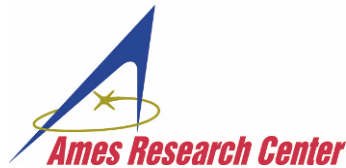


Documentation Close-Out Review (DCR)

Stephen Walker (PSE)

April 13, 2016 DOY 104



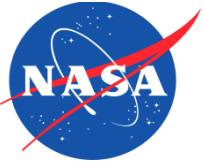
SAO



SETI INSTITUTE



STScI



Logistics



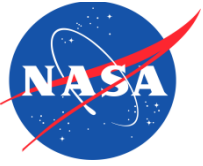
- Location: NASA Ames Building 244/ Rm 103
- Dial-in Information:
 - (818) 354-4044 or (844) 575-9329
- Webex Information:
 - [Join the meeting](#) or <https://jplwebex.jpl.nasa.gov/orion/join?siteurl=jplwebex>
 - Meeting number: 991 006 761
 - Password: KDR1
- Wireless Network Access:
 - Guest network access will be provided for all visitors
- Materials hosted at: <http://exep.jpl.nasa.gov/kdr/>
 - Username: telescope
 - Password: reactionwheel



Agenda- DCR Step 1

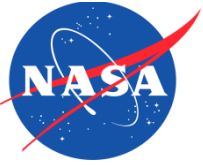


Topic	Speaker	Duration (min)	Time
Logistics/Agenda	Stephen Walker	5 min	10:00-10:05
Review of DCR Terms of Reference	Ingolf Heinrichsen	10	10:05-10:15
Project Status Summary	Charlie Sobeck	15	10:15-10:30
DCR Documentation Summaries -Documentation Scope -Documentation List -Product/Documentation Repositories	Stephen Walker	15	10:30-10:45
Introduction Handbooks/Manuals/Data Release Notes	Stephen Walker	5	10:45-10:50
-KIH & KAM Walkthrough	Mike Haas	60	11:00-12:00
Lunch Break (Delivered)		60 min	12:00-13:00
-KDRN & KDCH Walkthrough	Mike Haas	30	13:00-13:30
-KDPH Walkthrough	Jon Jenkins	45	13:30-14:15
Overview of ORP Documentation	Mike Haas	30	14:15-14:45
Overview of Pipeline Source Code Release	Stephen Walker	15	14:45-15:00
Schedule Status	Stephen Walker	10	15:00-15:10
Final Remarks (End of Formal Presentation)	Stephen Walker	5	15:10-15:15
Review Team Discussion	Ingolf Heinrichsen	60	15:15-16:15
Initial Review Team Feedback	Ingolf Heinrichsen	15 min	16:15-16:30



Kepler

Review of DCR Terms of Reference -Ingolf Heinrichsen



DCR Terms of Reference (TOR)



- Purpose:
 - The purpose of this DCR is to ensure that the legacy archive products are properly documented for use in future scientific studies after mission closeout
- Scope:
 - Provide legacy records of the mission instrument, data types, data processing, and the Kepler archives (MAST & NExSci)
 - Required documentation: Kepler Instrument Handbook (KIH), Kepler Data Processing Handbook (KDPH), Kepler Data Characteristics Handbook (KDCH), and Kepler Archive Manual (KAM)
 - Provide documentation of the science products that enable meeting the science goals
 - Ensure timely release of the Kepler pipeline source code

The DCR was established as part of the Kepler close-out plan and identified as one of the major milestones to be accomplished before Kepler close-out can be considered successful

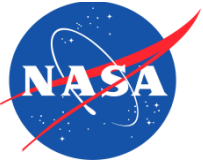


Introductions- DCR Review Team



Ingolf Heinrichsen (Chair)	Kepler Mission Manager (JPL)
Steve Howell	Kepler/K2 Project Scientist (ARC)
Nick Gautier	ExEP PCCB Science Advisor (JPL)
Mario Perez	HQ Kepler Program Scientist (NASA HQ)
Faith Abney	MAST Archive Lead
Rachel Akeson	NExSci Archive Lead
Thomas Barclay	Kepler/K2 GO Office Director
Jessie Dotson	Astrophysics Branch Chief (ARC)
Tom Roellig	Ames Astrophysics Branch (ARC)
Sean Carey	IPAC CalTech
Padi Boyd	TESS Guest Investigator Program Office Lead; Deputy Project Scientist for HST Operations
Doug Hudgins	Program Scientist, ExEP Science Mission Directorate (NASA HQ)
Scott Fleming	Archive Scientist, MAST Representative

David Breda: Review Manager

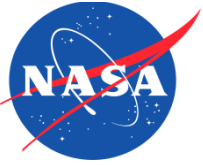


Expectations of Reviewers- DCR Step 1



- Identify any gaps in required documentation (KIH, KDPH, KDCH, and KAM)
 - Provide guidance to the project on the prioritization of RFA requests on the required documentation
- Review thoroughness of ORP review cycles
- Assess the status of plans to annotate and make the pipeline source code available to the community
- Identify any missing documentation
 - The review board may identify additional desirable documentation for HQ consideration as added scope
- Provide RFAs to the project within 7 days of DCR Step 1 meeting
 - Due to project by COB April 20, 2016

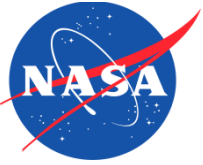
RFA responses from project by 5/20/16



Kepler

Project Status Summary

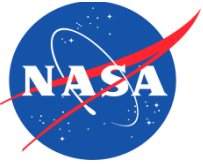
-Charlie Sobeck



Mission Timeline Summary



- Launched in 2009, the Kepler mission began gathering science data in May, after a two-month commissioning period.
- Science data collection ended in May 2013, after a second reaction wheel failed.
- Data is organized by quarters, separated by 90° spacecraft rotations to reorient the solar panels.
 - Commissioning data (a portion retroactively identified as Quarter 0) has been selectively provided to the archives, though not originally intended as a deliverable product.
- Mission data was processed quarter-by-quarter as it was received, with pixel files and light curves delivered to the MAST archive each quarter – each quarter processed by the the pipeline software version current at the time.
 - The full mission dataset was uniformly reprocessed with the penultimate pipeline software release (9.2), and fully processed again with the final pipeline release (9.3)
- Planet searches were conducted roughly annually on the accumulated dataset and result catalogs delivered to the NASA Exoplanet Archive at NExSci.



Mission Product Deliveries



The Kepler Mission has two primary deliverables:

- Observational datasets at MAST (with documentation)
 - Science data (pixels & light curves)
 - Calibration data (collateral, background, etc.)
 - Engineering data (housekeeping, navigation, etc.)

➡ Everything necessary to support legacy use of Kepler-collected data

- Transit search results at NExSci (with documentation)
 - Object catalogs
 - Candidate evaluations
 - Pipeline performance
 - Catalog assessment

➡ Everything necessary to compute planetary occurrence rates

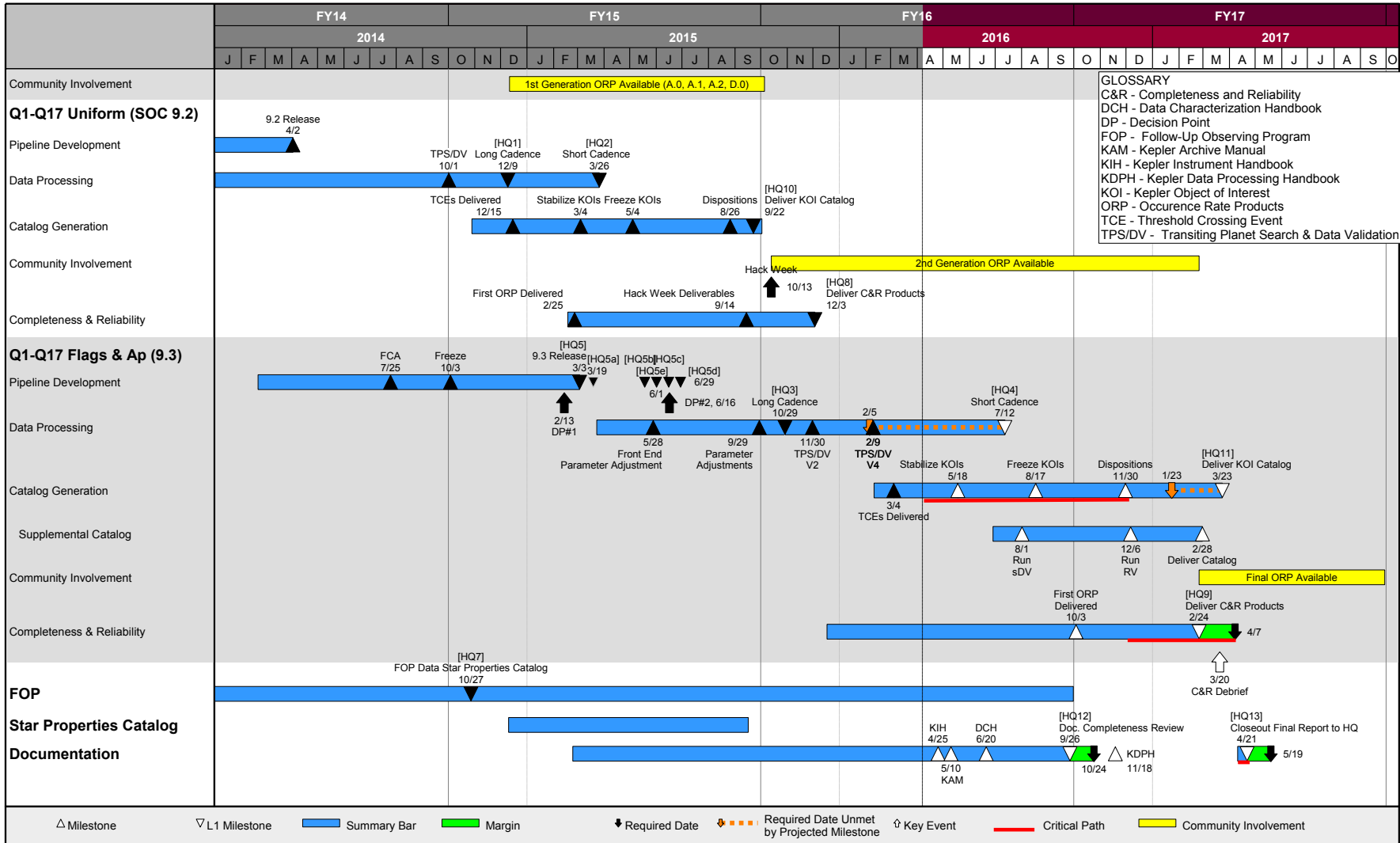


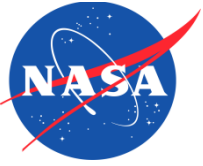
Level 1 Schedule



Kepler Closeout

Status Date: 04/06/2016





Schedule Assessment



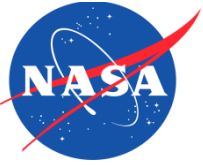
Kepler data gathering ended three years ago.

We have had 7 years of experience hosting the pixel/target data, with documentation at MAST. The final Long Cadence data (with documentation) was delivered last Fall.

Final Short Cadence processing is in progress with delivery scheduled for July, 2016.

We have delivered 5 previous Object Catalogs for hosting at the Exoplanet Archive, and have incrementally improved the products and documentation. The final catalog generation is in progress with final delivery scheduled for next March. Initial products have already been delivered.

Planet occurrence rate estimates have only been executed once, with the 9.2 pipeline software. Characterization of the 9.3 pipeline completeness and reliability has begun, and the final products/documentation are schedule for April next year.



Level 1 Schedule



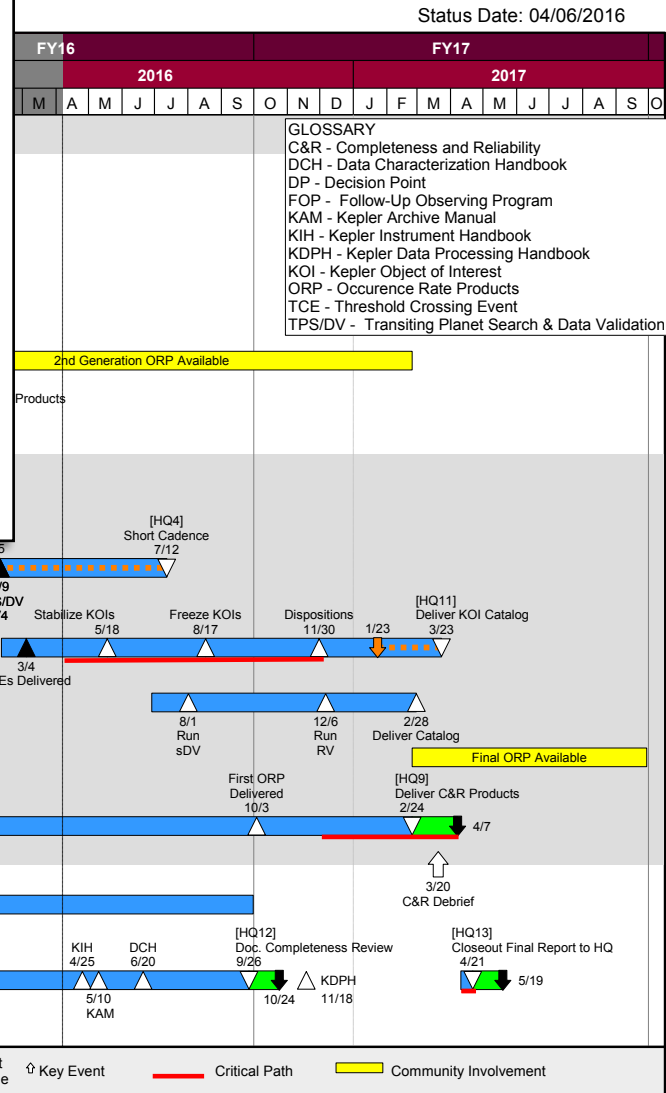
Kepler data gathering ended three years ago.

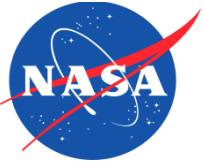
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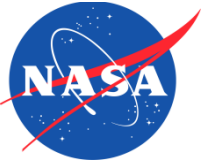
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DCR Documentation Summaries - Stephen Walker

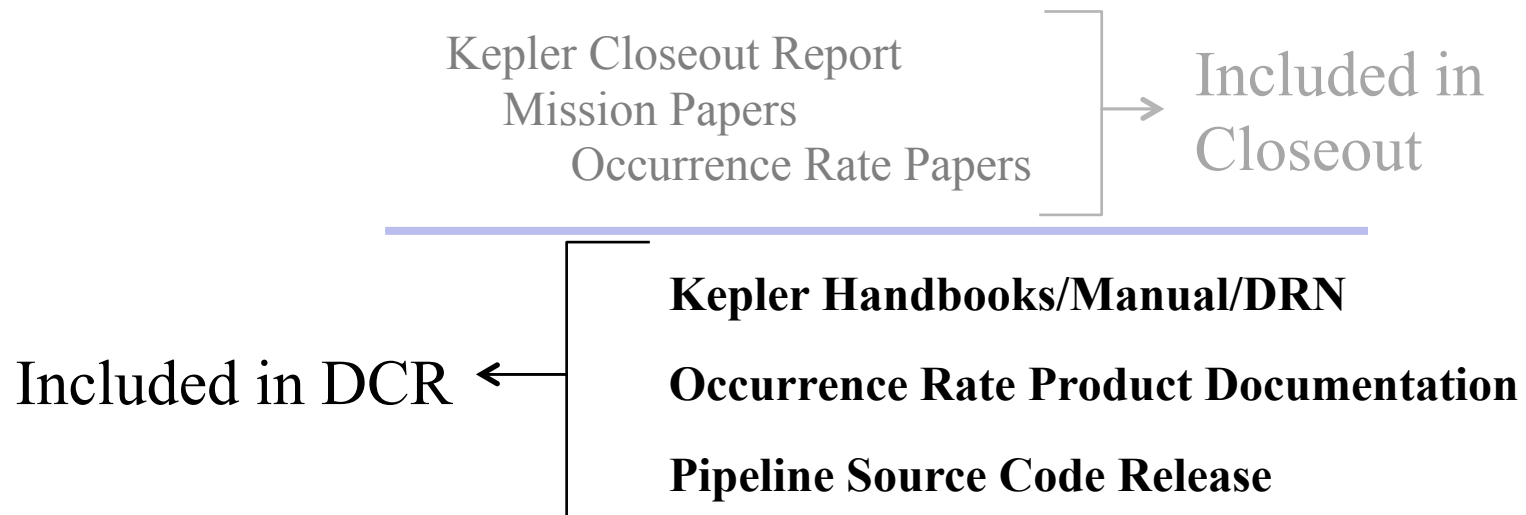
- Documentation Scope**
- Documentation List**
- Product/Documentation Repositories**

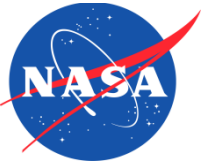


DCR Documentation Scope



- The Kepler closeout documentation that is required for the DCR represents the documentation that the community needs to effectively use the Kepler legacy data

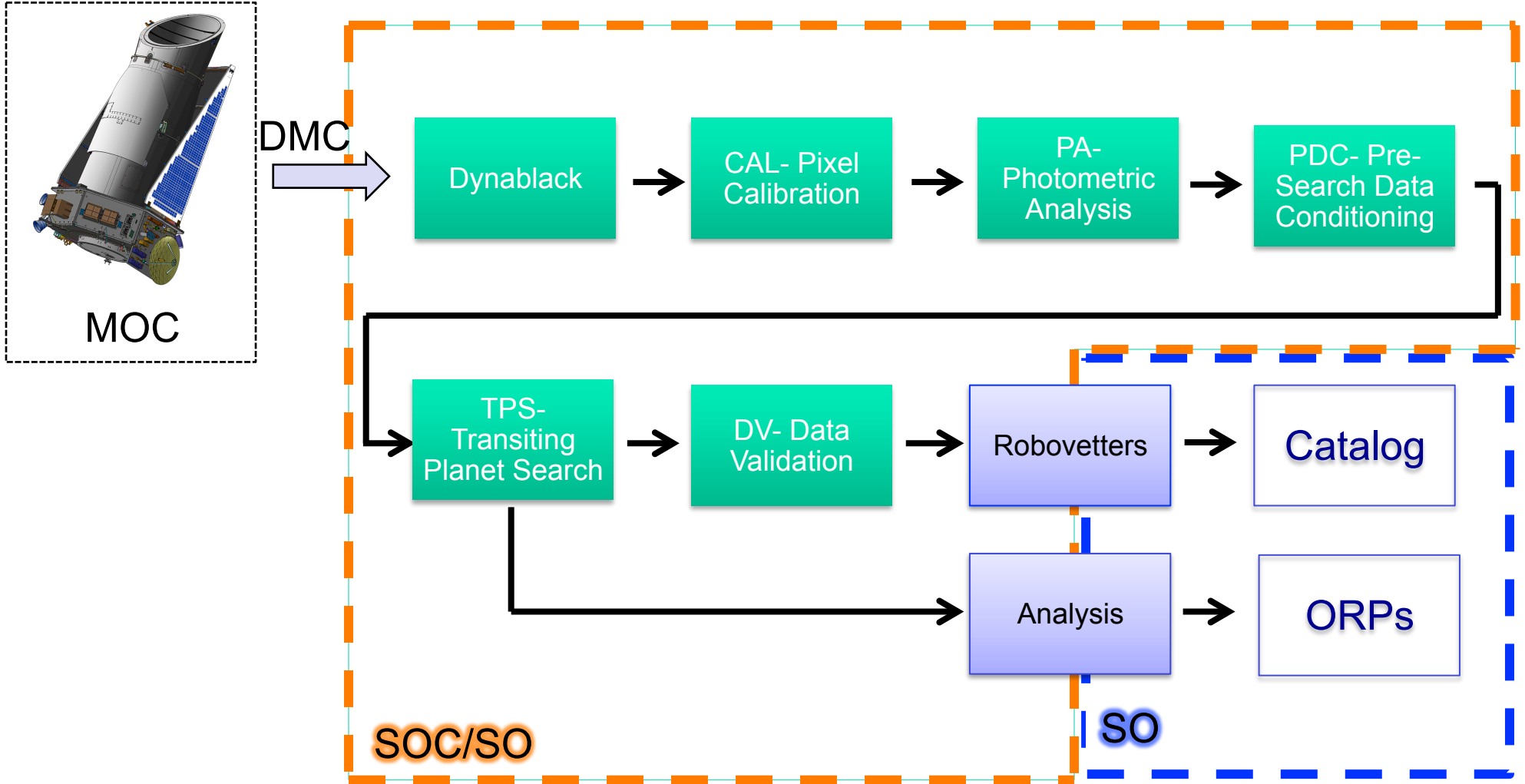


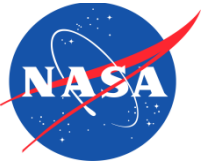


Responsible Mission Elements- Data Processing Flow



- Orientation to the data processing flow

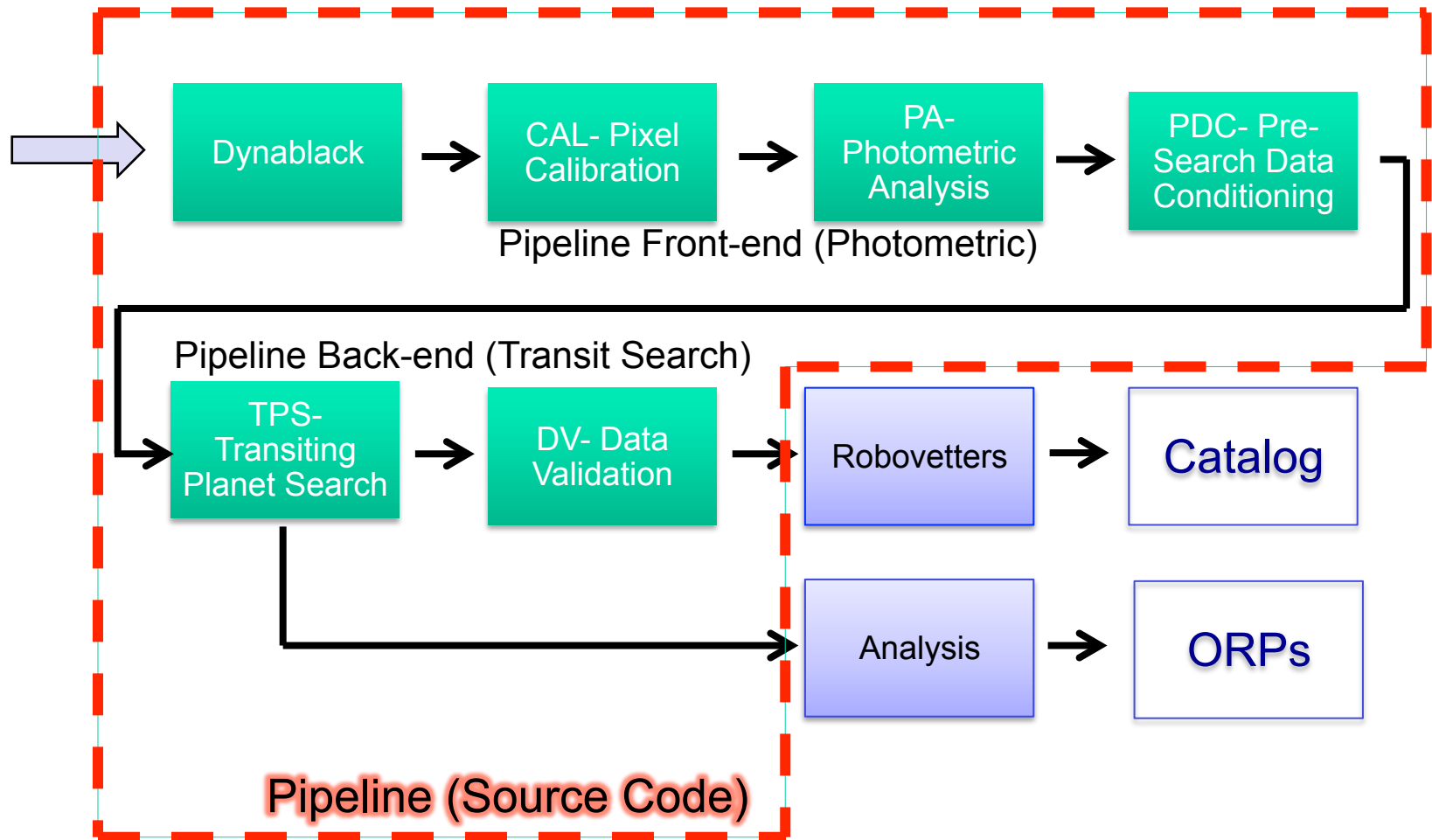
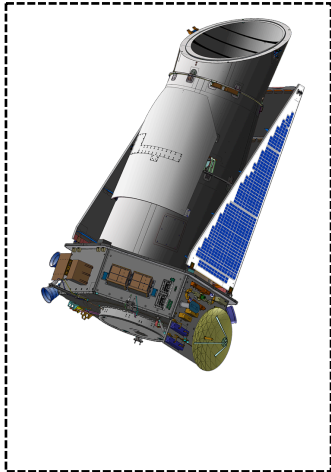




