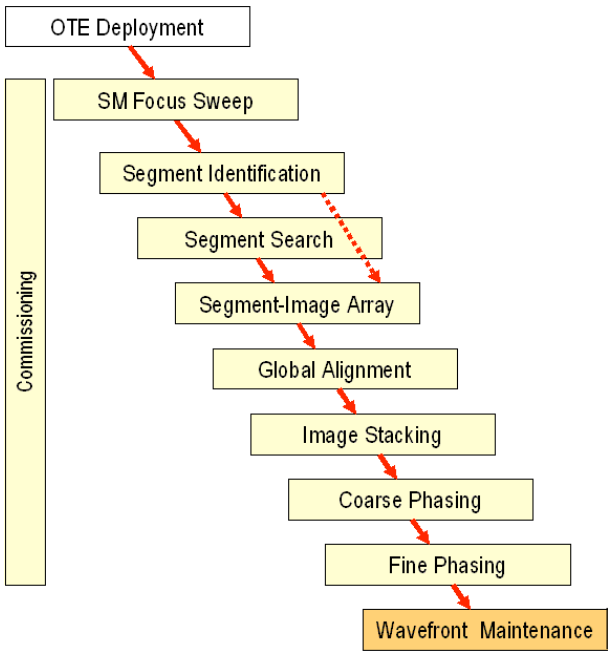

Figure 1: Phases of WFS&C Commissioning (A. Contos, Ball)

OTE-24, the "WFS&C Commissioning and Operations Plan", will serve as a WFS&C operations concept, especially for commissioning (which is more complex than routine operations). This document will be the main repository for WFS&C operations knowledge. OTE-24 will include a discussion of preconditions and exit criteria for the phases of WFS&C commissioning, the types of calibrations that are needed prior to commissioning, and a description of the types of proposals needed – both for success-oriented scenarios as well as for the most likely contingencies, as defined by the Ball WFS&C team.

6.0 Method for Segment Search

Following the first light target acquisition the secondary mirror focusing is performed using whichever images from the 18 mirror segments fall within the field of view. At this point, the focusing of individual segments, while not perfect, will produce images close to their maximum brightness. According to requirement PMBA-0350 after initial cool down and deployment, the tilt of each PMSA Interface Surface (PMSA-IS) about the X and Y axes shall be within 0.43 milliradians, radial of the nominal on-orbit PMSA-IS location defined in the Optics to Structure ICD, D35145. Equivalently, the tilt of each segment will be within 1.5 arc-minutes of the nominal axis. Each reflected segment image may, therefore, be displaced by twice this amount, or 3 arc-minutes. The NIRCam field of view is 2.2 arc-minutes square, so the requirement really says that most segment images should fall within a single NIRCam image at the outset. However, some segment images will fall outside the field and not be detected initially. The segment identification step will have shown how many and which segments are missing.

A rough estimate of how many segments will be missed in the initial image can be obtained by assuming that the 3 arc-minute radius represents the two-sigma extent of

a normal segment image distribution. Then 29%, or 5 of the images can be expected to fall within a 2.2 arc-minute square, leaving 13 outside.

To image the missing segments we will perform a two-cycle spiral search shifting each missing segment with a step size of 1.8 arc-minutes, slightly smaller than the NIRCam field size, so as to leave no gaps. This will require 25 images for the complete pattern and will cover a square of side 9.4 arc-minutes. A single spiral will cover a square of side 5.8 arc-minutes and should encompass 90% of the segment images. The double spiral can reasonably be expected to find all the segments.

A reasonable strategy is to first perform the one cycle spiral for those segments not seen in the segment identification images. This takes eight images for each missing segment. After examining these images, the second outer spiral, comprising a further 16 images, would only be done for segments which are still missing It is extremely unlikely that any segment images will fall outside the 9.4 arc-minute region covered by the double spiral search.

7.0 The spiral pattern

To assist in the preparation of commands, the details of the spiral search are given here. Displacements are in units of 1.8 arc-minutes and can be along the V2 and V3 coordinate directions, or any convenient pair of orthogonal directions.

