As of 10 June 2016

This GOES-R Level 2+ space weather Algorithm Theoretical Basis Document (ATBD) is preliminary and subject to change as the GOES-R Program prepares for a launch in late 2016.

The NOAA National Centers for Environmental Information (NCEI) is currently developing a demonstration version of the Satellite Product Analysis and Distribution Enterprise System (SPADES) which will host the L2+ algorithms. The operational SPADES will be instantiated by the National Weather Service in FY2017 to serve the needs of the Space Weather Prediction Center (SWPC).

Updated versions of the L2+ ATBDs will periodically be made available and posted to the SPADES website.

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NCEI

http://www.ngdc.noaa.gov/stp/space-weather/online-publications/stp_sii/spades/

NOAA NESDIS National Geophysical Data Center

GOES-R SWx XRS.10
ALGORITHM THEORETICAL BASIS DOCUMENT
Version *1.1*

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XRS.10 ALGORITHM THEORETICAL BASIS DOCUMENT VERSION HISTORY SUMMARY

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TABLE OF CONTENTS

LIST OF FIGURES 6
LIST OF TABLES 7
LIST OF EQUATIONS 7
LIST OF ACRONYMS 8
ABSTRACT 9
1.0 INTRODUCTION 10
1.1 Purpose of This Document 10
1.2 Who Should Use This Document 10
1.3 Inside Each Section 10
1.4 Related Documents 11
1.5 Revision History 11
2.0 OBSERVING SYSTEM OVERVIEW 11
2.1 Product Generated 12
2.2 Instrument Characteristics 12
3.0 ALGORITHM DESCRIPTION 13
3.1 Algorithm Overview 14
3.2 Processing Outline 14
3.3 Algorithm Input 16
3.3.1 Primary Sensor Data 17
3.3.2 Ancillary Data 17
3.4 Theoretical Description 17
3.4.1 Physics of the Problem 17
3.4.2 Mathematical Description 18
3.4.3 Algorithm Output 20
4.0 TEST DATA SETS AND OUTPUTS 20
4.1 Simulated/Proxy Input Data Sets 20
4.2 Output from Simulated/Proxy Inputs Data Sets 21
4.3 Construction of Simulated Quad-Diode Signal 21
4.4 Test Results Using Simulated Quad-diode signal, including uncertainty estimates 22
5.0 PRACTICAL CONSIDERATIONS 25
5.1 Numerical Computation Considerations 25
5.2 Programming and Procedural Considerations 25

5.3 Quality Assessment and Diagnostics 25
5.4 Exception Handling 26
5.5 Algorithm Validation 26

6.0 ASSUMPTIONS AND LIMITATIONS 26

6.1 Performance 27
6.2 Assumed Sensor Performance 27
6.3 Pre-Planned Product Improvements 27

7.0 REFERENCES 27

APPENDIX A, XRS.10 REQUIREMENTS 28

LIST OF FIGURES

Table 1. XRS.10 product data. 12
Figure 1. XRS solar diodes configuration. 13
Figure 2: XRS.10 Algorithm Flowchart Overview 16
Figure 3: Uniformly illuminated Sun and resulting illumination on quad-diode... 18
Figure 4: Uniformly illuminated Sun (with value 1), flare in southern hemisphere (with value 10) and resulting illumination on quad-diode. 19
Figure 5: Wavelength response of GOES-12 SXI Be-Thin and GOES-13 and 14 SXI Be12 images (http://www.swpc.noaa.gov/sxi/goes13/info/G13_genx_plots_compare.html)…. 20
Figure 6: Calculated vs. actual E-W (left) and N-S (right) locations for C-class flares. Events with problematic background are displayed in red..... 22
Figure 7: Same as **Figure 6**, but for M-class flares. 23
Figure 8: Same as **Figure 6**, but for X-class flares..... 23
Figure 9: Example of complicated series of events. C-class flare late in the sequence was incorrectly located due to bad background determination. 24
Figure 10: Example of two M-class flares that occurred within 1 hour of each other, yielding a poor determination of the location of the second one..... 24

LIST OF TABLES

Table 1. XRS.10 product data. 12

LIST OF EQUATIONS

Equation 1: Location equation in X and Y direction for uniformly bright Sun. Corresponds to **Figure 3**, with the solar brightness being 1..... 18
Equation 2: Location equation in X and Y direction for uniformly bright Sun with flare in southern hemisphere along the central meridian. Corresponds to **Figure 4** with the solar brightness being 1 and the flare brightness being 10. 19
Equation 3: Location equation in X and Y direction, including background correction (note: all quantities with subscript “B” denote background measurements). 20

LIST OF ACRONYMS

ATBD	Algorithm Theoretical Basis Document
CIRES	Cooperative Institute for Research in Environmental Sciences
EW	East-west
LASP	Laboratory for Atmospheric and Space Physics
NGDC	National Geophysical Data Center
NS	North-south
SEP	Solar energetic particle
SWPC	Space Weather Prediction Center
XRS	X-ray Sensor

ABSTRACT

This document describes the XRS.10 algorithm. This algorithm calculates flare location based on quad-diode measurements from the GOES-R series XRS detectors. The logical flow of the algorithm is outlined, including error handling methods, how validation using proxy data sets was accomplished, and explanations of assumptions.

1.0 INTRODUCTION

1.1 Purpose of This Document

The purpose of this document is to provide product developers, reviewers, and users with a theoretical description (scientific, algorithmic, and mathematical) of the GOES-R XRS.10 Flare Location algorithm. This document will describe the design and development of the XRS.10 algorithm, which will ingest quad-diode values, returning a flare location. This document provides the operational requirements for this product and defines how these requirements are met with this algorithm. The algorithm inputs, processing, and outputs are described in enough detail to design, develop, test, and implement the necessary processing software.

1.2 Who Should Use This Document

The members of the Space Weather Forecast Office and the Research and Customer Requirements Section of the SWPC should use this ATBD to verify that their operational requirements are being met by the proposed algorithm. They should also use it to understand the strengths and weaknesses of the algorithm as well as its accuracy and applicability. It should also be used by the party responsible to design, develop, test, validate and implement the algorithm into the final operational processing system.