Pipeline Defined

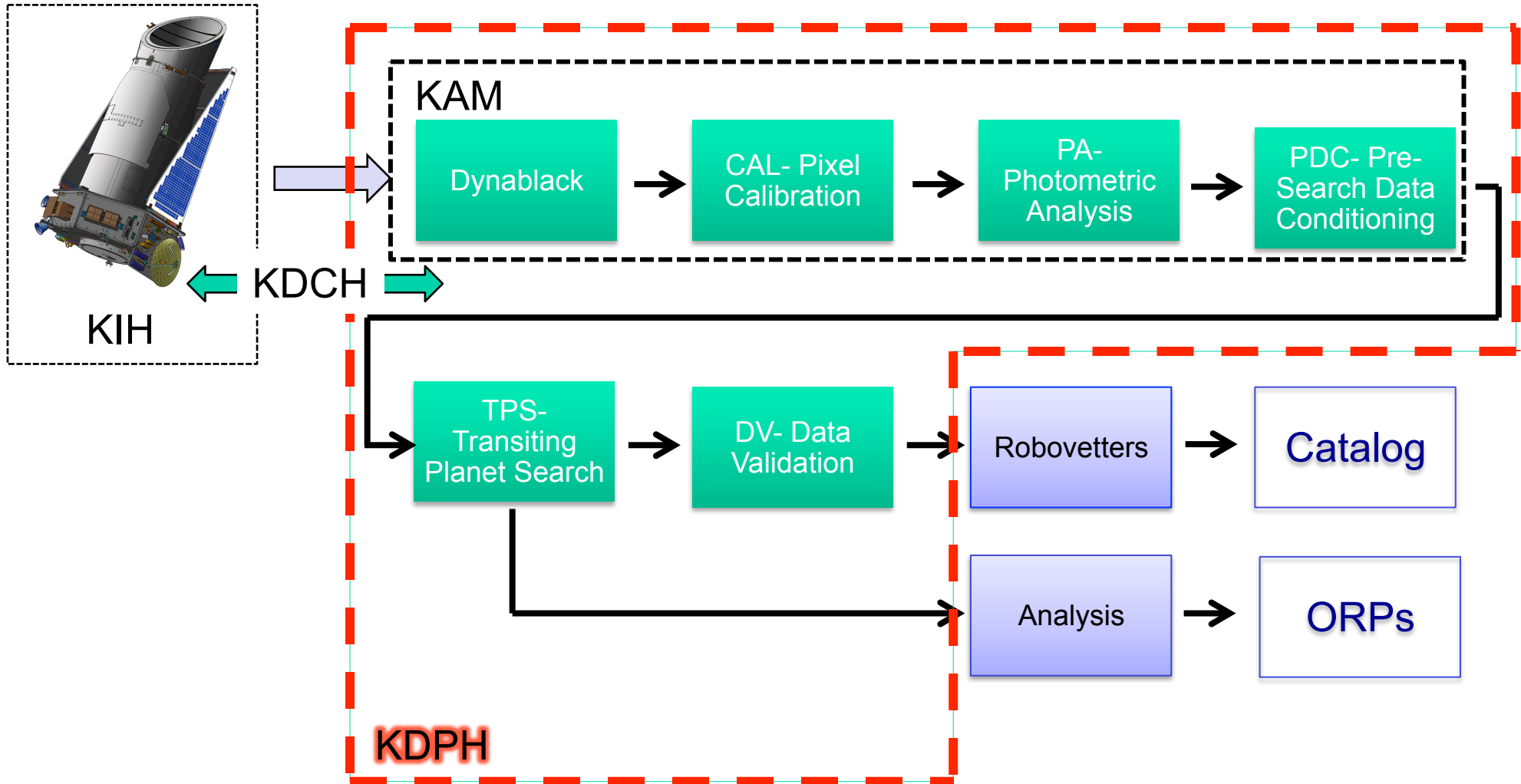


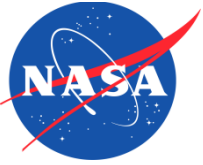
- Pipeline has been evolved over past 7 years
- Robovetters and analyses developed over the past 2 years





DCR Required Documents





Kepler Documentation List



- Products H
 - **H.0- Kepler Instrument Handbook (KIH)**
 - **H.1- Kepler Data Characteristics Handbook (KDCH)**
 - **H.2- Kepler Data Processing Handbook (KDPH)**
 - **H.3- Kepler Archive Manual (KAM)**
 - Includes the Data Release Notes for the final processing
 - H.4- Data Release Notes 25 (DRN)
- Products A, B, C, D, E, & F
 - Documentation of the Occurrence Rate Products (ORPs)
 - Each ORP has its own documentation
- Products P
 - Software release of the Pipeline Source Code

Step 1 documents will have walkthrough or overview presented today

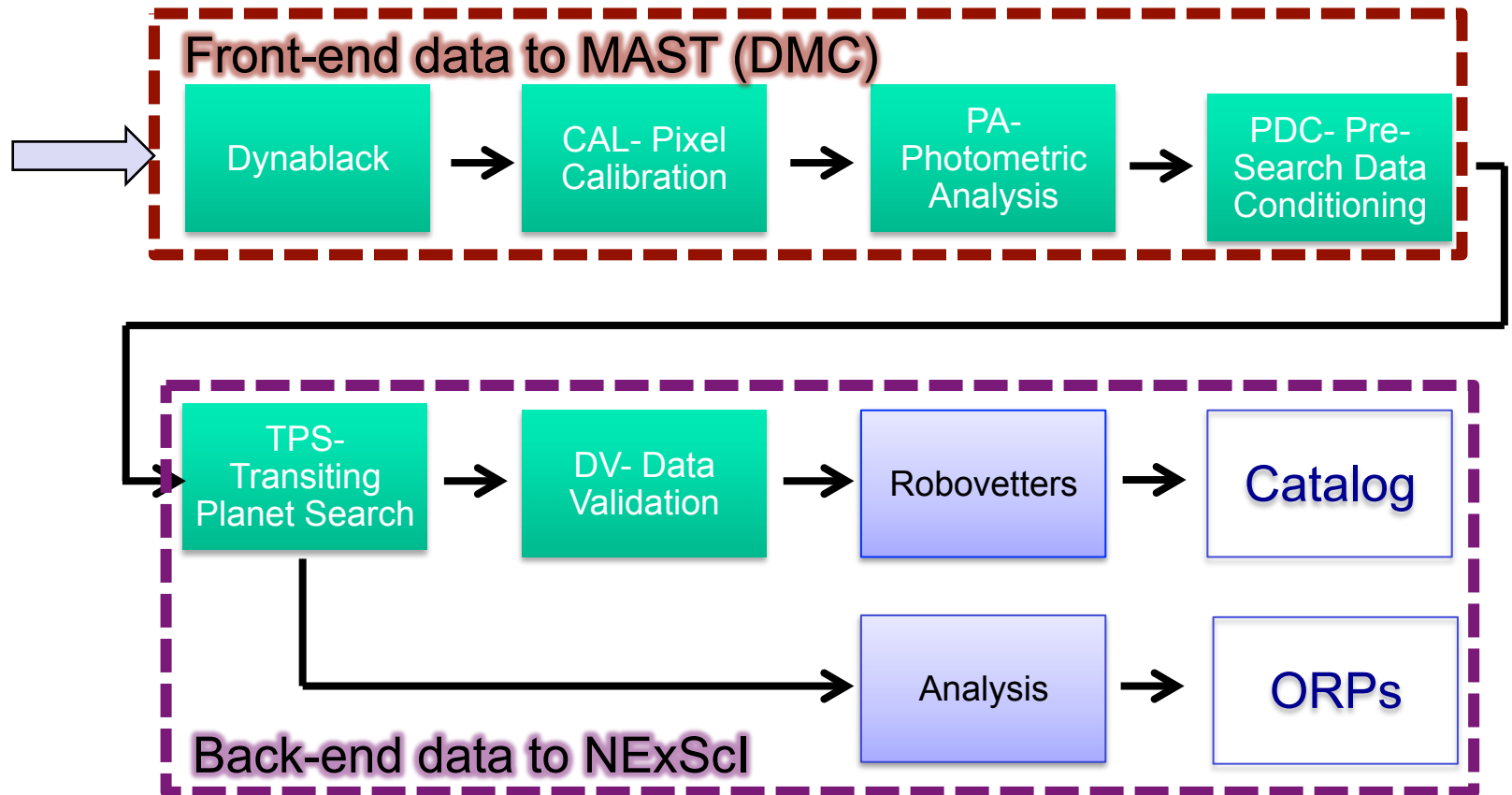
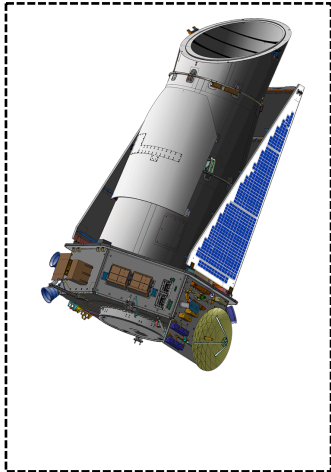
ID	Documentation/Product Name	Walkthru
H.0	Kepler Instrument Handbook (KIH)	Step 1
H.1	Kepler Data Characteristics Handbook (KDCH)	Step 1
H.2	Kepler Data Processing Handbook (KDPH)	Step 1
H.3	Kepler Archive Manual (KAM)	Step 1
H.4	Data Release Note (DRN)	
A.0	Stellar Properties Catalog	
A.1	RMS CDPP	
A.2	Data Quality Metrics	
A.3	Multiple-Event Statistic Effective Threshold Table	
B.0	Threshold-Crossing Event (TCE) Table	
B.1	TCE Stellar and Planetary Parameters	
B.2	Data Validation Report	
B.3	Data Validation One-Page Summary	
B.4	Supplemental Data Validation Report	
B.5	Supplemental Data Validation 1-Page Summary	
B.6	TCERT Vetting Products	
B.7	DV Time Series	
B.8	Centroid-Robovetter Score	
B.9	Flux-Robovetter Score	
B.12	Bootstrap Metric	Step 1
C.0	KOI Table	
C.1	KOI Dispositions	
C.2	Model Fit Parameters & Associated Error Bars	Step 1
C.3	FP "Reasons"	
C.4	Astrophysical False Positive Probability	
C.5	Astrophysical Positional Probability	
C.6	MCMC Posterior Chains	Step 1
D.0	Average Detection Efficiency	
D.1	Single-Target Detection Efficiency	
D.2	TCERT Detection Efficiency	
D.3	TPS Sensitivity Products	
D.4	Sensitivity Contours	
D.5	TCERT Reliability Metric	
E.0	FPWG Certification Results	Step 1
F.0	"Gold" Standard Star Spectroscopic Catalog	
F.1	"Platinum" Standard Star Spectroscopic Catalog	
F.2	KOI Spectroscopic Stellar Catalog	
F.3	KOI Imaging Detection Catalog	
F.4	KOI Imaging Detection Sensitivity Curves	
P.0	Pipeline Source Code Release	
P.1	Pipeline Processing Parameters	
P.2	Source Code Release Notes (SCRN)	



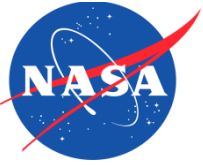
Data Products to Archive Repositories



- MAST receives front-end documentation
 - KIH, KAM, KDCH, KDPH, and KDRN



- NExSci receives back-end ORP documentation
 - Individual documentation for each ORP

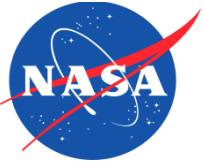


Product/Document Repositories



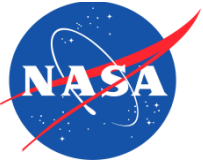
- Mikulski Archive for Space Telescopes (MAST)
 - Provides an interface to the Kepler archival data from the S/C raw data and the processed data from the Kepler pipeline
- NASA Exoplanet Science Institute (NExSci)
 - Online astronomical exoplanet and stellar data
 - Provides an interface to Kepler Occurrence Rate Products (ORPs)
- GitHub
 - Software release location
- MAST, NExSci, and GitHub are not managed by the Kepler project

ID	Documentation/Product Name	Repository
H.0	Kepler Instrument Handbook (KIH)	MAST
H.1	Kepler Data Characteristics Handbook (KDCH)	MAST
H.2	Kepler Data Processing Handbook (KDPH)	MAST
H.3	Kepler Archive Manual (KAM)	MAST
H.4	Data Release Note (DRN)	MAST
A.0	Stellar Properties Catalog	NExSci
A.1	RMS CDDP	NExSci
A.2	Data Quality Metrics	NExSci
A.3	Multiple-Event Statistic Effective Threshold Table	NExSci
B.0	Threshold-Crossing Event (TCE) Table	NExSci
B.1	TCE Stellar and Planetary Parameters	NExSci
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B.3	Data Validation One-Page Summary	NExSci
B.4	Supplemental Data Validation Report	NExSci
B.5	Supplemental Data Validation 1-Page Summary	NExSci
B.6	TCERT Vetting Products	NExSci
B.7	DV Time Series	NExSci
B.8	Centroid-Robovetter Score	NExSci
B.9	Flux-Robovetter Score	NExSci
B.12	Bootstrap Metric	NExSci
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C.1	KOI Dispositions	NExSci
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C.5	Astrophysical Positional Probability	NExSci
C.6	MCMC Posterior Chains	NExSci
D.0	Average Detection Efficiency	NExSci
D.1	Single-Target Detection Efficiency	NExSci
D.2	TCERT Detection Efficiency	NExSci
D.3	TPS Sensitivity Products	NExSci
D.4	Sensitivity Contours	NExSci
D.5	TCERT Reliability Metric	NExSci
E.0	FPWG Certification Results	NExSci
F.0	"Gold" Standard Star Spectroscopic Catalog	NExSci
F.1	"Platinum" Standard Star Spectroscopic Catalog	NExSci
F.2	KOI Spectroscopic Stellar Catalog	NExSci
F.3	KOI Imaging Detection Catalog	NExSci
F.4	KOI Imaging Detection Sensitivity Curves	NExSci
P.0	Pipeline Source Code Release	GitHub
P.1	Pipeline Processing Parameters	GitHub
P.2	Source Code Release Notes (SCRN)	GitHub



Kepler

Introduction Handbooks/Manual/DRN -Stephen Walker

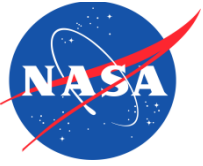


Handbooks/Manuals/DRN



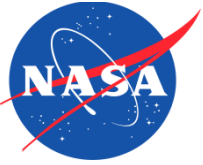
- All handbooks/manuals/DRNs have released versions
 - Reviewers were provided versions of the required handbooks/manuals on March 23, 2016 to allow review and identification of current gaps in the handbooks/manuals
 - Data Release Notes were released with each processing activity cycle
- Walkthrough will include:
 - Purpose of each document
 - The contents of each document
 - Current document status
 - Details of the planned updates
 - Overview of document and walkthrough of key sections of each handbook/manual

Overview provides entire review board with same familiarity to the handbooks/manuals and details on the planned document's scope



Kepler

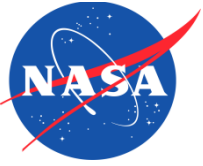
Kepler Instrument Handbook (KIH) - Mike Haas



KIH Purpose & Content



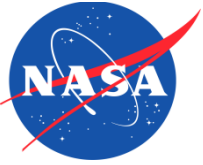
- Purpose
 - Document design, performance, and operational constraints of the Kepler hardware to support legacy science by the community
- Content
 - Introduction to mission, including flight segment design, focal plane format, and data collection modes
 - Design details for optics, detectors, and read-out electronics
 - Properties and performance of as-built focal plane based on ground tests
 - Data handling procedures, including observing modes, timing information, data compression, *etc.*



KIH Status



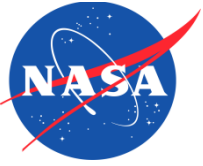
- Originally released in July, 2009
 - 4 months after launch of spacecraft
 - 2 months after science observations began
- Revised during February – April, 2016
 - Instrument design is unchanged, so only minor updates were required
 - Completed all necessary revisions; currently under internal review
- Revisions include:
 - Replaced pre-launch predictions with in-flight performance
 - Updated references
 - Replaced internal Ball documents with publications or documents available at MAST
 - Collected internal Ames documents for hosting at MAST
 - Retained some “grey-literature” references to aid project readers
 - Removed references to supplemental materials now available in FITS headers or as focal-plane characterization models



KIH Status (2)



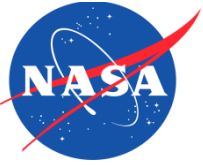
- What was not done:
 - Original document had section entitled “Known Revisions for Next Version”
 - These items were all overcome by events or solved in other ways, so this page was simply deleted
 - Anticipated some updates associated with delivery of focal-plane characterization models to MAST, however:
 - Found existing model descriptions adequate from a hardware perspective
 - File names, formats, and content fit better in Kepler Archive Manual (in § 2.3.5)



KIH Table of Contents



1. Introduction to Instrument Handbook
2. Introduction to Kepler
3. Optics and Images
4. Detector Properties
5. Local Detector Electronics
6. Electronic Image Artifacts & Mitigation
7. Observing with Kepler
8. Acronyms and Abbreviations
9. References



KIH Table of Contents

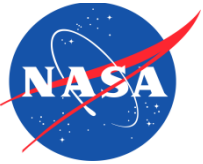


1. Introduction to Instrument Handbook

Sections broken down into subsections when warranted

2. Introduction to Kepler

3. Optics	2. Introduction to Kepler
4. Detect	2.1 Mission Overview
5. Local I	2.2 Commissioning
6. Electro	2.3 Celestial Field of View
7. Observ	2.4 Categories of Observing Programs
8. Acrony	2.5 Flight System Elements
9. Refere	2.6 Pixels of Interest
	2.7 Full Field Images
	2.8 Examples of Full Field Images
	2.9 Ground Test Data Relevant to Flight Calibration



KIH Table of Contents



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2.4 Categories of Observing

2.5 Flight System Elements

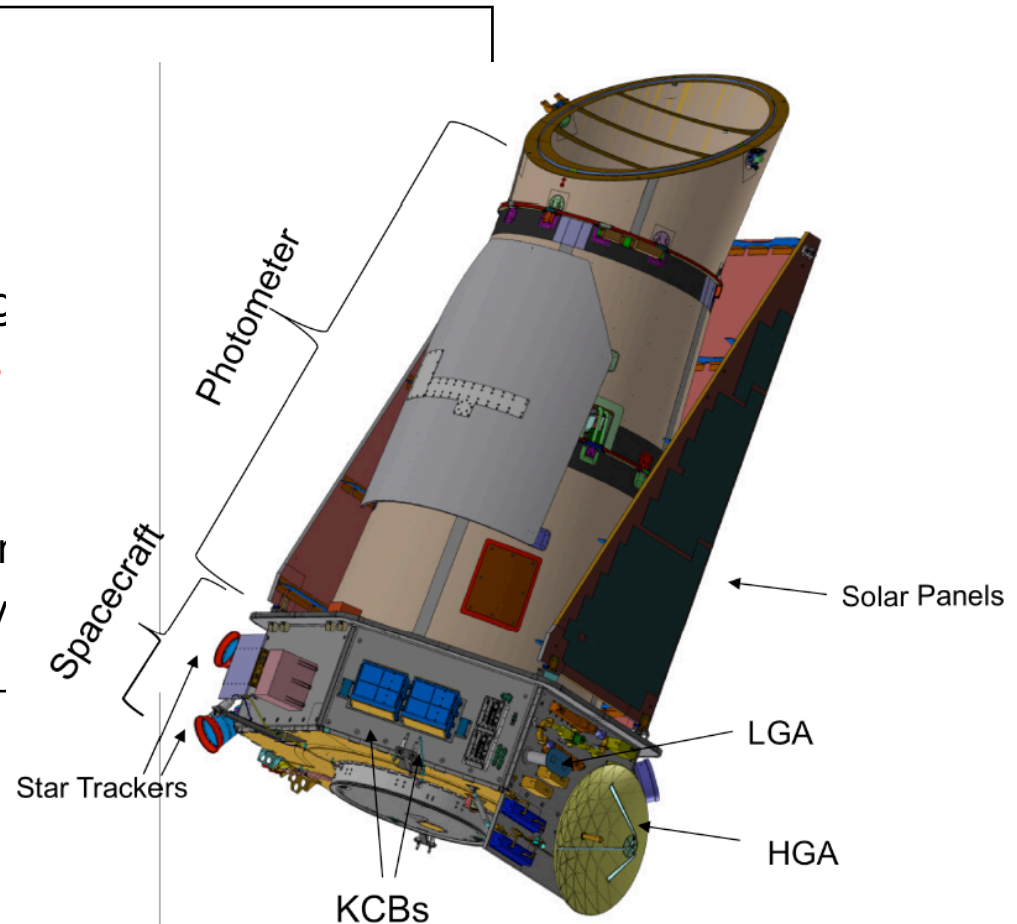
2.6 Pixels of Interest

2.7 Full Field Images

2.8 Examples of Full Field Images

2.9 Ground Test Data Review

Flight segment components defined and described





KIH Table of Contents



1. Introduction to Instrument Handbook

Subsections broken down into subsubsections when warranted

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2.3 Celestial Field of View

7. Observ

2.4 Categories of Observing Programs

8. Acrony

2.5 Flight System Elements

9. Refere

2.6 Pixels of Interest

2.7 Full

2.6 Pixels of Interest

2.8 Exa

2.6.1 Targets and Apertures

2.9 Gro

2.6.2 Kinds of Targets

Calibration

2.6.2.1 Long Cadence

2.6.2.2 Short Cadence

2.6.2.3 Reference

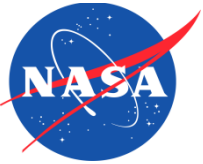
2.6.2.4 Background

2.6.3 Collateral Data

2.6.3.1 Long Cadence

2.6.3.2 Short Cadence

2.6.3.3 Reference



KIH Table of Contents



1. Introduction to Instrument Handbook

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8. Acrony 2.5 Flight System Elements

9. Refere 2.6 Pixels of Interest

2.6.1 Targets and Apertures

2.6.2 Kinds of Targets

2.6.2.1 Long Cadence

2.6.2.2 Short Cadence

2.6.2.3 Reference

2.6.2.4 Background

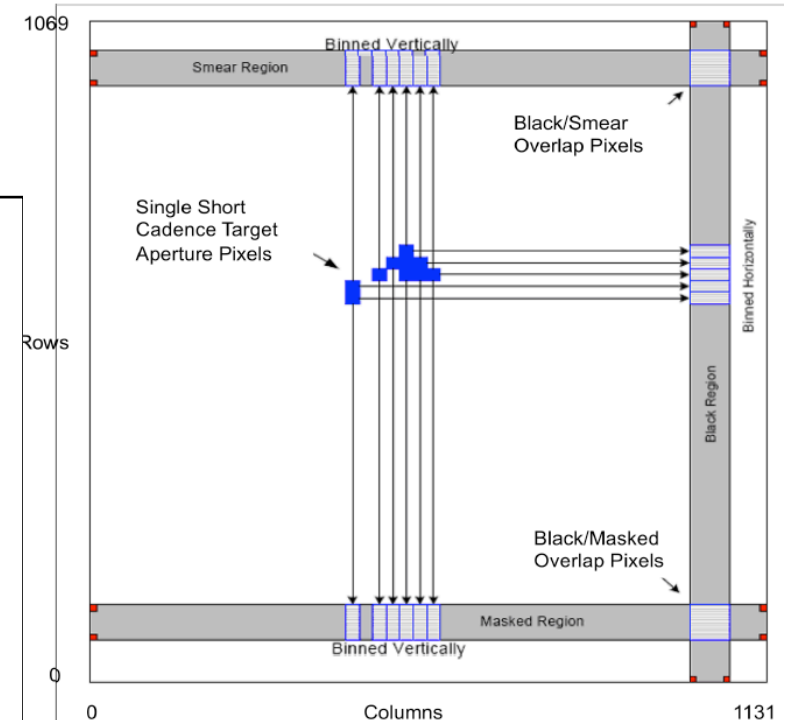
2.6.3 Collateral Data

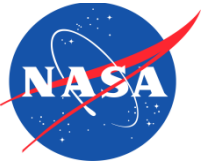
2.6.3.1 Long Cadence

2.6.3.2 Short Cadence

2.6.3.3 Reference

Data collection strategy for short-cadence collateral is illustrated



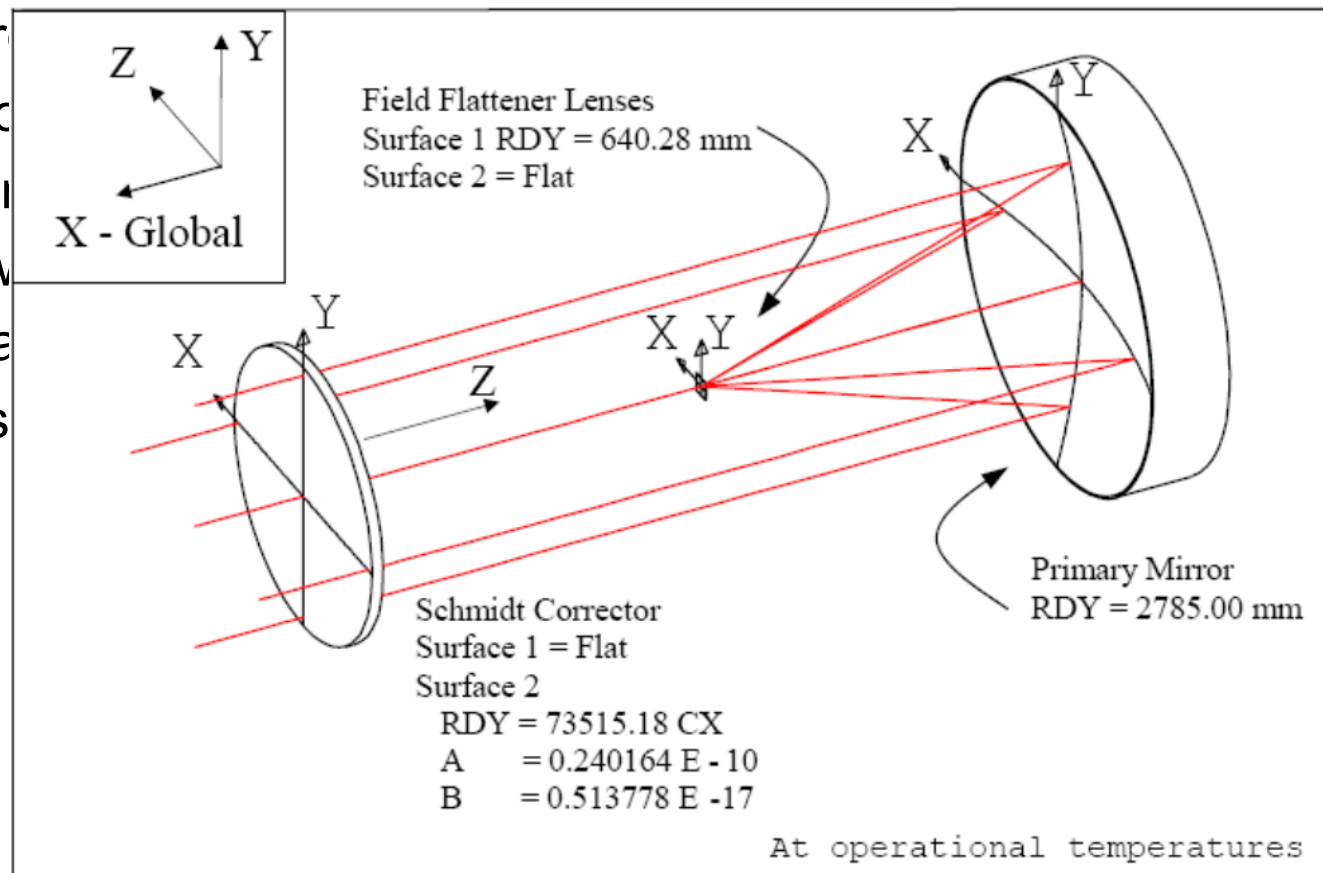


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5. Local Detec
6. Electronic I
7. Observing v
8. Acronyms a
9. References

