COS Acceptance Testing

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October 11, 2006

Summary

A detailed acceptance test for COS has been performed. A verification test shows that BOT is giving the correct answers. Exposure expansion, pointing adjustments, actual duration usage, and visualization are all functioning properly, and BOT can handle error conditions gracefully and provides meaningful feedback to the users.

Two issues with the Aladin display have been found – a slight misalignment of the BOT overlay with the DSS image, and a broken link in the Aladin spreadsheet; both of these are known issues with PRs previously filed. None of these issues is severe enough to warrant a delay in the release of the tool for COS usage (using GSC2 data only).

The V_{crit} values have not been implemented. This is covered in an existing PR, and should be closed prior to the release of the tool for COS usage.

Introduction

For this test, the following target and exposure was used:

Target: LOW-LAT-FIELD – 18h 41m 01.91s, -35^{o} 29’ 32.90”

Exposure: COS/FUV, TIME-TAG, G130M/1300, PSA, 1000s, BUFFER-TIME=500

For regression testing, I also used the following exposures:

- COS/FUV (NUV), ACQ, G160M/1589 (MIRROR), BOA, 100s, SCAN-SIZE=4
- COS/FUV (NUV), ACQ/PEAKXD, F160M/1589 (G185M/1850), BOA, 1000s
- COS/FUV (NUV), ACQ/PEAKD, G140L/1105 (G285M/2709), PSA, 1000s, SEGMENT=A, STEP-SIZE=0.5
- COS/FUV (NUV), ACCUM, G130M/1300 (G225M/2250), PSA, 1000s
- COS/NUV, ACQ/IMAGE, MIRROR, BOA, 100s

When appropriate, modifications to the exposure (e.g. POS TARG) are detailed below.

This target/exposure was used to perform the following:

Test	Definition
Verification	Comparison with manual calculations
New features	Exposure expansion, pointing adjustment, actual duration, visualization

Exception Handling	Bad exposure, unsupported exposure, network query, cancel operations

For each test, both the tabular and graphic output products are included for ease of comparison with future test results; note that "dummy" values are presently in the look-up tables, so the status of an object (safe or health) will likely change when real values are used.

Verification Test

Since COS has never been in BOT before, a thorough verification of the instrument was performed. This check involved manually determined the count rate for objects of known spectral type and V magnitude, and comparing with the results from BOT. Three distinct tested were performed – a Grating check, an Aperture check, and a Trigger check.

Grating Check

For each spectral element, exposures using two central wavelengths and the PSA aperture were processed; for the NUV MIRRORs, only one exposure was used. The table below shows the configurations that were processed. In each case, the predicted count rates were in agreement with those determined by BOT.

Detector	Grating	Cen Wave	Sp. Type	V
FUV	G130M	1300	A5	14.85
	G130M	1300	G2	15.85
	G130M	1327	A5	14.85
	G130M	1327	G2	15.85
	G140L	1105	A5	14.85
	G140L	1105	G2	15.85
	G140L	1230	A5	14.85
	G140L	1230	G2	15.85
	G160M	1577	A5	14.85
	G160M	1577	G2	15.85
	G160M	1623	A5	14.85
	G160M	1623	G2	15.85
NUV	G185M	1786	A5	14.85
	G185M	1786	G2	15.85
	G185M	2010	A5	14.85
	G185M	2010	G2	15.85
	G225M	2186	A5	14.85
	G225M	2186	G2	15.85
	G225M	2410	A5	14.85
	G225M	2410	G2	15.85
	G230L	2635	A5	14.85
	G230L	2635	G2	15.85
	G230L	3360	A5	14.85
	G230L	3360	G2	15.85
	G285M	2617	A5	14.85
	G285M	2617	G2	15.85
	G285M	3094	A5	14.85
	G285M	3094	G2	15.85
	MIRROR		A5	14.85
	MIRROR		G2	15.85
	MIRRORB		A5	14.85
	MIRRORB		G2	15.85

Since the BOT presently has place-holder values for the standard count rates, the values are not shown in the table. To determine the standard (V=15) count rates, the following algorithm was used:

Item	Value	Counts
Detector	FUV A	1000
	FUV B	2000
	NUV	3000
Limit	Global	0
	Local	100
Spectral Type	O	10
	B	20
	A	30
	F	40
	G	50
	K	60
	M	70
Sub-type	0	0
	1	1
	2	2
	4	4
	5	5
Central Wavelength	xxxx	.xxxx

Aperture Check

COS has two science apertures – the PSA and the BOA. When using the BOA, the count rates are reduced, with the amount being a function of the grating selected; note that the true throughput of the BOA aperture may in fact not be element dependent, but the software was written to support such a capability. For the BOA aperture, one exposure using each spectral element was processed. The table below shows the configurations that were processed. In each case, the predicted count rates were in agreement with those determined by BOT.