1.3 Inside Each Section

Section 2.0 OBSERVING SYSTEM OVERVIEW:
Describes the GOES-R XRS instrument and the measurements that serve as input to the algorithm.

Section 3.0 ALGORITHM DESCRIPTION:
Describes the development, theory, and mathematics of the XRS.10 algorithm. Describes the logical flow of the algorithm, including input and output flow.

Section 4.0 TEST DATA SETS AND OUTPUTS:
Describes the test data sets used to characterize the performance of the algorithm and the data product quality. Describes the results from the algorithm processing on the input data.

Section 5.0 PRACTICAL CONSIDERATIONS:
Discusses issues involving numerical computation, programming and procedures, quality assessment, diagnostics, and exception handling.

Section 6.0 ASSUMPTIONS AND LIMITATIONS:
Describes assumptions made in the implementation of the calculation of flare location and assumptions made in validation, testing, and error handling of the algorithm.

Section 7.0 REFERENCES:
Relevant publications.

Appendix A XRS.10 requirements
Gives the full set of requirements for the algorithm being described in this ATBD.

1.4 Related Documents

"GOES-R Series Acronym & Glossary Document", DOC/NOAA/NASA (GOES-R Program/Code 417), P417-R-LIST-0142, July 9, 2008.

1.5 Revision History

Version	Date	Author	Revision
1.0	08/10/2013	Alysha Reinard	Draft

2.0 OBSERVING SYSTEM OVERVIEW

The GOES XRS measurements have been a crucial component of space weather operations since 1975, providing an accurate measurement of geo-effective X-ray irradiance from second-to-second real-time conditions to solar-cycle time scales. The integrated 0.1–0.8 nm irradiance is the definitive metric for solar flare classifications, and is a keystone in SWPC operations.

XRS algorithms provide irradiance value, daily background X-ray index, ratio of short and long channels, event (flare) detection and flare location. Each of these algorithms is important to space weather forecasting. The daily background X-ray index is used to characterize coronal evolution from days to years, including active region evolution, solar rotation, and solar-cycle variations. The relative intensity of an X-ray flare above an estimated background can be used as an index to flare intensities and daily active region activity. Flare detection (XRS.07) and flare location (XRS.10) both contribute to forecaster situational awareness. Flares are often associated with SEPs, which modify the ionosphere, impact astronauts and cause satellite failures. Space Weather Forecasters need to know a) when a flare occurs (so they can produce warnings), and

b) where the flare occurs on the solar disk (so they know the origin and thus potential of geoeffectiveness of any potential SEP.)

2.1 Product Generated

The XRS.10 algorithm calculates the location of the flare in the solar coordinate system (e.g. N24E04). Because this is a new capability it is important to verify the accuracy of this algorithm in advance of GOES-R launch.

The following data will be included in the XRS.10 Flare Location product:

Table 1. XRS.10 product data.

Data	Value	Note
Status flag	0: no issues 1: less than N frames included in background calculation, where N is the number of background frames requested 2: missing background 3 missing data	Background frames with a signal larger than the target time signal are not used.
Flare location	Flare location, solar coordinates	If flare location cannot be calculated, 99N99E is returned
Flare location time	Julian Day	The corresponding time stamp

2.2 Instrument Characteristics

Prior to GOES-R, the XRS instrument measured X-ray flux using two bandpass channels from a heritage design employing an ion-chamber. These channels are commonly referred to as the XRS-A (0.05-0.4 nm) and XRS-B (0.1-0.8 nm), both of which are in the soft X-ray portion of the electromagnetic spectrum. The ion-chamber design has two limitations: it ‘bottom-outs’ during low periods of solar activity since it is unable to effectively measure X-ray flux $\Phi < 1.0 \times 10^{-8}$ W/m^2 (approximately), and the instrument becomes saturated during major flares ($\Phi > 1.7 \times 10^{-3}$ W/m^2, approximately).

The primary goal of the re-designed XRS instrument in GOES-R is to continue the XRS measurements in the same spectral channels, while improving on the limitations of the legacy instrument. The new XRS instrument design addresses these limitations, while adding additional capabilities. The changes include using Si photodiodes instead of ionization cells, using multiple channels to allow wider dynamic range, providing quadrant photodiodes for real-time flare location measurements, and improved detailed calibrations using the NIST Synchrotron Ultraviolet Radiation Facility (SURF) in Gaithersburg, Maryland.

The new design will provide an irradiance range of more than 6 orders of magnitude by including two photodiode sets covering different portions of the irradiance range for each of the XRS A and B channels, XRS-A1 and XRS-A2, and a similar specification for XRS-B (B1 and B2).

Figure 1 illustrates the instrument solar diode sensors that measure both the XRS-A and XRS-B channels in addition to the “dark” photodiodes that measure background signal variations. It also shows the configuration of the quadrant photodiodes, which are used to measure high activity and determine flare location.