Code V ray trace of telescope is included



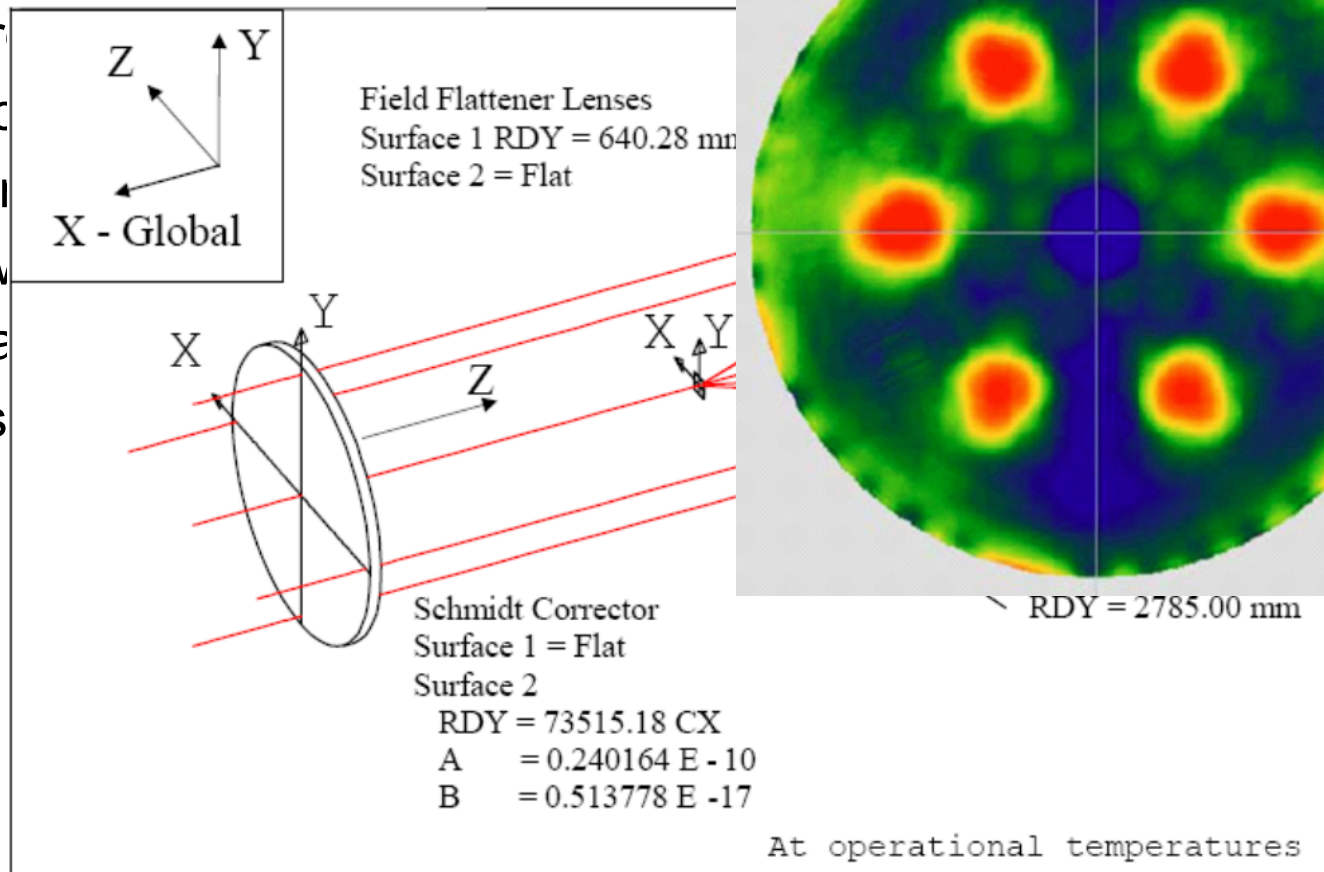


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Aberration of primary reported



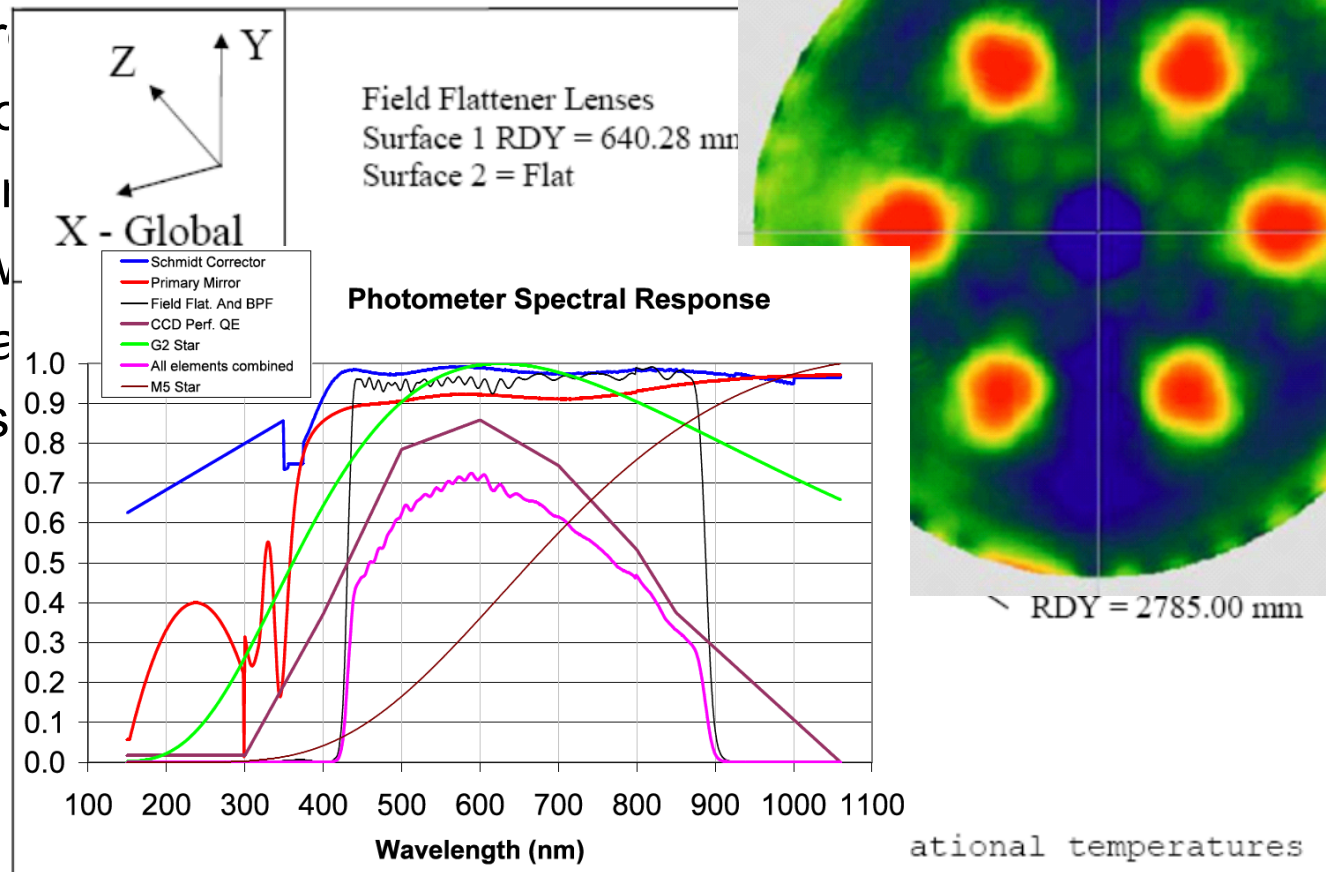


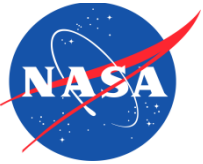
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Spectral response provided



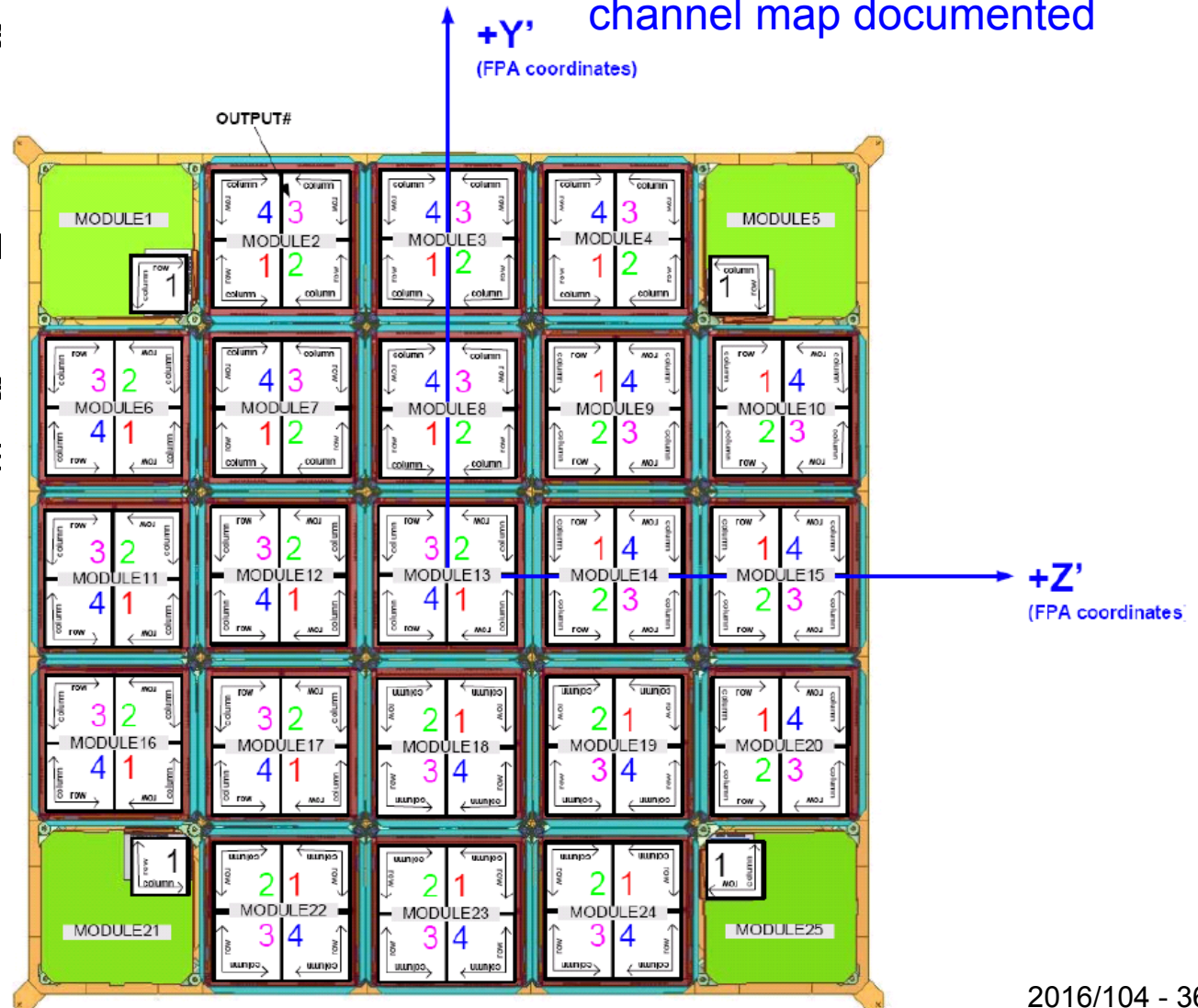


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CCD orientation and channel map documented



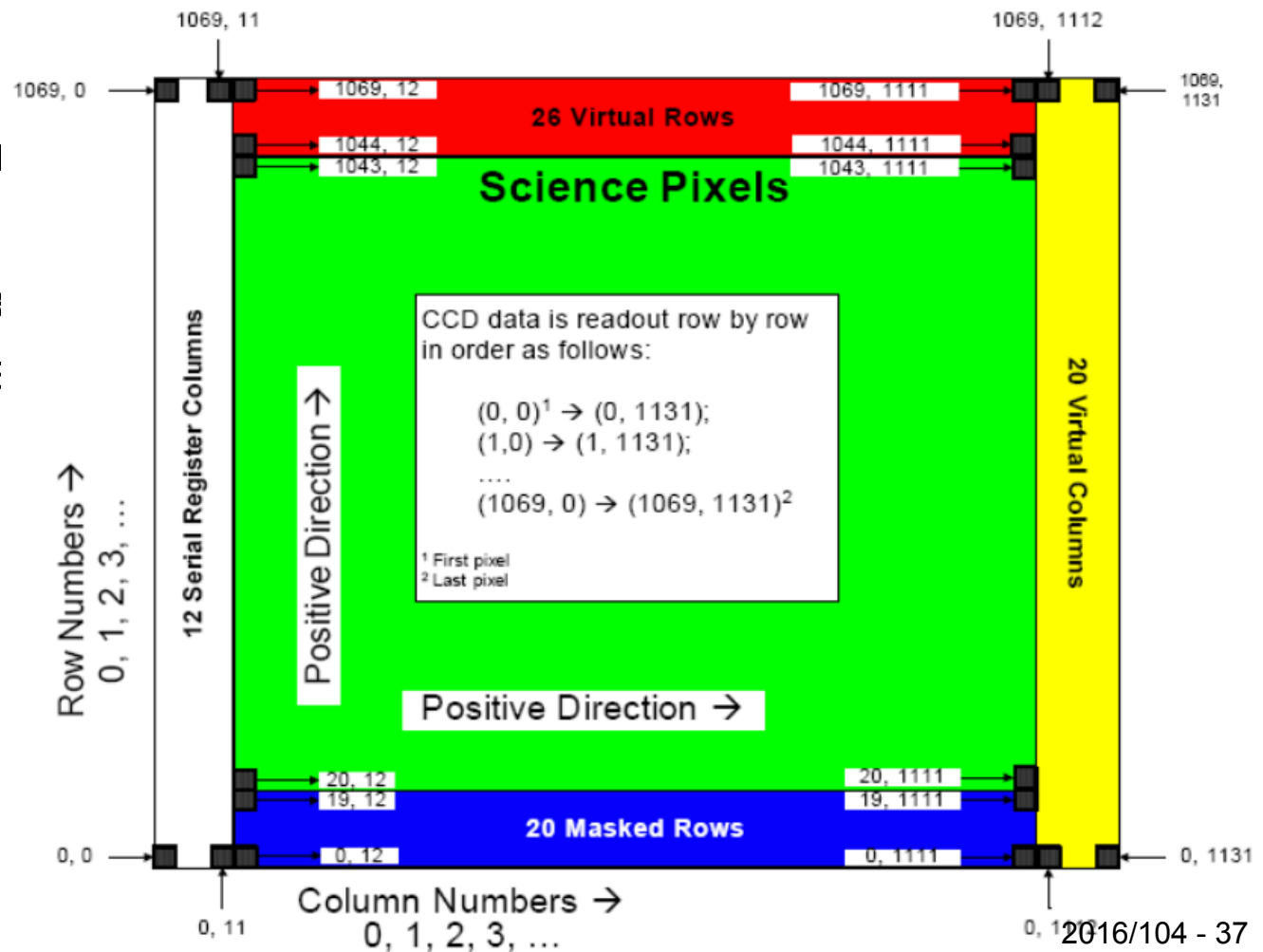


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CCD science & collateral regions defined



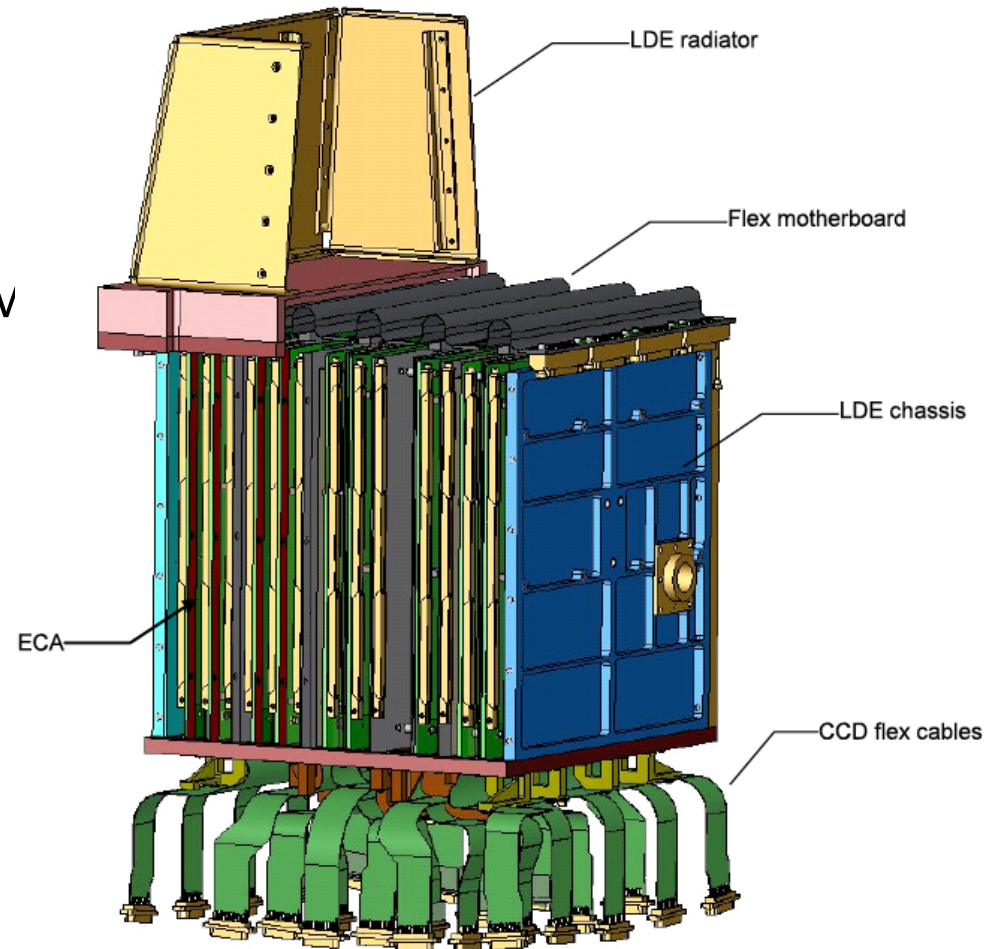


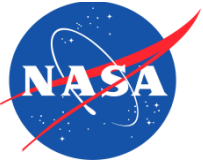
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Geometry of LDE described



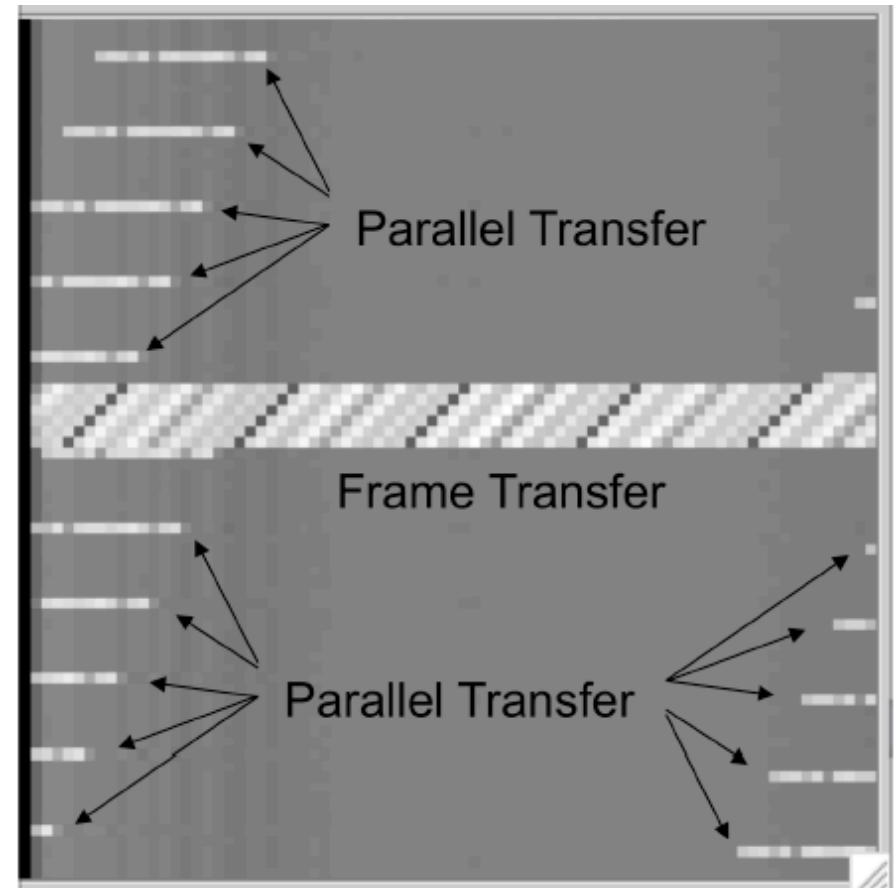


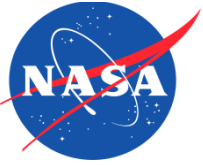
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Electronic crosstalk
illustrated & explained



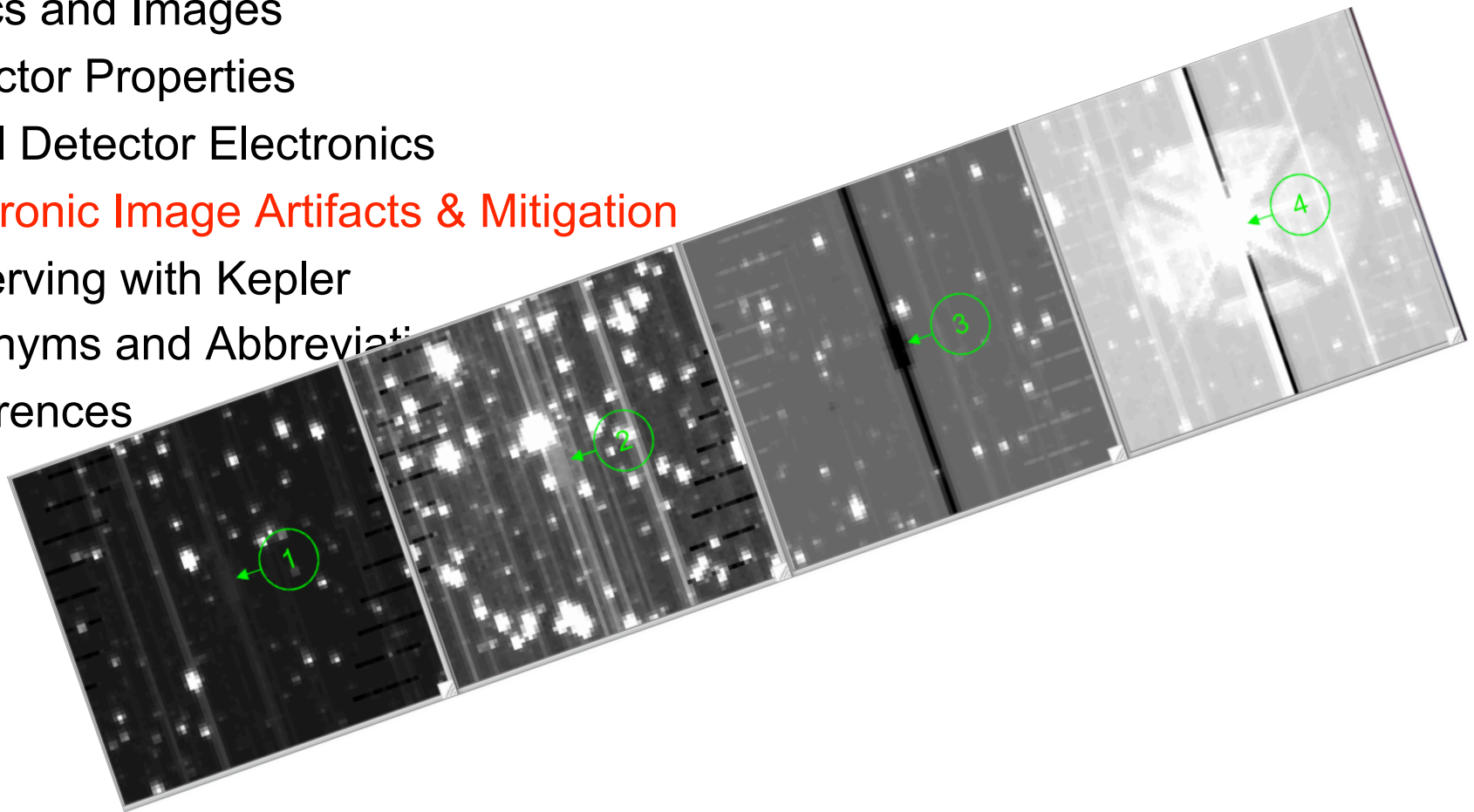


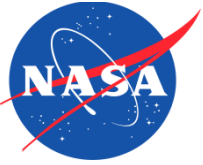
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Examples of optical & electronic artifacts given



