New Features in the SPOC Pipeline Release 4.0

Jon M. Jenkins[a], Joseph D. Twicken[b], Peter Tenenbaum[b], Mark Rose[d], Eric Ting[a], Jeffrey C. Smith[b], Rob Morris[b], Douglas A. Caldwell[b], Bill Wohler[b], A. Dean Chacon[c], and Chris Henze[a]

[a]NASA Ames Research Center, [b]SETI Institute, [c]Millenium Engineering, [d]Leidos

Abstract

The Science Processing Operations Center is in the process of testing and deploying Release 4.0 of the codebase in the March 2019 timeframe. This paper describes the new features of the software and their likely impact on the quality of the TESS science data products. The major goals of Release 4.0 are to improve the extraction of photometry from the pixels in light of the non-uniform pointing performance and the identification of instrumental signatures from the light curves. We also describe modifications to the FFI pipeline to allow the generation of FFI light curves, correction of the instrumental systematics therein, and planet searches, primarily for the purpose of validating the 2-min pipeline against the FFI pipeline, but also to be able to provide cotrending basis vectors (CBVs) derived directly from the FFIs to the public to aid them in their extraction and correction of photometry. We also discuss the improvements in photometric performance of the pipeline and its various components.

The lapse in funding experienced between 22 December 2018 and 27 January 2019 significantly delayed our ability to conduct integration testing as planned for late December/early January, delaying the start of V&V by one month to the end of February 2019.

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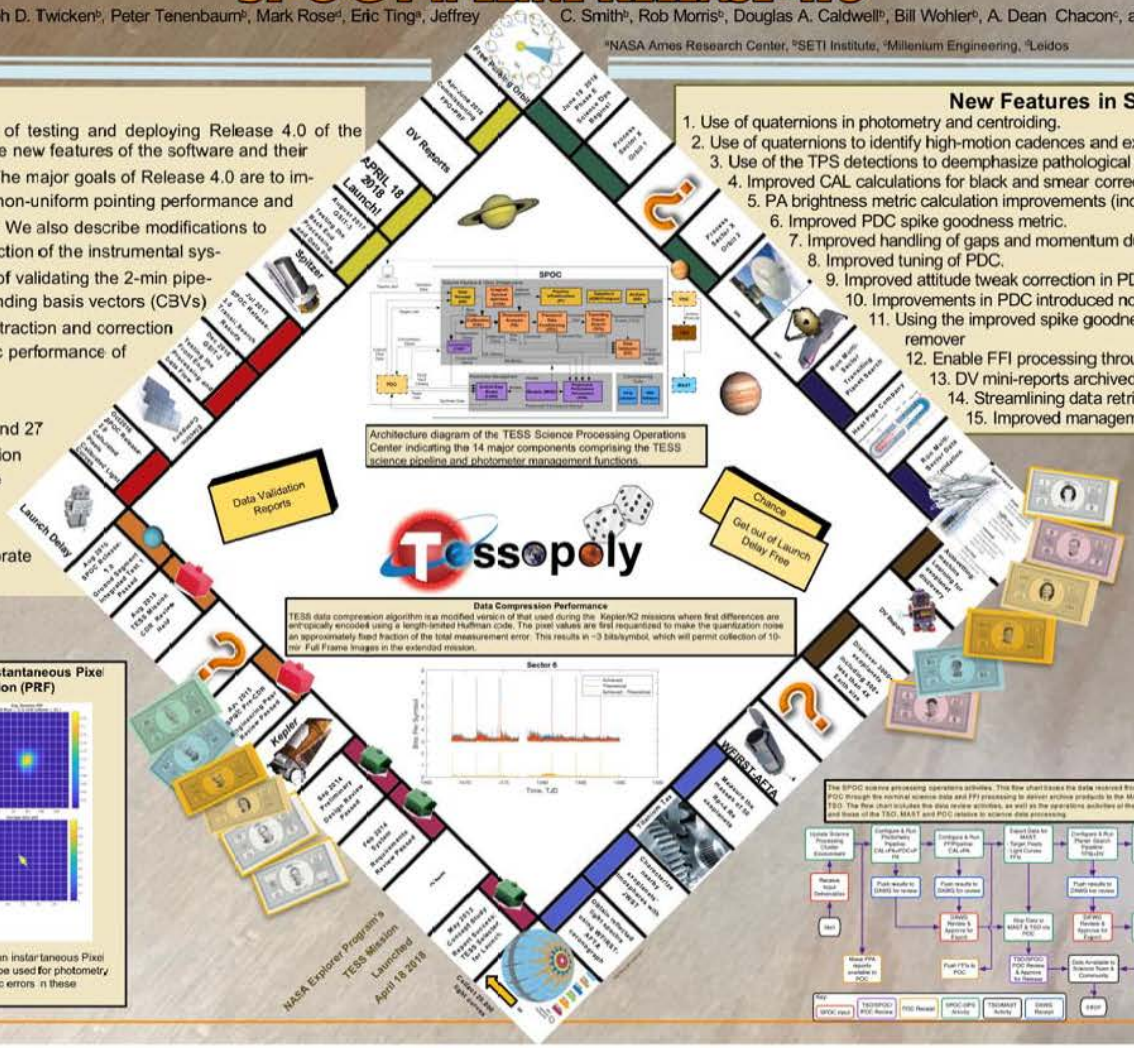
New Features in SPOC 4.0