Detector	Grating	Cen Wave	Sp. Type	V
FUV	G130M	1300	A5	14.85
FUV	G130M	1300	G2	15.85
FUV	G140L	1105	A5	14.85
FUV	G140L	1105	G2	15.85
FUV	G160M	1577	A5	14.85
FUV	G160M	1577	G2	15.85
NUV	G185M	1786	A5	14.85
NUV	G185M	1786	G2	15.85
NUV	G225M	2186	A5	14.85
NUV	G225M	2186	G2	15.85
NUV	G230L	2635	A5	14.85
NUV	G230L	2635	G2	15.85
NUV	G285M	2617	A5	14.85
NUV	G285M	2617	G2	15.85
NUV	MIRROR		A5	14.85
NUV	MIRROR		G2	15.85
NUV	MIRRORB		A5	14.85
NUV	MIRRORB		G2	15.85

Since the BOT presently has place-holder values for the standard count rates, as well as for the aperture throughput, the values are not shown in the table. The aperture correction values are:

Detector	Grating	Factor
FUV	G130M	0.10
FUV	G140L	0.15
FUV	G160M	0.20
NUV	G185M	0.25
NUV	G225M	0.30
NUV	G230L	0.35
NUV	G285M	0.40
NUV	MIRROR	0.45
NUV	MIRRORB	0.50

Trigger Check

For each detector, there are both local and global trigger limits; in the case of the FUV detector, both segments A and B are checked; there is also a global field check performed. One exposure for each detector was run, with the count rates just below and just above the trigger values, to verify that the triggers were properly set. The triggers are the following:

Detector	Local	Global
FUV	40	15,000
NUV	675	90,000

The table below shows the configurations that were processed. In each case, the appropriate warnings were trigger at the predicted count rate values.

Local trigger test

Detector	Grating	Cen Wave	Sp. Type	V	Local A	Local B
FUV	G130M	1300	A5	18.54	safe	
FUV	G130M	1300	A5	18.53	unsafe	
FUV	G130M	1300	A5	19.27		safe
FUV	G130M	1300	A5	19.26		unsafe
NUV	G185M	1786	A5	16.64	safe	
NUV	G185M	1786	A5	16.63	unsafe	

Global trigger test

Detector	Grating	Cen Wave	Sp. Type	V	Global A	Global B
FUV	G130M	1300	A5	12.20	safe	
FUV	G130M	1300	A5	12.19	unsafe	
FUV	G130M	1300	A5	12.89		safe
FUV	G130M	1300	A5	12.88		unsafe
NUV	G185M	1786	A5	11.36	safe	
NUV	G185M	1786	A5	11.35	unsafe	

Field global test

Detector	Grating	Cen Wave	Sp. Type	V	Global A	Global B
FUV	G130M	1300	A5	13.00	safe	
FUV	G130M	1300	G2	12.50	safe	
Total					unsafe	
FUV	G130M	1300	A5	14.00		safe
FUV	G130M	1300	G2	13.00		safe
Total						unsafe
NUV	G185M	1786	A5	12	safe	
NUV	G185M	1786	G2	12	safe	
Total					unsafe	

V_{crit} Check

In order to account for reddening, each spectral element has a critical V magnitude above which all objects are considered O5 stars. These values are:

Detector	Spectral Element	V_{crit}
FUV	G130M	10.86
	G140L	11.04
	G160M	11.72
NUV	G185M	6.97
	G225M	6.79
	G230L	7.31
	G285M	9.45
	MIRROR	6.97
	MIRRORB	6.97

One exposure for each spectral element was run with two targets – one with V_{crit} and one 0.01^{m} fainter than V_{crit} – to verify that the correct values were in place.