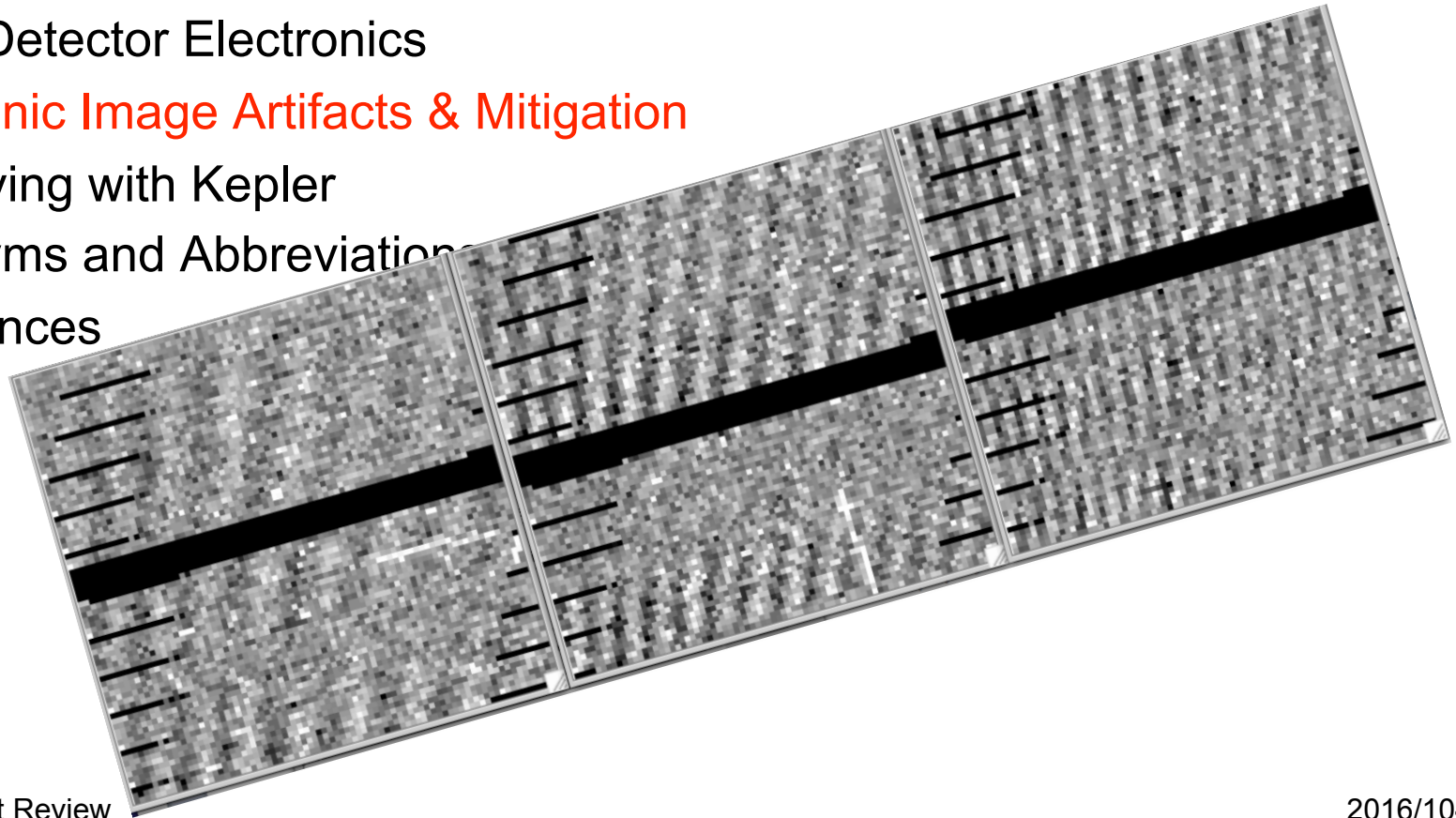


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Thermal dependence of
Moiré Pattern Drift illustrated



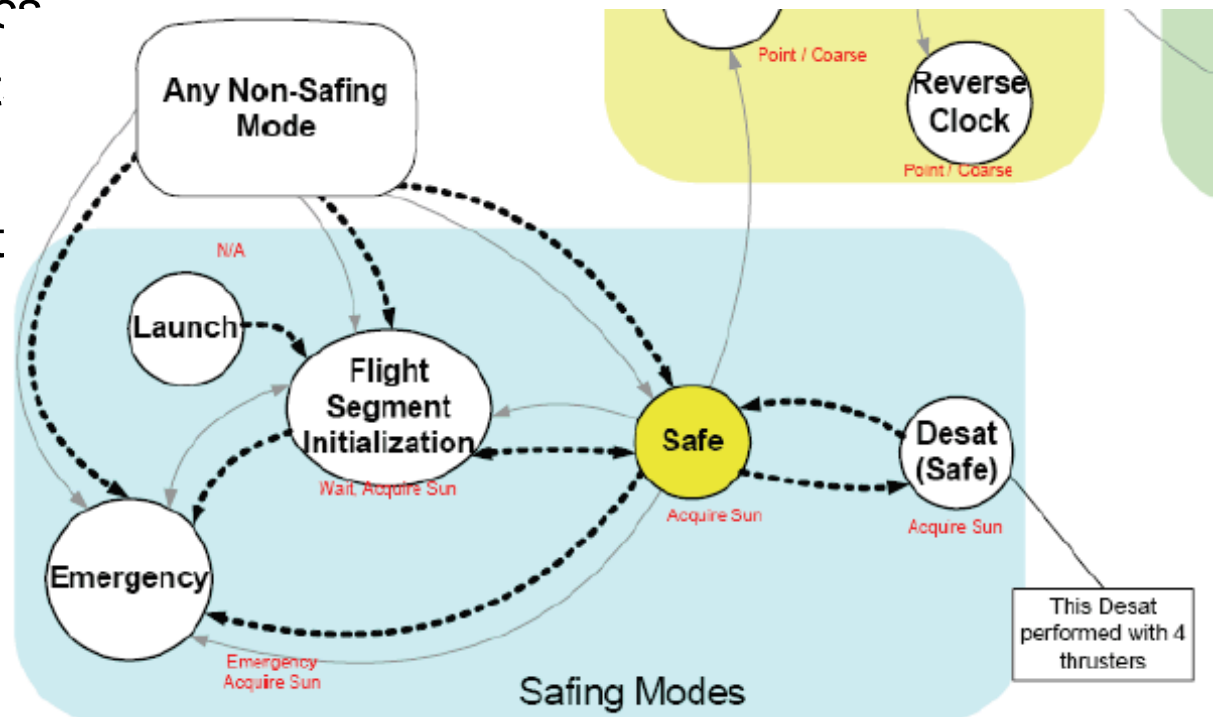


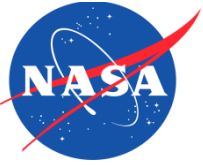
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Instrument modes
defined and described





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2. Introduction to Kepler
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6. Electronic Image Artifacts & Mitigation
7. Observing with Kepler

8. Acronyms These and related parameters may be confirmed by examining these items in the primary FITS header of an LC target pixel file (this example from CDPF data):
9. References

```
FGSRPER=          103.79 / FGS frame period (milli-seconds)
NUMFGSFP=           58 / number of FGS frame periods per exposure
EXP_TIME=         6.01982 / exposure time (seconds)
READTIME=         518.95 / read out time (milli-seconds)
INT_TIME=         6.53877 / integration time (seconds) (exp + readout time)
NUMSHORT=          9 / number of integrations in a short cadence frame
TEXP_SC =         54.1784 / total short cadence exposure time (seconds)
TREAD_SC =         4.67055 / total short cadence readout time (seconds)
TINT_SC =         58.8489 / total short cadence integration time (seconds)
SHRTLONG=          30 / number of short cadences per long cadence
NUM_FFI =          270 / number of integrations in a science FFI
```



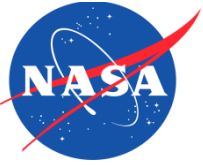
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Tables of detector characteristics included

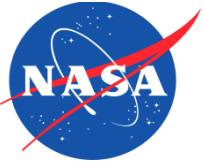
Mod Out	Ch	ECA	Time Slice	ECA input #	Read Noise Side 2 DN	Read Noise Side 2 e-	Gain Side 2 (e-/DN)	Under shoot %	Well depth e-	RB Moire
2.4	4	503	4	1	1.06	111.0	104.8	0.44	1.05E+06	
3.1	5	502	1	1	0.72	80.5	111.9	0.26	1.18E+06	
3.2	6	502	1	1	0.82	92.0	112.0	0.22	1.18E+06	
3.3	7	502	1	1	1.59	149.0	93.5	0.30	1.09E+06	
3.4	8	502	1	1	1.06	108.1	101.8	0.47	1.05E+06	
4.1	9	501	3	5	0.79	88.6	111.6	0.71	1.01E+06	
4.2	10	501	3	5	0.77	73.9	95.6	0.69	9.47E+05	
4.3	11	501	3	5	0.80	83.2	104.7	0.36	1.10E+06	
4.4	12	501	3	5	0.74	84.2	113.5	0.60	1.13E+06	
6.1	13	504	3	2	0.74	84.0	113.2	0.49	1.07E+06	
6.2	14	504	3	2	0.79	78.8	99.9	0.16	1.02E+06	
6.3	15	504	3	2	0.77	83.1	108.1	0.17	1.08E+06	
6.4	16	504	3	2	0.73	81.8	111.8	0.59	1.05E+06	
7.1	17	503	5	2	0.76	85.4	111.7	0.40	1.02E+06	
7.2	18	503	5	2	0.73	81.0	111.0	0.17	1.04E+06	
7.3	19	503	5	2	0.77	85.9	111.1	0.15	1.02E+06	
7.4	20	503	5	2	0.78	85.6	110.1	0.46	1.03E+06	
8.1	21	502	2	2	0.72	80.2	111.9	0.31	1.07E+06	
8.2	22	502	2	2	0.91	95.0	104.7	0.07	1.06E+06	



KIH Conclusions



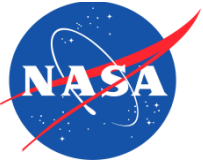
- Document has existed in near-final form (-001) for almost 7 years
 - Feedback from community has been negligible, indicating that document adequately describes Kepler hardware for legacy science
 - Update is complete and under internal review
 - Required changes were minimal
 - Signed revision (-002) will be available well before DCR



Kepler

Kepler Archive Manual (KAM)

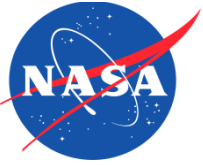
- Mike Haas



KAM Purpose & Content



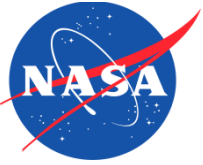
- Purpose
 - Document Kepler data products residing at MAST for legacy science by the community
 - Document MAST tools for data search, retrieval, and analysis
- Content
 - Description of Kepler data products
 - Kepler Input Catalog (KIC) for target selection
 - Science data in raw and various states of processing (*i.e.*, TPFs, light curves, FFIs)
 - Calibration data (*i.e.*, collateral, background, *etc.*)
 - Engineering data (*i.e.*, ancillary engineering data)
 - Focal-plane characterization models used in data processing and analysis
 - Introduction to MAST search, retrieval, and analysis tools with worked examples



KAM Status



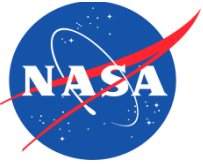
- Originally released before launch in August, 2009
- Updated regularly during the mission to:
 - Reflect changes in data access, file format, and file content
 - Describe new products as they were developed and released
- Revised five times, most recently in mid-2014
- Update required to capture results of final data processing cycle (*i.e.*, Data Release 25), which is well defined because:
 - Pipeline development frozen
 - Final long-cadence data delivered
 - Final short-cadence processing underway
- Completed all necessary revisions; currently under internal review



Recent KAM Updates



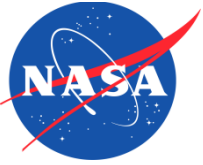
- Included new rolling band flags produced by dynamic black module
 - Described quality flags in Target Pixel (§ 2.3.2) & Collateral Data Files (§ 2.3.7)
 - Discussed meaning and use of rolling band flags (§ 2.3.1.1)
- Added major section describing focal-plane characterization models used for final processing and analysis (*i.e.*, flats, gain, undershoot, *etc.*) (§ 2.3.5)
- Expanded description of Ancillary Engineering data and added table of mnemonics (Appendix B.5)
- Reported changes in World-Coordinate System for FFIs (§ 2.3.3)
- Added information about PDC's handling of crowding and contamination (§ 2.3.1.2)
- Described latest data access methods available from MAST, including direct download and "The Portal" (§ 3)
- Reviewed entire document for compliance with final legacy data products (*i.e.*, Data Release 25)
- Updated signature, author, and change log pages



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4. References
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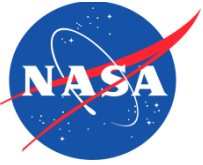


1. Introduction

- 2. Kepler
- 3. Search
- 4. Append

1. Introduction
1.1 Overview of Kepler
1.2 Overview of Data Flow
1.3 Related Documents
1.4 Overview of MAST
1.5 User Support Services
1.6 Getting Your Data
1.7 Publication Acknowledgement

Sections broken down into subsections when warranted



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2. Kepler Data Products

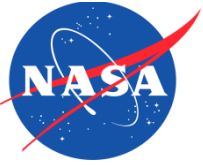
2.1 Introduction

2.2 File Name Syntax

2.3 Data in the Archive

2.4 Keyword Definitions

Section 2 describes
Kepler-generated products



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2.4 Keyw 2.3 Data in the Archive

2.3.1 Light Curve Files

2.3.2 Target Pixel Data

2.3.3 Full Frame Image

2.3.4 Cotrending Basis Vectors

2.3.5 Focal Plane Characterization Models

2.3.6 Background Data Files

2.3.7 Collateral Data Files

2.3.8 Artifact Removal Pixel Data Files

2.3.9 Reverse Clock Data Files

2.3.10 Ancillary Engineering Data

Separate subsection for each data product



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1. Introduction Each file type is versioned

2. Kepler Data Products

3. Search 2. Kepler Data Products

4. Referer 2.1 Introduction

5. Append 2.2 File Name Syntax

2.3 Data in "

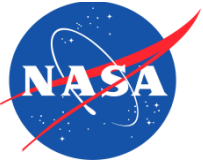
Table 2-2 File Version Numbers described in this Archive Manual
Archive Manual Section

File Type	Version *	Archive Manual Section
Light Curves Files	6.1	2.3.1
Target Pixel Files	6.1	2.3.2
Full Frame Images	3.1	2.3.3
Background	3.0	2.3.6
Collateral/ARP	2.0	2.3.7 - 2.3.8
CBVs	4.0	2.3.4
Focal Plane Characteristics	1.0	2.3.5

*See the keyword FILEVER in the header of each file.

2.3.9 Reverse Clock Data Files

2.3.10 Ancillary Engineering Data



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1. Introduction
 2. Kepler Data Products
- Keywords and columns are defined

3. **TIMECORR** [32-bit floating point] – The barycenter correction calculated by the pipeline plus the time slice correction. This column allows users to revert back to non-barycentric times, if required. To convert the times in the TIME column to the Julian Day of the observation, use the following formula:

5.

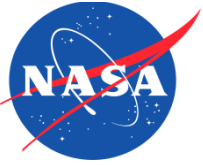
$$\begin{aligned} \text{JD}[i] &= \text{BJD}[i] - \text{TIMECORR}[i] + \text{time_slice_correction} \\ &= \text{BJD}[i] - \text{TIMECORR}[i] + (0.25 + 0.62(5 - \text{TIMSLICE})) / (86400) \end{aligned}$$

where TIMSLICE is given in the header. To obtain the times in Julian Day reported by the spacecraft, subtract the TIMECORR column from the TIME column.

CADENCENO [32-bit integer] – The cadence number is a unique integer that is incremented by one with each cadence.

SAP_FLUX [32-bit floating point] – The flux in units of electrons per second contained in the optimal aperture pixels collected by the spacecraft. This light curve is the output of the PA module in the SOC pipeline.

SAP_FLUX_ERR [32-bit floating point] – The error in the simple aperture photometry as determined by PA in electrons per second. The reported errors for each cadence are a sum of the minimal error calculation (shot noise plus read noise) and an offset term to account for the extra error from the full propagation of errors.



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3. Search 2. Kepler Data Products

4. Referer 2.1 Introduction

5. Append 2.2 File Name Syntax

2.3 Data in the Archive

2.4 Keyword Definitions

Data flags are defined

Table 2-3 – Bits for the QUALITY and SAP_QUALITY data column.

Bit	Value	Explanation
1*	1	Attitude Tweak
2*	2	Safe Mode
3*	4	Spacecraft is in coarse point. Set manually to pad not-in-fine point data.
4*	8	Spacecraft is in Earth point. First real cadence after Earth point.
5	16	Reaction wheel zero crossing
6*	32	Reaction wheel desaturation event
7*	64	Argabrightening detected across multiple channels on this cadence
8	128	Cosmic Ray was found and corrected in optimal aperture pixel
9*	256	Manual Exclude. The cadence was excluded because of an anomaly.
10	512	This bit is unused by <i>Kepler</i> .
11	1024	SPSD detected. This bit is flagged on the last non-gapped cadence before the maximum positive change due to the detected SPSD.
12	2048	Impulsive outlier removed before cotrending
13*	4096	Argabrightening event on specified CCD mod/out detected
14	8192	Cosmic Ray detected on collateral pixel row or column in optimal aperture
15*	16384	Detector anomaly flag raised
16*	32768	Spacecraft is not in fine point.
17*	65536	No data collected.
18	131072	Rolling Band detected in optimal aperture.
19	262144	Rolling Band detected in full mask.
20	545288	Possible thruster firing. Not set in <i>Kepler</i> data
21	1048576	Thruster firing. Not set in <i>Kepler</i> data.



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4. Referer 2.1 Introduction

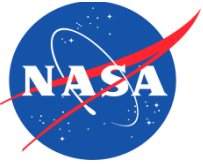
5. Append 2.2 File Name Syntax

2.3 Data in the Archi

2.4 Keyword Definitio

Focal-plane characterization models documented in a major new section

FC Model	§	File Name	P/L?	Supporting Documents
clock-state-mask	1	clock_state_mask_KADN-26205_20081218.fits	Y	KADN-26205
2-D black	2	kplr2015238_2dblack.fits, kplr2015238_2dblack-uncert.fits,	Y	
dynamic black	3	black-retrieval-tool directory, kplr<YYYYDOYHHMMSS>-q<##>-<mmo>- dr<##>_dynablack.mat ("blob file")	Y	
1-D black	4	extract_one_d_black_from_blob.m, kplr<YYYYDOYHHMMSS>-q<##>-<mmo>- dr<##>_1dblack.mat	Y	
scene-dependent rows	5	is_scene_dependent.m kplr2015279231411-dr25_blackrowmask.txt	Y	
bad smear columns	6	is_saturated_smear_column.m	Y	
read noise	7	kplr2008102416_read-noise.txt	Y	
gain	8	kplr2008072318_gain.txt	Y	KADN-26196
linearity	9	kplr2009060215_linearity.txt	Y	KADN-26196
undershoot	10	kplr2008102809_undershoot.txt	Y	KADN-26197
large-scale flat	11	kplr2015236_largeflat.fits	Y	
small-scale flat	12	kplr2015236_smallflat.fits, kplr2015236_smallflat-uncert.fits	Y	
invalid pixels	13	n/a	N	
pointing	14	kplr2013050211_pointing.txt	Y	KADN-26285
roll-time	15	kplr2013040800_rolltime.txt	Y	
focal-plane geometry	16	kplr2009060418_geometry.txt	Y	KADN-26285
simplified (RA, DEC) to pixel mapping	14-16	morc_2_ra_dec_4_seasons.xls	N	
point spread function	17	kplr<module>.<output>_<yyyyddd>.fits	Y	
video crosstalk	18	kplr_2015111701_video_crosstalk_rec_src.csv	N	
spectral response	19	kplr_2015120120_spectral_response.csv	N	



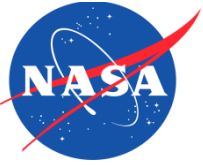
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Section 3 describes MAST site, products, and tools

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3. Searching Archive for Kepler Data
 - 3.1 The MAST Kepler Catalogs
 - 3.2 The MAST Home Page
 - 3.3 MAST Discovery Portal (aka Portal)
 - 3.4 MAST Classic Interface
 - 3.5 FFI and Engineering Data Search and Retrieval or Download
 - 3.6 Other useful tools for MAST
 - 3.7 Alternate Methods for Downloading Data



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 - 3.4 MAST Classic Interface
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 - 3.6 Other useful tools for MAST
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4. Reference
5. Appendix

Web interfaces are described

[Archive Status](#) **Kepler Data Search & Retrieval** [Help](#)
[Field Descriptions](#)

[Standard Form](#) [File Upload Form](#)

Search [Reset] [Clear Form]

Target Name Resolver Radius (arcmin)
Right Ascension Declination Equinox
J2000

Kepler ID Investigation ID 2Mass ID
1571152

KEP Mag Target Type Release Date
 Long Cadence Short Cadence

Teff Log G Quarter

Condition Flag
All Targets

User-specified field 1 Field Descriptions User-specified field 2 Field Descriptions
Kepler ID Kepler ID

User-specified field 3 Field Descriptions User-specified field 4 Field Descriptions
Kepler ID Kepler ID

Output Columns up down remove reset
Mark Kepler ID Dataset Name Target Type Archive Class Actual Start Time Actual End Time Release Date

Sort By: ang_sep () [Reverse] Kepler ID [Reverse] null [Reverse]

Output Coords: Sexagesimal Degrees Hours

Output Format HTML_Table

Remove Null Columns Make Rows Distinct Skip formatting

Maximum Records: 5001
Records per Page: 500

Search [Reset] [Clear Form]



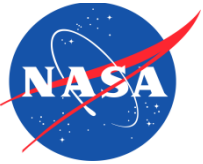
KAM Table of Contents



1. Introduction
2. Kepler Data Products
3. Searching Archive for Kepler Data
4. Reference
5. Appendix
 - 3.1 The MAST Kepler Catalog
 - 3.2 The MAST Home Page
 - 3.3 MAST Discovery Portal
 - 3.4 MAST Classic Interface
 - 3.5 FFI and Engineering Data
 - 3.6 Other useful tools for MAST
 - 3.7 Alternate Methods for Data

Functionality is explained

The screenshot displays the MAST Kepler archive search interface. At the top, there is a search bar with the text 'KIC1026957' and a 'Search' button. Below the search bar, there are several filters and a table of observations. The table has columns for 'Name', 'Quantity', and 'Actions'. The 'Name' column lists various observation types such as 'KEPLER', 'NUV', 'OPTICAL', 'UV', 'Red_giant', 'Eclipsing_binary', 'False_Positive', 'Planetary_candidate', 'Exoplanet', 'False_Positive', 'EX', 'EX_STKS', 'EX_GO40011', 'GO40033', 'William Borucki', 'Susan Thompson', 'Martin Still', 'Kepler Key Project', and 'Overlap of EX and STKS'. The 'Quantity' column shows the number of observations for each type. The 'Actions' column contains icons for viewing and downloading. On the right side, there is an 'AstroView' window showing a star field with a red dashed circle around a specific star. A blue arrow points to the search bar with the text 'The One Box'.