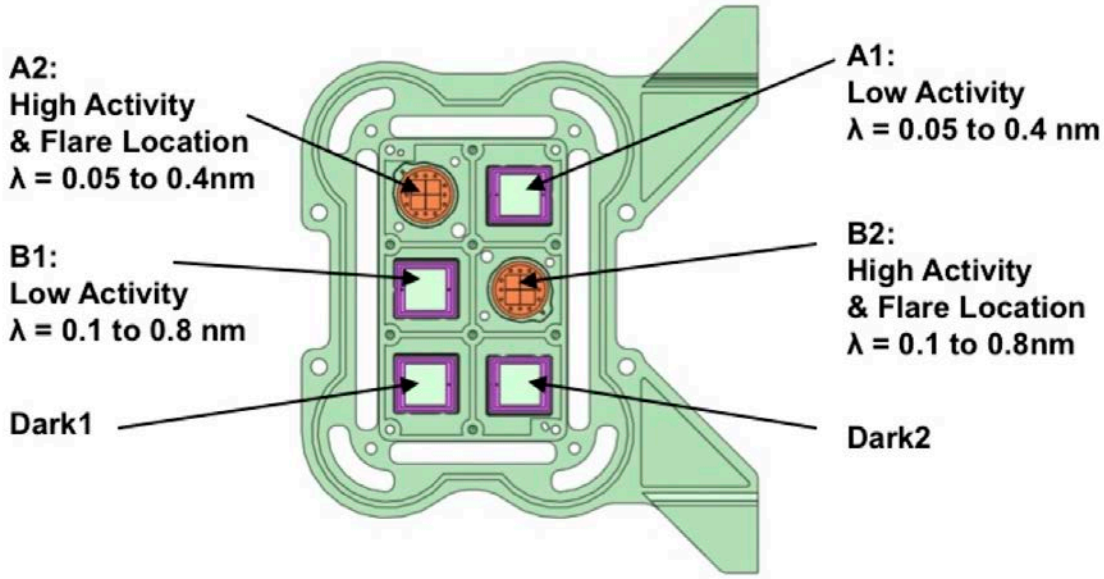

Figure 1. XRS solar diodes configuration.

3.0 ALGORITHM DESCRIPTION

The XRS.10 Flare Location algorithm uses the signals from each of the 4 quad-diodes in the solar maximum (low sensitivity) detector of XRS-B to calculate the approximate

location of a flare. This calculation can be done very quickly, providing a nearly instantaneous (<3 second) product. The result from this algorithm provides important situational awareness to the SWPC forecasters.

The XRS.10 Flare location algorithm is designed to be robust (i.e., all exception conditions are anticipated and only valid data is passed on) and computationally efficient. The algorithm will demonstrate no “memory leaks” or other computational exceptions resulting in failure or errors.

The algorithm is designed to be a callable routine for increased flexibility and extensibility in final implementation. The algorithm will be triggered based on a flare detection by the XRS.07 algorithm. The XRS.10 algorithm will calculate flare position every three seconds, with the first results no more than three seconds from the time that XRS.07 provides a “EVENT_START,” until XRS.07 provides a “EVENT_PEAK”. The updated flare position will be provided at each time step, but only the final value (corresponding to “EVENT_PEAK”) will be retained in the final output.

The algorithm design is language-independent, easily implemented in Python, Fortran or C/C++. However, the XRS.10 code will be delivered in the Python programming language.

3.1 Algorithm Overview

The algorithm will be a callable subroutine or object, so it is assumed the caller of the subroutine will provide it inputs of the historical or near real-time data in data tables or a similar data array structure. Correspondingly, the algorithm will return output data to the caller in a data table or array structure.

The input data can be in scientific units of W/m^2 or in counts. As long as all of the quad-diode values are in the same units, the units do not matter. The algorithm assumes time values corresponding to the measurement data values are in units of the Julian Day, and the data are ordered in time.

3.2 Processing Outline

Figure 2 below presents a flowchart outlining the sequence of operations. Briefly, the sequence of operations is as follows. Here, N is the number of desired background frames, the x/y offset refers to the offset of the XRS instrument from the center of the solar disk and the EXIS roll angle refers to the angle between solar north and the top of the EXIS instrument.

1. Read in quad-diode signals, missing/corrupt data flags, EXIS roll angle, and x/y offsets for the previous N*4 valid frames (Note that here “valid” indicates that there are no missing/corrupt data flags).
2. Read in current (target) quad-diode signal, missing/corrupt data flag, EXIS roll angle and x/y offsets.
3. If XRS roll angle and x/y offsets vary by more than TBD from target frame then correct quad-diode signal in each previous frame for roll and offset to match target frame.
4. Compare each background quad-diode signal to the associated target signal and retain as “good” only those frames for which the signal in each quad-diode is smaller than in the associated target quad-diode.
5. Average most recent N good frames to construct background. The status flag is set to “0”. If N good frames are not available, average the frames available and change the status flag to ‘1’. If no background frames are available, change the status flag to ‘2” and skip to step 7.
6. Subtract background
7. Calculate x/y position of flare.
8. Correct position for x/y offset and roll angle.
9. Convert to solar coordinate system
10. Display flare position.
11. Check whether the most recent result from XRS.07 indicates EVENT_PEAK.
12. If not, read in new quad-diode signal x/y offset and EXIS roll angle and to step 3, if so, end calculation and write flare time and final location to file.

The value N is currently set at 20 (1 minute of 3 second data), but will be an adjustable parameter that will need to be determined at PLT. Another adjustable parameter will be the delay time between the background frames and the frame corresponding to EVENT_START. That value is currently set at 0 (i.e. the last background frame is directly followed by the first flare frame). This value is also set to be adjustable so that a delay time can be built in. This may be necessary because the XRS.07 algorithm will designate an EVENT_START only once a clear rise has been observed, and thus the “pre-event” frames will contain part of that rise.

A note about step 3. Correcting for x/y offset and roll angle is not necessary when averaging the background frames and subtracting from the target frame if the change in offset and roll angle is not significant. If at all possible, it is better to manipulate the raw data and only correct for offset and roll angle at the end, when calculating flare location.

Note that the background is recalculated each time, but should be based on the same pre-flare time period. The reason for the recalculation is that background frames can be higher than the target frame, particularly early in the flare. Those background frames

that have higher signal than the target frame are removed from the calculation (see section 4.4 for more details). However, as the flare intensity increases, those background frames can be safely included in the background calculation.