Issue

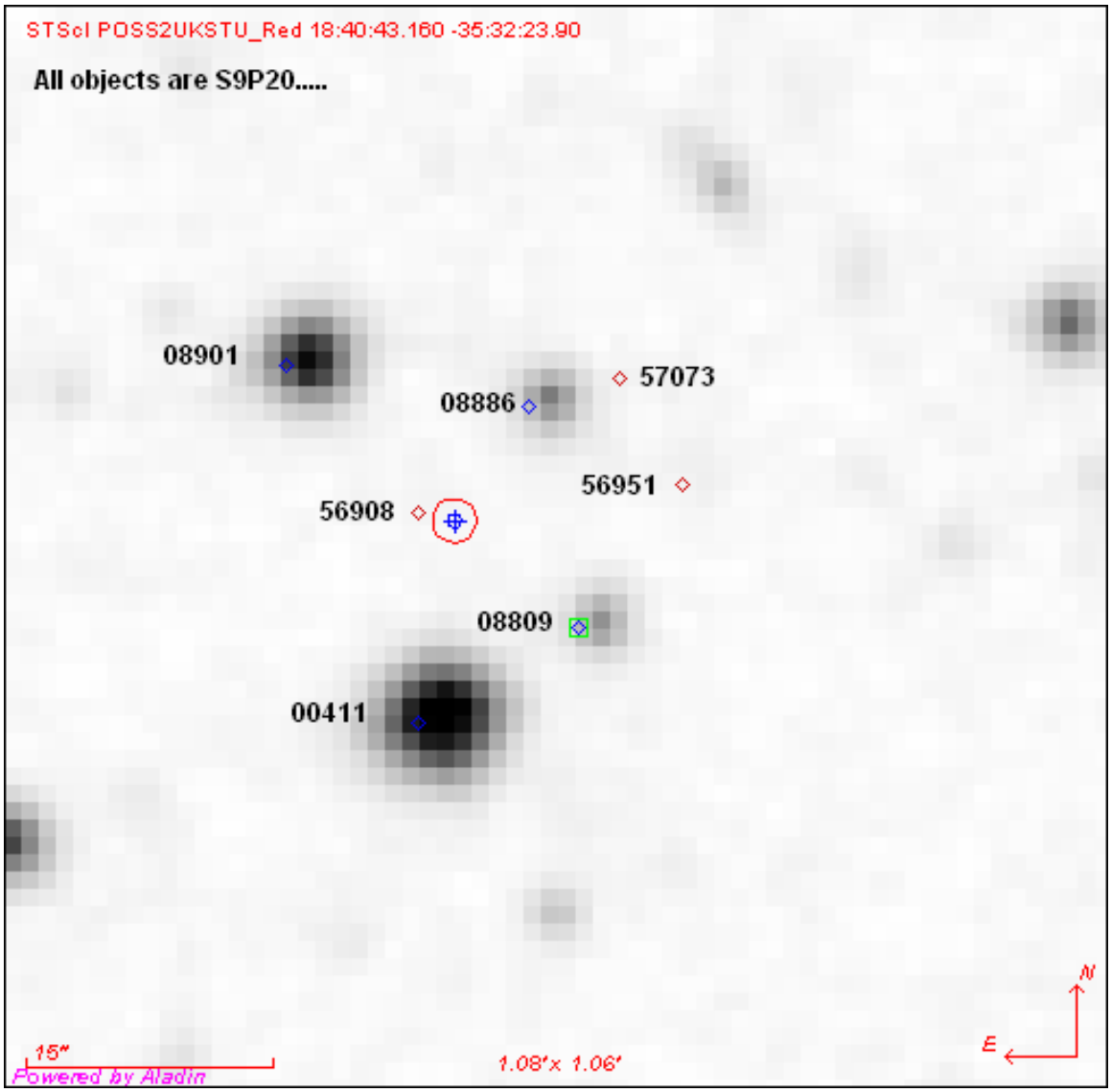
The V_{crit} values are not implemented; this is covered under APT-BOT PR 56773, and *should be corrected prior to the release of the tool for COS usage.*

Regression Test

Since COS is new to BOT, it is not possible to perform a regression test at this time. However, a basic exposure was processed in BOT to serve as comparison for future regression testing. The test exposure was run through both the BOT/Aladin interface, a search radius of 13.5". The 7 objects detected were:

OBJECT ID	RA	Dec	F	J	V	B-V	Type
S9P2000411	18 41 2.0628	-35 29 44.67	13.1	13.86	13.45	0.21	A5V
S9P2008809	18 41 1.3143	-35 29 38.86	16.08	17.66	16.82	0.79	G5V
S9P2008886	18 41 1.5784	-35 29 26.01	15.77	17.12	16.39	0.63	G2V
S9P2008901	18 41 2.7354	-35 29 24.05	14.25	14.86	14.54	0.09	A1V
S9P2056908	18 41 2.0884	-35 29 32.37	---	20.44	---	---	not a star
S9P2056951	18 41 0.8303	-35 29 30.40	---	19.59	---	---	not a star
S9P2057073	18 41 1.1418	-35 29 24.24	---	20.18	---	---	not a star

The field map, showing the objects found, is given below.



I also confirmed that the same objects were found using all operating modes (ACQ, ACQ/PEAKXD, ACQ/PEAKD, ACCUM, and TIME-TAG; for NUV, ACQ/IMAGE was also checked), and that the count rates for ACCUM mode were identical with those in TIME-TAG mode.

Issue

There appears to be a slight misalignment between the BOT overlay and the DSS image, which is 0.2" in both RA and Dec. The RA offset is consistent (the BOT overlay is always east of the star), while the Dec offset is sometimes north and sometimes south. This discrepancy is small enough (0.2 pixels) to be of no concern, but is covered under APT-VTT PR 56217.

New Features

Exposure Expansion

For the COS, there are two ways for exposures to be expanded – number of iterations greater than 1 and the use of a pattern. The pattern case is detailed in the Pointing Adjustment section below. For the number of iterations test, a value of 3 was used. In this case, three identical sub-exposures were generated, and BOT processing was performed on all three sub-exposures with identical results. Aladin did display the BOT overlay, although there was only 1 image plane shown, unlike the Pattern case where each sub-exposure was its own plane. Since the number of iterations planes would all be, by definition, identical, showing only 1 plane is acceptable (however, if the actual duration field was used, a problem could result; see below).