KAM Table of Contents



1. Introduction

Worked examples are given

2. Kepler Data Products

3. Searching Archive for Kepler Data

4. Referer 3. Searching Archive for Kepler Data

5. Append

3.1 The MAST Kepler Catalog

3.2 The MAST Home Page

3.3 MAST Discovery Portal

3.4 MAST Classic Interface

3.5 FFI and Engineering Data

3.6 Other useful tools for MAST

3.7 Alternate Methods for Data

Mark	Kepler ID	Investigation ID	Dataset Name	Quarter
<input type="checkbox"/>	1873513	GO40063	KPLR001873513-2012277125453	14
<input type="checkbox"/>	1873513	GO40063	KPLR001873513-2013011073258	15
<input type="checkbox"/>	1873513	GO40063	KPLR001873513-2013098041711	16
<input type="checkbox"/>	1873513	GO40063	KPLR001873513-2013131215648	17
<input type="checkbox"/>	2860885	EX	KPLR002860885-2009166043257	1
<input type="checkbox"/>	2860885	EX	KPLR002860885-2009259160929	2
<input type="checkbox"/>	2860885	EX	KPLR002860885-2009350155506	3
<input type="checkbox"/>	2860885	EX	KPLR002860885-2010265121752	6
<input type="checkbox"/>	2860885	EX	KPLR002860885-2011271113734	10
<input type="checkbox"/>	2860885	EX	KPLR002860885-2012277125453	14
<input type="checkbox"/>	3430205	EX	KPLR003430205-2009131105131	0
<input type="checkbox"/>	3430205	EX	KPLR003430205-2009166043257	1
<input type="checkbox"/>	3430205	EX	KPLR003430205-2009259160929	2
<input type="checkbox"/>	3430205	EX	KPLR003430205-2009350155506	3
<input type="checkbox"/>	3430205	EX	KPLR003430205-2010078095331	4
<input type="checkbox"/>	3430205	EX	KPLR003430205-2010265121752	6
<input type="checkbox"/>	3430205	EX	KPLR003430205-2010355172524	7
<input type="checkbox"/>	3430205	EX	KPLR003430205-2011271113734	10
<input type="checkbox"/>	3430205	EX	KPLR003430205-2012004120508	11
<input type="checkbox"/>	3430205	EX	KPLR003430205-2012277125453	14
<input type="checkbox"/>	3750264	EX	KPLR003750264-2010174085026	5
<input type="checkbox"/>	3750264	EX	KPLR003750264-2010265121752	6
<input type="checkbox"/>	3750264	EX	KPLR003750264-2010355172524	7



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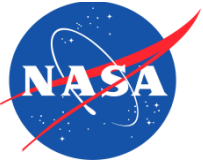


1. Introduction
2. Kepler Data Products
3. Searching Archive for Kepler Data
4. References
5. Appendices

Appendices document file headers and define terms

5. Appendices

- A.1 Kepler Light Curve File Headers
- A.2 Target Pixel File Headers
- B.1-4 Full-Frame Image (FFI) Headers
- B.5 Ancillary Data Description
- C.1 Cotrending Basis Vector Headers
- C.2 Pixel Response Function Headers
- D.1 Glossary of Terms
- D.2 Common Acronyms



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1. Introduction
2. Kepler Data Products
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4. References
5. Appendices

FITS file headers included

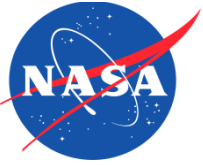
A.1b: Light Curve File LIGHTCURVE Extension Header

This header describes the detector and the time period over which the data was collected.

Example LIGHTCURVE header

XTENSION= 'BINTABLE' / marks the beginning of a new HDU
BITPIX = 8 / array data type
NAXIS = 2 / number of array dimensions
NAXIS1 = 100 / length of first array dimension
NAXIS2 = 4573 / length of second array dimension
PCOUNT = 0 / group parameter count (not used)
GCOUNT = 1 / group count (not used)
TFIELDS = 20 / number of table fields
TTYPE1 = 'TIME ' / column title: data time stamps
TFORM1 = 'D ' / column format: 64-bit floating point
TUNIT1 = 'BJD - 2454833' / column units: barycenter corrected JD
TDISP1 = 'D14.7 ' / column display format
TTYPE2 = 'TIMECORR' / column title: barycenter - timeslice correction
TFORM2 = 'E ' / column format: 32-bit floating point
TUNIT2 = 'd ' / column units: day
TDISP2 = 'E13.6 ' / column display format
TTYPE3 = 'CADENCENO' / column title: unique cadence number
TFORM3 = 'J ' / column format: signed 32-bit integer

5. Appendices
 - A.1 Kepler Light Curves
 - A.2 Target Pixel Files
 - B.1-4 Full-Fraction Images
 - B.5 Ancillary Data
 - C.1 Cotrending Mask
 - C.2 Pixel Resolution
 - D.1 Glossary
 - D.2 Common Parameters



KAM Conclusions



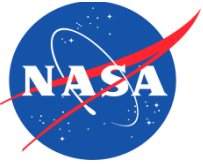
- Document updated frequently throughout mission
 - Feedback from community incorporated into subsequent revisions
 - Changes to file formats, introduction of new data products, and documentation of new tools completed as mission evolved

- Final revision (-006) is complete and under internal review
 - Required changes were significant in some areas:
 - Added 16 (of 17) focal-plane characterization models
 - Added new MAST tools for data retrieval and visualization
 - Signed revision will be available well before DCR



Kepler Data Release Notes (KDRN)

- Mike Haas



KDRN Purpose & Content



- Purpose
 - Identify and document each unique release of data to public
- Content
 - List of released data sets (*i.e.*, data types & observation intervals)
 - Changes to pipeline and their impact on data
 - Evaluation of photometric performance
 - Summary of features and anomalies present in data



KDRN Status

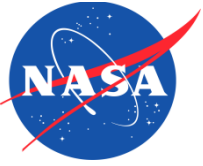


There have been 25 data releases

Rel	Qtrs	SOC	Date
2	Q0, Q1	5.0	10/21/09
3	Q2	6.0	1/20/10
4	Q3	6.1	4/15/10
5	Q0, Q1	6.1	6/4/10
6	Q4	6.1	7/22/10
7	Q2	6.1	9/16/10
8	Q5	6.2	10/25/10
9	Q6	6.2	1/20/11
10	Q7	6.2	4/13/11
11	Q8	7.0	7/22/11
12	Q9	8.0	11/30/11
13	Q10	8.0	2/15/12

Rel	Qtrs	SOC	Date
14	Q0-Q4	8.0	3/15/12
15	Q11	8.0	5/3/12
16	Q5-Q8	8.1	5/22/12
17	Q12	8.1	8/23/12
18	Q13	8.2	10/23/12
19	Q14	8.3	2/4/13
20	Q15	9.0	4/27/13
21	Q0-Q14	8.3	5/7/13
22	Q16	9.0	8/2/13
23	Q17	9.1	12/13/13
24	Q0-Q17	9.2	4/2/15
25*	Q0-Q17	9.3	12/9/15

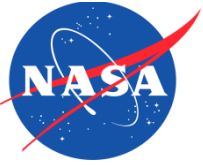
* Minor revision required once short-cadence data is processed & delivered



KDRN Evolution



- Over time, data release notes (KDRN) became repetitive because each quarter of data shares characteristics with previous quarters
 - Notes became difficult to maintain and monotonous for users to read
- Extracted common data characteristics to create Kepler Data Characteristics Handbook (KDCH)
 - Older KDRN resemble KDCH
 - Newer KDRN only provide release information
 - State what is being released and why
 - Reference KDCH, KDPH, and KAM for details
- All KDRN are publically available at MAST
- Starting with DR 24, extended data release concept to include occurrence rate products (ORP) delivered to NExSci
 - Clarifies fact that final light curves (DR 25) were used to generate final ORP (DR 25)



Kepler

Kepler Data Characteristics Handbook (KDCH)

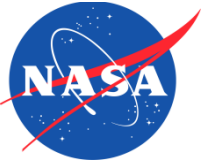
- Mike Haas



KDCH Purpose



- Purpose
 - Collect and document phenomena identified in Kepler data
 - Astrophysical (*e.g.*, coronal mass ejections, smear corruption by bright star)
 - Spacecraft (*e.g.*, safemodes, reaction wheel zero crossings)
 - Photometer (*e.g.*, sudden pixel sensitivity dropouts, thermally induced image motion)
 - Describe how these “features” are treated/corrected by pipeline
 - Simplify Kepler Data Release Notes (KDRN)
 - KDRNs document individual processing releases of specified data sets
 - KDCH addresses underlying features of data itself
 - Help users understand data collection and pipeline processing so that they can distinguish artifacts from astrophysical phenomena

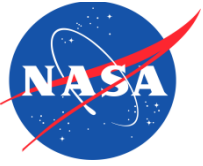


KDCH Content



- Content
 - Summarize data collection dates, cadence ranges, and units
 - Define data terminology: set, processing, product, release
 - Evaluate performance, particularly changes in sensitivity due to improvements in processing algorithms
 - Report unique historical events affecting data
 - Report ongoing phenomena present in data
 - Provide information on time and time stamps
 - Describe ensemble cotrending basis vectors

 - Provide explanatory text, figures, and tables throughout to best reveal and explain characteristics of the data



KDCH Status



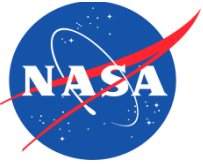
- Released regularly during mission (2010, 2011 x 2, and 2013)
 - Reported data characteristics as data were collected, processed, and analyzed (a companion to Data Release Notes)
 - Updated most recently after SOC 9.0 was released and Q15 was processed
- Requires updates to capture characteristics of Q16 & Q17 data and any changes associated with SOC 9.2 / 9.3 reprocessing
 - Final pipeline processing nearly complete, so all planned updates known
- Revision in progress; complete draft for internal review due mid-April



KDCH Updates Planned



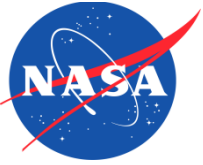
- Expand cadence range to include Q16 and Q17
 - Update historical/on-going information (e.g., second reaction wheel failure)
- Summarize results of final full-mission reprocessing
 - Update sensitivity information
 - Document algorithmic improvements/enhancements
- Update short-cadence spurious frequency table (§5.11) based on recent spectral analysis
- Include new section for scrambled short-cadence collateral data (KAR-1193)
 - Problem fixed for DR 25, but impacts all previous data releases



KDCH Table of Contents



1. Introduction
2. Release Description
3. Evaluation of Performance
4. Historical Events
5. Ongoing Phenomena
6. Time and Time Stamps
7. Ensemble Cotrending Basis Vectors
8. Contents of Supplement
9. References
10. List of Acronyms and Abbreviations
11. Appendix A – Improvements in SOC Pipelines 8.3 and 9.0



KDCH Table of Contents



- 1. Introduction
- 2. Release Description
- 3. Evaluation of Performance

Historical events happen once or infrequently

4. Historical Events

- 5. Ongoing
- 6. Time and
- 7. Ensembl
- 8. Contents
- 9. Referenc
- 10. List of Ac
- 11. Appendix

4. Historical Events
4.1 Kepler Mission Timeline
4.2 Safe Mode
4.3 Loss of Fine Point
4.4 Attitude Tweaks
4.5 Variable FGS Guide Stars
4.6 Module 3 Failure
4.7 Reaction Wheel Failure
4.8 CH Cyg Corrupts Smear Correction

nd 9.0



KDCH Table of Contents



1. Introduction
2. Release Description
3. Evaluation of Performance

Mission timeline shows unique spacecraft-related events – this is an example of something that needs to be updated

4. Historical Events

5. Ongoing

6. Time

7. Ensemble

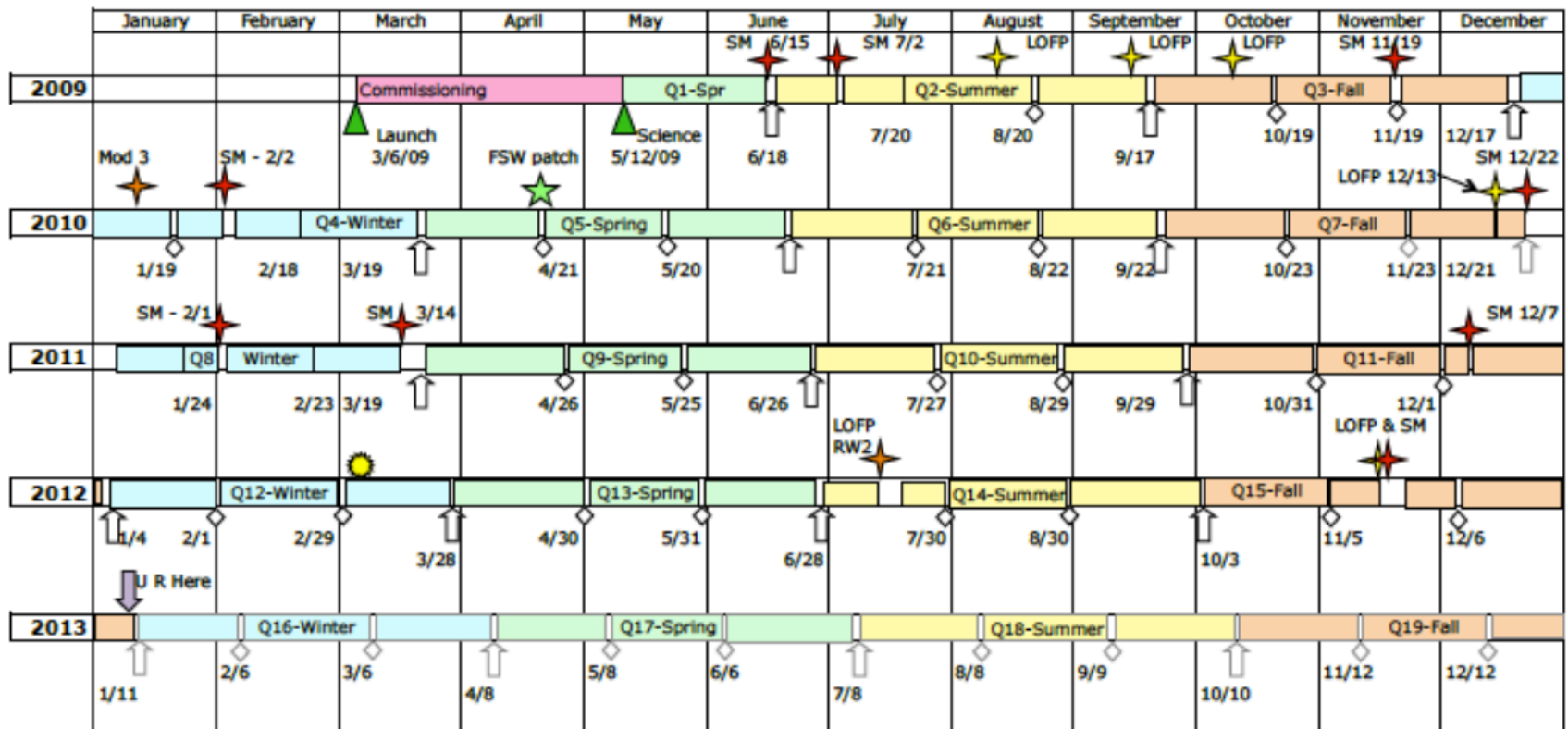
8. Content

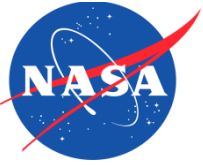
9. Reference

10. List of

11. Appendix

Kepler Mission Timeline





KDCH Table of Contents



1. Introduction
2. Release Description
3. Evaluation of Performance
4. Historical Events

Ongoing phenomena occur frequently; some continuously

5. Ongoing Phenomena

6. Time and
7. Ensembl
8. Contents
9. Referenc
10. List of Ac
11. Appendix

5.0 Ongoing Phenomena

- 5.1 Image Motion
- 5.2 Focus Changes
- 5.3 Momentum Desaturation
- 5.4 Reaction Wheel Zero Crossings
- 5.5 Downlink Earth Point
- 5.6 Manually Excluded Cadences
- 5.7 Incomplete Apertures Give Flux and Feature Discontinuities
- 5.8 Argabrightening
- 5.9 Pixel Sensitivity Dropouts



KDCH Table of Contents



- 1. Introduction
- 2. Release Description
- 3. Evaluation of Performance
- 4. Historical Events

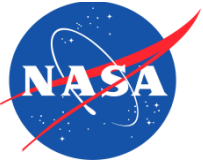
Mixture of spacecraft, photometer and astrophysical events

5. Ongoing Phenomena

6. Time and 5.0 Ongoing Phenomena

- 7. Ensembl 5.1 Image Motion
- 8. Contents 5.2 Focus Changes
- 9. Referenc 5.3 Momentum Desat
- 10. List of Ac 5.4 Reaction Wheel Z
- 11. Appendix 5.5 Downlink Earth P
- 5.6 Manually Exclude
- 5.7 Incomplete Apertu
- 5.8 Argabrightening
- 5.9 Pixel Sensitivity Dropouts

- 5.10 Short Cadence Requantization Gaps
- 5.11 Spurious Frequencies in SC Data
- 5.12 Propagation of Uncertainties
- 5.13 Onboard Spacecraft Errors
- 5.14 Coronal Mass Ejections
- 5.15 Attenuation of Long Period Signals
- 5.16 Anomaly Summary Table and Figure

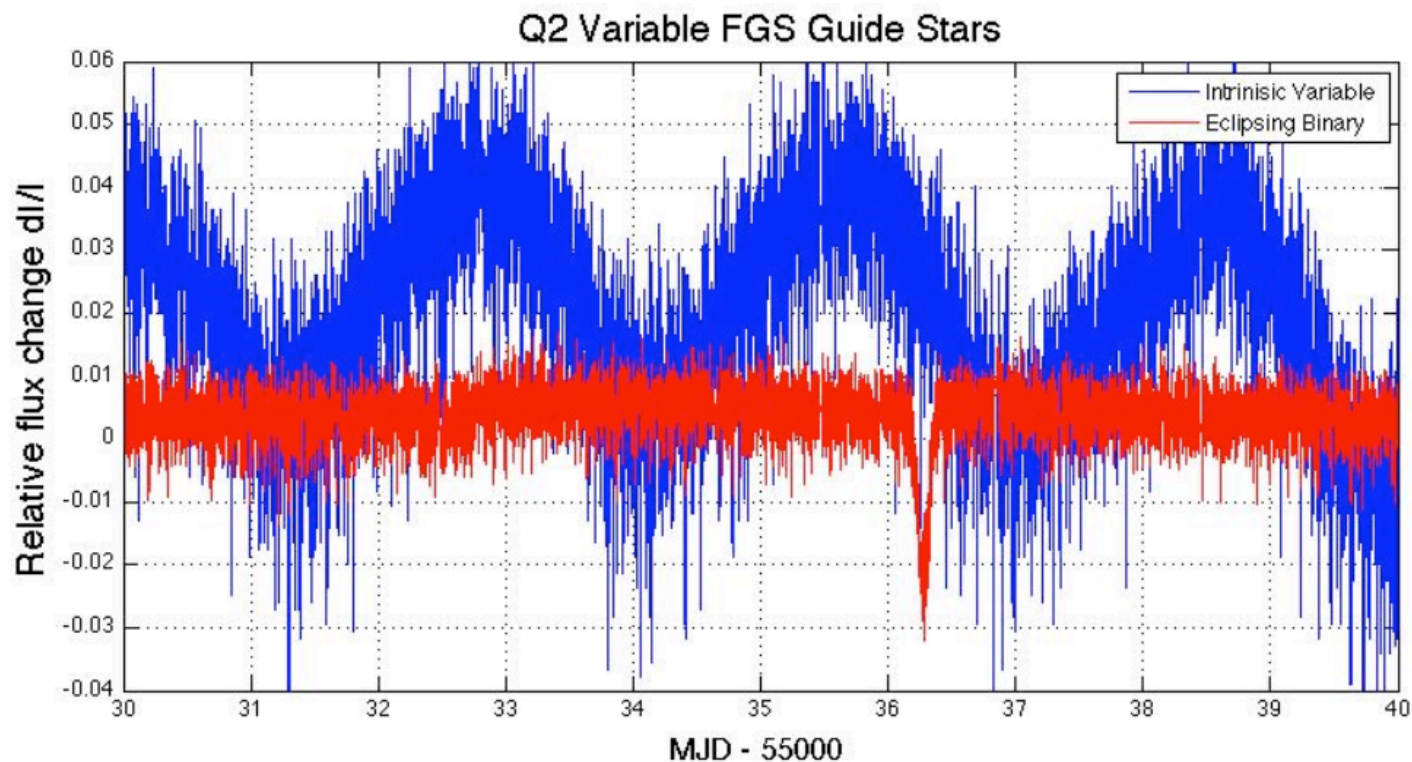


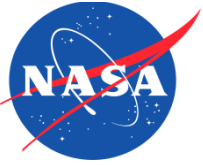
KDCH Table of Contents



1. Introduction
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6. Time an
7. Ensemb
8. Content
9. Referen
10. List of A
11. Append

Choosing unknown eclipsing binary stars for guiding shakes whole spacecraft and introduces periodic signals into all stars





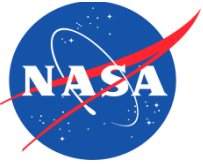
KDCH Conclusions



- The updates to the KDCH are clearly defined because
 - Data collection is complete
 - Data processing is sufficiently far along
- Final revision (-005) is in progress
 - Required changes are minor
 - Signed revision will be available well before DCR



Kepler Data Processing Handbook (KDPH) - Jon Jenkins

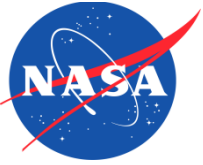


KDPH Purpose & Content



- Purpose
 - Document algorithms used to produce the Kepler legacy archival data products, including the light curves and associated products, and the threshold crossing events and associated Data Validation reports and products

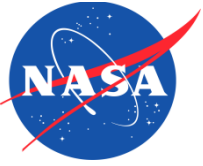
- Content
 - Introduction and overview of science data processing
 - Photometric Pipeline
 - Image artifact handling and flagging (Dynablack)
 - Pixel level calibrations (CAL)
 - Photometric analysis (PA)
 - Instrumental signature and systematic error identification and removal (PDC)
 - Transit Search Pipeline
 - Transiting planet search (TPS)
 - Bootstrap statistic
 - Data Validation (DV)



KDPH Status



- Originally released in April 2011
 - Documented first complete science pipeline
 - Corresponded to SOC 6.2(!)
 - Original SPIE chapter inputs were limited to only 12 pages
- Updated input material describing the pipeline algorithms is to be compiled within the final KDPH
 - Significant progress made on input documentation for the KDPH since software development was completed
 - Most of input material is drawn from publications between 2010 and 2016
 - Updated chapters are more comprehensive and detailed
 - Content ~75% complete
 - Most of remaining content to be developed is in the “back end” (TPS & DV)
 - The input material needs to be compiled into a book (which is underway)



KDPH Table of Contents



PART I KEPLER SCIENCE OPERATIONS

- 1 Philosophy and Scope
- 2 Introduction to Kepler Data Processing
- 3 The Kepler Input Catalog
- 4 Target and Aperture Definition

} Only Minor
Revisions
required

PART II THE KEPLER PHOTOMETRIC PIPELINE

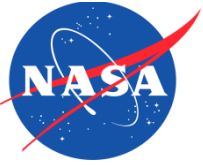
- 5 Dynamic Black Correction
- 6 Pixel Level Calibrations
- 7 Photometric Analysis
- 8 Finding Optimal Apertures
- 9 Presearch Data Conditioning

} Input Material
Nearly
Complete

PART III TRANSIT SEARCH ENGINE

- 10 Transiting Planet Search
- 11 A Statistical Bootstrap Test
- 12 Data Validation Diagnostic Tests
- 13 Data Validation Model Fitting

} Input Material
~50%
Complete



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- 3 The Kepler Input Catalog
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PART II THE KEPLER PHOTOMETRIC PIPELINE

- 5 Dynamic Black Correction
- 6 Pixel Level Calibrations
- 7 Photometric Analysis
- 8 Finding Optimal Apertures
- 9 Presearch Data Conditioning

PART III TRANSIT SEARCH ENGINE

- 10 Transiting Planet Search
- 11 A Statistical Bootstrap Test
- 12 Data Validation Diagnostic Tests
- 13 Data Validation Model Fitting



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PART I KEPLER SCIENCE OPERATIONS

- 1 Philosophy
- 2 Introduction
- 3 The Kepler
- 4 Target and

PART II THE KEPLER

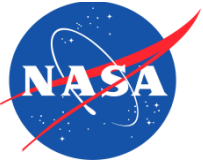
- 5 Dynamic B
- 6 Pixel Level
- 7 Photometri
- 8 Finding Op
- 9 Presearch

PART III TRANSIT S

- 10 Transiting
- 11 A Statistic
- 12 Data Valid
- 13 Data Validation Model Fitting

2 INTRODUCTION TO KEPLER DATA PROCESSING

- 2.1 Science Operations Architecture
- 2.2 Science Concept to Sources: the Kepler FOV and Input Catalog
 - 2.2.1 FOV
 - 2.2.2 Stellar Classification Program
 - 2.2.3 Kepler Input Catalog
- 2.3 Target Management: Targets to Target Definitions
- 2.4 Flight System: Pixel Tables to Cadence Data Sets
- 2.5 Photometry Pipeline: Cadence Data Sets to Flux Time Series
- 2.6 Planet Search Pipeline: Flux Time Series to Valid Transits
- 2.7 SOC Software Releases
- 2.8 Data Archive



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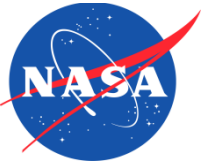
- 5 Dynamic Black Correction
- 6 Pixel Level Calibrations
- 7 Photometric Analysis
- 8 Finding
- 9 Presearch

PART III TRANSITS

- 10 Transiting
- 11 A Statistical
- 12 Data Validation Diagnostic Tests
- 13 Data Validation Model Fitting

Flagging and Correction of Pattern Noise in the Kepler Focal Plane Array

Jeffery J. Kolodziejczak^{*a}, Douglas A. Caldwell^b, Jeffrey E. Van Cleve^b, Bruce D. Clarke^b,
 Jon M. Jenkins^b, Miles T. Cote^b, Todd C. Klaus^b, Vic S. Argabright^c
^aSpace Science Office, VP62, NASA Marshall Space Flight Center, Huntsville AL USA 35812;
^bSETI Institute/NASA Ames Research Center, 1600 Commerce Street, Boulder, CO USA 80301;
^cBall Aerospace & Technologies Corp., 1600 Commerce Street, Boulder, CO USA 80301;
^dOrbital Sciences Corporation/NASA Ames Research Center, M/S 244-30, Moffett Field, CA, USA 94305;
^eNASA Ames Research Center, M/S 244-30, Moffett Field, CA, USA 94305



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- 1 Philosophy and Scope
- 2 Introduction to Kepler Data Processing
- 3 The Kepler Input Catalog
- 4 Target and Aperture