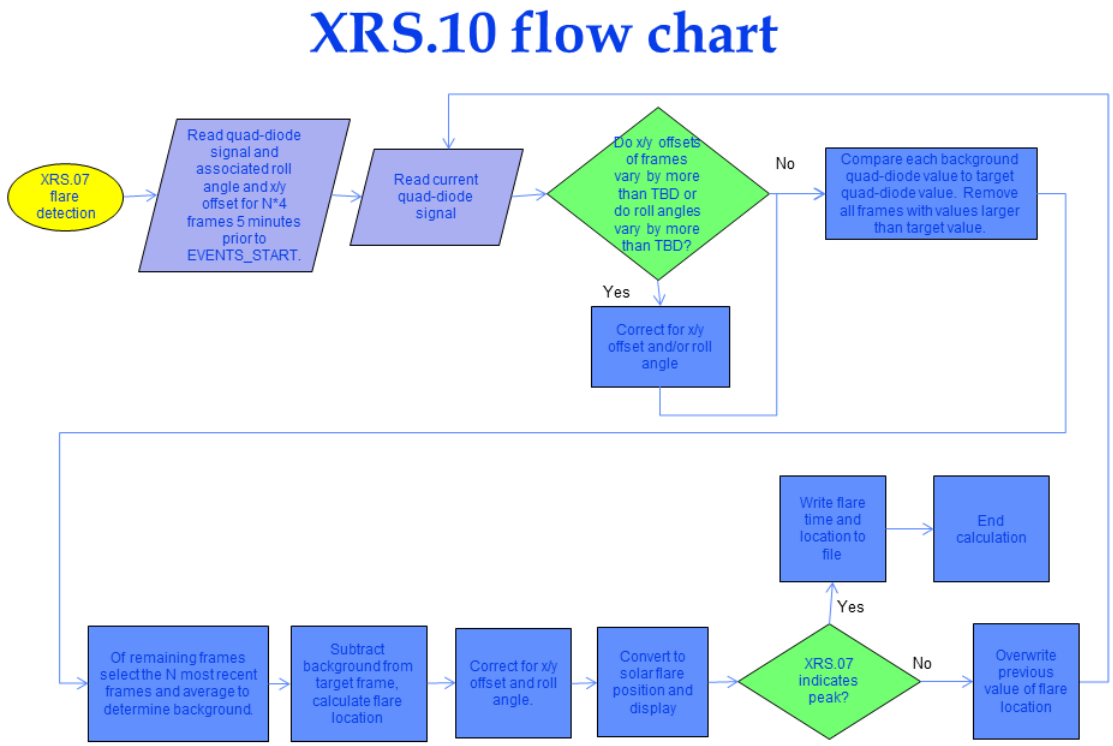

Figure 2: XRS.10 Algorithm Flowchart Overview

3.3 Algorithm Input

- Data:
  - Signal (irradiance or counts) from all four of the XRS-B quad-diodes
    - Note that if XRS-B data is not available, this algorithm can and should be called using XRS-A quad-diode data.
  - EXIS X and Y offsets from solar center
  - EXIS roll angle

- Timestamp of XRS_B values, in Julian Days
- Unique value to indicate missing or corrupt data

- Table of the adjustable values
  - N, the number of frames desired for background correction
  - delay time between the background frames and the frame corresponding to EVENT_START

3.3.1 Primary Sensor Data

GOES-R XRS has six channels (Chamberlin et al., 2009): XRS-A1 & XRS-B1 are larger Si diodes to measure low X-ray flux, and XRS-A2 & XRS-B2 are smaller, quadrant Si diodes to measure high X-ray flux, and to also provide approximate flare location on the solar disk. There are also two “dark” channels to measure the effect of energetic particles on the XRS data. The ‘A’ channels measure the integrated 0.05-0.4 nm X-ray flux, and the ‘B’ channels measure the integrated 0.1-0.8 nm flux. The XRS.10 algorithm will use the quad-diode sensor data from XRS-B2.

3.3.2 Ancillary Data

The XRS.10 algorithm requires the status of XRS.07 algorithm, specifically EVENT_START and EVENT_PEAK.

3.4 Theoretical Description

The calculation of the XRS.10 flare location is straightforward and quick. The algorithm will only be run when a flare has been detected. The algorithm will be a stand-alone subroutine other software can execute.

3.4.1 Physics of the Problem

For the first time, GOES XRS will consist of a quad-diode with a square aperture in front. The ratios of the illumination received by each quadrant give the position of the light source in the field of view. The full irradiance is preserved as the sum of the currents in all four quadrants.

3.4.2 Mathematical Description

The algorithm will first examine the quad-diode quality flags, included as part of the metadata input to the subroutine, to verify the valid range of quad-diode measurements.

For a uniformly illuminated Sun, each of the quad-diodes will be equally illuminated, as in **Figure 3**. Equation 1 provides the details to determine the X and Y coordinates, which in this case are 0, i.e. the solar center.

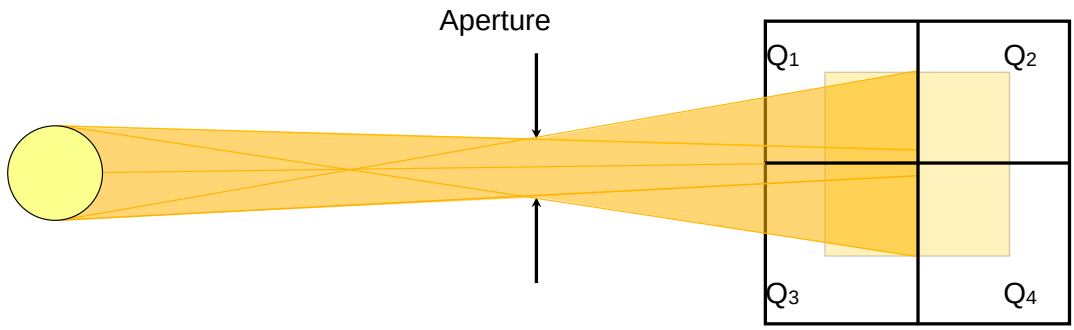

Figure 3: Uniformly illuminated Sun and resulting illumination on quad-diode.

$$X = ([Q_2 + Q_4]-[Q_1 + Q_3])/sum = ([(1/4)+(1/4)]-[(1/4)+(1/4)])/(1) = 0.00$$
$$Y = ([Q_1 + Q_2]-[Q_3 + Q_4])/sum = ([(1/4)+(1/4)]-[(1/4)+(1/4)])/(1) = 0.00$$

Equation 1: Location equation in X and Y direction for uniformly bright Sun. Corresponds to **Figure 3**, with the solar brightness being 1.

When a flare occurs in the southern hemisphere, at 0W, with a brightness of 10, as in **Figure 4**, the relevant equations (**Equation 2**) indicate that the flare location has an X value of 0 and a Y value of 0.55.