Pointing Adjustment

There are 3 different types of pointing adjustments valid for the COS – POS TARG, PATTERN, and use as a PARALLEL instrument.

POS TARG

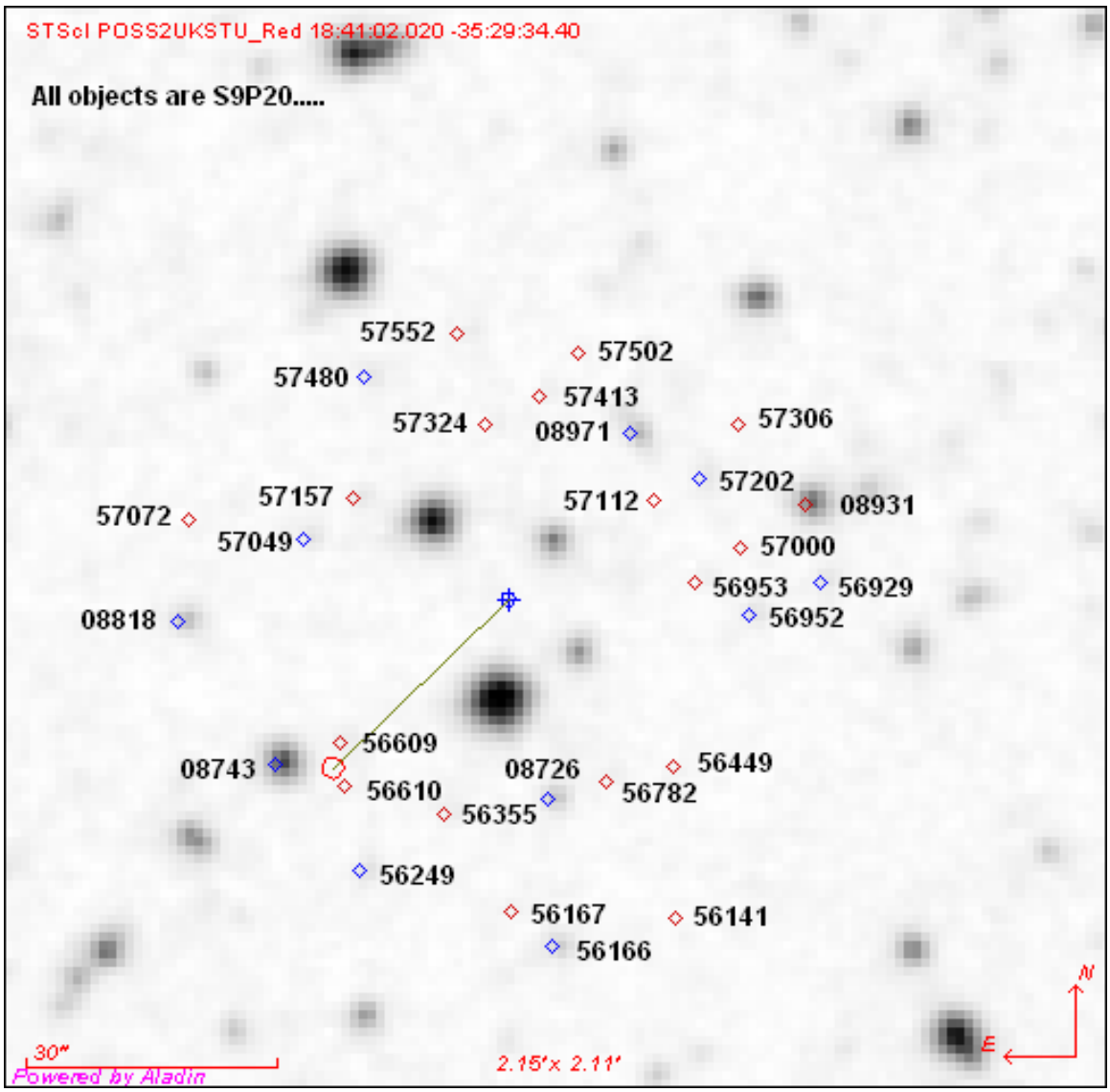
For this test, the standard exposure was modified by adding a POS TARG of X=-20” and Y=-20”. The direction of the POS TARG is important in this test, and in order to be able to simply predict the size of the POS TARG motion, the motion must be in the same direction as the "Search Radius Vector" which is defined as the point from the fiducial to the outermost corner of the Aperture. A selection in a different direction makes the calculation of the motion vector more complicated.

The test exposure was run through both the new BOT/Aladin interface, using an expanded search radius of 41.8”, which resulted in a circle being analyzed to support any possible ORIENT value. Based on the size of the POS TARG, this increase in search radius is exactly what was predicted (i.e. SQRT(20*20 + 20*20) = 28, which when added to the standard 13.5” yields 41.5”).