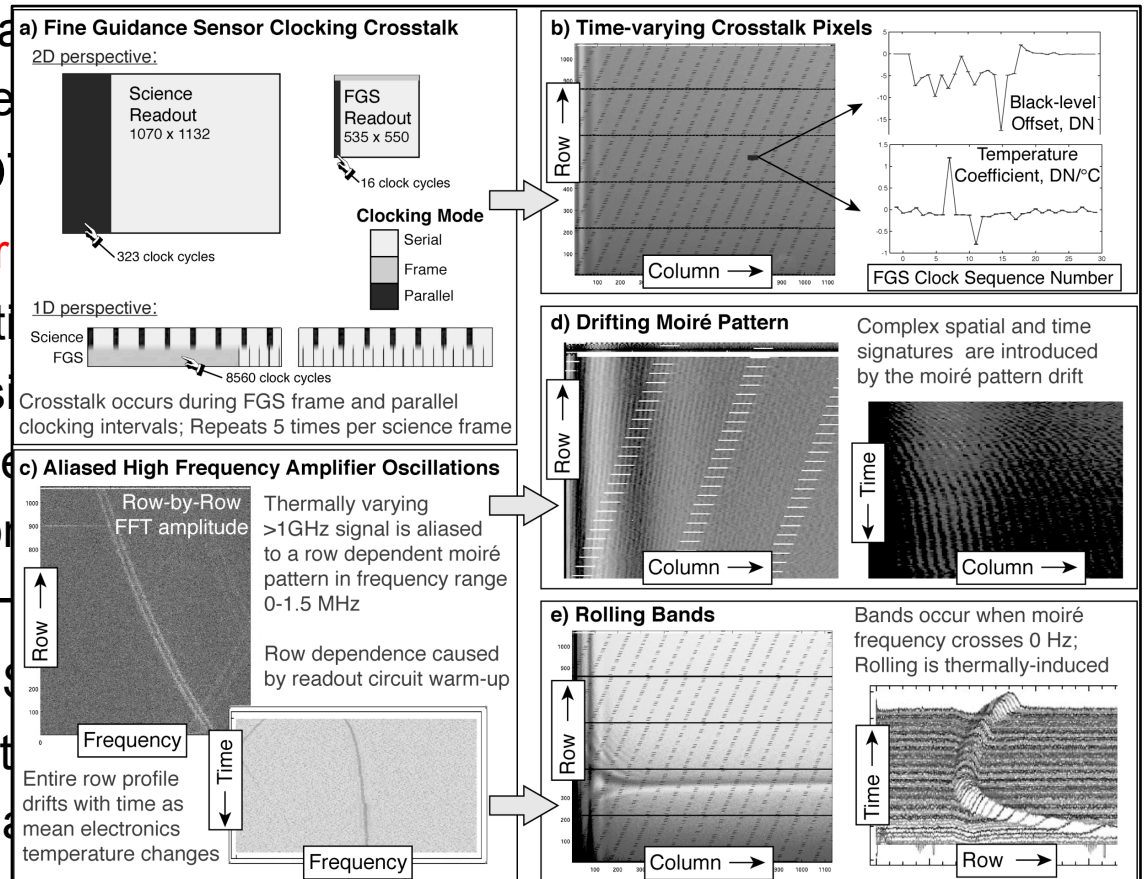
Electronic Image Artifacts

PART II THE KEPLER PHOTOGRAPHY

- 5 Dynamic Black Correction
- 6 Pixel Level Calibration
- 7 Photometric Analysis
- 8 Finding Optimal Apertures
- 9 Presearch Data Comparison

PART III TRANSIT SEARCH

- 10 Transiting Planet Search
- 11 A Statistical Bootstrap
- 12 Data Validation Diagnostics
- 13 Data Validation Model Fitting





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- 4 Target and Aperture Definition

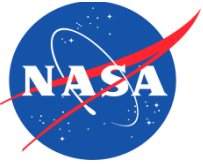
PART II THE KEPLER PHOTOMETRIC PIPELINE

- 5 Dynamic Black Correction
- 6 Pixel Level Calibrations
- 7 Photometric Analysis
- 8 Finding Optimal Apertures
- 9 Presearch Data Conditioning

KADN-26142:
Pixel Level Calibration

PART III TRANSIT SEARCH ENGINE

- 10 Transiting Planet Search
- 11 A Statistical Bootstrap Test
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- 13 Data Validation Model Fitting



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3 The Kepler Input Catalog

4 Target and Aperture

PART II THE KEPLER PHOTOMETRY

5 Dynamic Black Correction

6 Pixel Level Calibration

7 Photometric Analysis

8 Finding Optimal Apertures

9 Presearch Data Cleaning

PART III TRANSIT SEARCH

10 Transiting Planet Detection

11 A Statistical Bootstrap

12 Data Validation I

13 Data Validation II

6 Pixel Level Calibrations

6.1 Kepler Data Formats and CAL Unit of Work

6.1.1 CAL Data Types: Long and Short Cadence and Full Frame Images

6.1.2 Focal Plane Array

6.1.3 Pixel Collection

6.1.4 Photometric and Collateral Data

6.1.5 Processing Order

6.1.6 Data Gap

6.1.7 What CAL is Not Designed To Do

6.2 Calibration

6.2.1 Compute Raw Black Uncertainties

6.2.2 Models

6.2.3 Fixed Offset, Mean Black, and Spatial Co-Adds

6.2.4 Black Correction

6.2.5 Nonlinearity and Gain Correction

6.2.6 LDE Overshoot/Undershoot Correction

6.2.7 Smear and Dark Correction

6.2.8 Flat Field Correction

6.2.9 Additional Functionality in CAL



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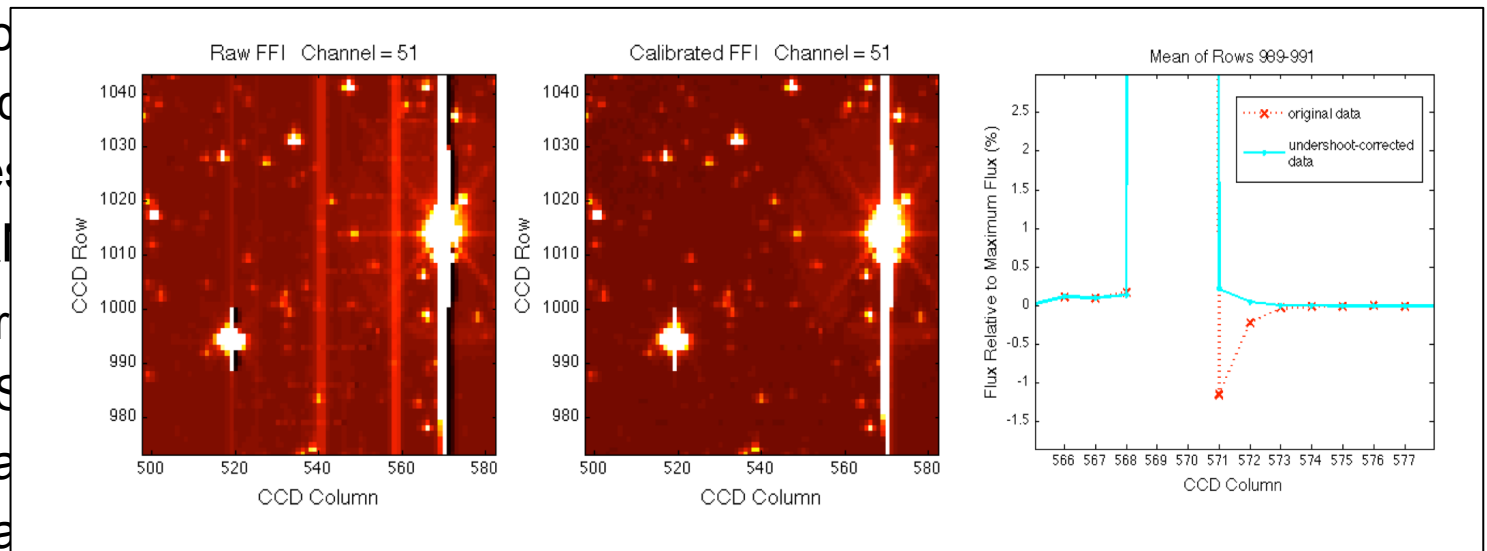
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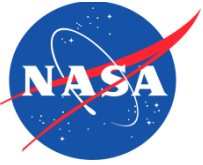
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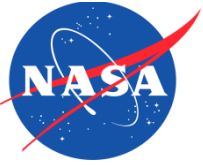
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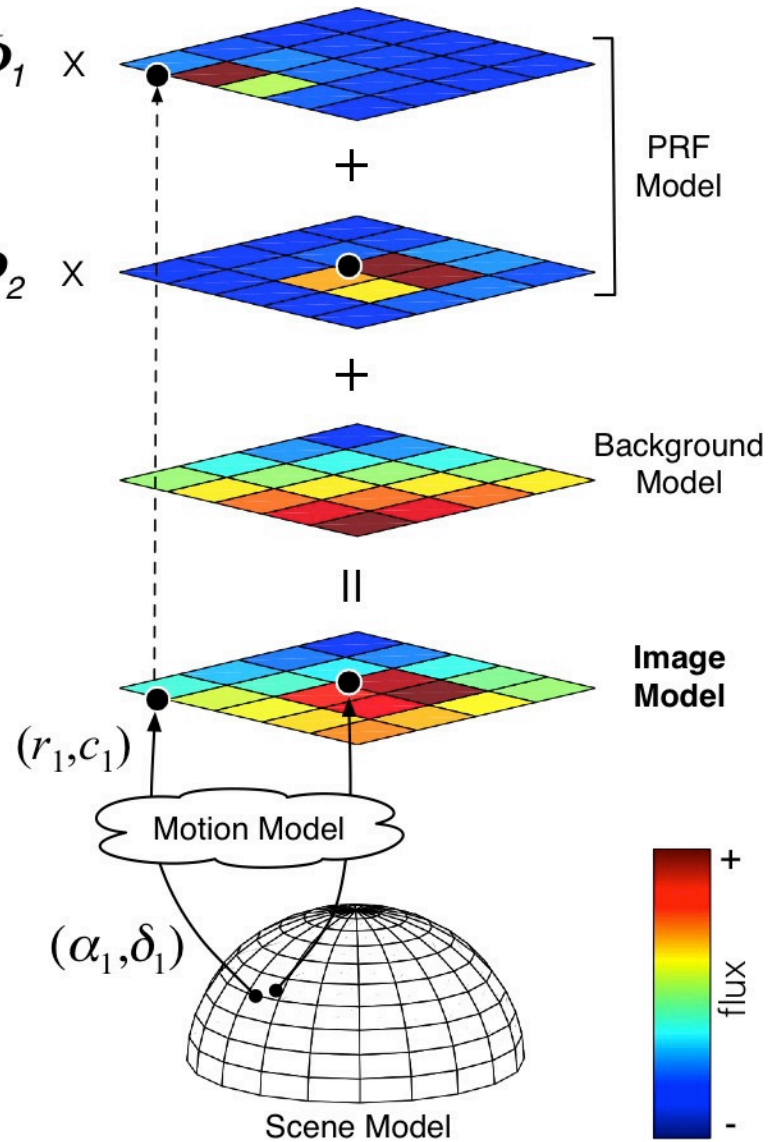
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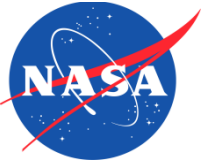
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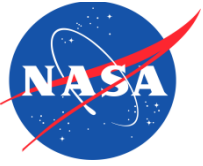
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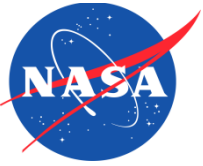
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Finding Optimal Apertures in Kepler Data

Jeffrey C. Smith^{*,1,2}, Robert L. Morris^{1,2}, Jon M. Jenkins¹, Stephen T. Bryson¹, Douglas A. Caldwell^{1,2}, Forrest R. Girouard^{1,3}

ABSTRACT

With the loss of two spacecraft reaction wheels precluding further data collection in the Kepler primary mission, even greater pressure is placed on the pipeline to eke out every last transit signal in the data. To that end

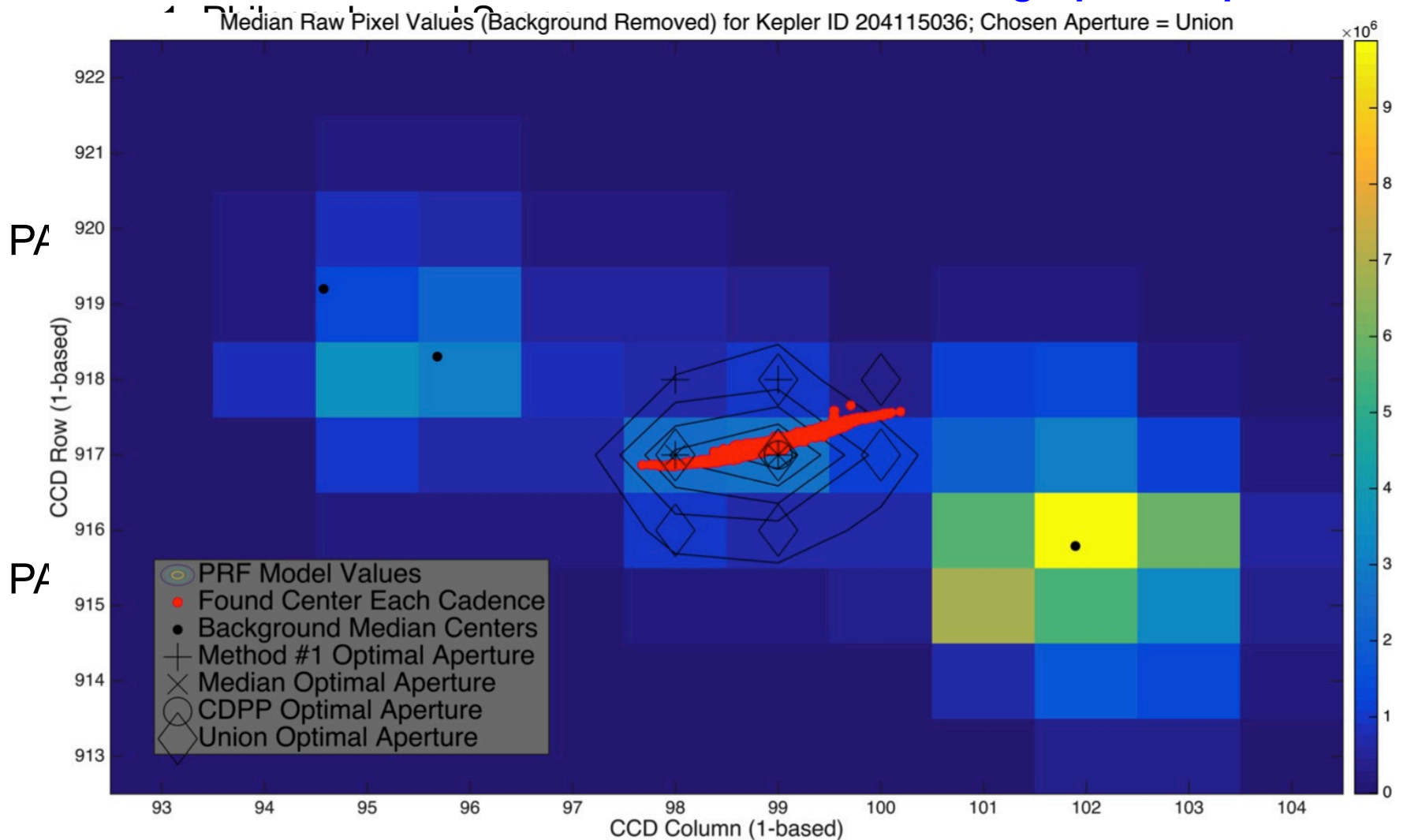


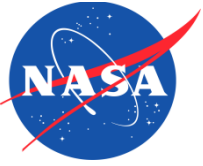
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Finding Optimal Apertures





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Kepler Presearch Data Conditioning I—Architecture and Algorithm for Error Correction in Kepler Light Curves

MARTIN C. STUMPE,^{1,2} JEFFREY C. SMITH,^{1,2} JEFFREY E. VAN CLEVE,^{1,2} JOSEPH D. TWICKEN,^{1,2} THOMAS S. B. LEE,^{1,2} MICHAEL N. FANELLI,^{1,3} FORREST R. GIROUARD,^{1,4} JON M. JENKINS,^{1,2} JEFFERY J. KOLODZIEJCZAK,^{1,2} SEAN D. MURPHY,^{1,2} AND JAMES W. MOSELEY,^{1,2}

PART II THE KEPLER PHOTOMETRY

- 5 Dynamic Black Correlation
- 6 Pixel Level Calibration
- 7 Photometric Analysis
- 8 Finding Optimal Apertures

Kepler Presearch Data Conditioning II - A Bayesian Approach to Systematic Error Correction

JEFFREY C. SMITH,^{1,2} MARTIN C. STUMPE,^{1,2} JEFFREY E. VAN CLEVE,^{1,2} JON M. JENKINS,^{1,2} THOMAS S. B. LEE,^{1,2} MICHAEL N. FANELLI,^{1,3} FORREST R. GIROUARD,^{1,4} JEFFERY J. KOLODZIEJCZAK,^{1,2} SEAN D. MURPHY,^{1,2} AND JAMES W. MOSELEY,^{1,2}

ABSTRACT
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Multiscale Systematic Error Correction via Wavelet-Based Methods for Kepler Data

MARTIN C. STUMPE,^{1,2,3} JEFFREY C. SMITH,^{1,2} JOSEPH H. CATANZARITE,^{1,2} JEFFREY E. VAN CLEVE,^{1,2} JOSEPH D. TWICKEN,^{1,2} AND FORREST R. GIROUARD^{1,4}

ABSTRACT
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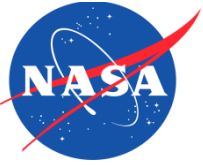
Received 2013 November 06; accepted 2013 November 23; published 2014 January 13

9 Presearch Data Conditioning

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ABSTRACT. The previous presearch data conditioning algorithm, PDC-MAP, for the Kepler pipeline performs very well for the majority of targets in the *Kepler* field of view. However, for a minority, PDC-MAP has its limitations. To further minimize the number of targets for which this is the case, we have developed a new algorithm, PDC-MAP2, which is designed to address these limitations.



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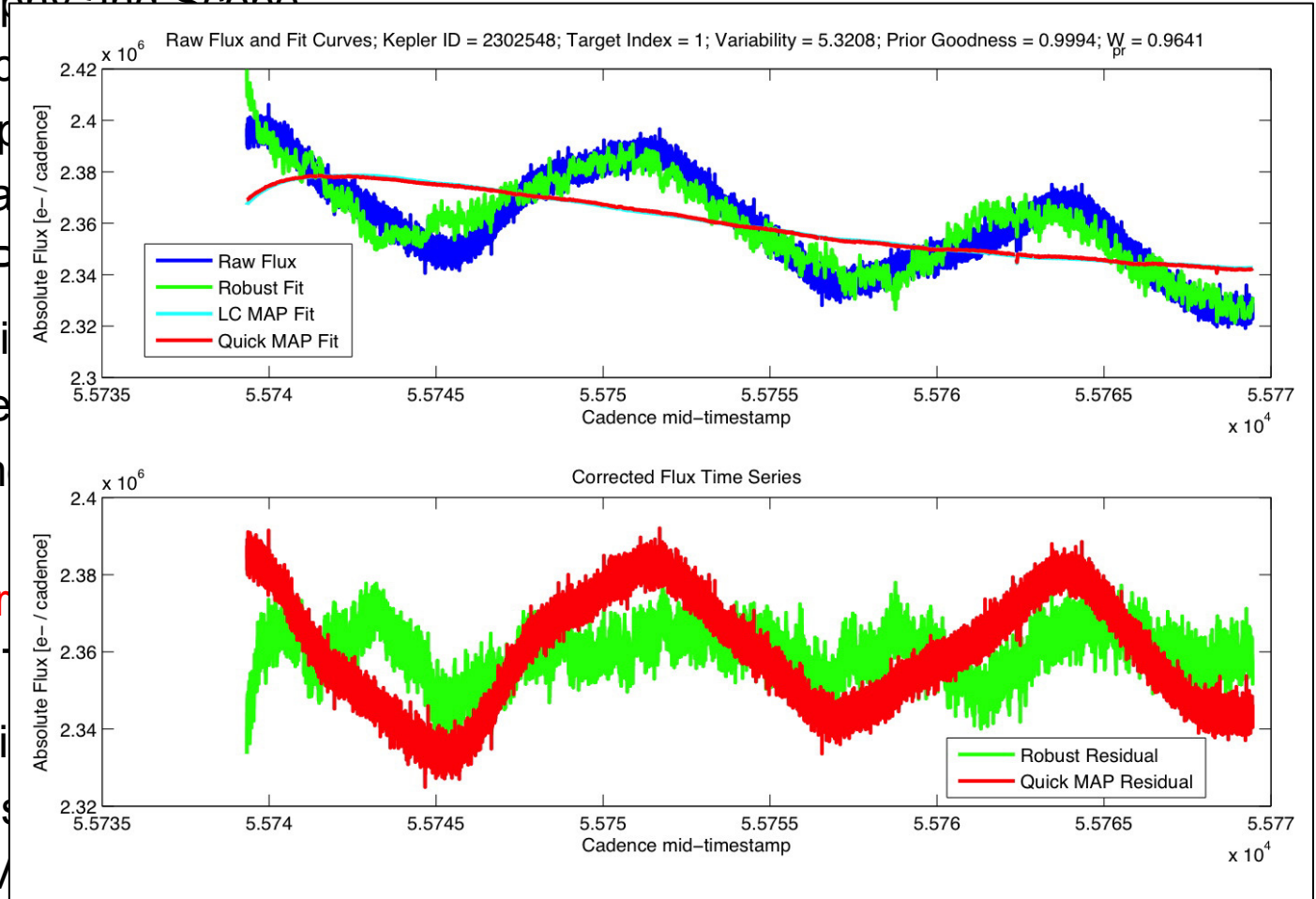
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10 Transits

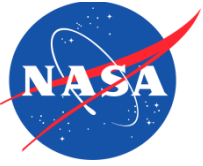
11 A Statistics

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MAP generally preserves stellar variability better than robust fitting



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Transiting planet search in the *Kepler* pipeline

Jon M. Jenkins^{o,a}, Hema Chandrasekaran^{a,b}, Sean D. McCauliff^c, Douglas A. Caldwell^a, Peter Tenenbaum^a, Jie Li^a, Todd C. Klaus^c, Miles T. Cote^d, Christopher Middour^c

^aSETI Institute/NASA Ames Research Center, M/S 244-30, Moffett Field, CA USA 94305

χ^2 DISCRIMINATORS FOR TRANSITING PLANET DETECTION IN *KEPLER* DATA

SHAWN SEADER, PETER TENENBAUM, JON M. JENKINS, AND CHRISTOPHER J. BURKE
SETI Institute, NASA Ames Research Center, Moffett Field, CA 94035, USA; shawn.seader@nasa.gov, peter.tenenbaum@nasa.gov,
jon.jenkins@nasa.gov, christopher.j.burke@nasa.gov

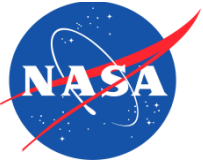
Received 2013 February 27; accepted 2013 May 4; published 2013 June 3

ABSTRACT

The *Kepler* spacecraft observes a host of target stars to detect transiting planets. Requiring a 7.1σ detection in three years of data yields over 100,000 detections, many of which are false alarms. After a second cut is made

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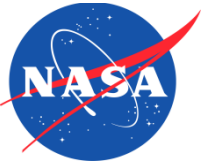
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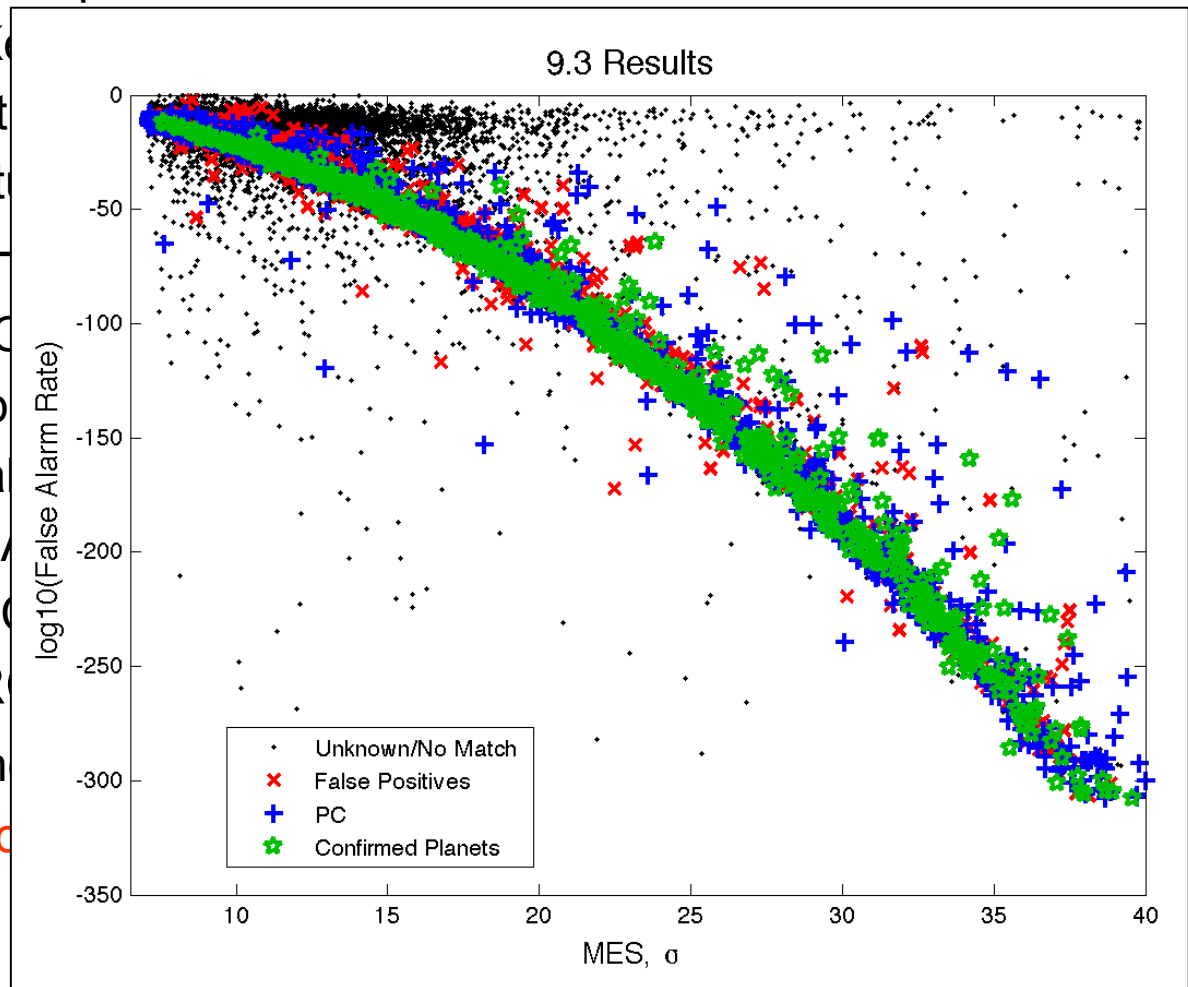
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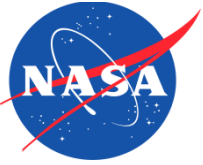
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Characterizing False Alarm Rates vs. SNR