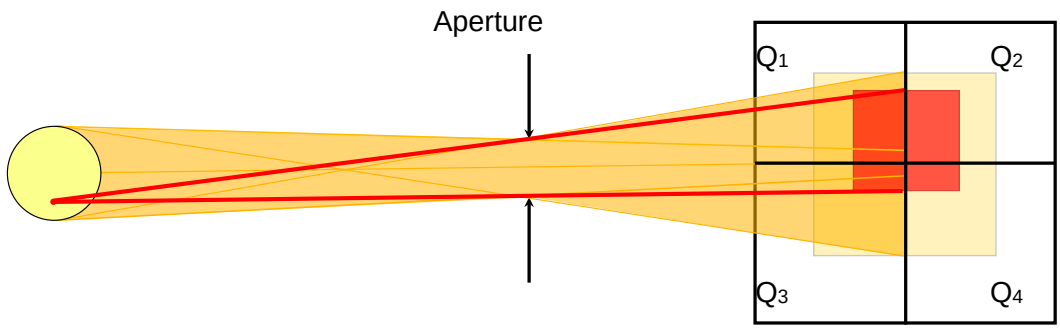

Figure 4: Uniformly illuminated Sun (with value 1), flare in southern hemisphere (with value 10) and resulting illumination on quad-diode.

$X=([Q_2 + Q_4]-[Q_1 + Q_3])/sum = ([(¼+4)+(¼+1)]-[(¼+4)+(¼+1)])/(1+10) = 0.00$
$Y=([Q_1 + Q_2]-[Q_3 + Q_4])/sum = ([(¼+4)+(¼+4)]-[(¼+1)+(¼+1)])/(1+10) = \mathbf{0.55}$
Equation 2: Location equation in X and Y direction for uniformly bright Sun with flare in southern hemisphere along the central meridian. Corresponds to **Figure 4** with the solar brightness being 1 and the flare brightness being 10.

As the Sun is not generally uniformly bright, we subtract the background from the target frame (during the flare). We calculate a background based on the N most recent frames of good XRS quad-diode data prior to the frame associated with EVENT_START. To do this, we take the N*4 previous frames and remove those with quality flags indicating missing/corrupt data. We then compare each of the remaining frames to the target frame and remove any frames where one or more of the quad-diode measurements are higher than the measurement for that quad-diode in the target frame. Finally, we average the N most recent values for each of the 4 quad-diode positions separately. The resulting 4 diode-specific averaged background values are then subtracted from the 4 target frame quad-diode values. The resulting equations are shown in Equations 5 and 6.

$X=([(Q_2-Q_{2B})+(Q_4-Q_{4B})]-[Q_1-Q_{1B})+(Q_3-Q_{3B})])/(sum-sum_B)$
$Y=([(Q_1-Q_{1B})+(Q_2-Q_{2B})]-[Q_3-Q_{3B})+(Q_4-Q_{4B})])/(sum-sum_B)$
Equation 3: Location equation in X and Y direction, including background correction (note: all quantities with subscript "B" denote background measurements).

3.4.3 Algorithm Output

1. Flare location in Solar coordinate system
2. The corresponding Julian Day timestamp at a resolution of 1 second

4.0 TEST DATA SETS AND OUTPUTS

Proxy data is constructed using SXI images. Flare locations calculated using the algorithm are compared to flare locations as given at NGDC (ftp://ftp.ngdc.noaa.gov/STP/space-weather/solar-data/solar-features/solar-flares/x-rays/goes/).

4.1 Simulated/Proxy Input Data Sets

A forward model was developed to transform existing GOES SXI "Beryllium thin" images into a simulated quad-diode response. Figure 5 shows the wavelength response for the SXI instruments on GOES-12 and GOES-13 (noted as SXI-N in the figure). The SXI wavelengths (6-20Å) compare reasonably well to the XRS-B wavelengths (1-8Å).

We used the resulting quad-diode proxy values to calculate flare location and compared with NGDC "truth" flare locations. We used SXI images from all days that contained an X-class flare from 2001-2013. SXI Beryllium thin images were generally

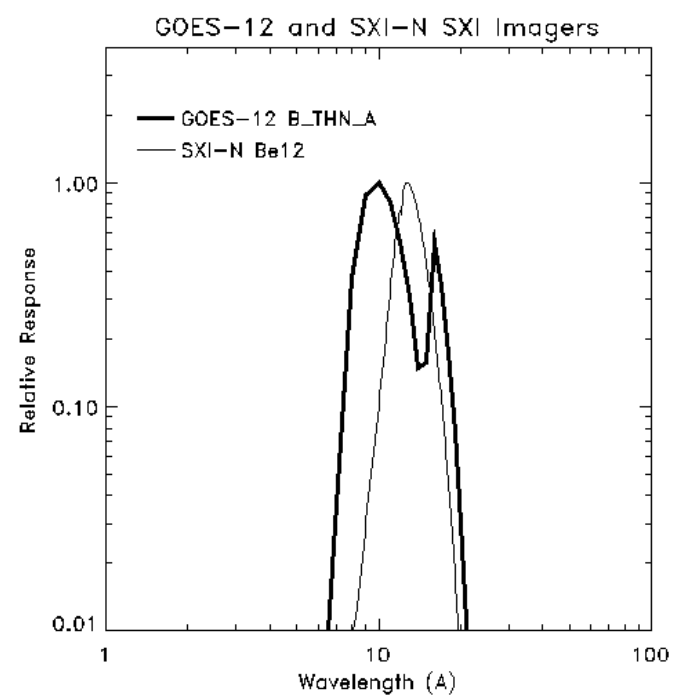

Figure 5: Wavelength response of GOES-12 SXI Be-Thin and GOES-13 and 14 SXI Be12 images (http://www.swpc.noaa.gov/sxi/goes13/info/G13_genx_plots_compare.html).

available every 7-8 minutes. (Note that XRS data will be available every 3 seconds).