The 29 objects detected were:

OBJECT ID	RA	Dec	F	J	V	B-V	Type
S9P2008726	18 41 1.4876	-35 29 55.82	17.28	18.02	17.62	0.17	A5V
S9P2008743	18 41 4.1015	-35 29 52.56	15.09	16.08	15.55	0.36	F0V
S9P2008818	18 41 5.0563	-35 29 36.34	16.93	18.07	17.46	0.47	F5V
S9P2008931	18 40 59.1143	-35 29 20.75	15.4	16.26	---	---	not a star
S9P2008971	18 41 0.8021	-35 29 13.03	16.49	16.93	16.71	-0.04	B5V
S9P2056141	18 41 0.2537	-35 30 9.29	---	21.08	---	---	not a star
S9P2056166	18 41 1.4117	-35 30 13.08	17.51	19.21	18.31	0.86	K0V
S9P2056167	18 41 1.8065	-35 30 9.09	---	20.08	---	---	not a star
S9P2056249	18 41 3.2692	-35 30 4.77	18.65	19.05	18.85	-0.14	B1V
S9P2056355	18 41 2.4846	-35 29 57.92	---	19.61	---	---	not a star
S9P2056449	18 41 0.3052	-35 29 51.80	---	21.21	---	---	not a star
S9P2056609	18 41 3.4945	-35 29 49.93	19.76	19.26	19.57	-0.94	not a star
S9P2056610	18 41 3.4397	-35 29 55.02	---	21.04	---	---	not a star
S9P2056782	18 41 0.9424	-35 29 53.69	---	19.72	---	---	not a star
S9P2056929	18 40 58.9492	-35 29 29.73	18.92	19.12	19.04	-0.31	**O5V**
S9P2056952	18 40 59.6174	-35 29 33.82	18.72	19.68	19.16	0.25	A5V
S9P2056953	18 41 0.1455	-35 29 30.28	---	20.33	---	---	not a star
S9P2057000	18 40 59.7094	-35 29 25.91	---	21.7	---	---	not a star
S9P2057049	18 41 3.8817	-35 29 26.24	18.86	19.12	19	-0.26	**O5V**
S9P2057072	18 41 4.9906	-35 29 24.43	---	21.64	---	---	not a star
S9P2057112	18 41 0.5613	-35 29 20.75	---	21.97	---	---	not a star
S9P2057157	18 41 3.4216	-35 29 21.39	19.41	19.43	19.45	-0.5	not a star
S9P2057202	18 41 0.1295	-35 29 18.02	18.78	19.16	18.97	-0.17	B1V
S9P2057306	18 40 59.7690	-35 29 11.70	---	22.08	---	---	not a star
S9P2057324	18 41 2.1841	-35 29 12.43	---	21.56	---	---	not a star
S9P2057413	18 41 1.6730	-35 29 9.13	---	19.7	---	---	not a star
S9P2057480	18 41 3.3572	-35 29 7.28	18.81	19.65	19.2	0.16	A5V
S9P2057502	18 41 1.3128	-35 29 3.94	---	21.75	---	---	not a star
S9P2057552	18 41 2.4743	-35 29 2.06	---	21.29	---	---	not a star

The field map, showing the objects found, is given below.



The objects are all in the area that is expected.