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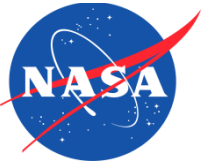
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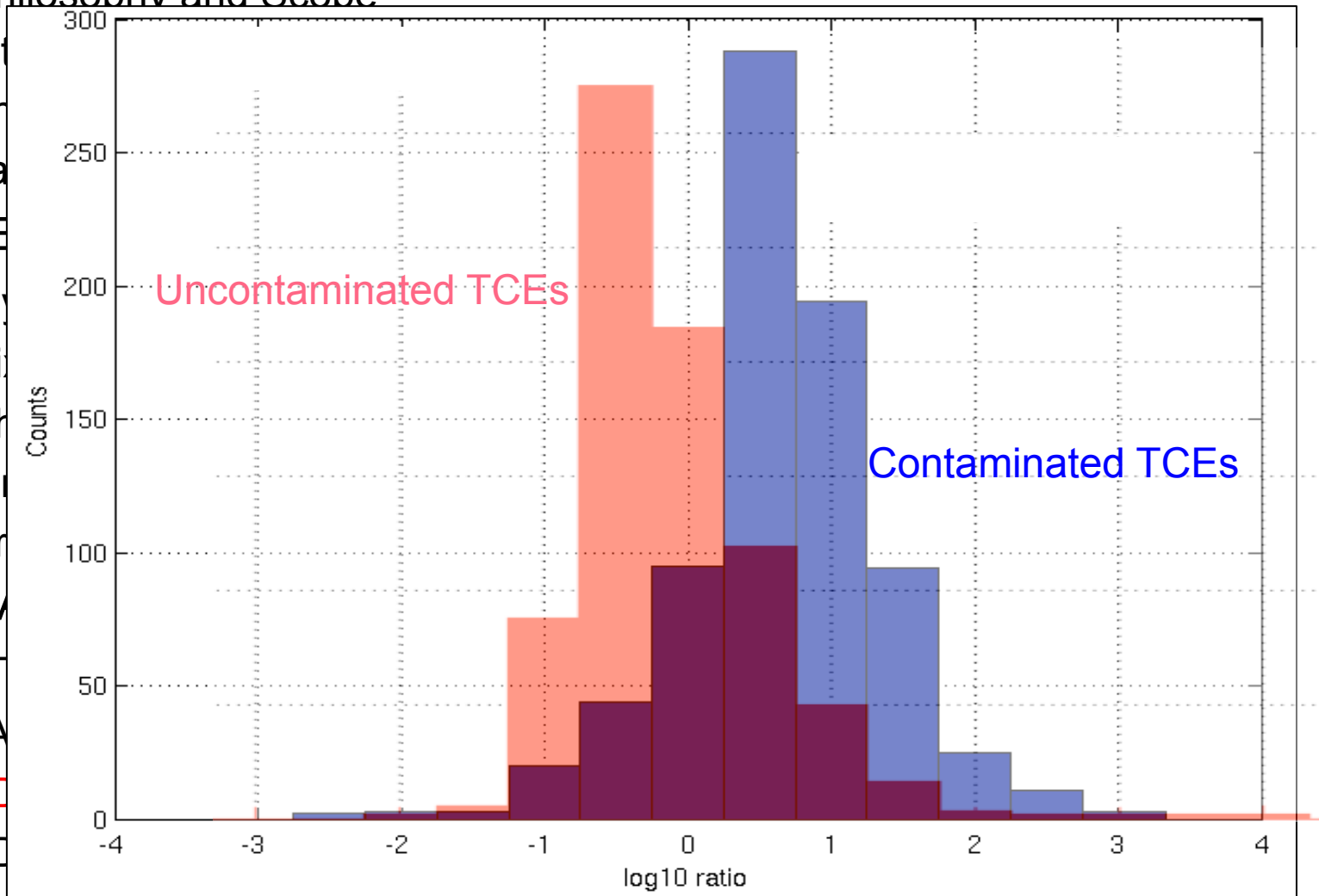
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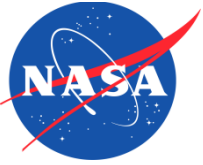
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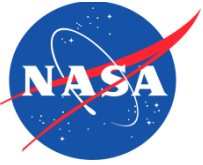
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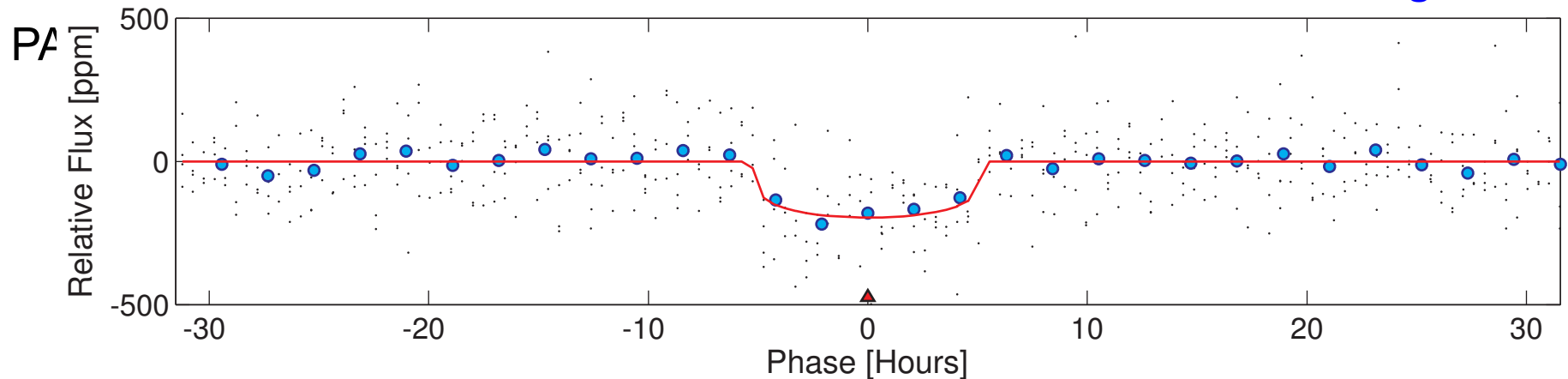
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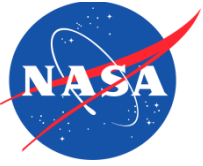
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Limb-Darkened Transit Model Fitting



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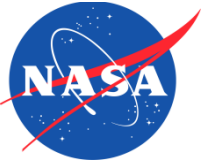
KDPH Conclusions



- The updates to the KDPH are clearly defined
 - Kepler code is frozen and final processing complete
 - Front-end KDPH deliveries are nearly complete
 - ~50% of the back-end KDPH deliveries are complete
- Final version (-002) is underway and signed release is scheduled for Fall 2016
 - Front-end KDPH will be ready for DCR review in mid-June, well before DCR Step 2
 - Back-end KDPH will be ready for DCR review in September, ahead of the DCR Step 2 in October



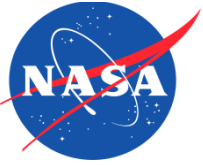
Occurrence Rate Products (ORP) - Mike Haas



ORP Purpose & Content



- Purpose
 - Characterize target stars
 - Find and evaluate planet candidates
 - Assess resulting planet-candidate catalog
 - Characterize pipeline performance
 - Compute planet occurrence rates
 - Provide multiple entry points for scientific community
- Content
 - Stellar Properties Catalog
 - Threshold Crossing Event (TCE) Catalog
 - Kepler Object of Interest (KOI) Catalog
 - Completeness & Reliability Products

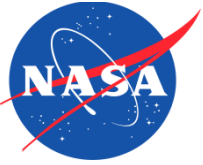


ORP Status



ORP Set	Source	First NExSci Delivery & Date	Primary Documentation
Stellar Properties Catalog	Stellar Properties Working Group	Q1-Q12 in March, 2013	KSCI & Publication
Threshold-Crossing Event (TCE) Catalog	Data Validation (DV) module of SOC pipeline	Q1-Q12 search in December, 2012	Publication & on-line material
Kepler Object of Interest (KOI) Catalog	Science Office with support from TCERT	Q1-Q6 in February, 2013	Publication & on-line material
Completeness & Reliability Products	Science Office	Q1-Q17 DR 24 in January, 2016	Numerous KSCIs & Publications

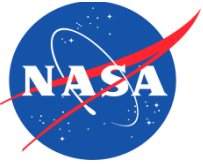
- First three ORP sets are mature
 - Produced & delivered to NExSci Exoplanet Archive multiple times (once per pipeline release or “activity cycle”)
 - Documentation peer reviewed and public for > 3 years
- Fourth ORP set is significantly less mature
 - Completed first-time delivery earlier this year (for DR24)



Stellar Properties Documentation



- Kepler Input Catalog (KIC; Brown et al., 2011)
 - Released before launch
 - Used for data collection (*i.e.*, target management)
- Stellar Properties Catalog (ORP A.0)
 - Updated stellar properties in KIC based on subsequent observations and analysis
 - Released for last four KOI catalogs:
 - Q1-Q12 (*Rowe et al. 2013*)
 - Q1-Q16 (*Huber et al. 2014*)
 - Q1-Q17 DR24 (*KSCI-19083*)
 - Q1-Q17 DR25 (*KSCI-19097; Mathur et al. 2016, in prep*)

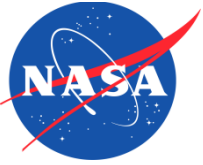


TCE Catalog Documentation



No.	Occurrence Rate Product	SOC 9.2 Doc	SOC 9.3 Doc
B.0	TCE table	Seader et al. 2015	Twicken et al. 2016
B.1	TCE stellar & planetary parameters	Seader et al. 2015	Twicken et al. 2016
B.2	Data Validation (DV) report	Seader et al. 2015	Twicken et al. 2016
B.3	DV one-page summary	Seader et al. 2015	Twicken et al. 2016
B.4	Supplemental DV report	N/A	Planned
B.5	Supplemental DV one-page summary	N/A	Planned
B.6	TCERT vetting products	KSCI-19104	Planned
B.7	DV time series	N/A	KSCI-19079
B.8	Centroid robovetter scores	N/A	Planned
B.9	Flux robovetter scores	N/A	Planned
B.12	Bootstrap metric	KSCI-19086	KSCI-19099

Hosted at: <http://exoplanetarchive.ipac.caltech.edu/index.html>
Notes: N/A = not delivered for SOC 9.2; gray = SOC 9.3 draft

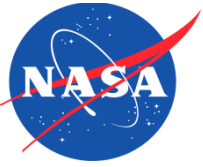


KOI Catalog Documentation



No.	Occurrence Rate Product	SOC 9.2 Doc	SOC 9.3 Doc
C.0	KOI table	Coughlin et al. 2015	Planned
C.1	KOI dispositions	Coughlin et al. 2015	Planned
C.2	Model fit parameters & associated errors	KSCI-19084	Planned
C.3	False-positive reasons	Coughlin et al. 2015	Planned
C.6	MCMC posterior chains	KSCI-19084	Planned

Hosted at: <http://exoplanetarchive.ipac.caltech.edu/index.html>

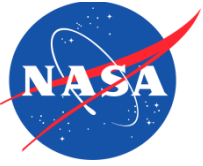


Completeness & Reliability Product Documentation



No.	Occurrence Rate Product	SOC 9.2 Doc	SOC 9.3 Doc
A.1	RMS CDPD	Burke et al. 2015	Planned
A.2	Data quality metrics	Burke et al. 2015	Planned
A.3	Multiple-event statistic threshold table	Burke et al. 2015	Planned
C.4	Astrophysical false-positive table	Morton et al. 2012; Montet et al. 2015	Planned
C.5	Astrophysical positional probabilities	KSCI-19092	Planned
D.0	Average detection efficiency	KSCI-19094	Planned
D.1	Single-target detection efficiency	N/A	Planned
D.2	TCERT detection efficiency	KSCI-19096	Planned
D.3	TPS sensitivity products	KSCI-19085	Planned
D.4	Sensitivity contours	N/A	Planned
D.5	TCERT reliability metric	N/A	Planned
E.0	FPWG certification results	KSCI-19093	Planned

Hosted at: <http://exoplanetarchive.ipac.caltech.edu/index.html>
Note: N/A = not delivered for SOC 9.2

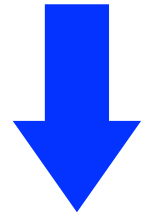


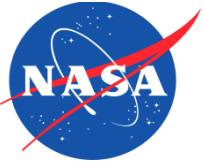
Completeness & Reliability Product Overview



- Occurrence rate calculations require an estimate of pipeline detection efficiency (or completeness) as a function of planet radius and orbital period for each individual star
- Occurrence Rate Products (ORP) provide three independent estimates:
 - Simple Analytic Completeness Model (ACM) uses single numbers to specify noise (A.1), amount of data (A.2), & depth of search (A.3)
 - Intermediate Analytic Completeness Model (ACM) uses full noise time series with detailed knowledge of data gaps (D.3)
 - Numerical Completeness Model (NCM) uses actual TPS machinery to perform ~500K flux-level transit injections per star
- Ultimately, all occurrence rate calculations must rely on either simple or intermediate ACM, because NCM is only affordable for <1% of stars
- Purpose of NCM is to characterize performance of TPS in a general sense and to understand/fix/document the limitations of ACM

Cost &
Fidelity

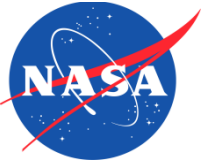




Completeness & Reliability Product Documentation



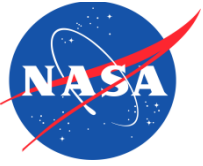
- Document results of TPS experiments:
 - Pixel-level transit injection provides pipeline detection efficiency averaged over multiple stars (D.0)
 - Flux-level transit injection provides pipeline detection efficiency contours for individual stars (D.1)
- Document constructed models:
 - Simple ACM (D.0, A.1, A.2, A.3)
 - Intermediate ACM (D.0, D.3)
- Document performance and limitations of constructed models, including worked examples (D.4)



Completeness & Reliability Product Documentation



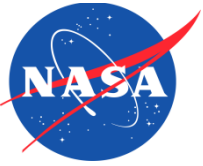
- Once transit search is performed (B.0) and planetary candidate catalog is constructed (C.0), how good is it?
 - **Completeness:**
 - What real planets found by pipeline are rejected by vetting? **D.2 (false negatives)**
 - **Reliability:**
 - What non-planets found by pipeline are passed by vetting? **D.5 (false positives)**
 - How many candidates are confirmed/indicted by manual inspection? **E.0 (FPWG)**
 - How many candidates are confirmed/indicted by follow-up observations **(F.2 – F.4)**
 - How many candidates are confirmed/indicted by detailed modeling? **C.4, C.5**
- While all these metrics inform completeness and reliability, it is ultimately up to science community to determine how/if they are used in specific occurrence rate calculations



Completeness & Reliability Oversight & Transition



- Several factors responsible for late development:
 - Their research nature: What will Kepler find? How will pipeline perform?
 - Dependence on fully automated catalog generation, first achieved for DR 24
 - Dependence on transit injection & inversion machinery, which matured in 2015
 - Deeper understanding of mission goals and changing attitudes towards open science
- Majority developed and delivered for Q1-Q17 DR 24 (i.e., SOC 9.2)
 - Documentation complete and available for review
 - Remainder matured for delivery in Q1-Q17 DR 25 (i.e., SOC 9.3)
- Recognizing late development and importance, regular external reviews conducted to guide development, exercise products, & review documents
 - Defined and presented at Occurrence Rate Product Review in October, 2014
 - Used by Hackmasters to compute occurrence rates in October, 2015
 - Updated Hackmasters on Feb 23; additional telecons in Summer/Fall, 2016
 - Planned Hackmaster outbrief after final products delivered in March, 2017



Planet Detection Metrics: Statistical Bootstrap Test



- Table of Contents (B.12, KSCI-19086)
 - Introduction
 - Theoretical Considerations
 - Column Definitions
 - Results
 - References

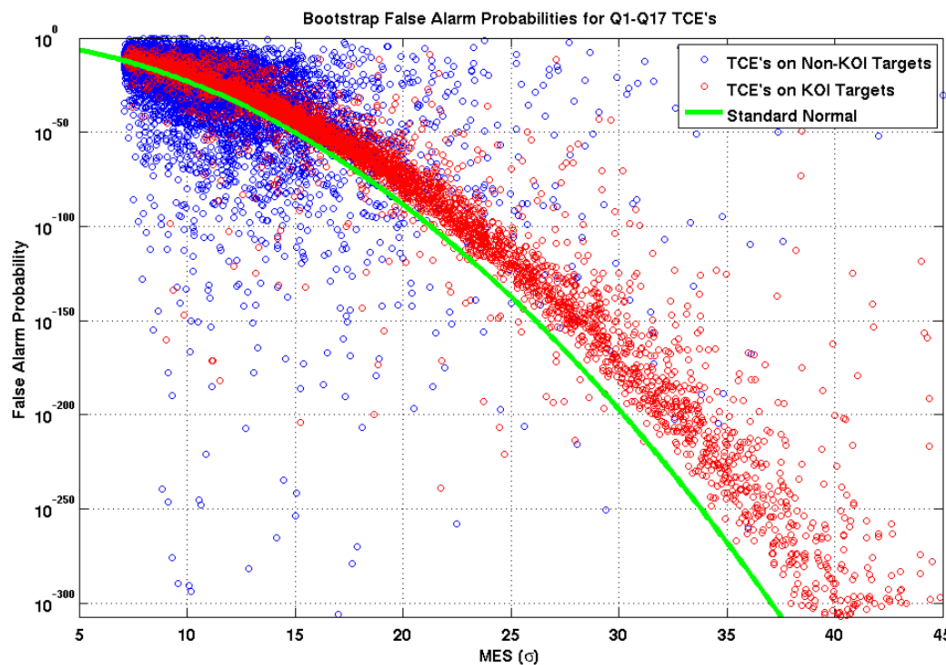
$$C_p = \sum_{i \in S} C(i) \text{ and } N_p = \sum_{i \in S} N(i). \quad (3)$$

The joint density of C_p and N_p can be determined from the joint density of the single-event statistic components C and N as

$$f_{C_p, N_p}(C_p, N_p) = f_{C, N}(C, N) * f_{C, N}(C, N) * \dots * f_{C, N}(C, N), \quad (4)$$

where ‘*’ is the convolution operator and the convolution is performed p times. This follows from the fact that the bootstrap samples are constructed from *independent* draws from the set of null (single-event) statistics with replacement.³ Given that convolution in the time/spatial domain corresponds to multiplication in the Fourier domain, Equation (4) can be represented in the Fourier domain as

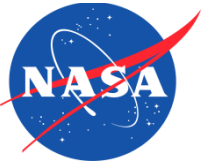
$$\Phi_{C_p, N_p} = \Phi_{C, N} \cdot \Phi_{C, N} \cdot \dots \cdot \Phi_{C, N} = \Phi_{C, N}^p, \quad (5)$$



boot_fap: The false alarm probability is the null MES statistics above the MES statistics is constructed by the bootstrap distributed with zero mean and unit var the whitening process, uncorrected syst deviates from this nominal distribution

boot_mesthresh: The search threshold r estimated from the bootstrap algorithm, that of a 7.1σ threshold on a Gaussian ($\sim 6.24e-13$).

boot_mesmean: The mean of the best-f distribution estimated by the bootstrap.

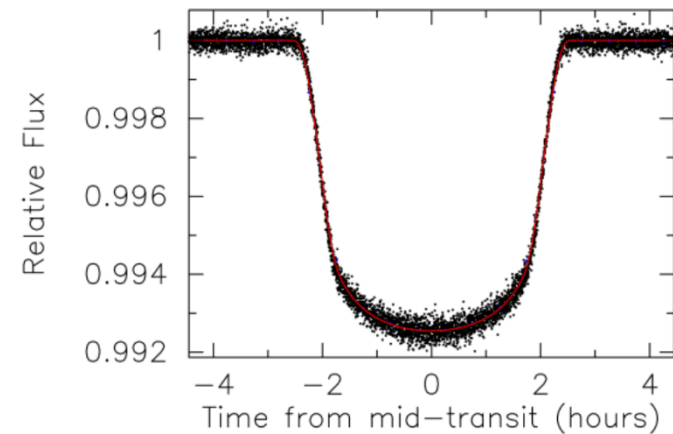
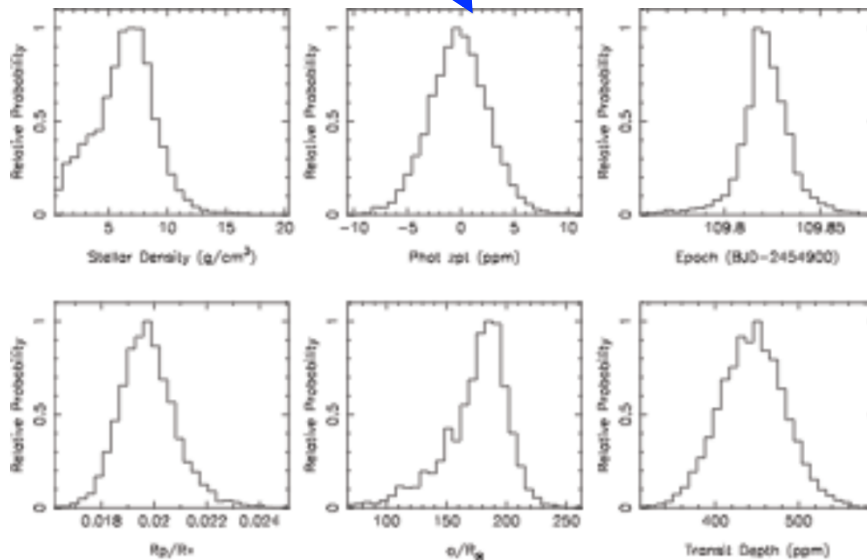


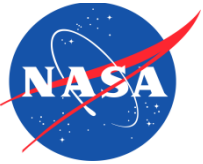
Uniform Modeling of KOIs: MCMC Data Release Notes



- Table of Contents (C.2 & C.6, KSCI-19084)
 - Introduction
 - Directory Structure
 - Best Fit, Chi-Square Minimization Parameters
 - Transit Timing Variations
 - Markov Chains
 - Using Files to Estimate Posteriors
 - References

- ▶ `koi156.n`
- ▶ `koi157.n`
 - `n0.dat` ← simultaneous best fit solution to all planets
 - `n1.dat`
 - ⋮ } best fit solutions for each planet individually
 - `n6.dat`
 - `koi0157.01.tt`
 - ⋮ } Transit timing measurements
 - `koi0157.06.tt`
 - `mcmc.157.n1.dat`
 - ⋮ } Markov-Chains
 - `mcmc.157.n6.dat`
- ▶ `koi158.n`

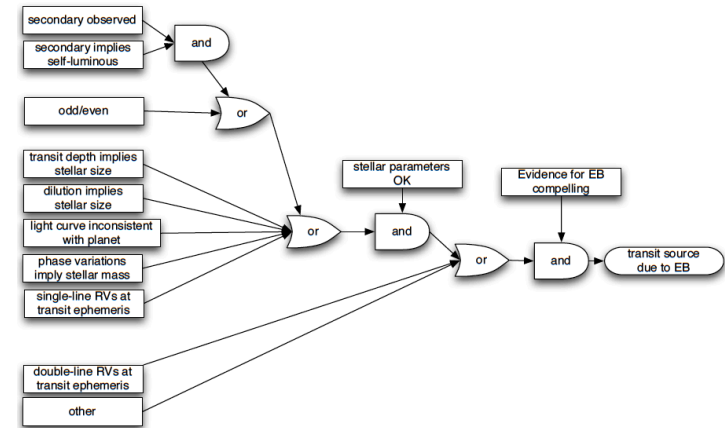




Kepler False Positive Table



- Table of Contents (E.0, KSCI-19093)
 - Introduction
 - False Positives and False Alarms
 - Differences Between the FP and KOI Tables
 - The FPWG Vetting Process
 - The False Positive Table
 - Identification Data
 - KOI False Positive Flags
 - High-Level FPWG Dispositions
 - Flux-Based Observational Flags
 - Offset Observational Flags
 - Period-Epoch Match Flags
 - False Alarm Observational Flags
 - Ground-Based Observational Flags
 - External False Positive Identification
 - Supporting Observational Information
 - Comments