4.2 Output from Simulated/Proxy Inputs Data Sets

The output is the calculated flare location, date, and one status flag:

- Flare_location
- Julian Date timestamp
- Flare_location_status_flag (indicates quality of the data and of the background that is subtracted)

4.3 Construction of Simulated Quad-Diode Signal

The proxy data were constructed using SXI Beryllium-Thin (Be-Thin) images. The SXI Be-Thin images are typically available every 7-8 minutes. Proxy quad-diode data were created by the following method:

1. SXI images were centered and cropped to a consistent size.
2. The algorithm stepped through each of the pixels in the image and used the x/y index of each pixel to determine the location of that pixel within the image.
3. The pixel location was then converted to arcseconds from image center (each SXIpixel is 5 arcseconds in size).
4. The minimum and maximum values of where light from the pixel fell on the simulated quad-diode were determined by multiplying that pixel's location by the distance from the aperture to the detector and then adding (for maximum) and subtracting (for minimum) half the aperture size.
5. The maximum and minimum locations determined the percentage of light from a given pixel that fell on each of the quad-diodes.
6. These values were summed over all the pixels in the image.

4.4 Test Results Using Simulated Quad-diode signal, including uncertainty estimates

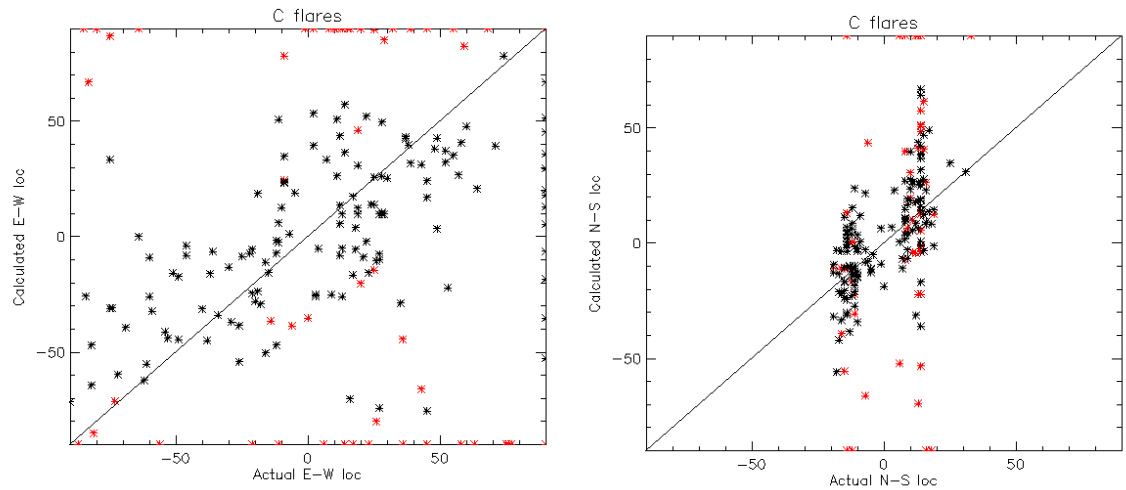

Figure 6: Calculated vs. actual E-W (left) and N-S (right) locations for C-class flares. Events with problematic background are displayed in red.

The simulated quad-diode data were used to determine flare location based on the algorithm described in section 3.4. For this data set we used N=10 frames to determine the background. The results were compared to the NGDC database of flare locations and are shown in **Figure 6**-**Figure 8** with EW location on the left and NS location on the right. Calculated values are shown on the y-axis and actual values are shown on the x-axis. Periods flagged as having bad background are shown in red and statistics are quoted for all flares and for flares with bad background removed. For C-class flares (**Figure 6**) we found a mean error of 9.7±8.1 arcminute. When we removed cases with bad background (30% of all flares) we found a mean error of 6.3±4.7 arcminutes. For M-class flares (**Figure 7**) we found a mean error of 5.5±5.4 arcminutes. After removing cases with bad background (9% of all flares) the mean error is 4.4±3.2 arcminutes. For X-class flares (**Figure 8**) the mean error is 3.6±2.5 arcminutes. There were no cases of bad background for X-class flares.

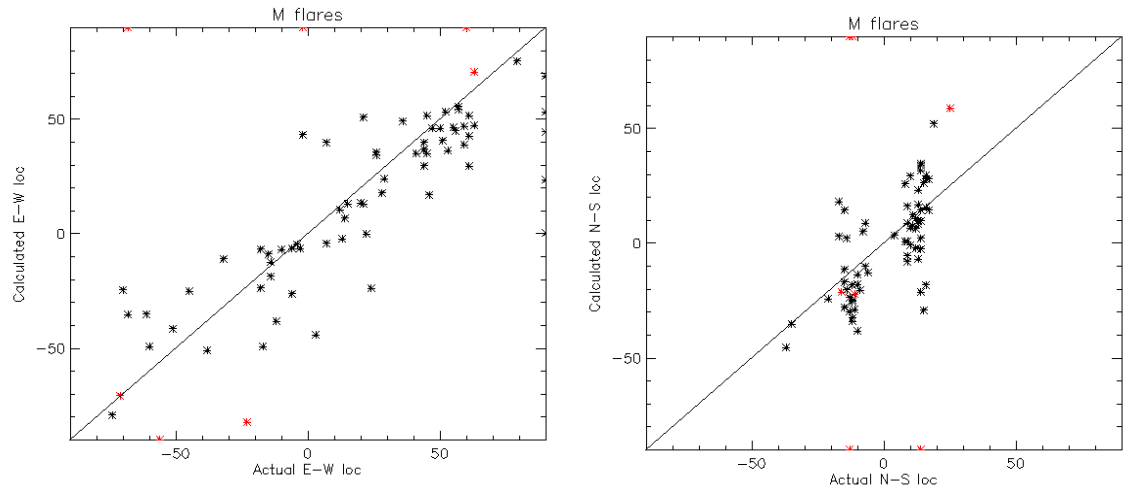

Figure 7: Same as **Figure 6**, but for M-class flares.