Pattern

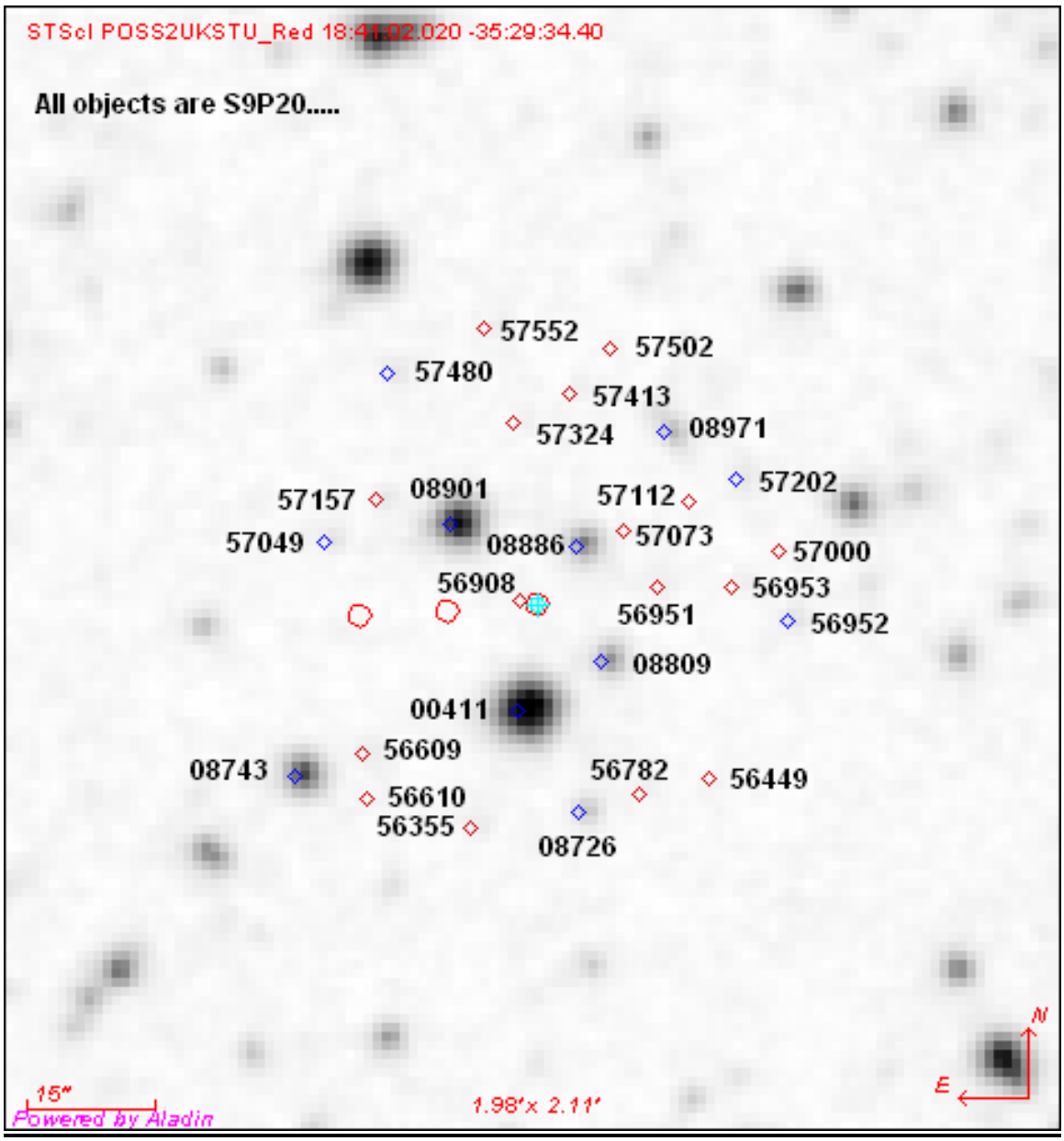
For this test, the standard exposure was modified by putting it in a PATTERN (a LINE with 3 points with a 10” spacing at an orientation of 225^{o}). The orientation was aligned closely with the "Search Radius Vector”.

The test exposure was run through both the new BOT/Aladin interface, which used different radii for its searches – one for the initial pointing (with the standard 13.5” search radius), one for the second pattern exposure (with the search radius increased to 23.5”), and one for the final pattern exposure (with a search radius of 33.5). The expanded search radii were exactly as predicted.

The 27 objects detected were:

OBJECT ID	RA	Dec	F	J	V	B-V	Type
S9P2000411	18 41 2.0628	-35 29 44.67	13.1	13.86	13.45	0.21	A5V
S9P2008726	18 41 1.4876	-35 29 55.82	17.28	18.02	17.62	0.17	A5V
S9P2008743	18 41 4.1015	-35 29 52.56	15.09	16.08	15.55	0.36	F0V
S9P2008809	18 41 1.3143	-35 29 38.86	16.08	17.66	16.82	0.79	G5V
S9P2008886	18 41 1.5784	-35 29 26.01	15.77	17.12	16.39	0.63	G2V
S9P2008901	18 41 2.7354	-35 29 24.05	14.25	14.86	14.54	0.09	A1V
S9P2008971	18 41 0.8021	-35 29 13.03	16.49	16.93	16.71	-0.04	B5V
S9P2056355	18 41 2.4846	-35 29 57.92	---	19.61	---	---	not a star
S9P2056449	18 41 0.3052	-35 29 51.80	---	21.21	---	---	not a star
S9P2056609	18 41 3.4945	-35 29 49.93	19.76	19.26	19.57	-0.94	not a star
S9P2056610	18 41 3.4397	-35 29 55.02	---	21.04	---	---	not a star
S9P2056782	18 41 0.9424	-35 29 53.69	---	19.72	---	---	not a star
S9P2056908	18 41 2.0884	-35 29 32.37	---	20.44	---	---	not a star
S9P2056951	18 41 0.8303	-35 29 30.40	---	19.59	---	---	not a star
S9P2056952	18 40 59.6174	-35 29 33.82	18.72	19.68	19.16	0.25	A5V
S9P2056953	18 41 0.1455	-35 29 30.28	---	20.33	---	---	not a star
S9P2057000	18 40 59.7094	-35 29 25.91	---	21.7	---	---	not a star
S9P2057049	18 41 3.8817	-35 29 26.24	18.86	19.12	19	-0.26	**O5V**
S9P2057073	18 41 1.1418	-35 29 24.24	---	20.18	---	---	not a star
S9P2057112	18 41 0.5613	-35 29 20.75	---	21.97	---	---	not a star
S9P2057157	18 41 3.4216	-35 29 21.39	19.41	19.43	19.45	-0.5	not a star
S9P2057202	18 41 0.1295	-35 29 18.02	18.78	19.16	18.97	-0.17	B1V
S9P2057324	18 41 2.1841	-35 29 12.43	---	21.56	---	---	not a star
S9P2057413	18 41 1.6730	-35 29 9.13	---	19.7	---	---	not a star
S9P2057480	18 41 3.3572	-35 29 7.28	18.81	19.65	19.2	0.16	A5V
S9P2057502	18 41 1.3128	-35 29 3.94	---	21.75	---	---	not a star
S9P2057552	18 41 2.4743	-35 29 2.06	---	21.29	---	---	not a star