1. Use of quaternions in photometry and centroiding.
2. Use of quaternions to identify high-motion cadences and exclude same.
3. Use of the TPS detections to deemphasize pathological cadences ("skyline flattening").
4. Improved CAL calculations for black and smear correction.
5. PA brightness metric calculation improvements (include crowding in calculation).
6. Improved PDC spike goodness metric.
7. Improved handling of gaps and momentum dumps in PDC.
8. Improved tuning of PDC.
9. Improved attitude tweak correction in PDC.
10. Improvements in PDC introduced noise and correlation goodness metrics
11. Using the improved spike goodness metric to minimize overfitting in the spike remover
12. Enable FFI processing through planet search.
13. DV mini-reports archived to MAST
14. Streamlining data retrieval and persistence to database
15. Improved management of jobs on the NAS Pleiades supercomputer

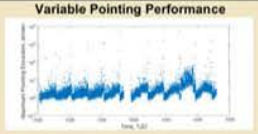


Architecture diagram of the TESS Science Processing Operations Center indicating the 14 major components comprising the TESS science pipeline and photometer management functions.

Data Compression Performance

TESS data compression algorithm is a modified version of that used during the Kepler/K2 missions where first differences are entropically encoded using a length-limited Huffman code. The pixel values are first requantized to make the quantization noise an approximately fixed fraction of the total measurement error. This results in ~3 bits/symbol, which will permit collection of 10-min Full Frame Images in the extended mission.

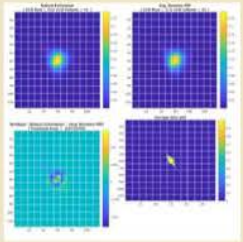
Variable Pointing Performance



Variable pointing performance, especially during the first several sectors, motivate many of the development features in SPOC 4.0. Excursions can greatly exceed 1 pixel. Pointing performance in more recent sectors (5) is much better behaved but is still variable over time.

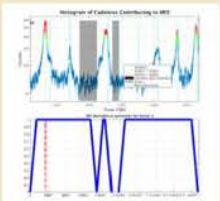
This variable pointing performance motivates many of the SPOC 4.0 features.

Reconstruction of the Instantaneous Pixel Response Function (PRF)



SPOC 4.0 allows us to reconstruct an instantaneous Pixel Response Function (PRF) that can be used for photometry and centroiding to reduce systematic errors in these quantities.

Reducing False Positives from Instrumental Signatures



Skyline plot from Sector 4 (top panel) showing how many transit signatures fell on each cadence. Deemphasis weights (bottom panel) were crafted from this histogram to significantly reduce the number of false positives detected in the pipeline.