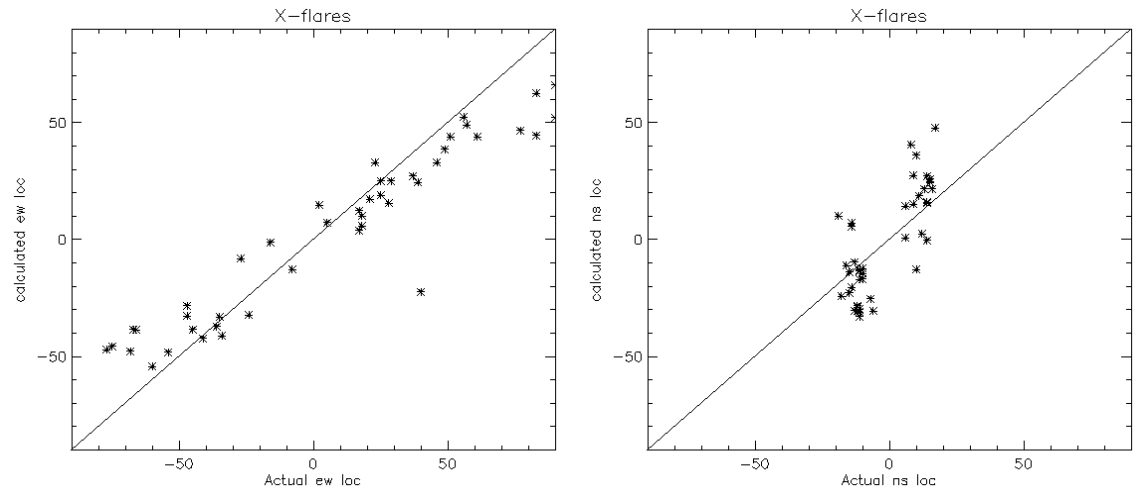

Figure 8: Same as **Figure 6**, but for X-class flares.

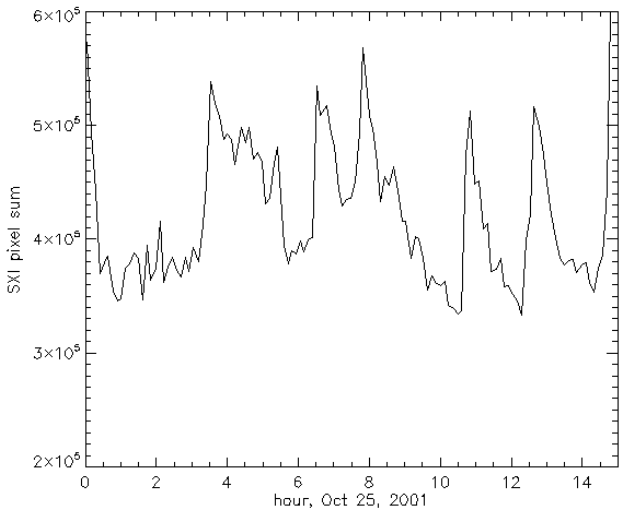

Figure 9: Example of complicated series of events. C-class flare late in the sequence was incorrectly located due to bad background determination.

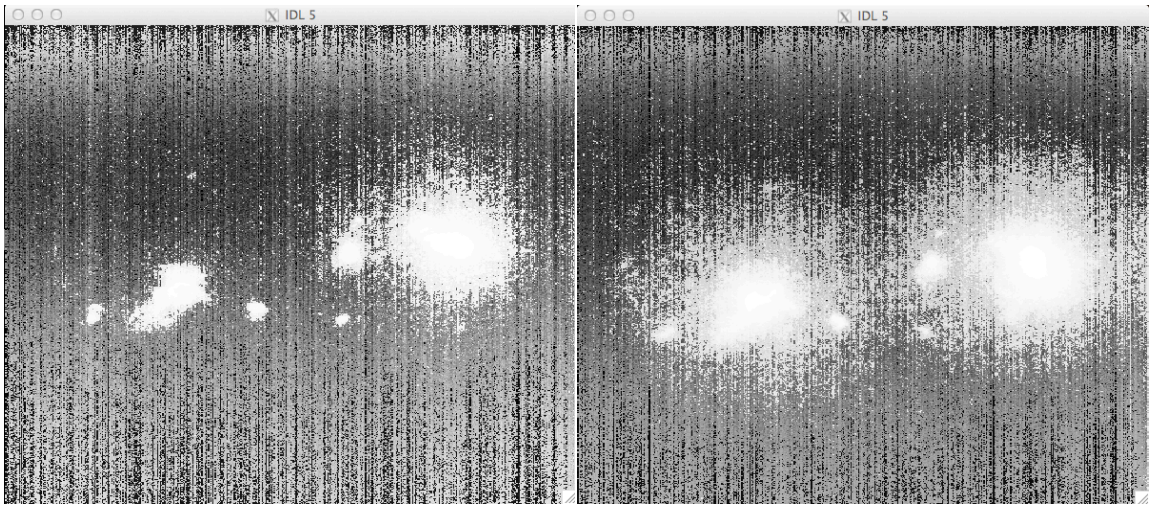

Figure 10: Example of two M-class flares that occurred within 1 hour of each other, yielding a poor determination of the location of the second one.

The algorithm did not perform as well when the Sun was very active, with multiple sequential flares. **Figure 9** shows an example of multiple C-class flares over the course of several hours on Oct 25, 2001. The locations of the C-class flares late in the series

had significant errors. Similarly, in **Figure 10** we show an example of two M-class flares that occurred within 1 hour of each other on June 11, 2003. An M4.5 flare began at 1621, peaked at 1636, and ended at 1650 at N12W59 (see bright region in left frame). At 1727 an M1.8 flare began at S16E23 (it peaked at 1727 and ended at 1800). The two regions are seen in the right frame of **Figure 10**. The N-S location of the second flare was quite close to the actual location, while the E-W location was significantly different.

5.0 PRACTICAL CONSIDERATIONS

The XRS.10 algorithm would need to be changed if XRS.07 algorithm outputs change. In addition, fine tuning will be needed during PLT to calibrate the conversion from x/y coordinates to solar coordinates. Adjustable parameters will be provided in a separate file. The adjustable parameters currently planned are number of frames for background calculation and what delay, if any, is needed between background frames and EVENT_START.