The field map, showing the objects found, is given below.



The objects are all in the area that is expected.

Parallel

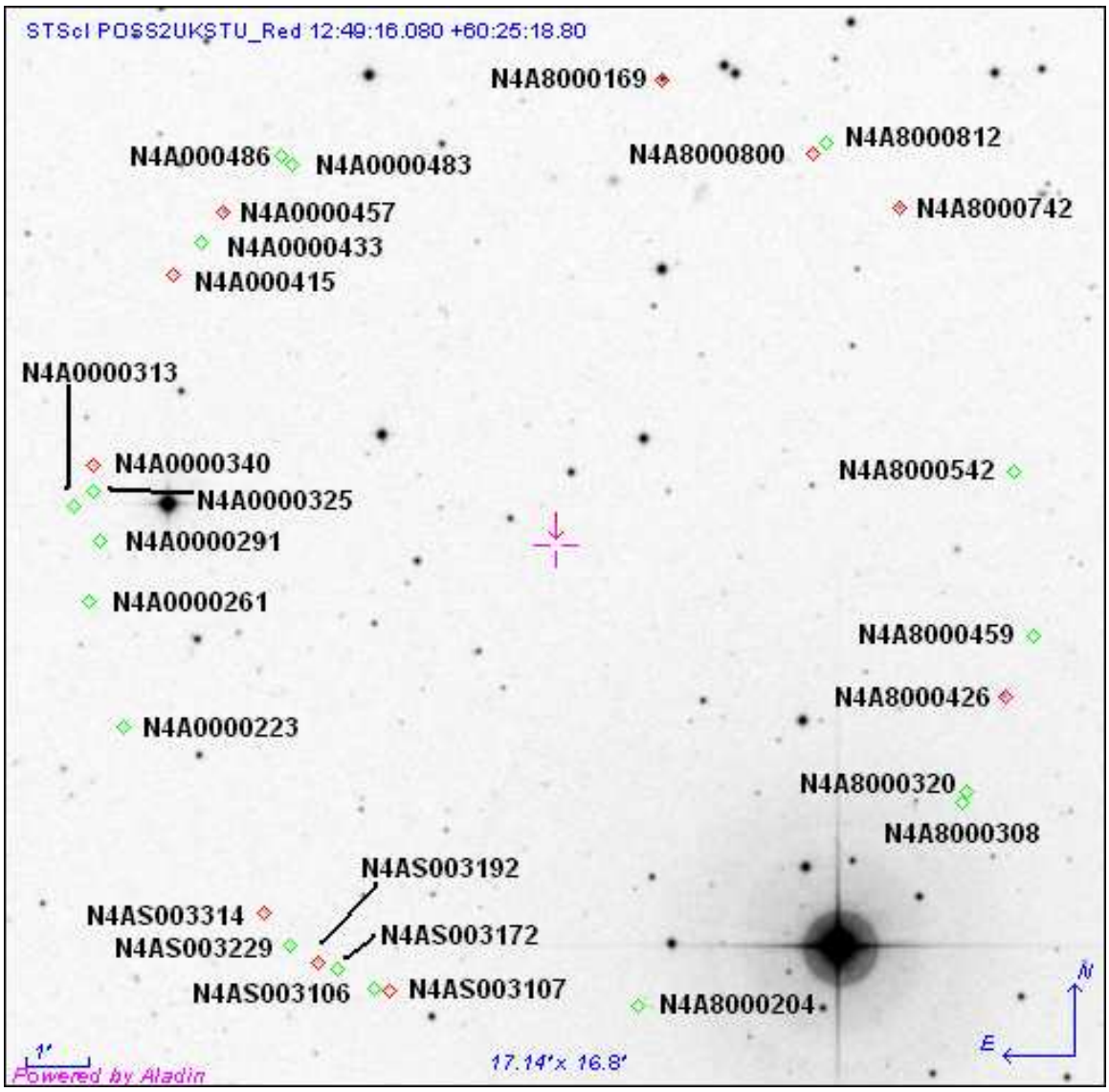
For this test, the standard exposure was modified making it be a coordinated parallel observation with a WPFC2 prime exposure. The test exposure was run through the new BOT/Aladin interface only, using a high latitude field (12^h 49^m 16.00^s, $+60^o$ 25' 22.0"). The search radius used by BOT was 7.56'. The separation between the PC and COS/PSA is 7.77', and after adding 0.23' for the standard search radius, the approximate search radius BOT should have used is 8.00', significantly larger than what was actually used.