- Definitions
- High-Level Dispositions
- Flux-based Observational Flags
- Offset Observational Flags
- Period-Epoch Match Flags
- False Alarm Observational Flags
- Follow-up Observational Flags
- External False Positive Identification Information
- Supporting Observational Data

Definitions

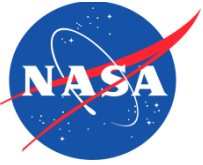
Database Column Name	Table Label
kepid†	KeplID
kepoi_name†	KOI Name
koi_period†	KOI Transit Period [days]

† Default column: these columns display in the interactive tal

High-Level Dispositions

(set by logical analysis on the observational flag)

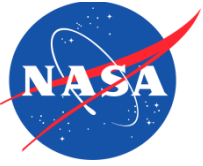
Database Column Name	Table Label
fpwg_disp_status†	High-Level Disposition
fpwg_disp_source†	Target Is Source High-Level Flag



ORP Conclusions



- SOC 9.2 effort provides documentation template and excellent dress rehearsal for SOC 9.3 effort
 - Every required document is included in IMS
 - Final documents will be stand-alone (*i.e.*, not deltas off SOC 9.2 docs) and contain worked examples as requested by Hackmasters
- Final documentation is scheduled for completion after DCR
 - RFAs from ORP Review (Oct 2014) were tracked and closed
 - RFAs from Hack Week (Oct 2015) are linked to IMS, reported weekly, and tracked through Monthly Management Reviews
 - Hackmasters are regularly updated on progress, encouraged to utilize products, and asked to scrutinize documentation



Kepler

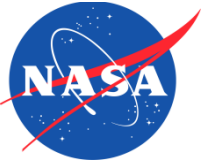
Overview of Pipeline Source Code Release - Stephen Walker



Pipeline Source Code Release



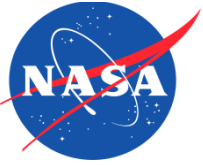
- Purpose
 - Provide scientific community reference documentation on the implementation of the pipeline algorithms
- Content/Format
 - Pipeline source code
 - Contains lines of code for all the pipeline modules
 - Maintains directory structure
 - Includes MATLAB source code (algorithms)
 - Provide the final processing parameters used
 - Includes Source Code Release Notes (SCRN) to serve the purpose of a read-me file



Summary Status on Pipeline Source Code Release



- Requests for source code release were received by the project directly from the community as well as through the Archives and GO
- Source code release has been worked on a non-interference basis by the project staff with support from ARC center resources
 - Worked with the center and NAS resources to determine source code release without extended software support for the non-executable code
- Source code documentation
 - Pipeline Source Code Release
 - Source Code Release Notes (SCRN)
 - Pipeline Processing Parameters
- Source code release will reside at GitHub and the archives may link to the source code location



Pipeline Source Code Release Tasks



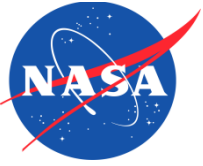
- Tasks complete
 - Final pipeline source code completed and final processing completed
 - Project inputs provided for the Software User Agreement (SUA)
 - Disclosure of Invention forms (NF1679) completed
 - Delivered final authors list (35 authors)
 - Completed copyright release and legal review of copyright release
 - Completed submission to the NASA Technology Transfer System (NTTS)
 - Software Release Request Authorization (SRRRA) submitted and signatures received
 - 3rd party library listing submitted
- Tasks remaining
 - Final edit and review of comments within the source code (Project Task)
 - Final center review for security and privacy risks (Center Task)
 - Source code review by legal and export control
 - SUA finalized and published
 - Final source code release approvals (Center Task)
 - Final package for delivery (Project Task)



Pipeline Source Code Release Conclusions



- Project preliminary efforts along with ARC center resources have cleared many hurdles
 - Resolved early legal issues
 - Obtained assignment of copyrights required prior to final release
 - Completed multiple center-level release tasks ahead of final authorization including receiving management, export, and commercialization approvals
- Final project steps for source code release are well defined and limited in scope
 - Final source code comment review has always been planned
- Center resources involved in the final review have participated in preliminary efforts and are prepared for final review



Kepler

Documentation Delivery Schedules

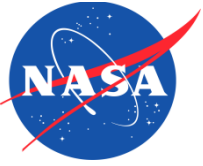
- Stephen Walker



Schedule Status- Documents Archived at MAST



ID	Documentation/Product Name	Repository	Walkthru				Document % Complete	Document Delivery Date	Unique ID
H.0	Kepler Instrument Handbook (KIH)	MAST	Step 1				90%	4/25/16	4747
H.1	Kepler Data Characteristics Handbook (KDCH)	MAST	Step 1				75%	6/20/16	4748
H.2	Kepler Data Processing Handbook (KDPH)	MAST	Step 1				50%	11/18/16	7906
H.3	Kepler Archive Manual (KAM)	MAST	Step 1				90%	5/10/16	4750
H.4	Data Release Note (DRN)	MAST					75%	7/12/16	7089

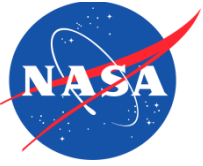


Schedule Status-



Products/Documents Archived at NExSci

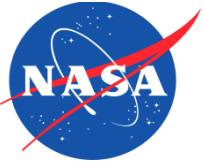
ID	Documentation/Product Name	Repository	Walkthru	Product % Complete	Product Delivery Date	Unique ID	Document % Complete	Document Delivery Date	Unique ID
A.0	Stellar Properties Catalog	NExSci		100%	2/2/16	7078	50%	5/3/16	7643
A.1	RMS CDP	NExSci		0%	10/3/16	7803	0%	10/3/16	7803
A.2	Data Quality Metrics	NExSci		0%	10/3/16	7803	0%	10/3/16	7803
A.3	Multiple-Event Statistic Effective Threshold Table	NExSci		0%	10/3/16	7803	0%	10/3/16	7803
B.0	Threshold-Crossing Event (TCE) Table	NExSci		100%	3/4/16	7080	90%	4/19/16	6824
B.1	TCE Stellar and Planetary Parameters	NExSci		100%	3/4/16	7080	90%	4/19/16	6824
B.2	Data Validation Report	NExSci		100%	3/4/16	7080	90%	4/19/16	6824
B.3	Data Validation One-Page Summary	NExSci		100%	3/4/16	7080	90%	4/19/16	6824
B.4	Supplemental Data Validation Report	NExSci		0%	7/28/16	7747	0%	7/28/16	7747
B.5	Supplemental Data Validation 1-Page Summary	NExSci		0%	7/28/16	7747	0%	7/28/16	7747
B.6	TCERT Vetting Products	NExSci		0%	11/30/16	7615	0%	11/30/16	7615
B.7	DV Time Series	NExSci		100%	3/4/16	7081	90%	4/19/16	6824
B.8	Centroid-Robovetter Score	NExSci		25%	11/30/16	7609	25%	11/30/16	7609
B.9	Flux-Robovetter Score	NExSci		25%	11/30/16	7609	25%	11/30/16	7609
B.12	Bootstrap Metric	NExSci	Step 1	50%	5/25/16	7649	50%	5/25/16	7649
C.0	KOI Table	NExSci		0%	11/30/16	7609	0%	11/30/16	7609
C.1	KOI Dispositions	NExSci		0%	11/30/16	7609	0%	11/30/16	7609
C.2	Model Fit Parameters & Associated Error Bars	NExSci	Step 1	0%	11/30/16	7609	0%	12/1/16	7677
C.3	FP "Reasons"	NExSci		0%	11/30/16	7609	0%	11/30/16	7609
C.4	Astrophysical False Positive Probability	NExSci		0%	3/16/17	7719	0%	3/16/17	7719
C.5	Astrophysical Positional Probability	NExSci		0%	10/5/16	7694	0%	10/5/16	7694
C.6	MCMC Posterior Chains	NExSci	Step 1	0%	12/1/16	7677	0%	12/1/16	7677
D.0	Average Detection Efficiency	NExSci		0%	9/29/16	7729	0%	9/29/16	7729
D.1	Single-Target Detection Efficiency	NExSci		0%	1/9/17	7805	0%	1/9/17	7805
D.2	TCERT Detection Efficiency	NExSci		0%	11/9/16	7737	0%	11/9/16	7737
D.3	TPS Sensitivity Products	NExSci		0%	10/24/16	7804	0%	10/24/16	7804
D.4	Sensitivity Contours	NExSci		0%	1/23/17	7806	0%	1/23/17	7806
D.5	TCERT Reliability Metric	NExSci		0%	11/9/16	7745	0%	11/9/16	7745
E.0	FPWG Certification Results	NExSci	Step 1	0%	4/27/16	6314	0%	4/27/16	6314
F.0	"Gold" Standard Star Spectroscopic Catalog	NExSci		100%	11/15/14	3304	50%	Fall 2016	FOP Task
F.1	"Platinum" Standard Star Spectroscopic Catalog	NExSci		100%	12/15/14	3264	50%	Fall 2016	FOP Task
F.2	KOI Spectroscopic Stellar Catalog	NExSci		100%	3/2/2016	4921	10%	August 2016	FOP Task
F.3	KOI Imaging Detection Catalog	NExSci		100%	3/2/2016	4921	10%	August 2016	FOP Task
F.4	KOI Imaging Detection Sensitivity Curves	NExSci		100%	3/2/2016	4921	10%	August 2016	FOP Task



Schedule Status- Source Code Documents at GitHub

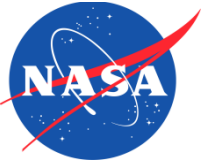


ID	Documentation/Product Name	Repository	Walkthru				Document % Complete	Document Delivery Date	Unique ID
P.0	Pipeline Source Code Release	GitHub					0%	2/10/17	5805
P.1	Pipeline Processing Parameters	GitHub					0%	2/10/17	5805
P.2	Source Code Release Notes (SCRN)	GitHub					0%	2/10/17	5805



Kepler

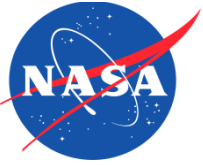
Final Remarks - Stephen Walker



Project DCR Assessment



DCR Area	Tasks for Final Revision	Assessment
Kepler Instrument Handbook (KIH)	Only minor updates required	Final release with planned updates available late April
Kepler Data Processing Handbook (KDPH)	Major updates and new chapters.	Final document delivery is in late 2016. Updated draft available in early October
Kepler Data Characteristics Handbook (KDCH)	Final document scope is clear. Final data characteristics are currently being compiled.	Final release with planned updates available mid-June
Kepler Archive Manual (KAM)	Pipeline 9.3 updates captured and document is in final review	Final release with planned updates available mid-May
Occurrence Rate Products (ORPs)	Final ORPs are delivered throughout 2016 and into early 2017	External review panel has endorsed final ORP list, content, and product accuracy goals
Pipeline Source Code Release	Legal review and releases have been completed. Code is being reviewed for release.	Final release planned for early 2017.

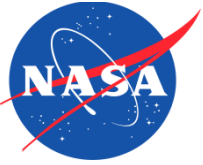


Conclusions- DCR Step 1



- Final documentation set is known and captured in the project schedule
- Significant project documents are nearing completion
 - KIH
 - KDCH
 - KAM
- Plans are in place to complete the remaining handbook
 - KDPH
- Most ORP documents have delivered 9.2 drafts and all have adequate oversight by the project's external ORP review board
- Remaining tasks for Pipeline Source Code release are within project scope and project tasks are scheduled

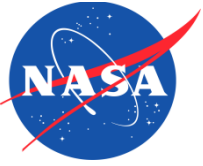
Closeout documentation is on-track for scheduled delivery and successful DCR Step 2 in October 2016



Work Remaining For Step 2

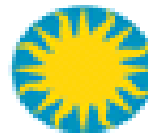
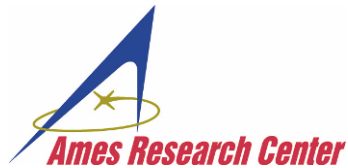


- Complete KIH, KDCH, KAM
- Complete review draft of KDPH with final completion schedule
- Execute ORP documentation schedule tasks to completion
- Continue process for source code release
- Address Step 1 actions



Background

April 13, 2016 DOY 104



SAO



SETI INSTITUTE



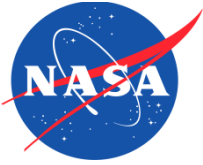
STScI



DCR Documentation List



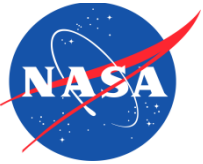
ID	Documentation/Product Name	Repository	Walkthru				Document % Complete	Document Delivery Date	Unique ID	DCR Step 1 Reference Document
H.0	Kepler Instrument Handbook (KIH)	MAST	Step 1				90%	4/25/16	4747	KSCI-19033-001
H.1	Kepler Data Characteristics Handbook (KDCH)	MAST	Step 1				75%	6/20/16	4748	KSCI-19040-004
H.2	Kepler Data Processing Handbook (KDPH)	MAST	Step 1				50%	11/18/16	7906	KSCI-19081-001
H.3	Kepler Archive Manual (KAM)	MAST	Step 1				90%	5/10/16	4750	KDMC-10008-005
H.4	Data Release Note (DRN)	MAST					75%	7/12/16	7089	KSCI-19064
ID	Documentation/Product Name	Repository	Walkthru	Product % Complete	Product Delivery Date	Unique ID	Document % Complete	Document Delivery Date	Unique ID	DCR Step 1 Reference Document
A.0	Stellar Properties Catalog	NExSci		100%	2/2/16	7078	50%	5/3/16	7643	KSCI-19097
A.1	RMS CDP	NExSci		0%	10/3/16	7803	0%	10/3/16	7803	Burke et al.
A.2	Data Quality Metrics	NExSci		0%	10/3/16	7803	0%	10/3/16	7803	Burke et al.
A.3	Multiple-Event Statistic Effective Threshold Table	NExSci		0%	10/3/16	7803	0%	10/3/16	7803	Burke et al.
B.0	Threshold-Crossing Event (TCE) Table	NExSci		100%	3/4/16	7080	90%	4/19/16	6824	Seader et al. 2015
B.1	TCE Stellar and Planetary Parameters	NExSci		100%	3/4/16	7080	90%	4/19/16	6824	Seader et al. 2016
B.2	Data Validation Report	NExSci		100%	3/4/16	7080	90%	4/19/16	6824	Seader et al. 2017
B.3	Data Validation One-Page Summary	NExSci		100%	3/4/16	7080	90%	4/19/16	6824	Seader et al. 2018
B.4	Supplemental Data Validation Report	NExSci		0%	7/28/16	7747	0%	7/28/16	7747	
B.5	Supplemental Data Validation 1-Page Summary	NExSci		0%	7/28/16	7747	0%	7/28/16	7747	
B.6	TCERT Vetting Products	NExSci		0%	11/30/16	7615	0%	11/30/16	7615	KSCI-19104
B.7	DV Time Series	NExSci		100%	3/4/16	7081	90%	4/19/16	6824	KSCI-19079
B.8	Centroid-Robovetter Score	NExSci		25%	11/30/16	7609	25%	11/30/16	7609	
B.9	Flux-Robovetter Score	NExSci		25%	11/30/16	7609	25%	11/30/16	7609	
B.12	Bootstrap Metric	NExSci	Step 1	50%	5/25/16	7649	50%	5/25/16	7649	KSCI-19086
C.0	KOI Table	NExSci		0%	11/30/16	7609	0%	11/30/16	7609	Coughlin et al. 2015
C.1	KOI Dispositions	NExSci		0%	11/30/16	7609	0%	11/30/16	7609	Coughlin et al. 2016
C.2	Model Fit Parameters & Associated Error Bars	NExSci	Step 1	0%	11/30/16	7609	0%	12/1/16	7677	KSCI-19084
C.3	FP "Reasons"	NExSci		0%	11/30/16	7609	0%	11/30/16	7609	Coughlin et al. 2016
C.4	Astrophysical False Positive Probability	NExSci		0%	3/16/17	7719	0%	3/16/17	7719	NExSci webpage
C.5	Astrophysical Positional Probability	NExSci		0%	10/5/16	7694	0%	10/5/16	7694	KSCI-19092
C.6	MCMC Posterior Chains	NExSci	Step 1	0%	12/1/16	7677	0%	12/1/16	7677	KSCI-19084
D.0	Average Detection Efficiency	NExSci		0%	9/29/16	7729	0%	9/29/16	7729	KSCI-19094
D.1	Single-Target Detection Efficiency	NExSci		0%	1/9/17	7805	0%	1/9/17	7805	
D.2	TCERT Detection Efficiency	NExSci		0%	11/9/16	7737	0%	11/9/16	7737	KSCI-19096
D.3	TPS Sensitivity Products	NExSci		0%	10/24/16	7804	0%	10/24/16	7804	KSCI-19085
D.4	Sensitivity Contours	NExSci		0%	1/23/17	7806	0%	1/23/17	7806	
D.5	TCERT Reliability Metric	NExSci		0%	11/9/16	7745	0%	11/9/16	7745	
E.0	FPWG Certification Results	NExSci	Step 1	0%	4/27/16	6314	0%	4/27/16	6314	KSCI-19093
F.0	"Gold" Standard Star Spectroscopic Catalog	NExSci		100%	11/15/14	3304	50%	Fall 2016	FOP Task	
F.1	"Platinum" Standard Star Spectroscopic Catalog	NExSci		100%	12/15/14	3264	50%	Fall 2016	FOP Task	
F.2	KOI Spectroscopic Stellar Catalog	NExSci		100%	3/2/2016	4921	10%	August 2016	FOP Task	
F.3	KOI Imaging Detection Catalog	NExSci		100%	3/2/2016	4921	10%	August 2016	FOP Task	
F.4	KOI Imaging Detection Sensitivity Curves	NExSci		100%	3/2/2016	4921	10%	August 2016	FOP Task	
ID	Documentation/Product Name	Repository	Walkthru				Document % Complete	Document Delivery Date	Unique ID	DCR Step 1 Reference Document
P.0	Pipeline Source Code Release	GitHub					0%	2/10/17	5805	
P.1	Pipeline Processing Parameters	GitHub					0%	2/10/17	5805	
P.2	Source Code Release Notes (SCRN)	GitHub					0%	2/10/17	5805	



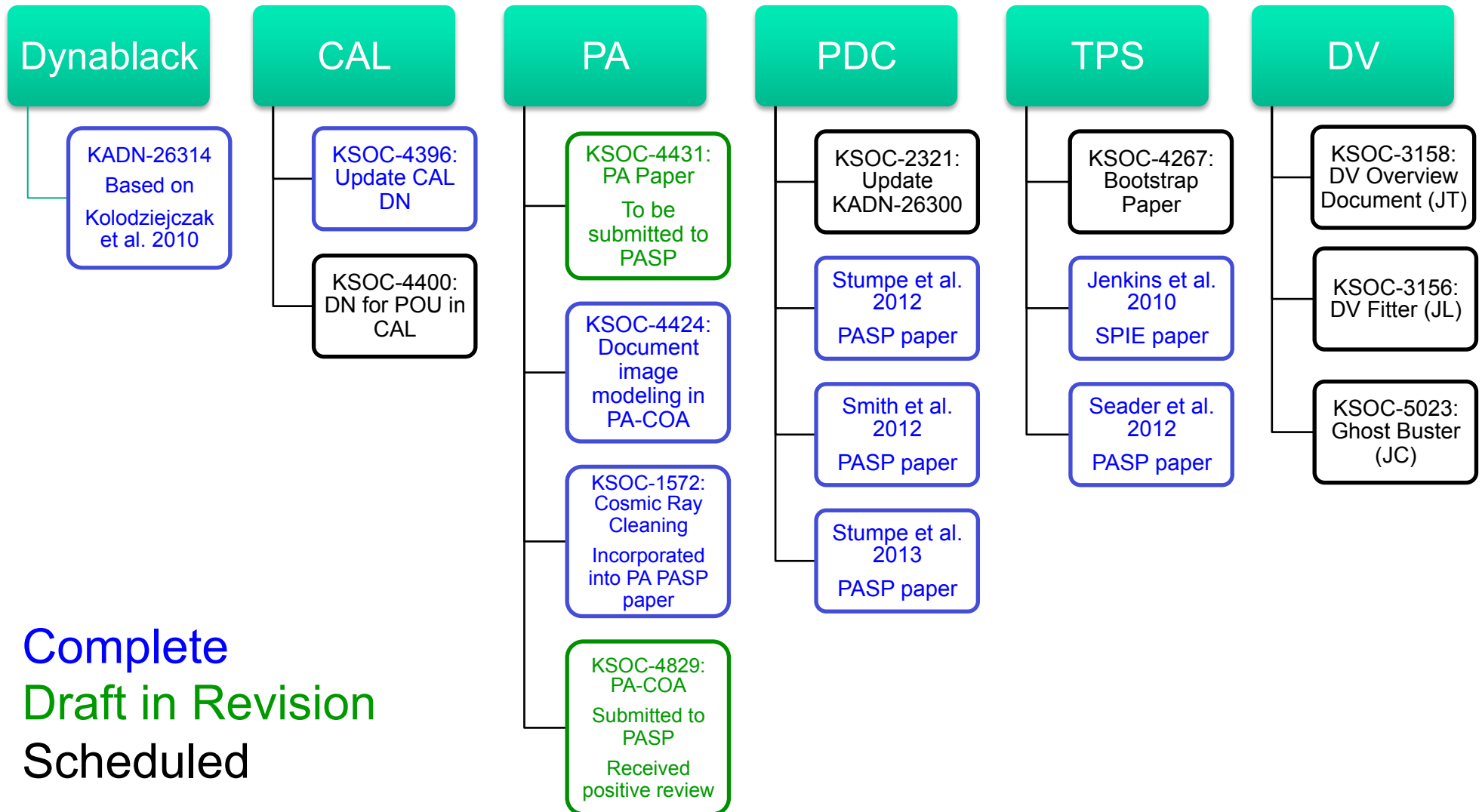
MAST Products



ID	Documentation/Product Name	Repository	Walkthru				Document % Complete	Document Delivery Date	Unique ID	DCR Step 1 Reference Document
R.1	Ancillary Engineering Data	MAST		100%	Data Collect	None				KAM, (KIH, KDCH,KDPH)
R.2	SPICE Kernel	MAST		100%	Data Collect	None				KAM, (KIH, KDCH,KDPH)
R.3	Reverse Clock Data	MAST		100%	Data Collect	None				KAM, (KIH, KDCH,KDPH)
M.1	Long-Cadence Target Pixel Files	MAST		100%	12/10/16	7058				KAM, (KIH, KDCH,KDPH)
M.2	Long-Cadence Light Curve Files	MAST		100%	12/10/16	7058				KAM, (KIH, KDCH,KDPH)
M.3	Short Cadence Target Pixel Files	MAST		50%	7/12/16	7059				KAM, (KIH, KDCH,KDPH)
M.4	Short-Cadence Light Curve Files	MAST		50%	7/12/16	7059				KAM, (KIH, KDCH,KDPH)
M.5	Full-frame Images	MAST		0%	7/12/16	7059				KAM, (KIH, KDCH,KDPH)
M.6	Artifact Removal Pixel Files	MAST		100%	12/10/16	7058				KAM, (KIH, KDCH,KDPH)
M.7	Background Pixel Files	MAST		100%	12/10/16	7058				KAM, (KIH, KDCH,KDPH)
M.8a	LC Collateral Data Files	MAST		100%	12/10/16	7058				KAM, (KIH, KDCH,KDPH)
M.8b	SC Collateral Data Files	MAST		75%	7/12/16	7059				KAM, (KIH, KDCH,KDPH)
M.9	Cotrending Basis Vector Files	MAST		100%	12/10/16	7058				KAM, (KIH, KDCH,KDPH)
M.10	Focal-Plane Characterization Models	MAST		100%	5/10/16	4750				KAM, (KIH, KDCH,KDPH)
M.11	PRF Commissioning Data Target Pixel Files	MAST		0%	8/11/16	7843				TBD
H.0	Kepler Instrument Handbook (KIH)	MAST	Step 1				90%	4/25/16	4747	KSCI-19033-001
H.1	Kepler Data Characteristics Handbook (KDCH)	MAST	Step 1				75%	6/20/16	4748	KSCI-19040-004
H.2	Kepler Data Processing Handbook (KDPH)	MAST	Step 1				50%	11/18/16	7906	KSCI-19081-001
H.3	Kepler Archive Manual (KAM)	MAST	Step 1				90%	5/10/16	4750	KDMC-10008-005
H.4	Data Release Note (DRN)	MAST					75%	7/12/16	7089	KSCI-19064



KDPH- Input Documentation



Complete
Draft in Revision
Scheduled



Acronyms



ORP	Occurrence Rate Product	TCE	Threshold Crossing Event
NExSci	NASA Exoplanet Science Institute	PDC	Pre-Search Data Conditioning (Pipeline)
MAST	Mikulski Archive for Space Telescopes	CAL	Pixel Calibration (Pipeline)
DCR	Documentation Close-out Review	PA	Photometric Analysis (Pipeline)
KIH	Kepler Instrument Handbook	TPS	Transiting Planet Search (Pipeline)
KDPH	Kepler Data Processing Handbook	DV	Data Validation (Pipeline)
KDCH	Kepler Data Characteristics Handbook	KDRN	Kepler Data Release Note
KAM	Kepler Archive Manual	SCRN	Source Code Release Note
WCS	World Coordinate System	PCCB	Program Change Control Board
IMS	Integrated Master Schedule	GO	Guest Observer Office
FOP	Follow-up Observing Program	COB	Close of Business
H & M	Handbooks & Manuals	SO	Science Office
C & R	Completeness & Reliability	SOC	Science Operations Center
Cat Gen	Catalog Generation	SUA	Software Users Agreement
SPWG	Stellar Properties Working Group	NTTS	NASA Technology Transfer System
FPWG	False Positive Working Group	SRRA	Software Release Request Authorization
KOI	Kepler Objects of Interest	MOC	Mission Operations Center
DMC	Data Management Center (MAST)	NAS	Numerical Aerodynamics Simulation