5.1 Numerical Computation Considerations

The lifecycle of the algorithm must be no more than 3 seconds. This is easily achieved. The input data are expected to be available at a 3-second cadence. Note, however, that XRS.07 runs on 1 minute cadence, so our first and last calculation will be dependent on that delay.

5.2 Programming and Procedural Considerations

The XRS.10 algorithm will be written in the Python computer language. The algorithm is simple enough that the program logic can easily be re-written in another language such as C/C++.

5.3 Quality Assessment and Diagnostics

The key goals for testing the algorithm are:

- Ensure the algorithm is consistent with measured flare locations.
- Ensure the algorithm performs all calculations within 3 seconds.
- The algorithm does not result in a “hung” condition or it does not result in any “memory leaks”.
- Ensure the algorithm handles any potential exceptions (e.g., missing data).

These goals can be met by developing a test-bed program that encapsulates the algorithm, reads from data files the simulated input data, then pipes the data to the algorithm, and finally retrieves the simulated output data. Test data is from GOES SXI,

forward modeled into a quad-diode format and the output is compared with measured solar flare locations.

5.4 Exception Handling

The algorithm shall trap all exceptions, and should flag bad background in the event that background data is missing or has values that average a higher value than the flare data for any of the 4 quad-diodes.

5.5 Algorithm Validation

The XRS.10 algorithm is tested with SXI data forward modeled to mimic the XRS quad-diode signal. Testing is statistical with all X-class flares (and any C-class or M-class flares that occurred on the same day) from 2001 to 2013 included.
The algorithm performed well, meeting the requirement of determining the location of X-class flares within 5 arcminutes. The primary cause of inaccurate locations was poor determination of background. That occurred when there were multiple flares occurring within a short time period. We note that the cadence of SXI images was 7-8 minutes, while the cadence of XRS quad-diode frames will be 3 seconds. This increased cadence will significantly improve the background determination and thus the flare location. Because of the increased cadence and lack of available test data at that cadence, we leave the number of frames required for background determination (N=20), and the delay between the background frames and EVENT_START (t=0) to be adjusted during PLT (with their default values indicated.

6.0 ASSUMPTIONS AND LIMITATIONS

1. It is assumed that the XRS.10 algorithm inputs will be:
    a. N*4 XRS-B2 quad-diode measurements with missing data flagged with a missing-value, i.e., -1.0×10^{-5}.
    b. Status flags corresponding to each quad diode measurement (i.e., 0=missing data, 1=verified data, 2=data out-of-range).
    c. EXIS x/y offsets
    d. EXIS roll angle
2. Sufficient data to calculate background, and that background frames are lower than the target quad-diode measurement. If either of these conditions are not true, background will be flagged to indicate that the flare location accuracy will be degraded.
3. Input data are assumed to be verified prior to input, as indicated by their status flag.
    a. For example, during eclipse periods, out-of-range data will be flagged in the status flag as missing or out-of-range on input, and/or the data contains a missing-value flag (e.g., -99999.0).

4. The adjustable parameters listed in Section 3.3.

6.1 Performance

The lifecycle of the algorithm (i.e., time to completed calculations from receipt of input to the output of data) shall be less than 3 seconds.

6.2 Assumed Sensor Performance

It is assumed the XRS instrument will operate within design requirements as specified in EXISPORD81 (417-R-EXISPORD-0116, 2008).

6.3 Pre-Planned Product Improvements

No improvements are currently planned.

7.0 REFERENCES

Chamberlin, P. C., F. G. Eparvier, A. R. Jones, and T. N. Woods, Next Generation X-Ray Sensors (XRS) for the NOAA GOES-R Series Satellites, SPIE Proceedings, in preparation, 2009.

APPENDIX A, XRS.10 REQUIREMENTS

CDR Revision, Approved 08/07/13

1. General

XRS.10.01.01	The algorithm shall meet a cadence of 3 seconds.
XRS.10.01.02	The algorithm shall not exceed a latency of 3 seconds.

2. Algorithm Inputs

XRS.10.02.01	The algorithm shall ingest all dark-corrected currents from the XRS quad-diodes.
XRS.10.02.02	The algorithm shall ingest the X and Y offsets from the Sun center.
XRS.10.02.03	The algorithm shall ingest spacecraft roll angle.
XRS.10.02.04	The algorithm shall ingest XRS quad-diode raw counts.
XRS.10.02.05	The algorithm shall ingest the outputs from the XRS.10 Event Detection Algorithm.

3. Processing

XRS.10.03.01	The algorithm shall report the location of a flare with a magnitude of X1 or greater to within 5 arcminutes.
XRS.10.03.02	The algorithm shall begin reporting the location of a flare within 3 seconds of the start of the flare, as identified by XRS.07.
XRS.10.03.03	The algorithm shall report the location of a flare at peak luminosity within 3 seconds of the flare reaching peak luminosity, as identified by XRS.07.
XRS.10.03.04	The algorithm shall continue to provide updates concerning the flare location until at least 30 seconds after the XRS.07 algorithm reports that the flare has peaked.

4. Algorithm Outputs

XRS.10.04.01	The algorithm shall output the flare location in heliographic coordinates if the flare occurs on the solar disk.
XRS.10.04.02	The algorithm shall output the flare location in terms of distance from the solar center and angle from Solar North if the flare occurs off of the solar disk.
XRS.10.04.03	The algorithm shall provide quality flags to indicate whether adequate data were available to support the locations it reports.

5. Error Handling

XRS.10.05.01 If quad diode measurements are missing, the algorithm shall wait for the next valid quad diode measurements.

6. Ancillary Data

XRS.10.06.01 The algorithm shall not ingest any ancillary data.

7. Associated System Requirements – **not** algorithm requirements

XRS.10.07.01 Remote backup capability shall be required for this product.

XRS.10.07.02 The XRS.10 algorithm will begin providing flare locations within 3s after the XRS.07 algorithm identifies the start of a flare event.