However, if I measure from the center of the PC aperture rather than the fiducial point, I get a search radius of 8.0', in agreement with the calculated value.

A total of 65 stars were found in the BOT, so the table below only lists the health-and-safety and safe objects (27). The objects detected were:

OBJECT ID	RA	Dec	F	J	V	B-V	Type
N4A0000223	12 50 9.8215	+60 22 18.95	18.45	20.52	19.44	1.13	K0V
N4A0000261	12 50 14.5776	+60 24 15.76	19.34	21.22	20.22	0.96	K0V
N4A0000291	12 50 13.6340	+60 25 11.69	20.5	21.24	20.85	-0.06	B5V
N4A0000313	12 50 17.0159	+60 25 42.22	20.06	21.32	20.64	0.42	F0V
N4A0000325	12 50 14.6310	+60 25 57.66	19.41	20.14	19.75	0.2	A5V
N4A0000340	12 50 14.6910	+60 26 21.19	18.12	20.2	19.12	1.14	K0V
N4A0000415	12 50 5.1867	+60 29 20.58	18.75	19.71	19.19	0.38	F0V
N4A0000433	12 50 1.9208	+60 29 52.81	19.51	21.7	20.57	1.09	K0V
N4A0000457	12 49 59.1042	+60 30 20.68	16.93	18.3	17.56	0.67	G5V
N4A0000483	12 49 50.6104	+60 31 7.56	19.22	21.36	20.25	1.13	K0V
N4A0000486	12 49 52.1237	+60 31 14.78	20.5	21.83	21.11	0.28	A5V
N4A8000169	12 49 4.0825	+60 32 34.85	14.58	15.64	15.06	0.48	F5V
N4A8000204	12 49 4.3772	+60 18 12.04	20.36	21.93	21.08	0.43	F5V
N4A8000308	12 48 24.3174	+60 21 28.00	20.52	22.04	21.22	0.36	F0V
N4A8000320	12 48 23.6384	+60 21 38.06	20.44	22.04	21.18	0.42	F0V
N4A8000426	12 48 19.1899	+60 23 7.88	16.82	17.97	17.35	0.55	F5V
N4A8000459	12 48 15.6967	+60 24 4.49	19.68	21.78	20.69	1.02	K0V
N4A8000542	12 48 18.5783	+60 26 37.12	19.43	22.02	20.74	1.32	K4V
N4A8000742	12 48 33.7430	+60 30 40.44	16.75	17.41	17.06	0.21	A5V
N4A8000800	12 48 44.8001	+60 31 29.36	18.4	19.68	18.99	0.63	G2V
N4A8000812	12 48 43.3132	+60 31 39.40	20.26	21.36	20.77	0.3	A5V
N4AS003106	12 49 37.4311	+60 18 21.36	20.08	22.06	21.02	0.81	G5V
N4AS003107	12 49 35.7125	+60 18 20.49	18.51	19.68	19.04	0.52	F5V
N4AS003172	12 49 42.0352	+60 18 39.11	19.61	20.84	20.17	0.51	F5V
N4AS003192	12 49 44.6498	+60 18 44.63	18.25	18.4	18.35	-0.18	B1V
N4AS003229	12 49 48.1560	+60 18 58.94	19.33	21.37	20.3	1.05	K0V
N4AS003314	12 49 51.5212	+60 19 29.63	17.76	20.46	19.16	1.57	M2V

The field map, showing the objects found, is given below.



Actual Duration

There are two ways in which the COS can use actual durations – a pattern exposure and a number of iterations greater than 1 exposure. For this test, the second piece of the pattern will have the actual duration set to 500s, and the second of three exposures in a number of iterations=3 will have the actual duration set to 500s.

Pattern

An examination of the BOT details shows that the revised exposure time for the second piece of the pattern was indeed detected by the tool (although since only count rates are relevant for COS, the exposure time change was not reflected in the output product).

Number of iterations

An examination of the BOT details shows that the revised exposure time for the second sub-exposure was indeed detected by the tool (only valid for ACCUM mode).

Issue
For actual duration and number of iterations, only the first sub-exposure is shown in Aladin. Since COS only utilizes count rates for bright object checking, this is not an issue.

Visualization

There are many aspects to this test, all of which have already been verified by the previous ACS/SBC and ACS/HRC testing

Issue
Aladin spreadsheet name link to an external html page with more details fails for the GSC2; this is covered with APT-VTT PR 56234.

Exception Handling

There are four types of exception handling to be tested; Network Query Error and Cancel Ongoing Operations have been verified in the ACS/SBC testing, and Bad Exposures has been verified in the ACS/HRC testing.

Unsupported Exposures

There are no unsupported modes for COS.