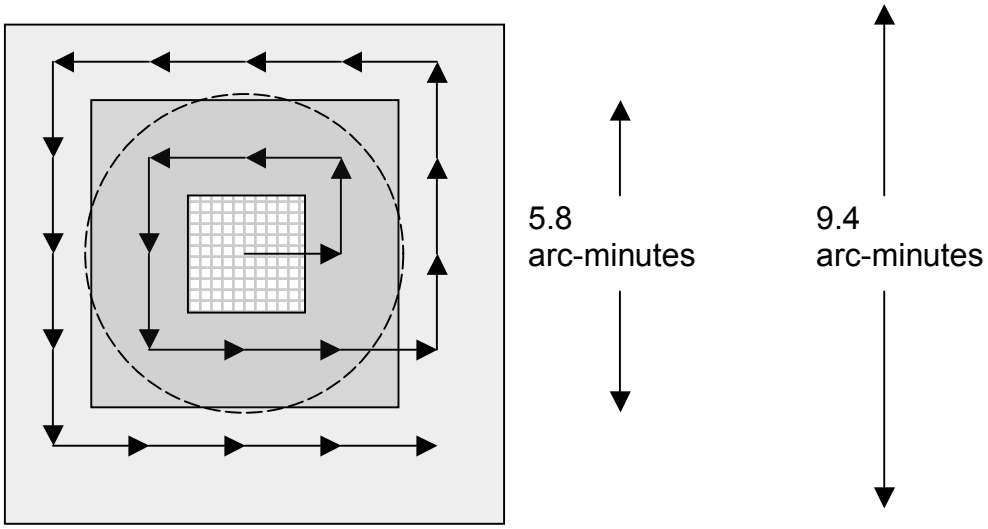

Figure 2: Spiral search pattern. There are 8 positions displaced 1.8 arc-minutes from the central position and 16 more at twice this displacement. The circle represents the region within which the initial segment images may be expected to fall. The outer square indicates the area coverage of the two cycle spiral. The darker inner square shows the coverage of a single spiral search. The 2.2 arc-minute NIRCam field is also shown.

8.0 Segment Search Proposal

This proposal, translated by the S&OC PPS into a Visit, will be used to perform the Segment Search

Program No.:7xx DRAFT JWST PHASE 1 PROPOSAL

Program title: JWST Segment Search

Synopsis: Find alignment of mirror segments aligned significantly away from the mean.

Sample and sky coverage:

Pre-selected isolated 10^{th} magnitude star in continuous observing zone

Basis for exposure time estimates (needed S/N and brightnesses):

Sufficient exposure to detect star in 10-100s exposures but not saturate detector with signal or noise.

Exposure times are TBD. 10 s exposures are placeholders being the minimum value for full-frame readout

Short exposures mitigate possible pointing instability and minimizes CR contamination.

PSF estimated from expected defocus and aberrations.

Persistent image transients limit target star brightness.

NFRAME1 = 1 low SNR trades speed of execution vs. read noise

NGROUP1 = 2 assists CR rejection, and increases photometric dynamic range of the imaging.

NINTEGRATE = 1

Various detector readout strategies are currently under consideration and an appropriate one will be selected at a later date.

Instruments and observing configurations:

NIRCam operational, star trackers operational.

No FGS lock assumed.

Scheduling requirements or constraints:

NIRCam operational and cool enough (about 100°K) to avoid excessive noise rate, or too rapid filling of the detector full well. Primary Mirror latched, Acquisition and First Light accomplished.

WFS&C Exec-created filenames TBD are available to Flight Operations System

Visit scenario:

NIRCam Imaging short wavelength WFS&C arm [A or B, TBD]

Slew to target

Filter: F210M

Pupil: Imaging pupil

Activity Descriptor: File **P7xx_SEGsearch_placeholder_01**
If **P7xx_SEGsearch_placeholder_01** exists:

Expose 10s (TBD) NFRAME1=1, NGROUP1=2

Move one of the missing segments to the next spiral search position in its individual pattern.

Repeat for the 8 positions in the inner spiral pattern.

Repeat for each missing segment.

Data from inner spiral set of observations returned to ground for review.

For any segments that are still not detected, take 16 images in the outer spiral search pattern

Comments:

Verify health/safety w/NIRCam - image persistence is unlikely to be a problem.

Dynamic range can be increased by increasing exposure time.

Target star and guide star isolation requirements TBD.

Complete set of inner and outer spiral mirror moves will be prepared in advance for all segments not found in the initial search. All inner spiral moves can be executed without interruption. After examination of this set, the outer spiral set will be activated only for segments still not found.

Risks and contingencies:

Total program time needed (days): 1

Each exposure will be 10 seconds with a 6 second read-out time. Allowing 100 seconds for moving a mirror segment gives a minimum time of 116 seconds per exposure.

To perform an inner spiral of 8 exposures would take about 15 minutes and, estimating that we will need 13 of these, gives a time of three and a half hours for all the inner spirals.

Again using the rough estimate that 10% or 2 segments will still be undetected leads to 2 sets of 16 outer spiral images requiring about one more hour of observing. So

even allowing for an hour to receive the data and a few hours of analysis, the whole program can be performed in one day.

Program written by: Colin Cox
Date first written Aug 3rd 2006
As-of date: Aug 9th 2006
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8.1 WFS&C-specific Calibration Data

Routine NIRCam science data processing (e.g., dark subtraction, bias subtraction, flat fielding, and CR rejection) will suffice.

8.2 Algorithm Requirements

Analysis will consist of studying image differences and matching shifts with segments

9.0 Conclusion

The STScI S&OC Ground System is capable of using the Proposal Planning System and other S&OC subsystems, together with the WFS&C Executive to perform all of the steps involved in Segment Search. No extra data processing steps over and above routine NIRCam data pipeline processing are needed.

10.0 References

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