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410-R-LIRD-0137
Version: 3.6

Geostationary Operational Environmental Satellite (GOES)

GOES-R Series Level I Requirements (LIRD)

May 2019

U.S. Department of Commerce (DOC)
National Oceanic and Atmospheric Administration (NOAA)
NOAA Satellite and Information Service (NESDIS)
National Aeronautics and Space Administration (NASA)

SIGNATURE PAGE

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LEVEL 1 REQUIREMENTS DOCUMENT (L1RD)
DOCUMENT CHANGE RECORD

VERSION	DATE	CCR #	SECTIONS AFFECTED	DESCRIPTION
Baseline	08/06/07	1066	All	Baseline the Level 1 Requirements Document
1.1	12/12/08	1259	TOC, LIRD83, LIRD84, LIRD244, LIRD245; LIRD246; Deleted LIRD 71-LIRD78; deleted LIRD 85-87; LIRD79 - LIRD84; LIRD245 – 246	CCR 1259 partially approved by DUS/ implemented. * Updates TOC * Adds new LIRD244 " Operational Capability Status" *Adds new LIRD245 and LIRD246 "Level I Budget and Schedule Requirements" *Deletes LIRD71- LIRD78 and LIRD85 - LIRD87 *Modifies LIRD83 and LIRD84 to reflect "System Operational Lifetime" *Re-numbers sections 5 & 6.
1.1	12/12/08	1275	LIRD246	Revises LIRD246 "Level I Budget and Schedule Requirements"
2.0	08/18/09	1296	LIRD109, TOC	*Delete Cloud Imagery: Coastal *DOORS automatically renumbers sections following a deletion
2.0	08/18/09	1314	LIRD159	Add CONUS & Mesoscale Coverages for Total Precipitable Water (TPW)
2.0	08/18/09	1318	LIRD161, TOC	*Delete Entire Product: Total Water Content (TWC) *DOORS automatically renumbers sections following a deletion
2.0	08/18/09	1346	LIRD131, LIRD153, LIRD155, LIRD157, LIRD166, LIRD187, LIRD223	* Add CONUS & Mesoscale (meso) to Refresh Rate/Coverage Rate (RR/CR) (LIRD131) * Add FD, CONUS, meso to RR/CR (LIRD153, LIRD155) * Add Full Disk coverage (LIRD157) * Updates Geo coverage/condition and RR/CR (LIRD166) * Updates FD RR/CR (LIRD187) * Delete CONUS & Mesoscale coverages (LIRD223)
2.0	08/18/09	1378	LIRD32, LIRD222, LIRD223, TOC	Change the name from Sea Surface Temperature to Sea Surface Temperature (skin)
2.0	08/18/09	1383	LIRD192	Change the accuracy
2.0	08/18/09	1384	LIRD211	Change the accuracy

LEVEL 1 REQUIREMENTS DOCUMENT (L1RD)
DOCUMENT CHANGE RECORD (CONTINUED)

2.0	08/18/09	1385	LIRD32, LIRD169, LIRD172, LIRD173, LIRD174, LIRD175, LIRD177, TOC	Radiation Budget: Updates * Downward Solar Insolation: Surface to Downward Shortwave Radiation: Surface (LIRD32, 172, 173) * Reflected Solar Insolation: TOA to Reflected Shortwave Radiation: TOA (LIRD32, 174, 175) * change measurement accuracy (LIRD169, 175, 177)
2.0	08/18/09	1386A	LIRD187	Updates Derived Motion Winds measurement accuracy & RR/CR
2.0	08/18/09	1417	LIRD153, LIRD155, LIRD157, LIRD159 LIRD204	Soundings: Product Parameter Updates * Legacy Vertical Moisture Profile – threshold for geo coverage/ conditions (LIRD153) * Legacy Vertical Temperature Profile - threshold for geo coverage/ conditions ; measurement accuracy (LIRD155) * measurement acc., removes ± (LIRD157) * TPW - threshold for geo coverage/ conditions ; measurement accuracy (LIRD159) * Surface Emissivity – measurement accuracy (LIRD204)
2.0	08/18/09	1418	TOC, LIRD32, LIRD193, LIRD194, LIRD198, LIRD200, LIRD215, LIRD218, LIRD219 LIRD221	Cryosphere: Prod Parameter Updates * deletes “Landlocked” (TOC, LIRD32, LIRD193, LIRD194) * deletes Sea & Lake Ice: Extent (TOC, LIRD32 LIRD219) * measurement accuracy and RR/CR (LIRD194, LIRD198) * measurement accuracy (LIRD200, LIRD215, LIRD221)
2.0	08/18/09	1419B	TOC, LIRD27, LIRD32, LIRD90, LIRD91, LIRD98, LIRD102, LIRD107, LIRD108, LIRD110, LIRD111, LIRD113, LIRD117, LIRD121, LIRD123, LIRD125, LIRD127, LIRD129, LIRD137, LIRD141, LIRD159, LIRD160, LIRD164, LIRD204, LIRD225	Clouds: Product Parameter Updates * update figure (LIRD27) * remove “Thickness” (LIRD32, LIRD110, LIRD111) * add “Appendix”(LIRD90) * update AA (LIRD91) * correct typographical errors/ omissions (LIRD98, LIRD102, LIRD107, LIRD108, LIRD137, LIRD141, LIRD159, LIRD160, LIRD204, LIRD225) * Measurement accuracy (LIRD107, LIRD111, LIRD113, LIRD117, LIRD121, LIRD123, LIRD125, LIRD127, LIRD129. LIRD164)
2.0	08/18/09	1425	TOC, LIRD32, LIRD105, LIRD131, LIRD133, LIRD139, LIRD140, LIRD141, LIRD143, LIRD184	Aviation: Product Parameter Updates * Turbulence to Tropopause Folding Turbulence Prediction (TOC, LIRD32, LIRD140, LIRD141) * Measurement accuracy (LIRD105, LIRD131, LIRD133, LIRD139, LIRD141, LIRD143, LIRD184) * typographical error (LIRD133)
2.0	08/18/09	1426A	LIRD148, LIRD150	Hydrology: Product Parameter Updates *Measurement accuracy (LIRD148, LIRD150)

LEVEL 1 REQUIREMENTS DOCUMENT (L1RD)
DOCUMENT CHANGE RECORD (CONTINUED)

2.0	08/18/09	1437	LIRD66, LIRD137	Revises Description of Geostationary Lightning Mapper (GLM) and lightning detection
2.0	08/18/09	1469	TOC, LIRD32, LIRD96, LIRD99, LIRD100, LIRD182	Aerosols: Product Parameter Updates * change Suspended Matter/Optical Depth to Aerosol Optical Depth (TOC, LIRD32, LIRD99, LIRD100) * typographical error (LIRD96, LIRD100) * Measurement accuracy (LIRD96, LIRD100, LIRD182)
3.0	04/29/10	1766	LIRD243	Remove temp reference in SXI refresh rate/coverage time
3.0	08/09/10	1841A	LIRD52	Clarifies GOES-R provides data to CLASS but does not archive data in CLASS
3.0	08/09/10	1842A	LIRD31, LIRD32, LIRD206, LIRD208	Increase coverage for vegetation products
3.0	09/23/10	1890	LIRD29, LIRD58 (deletes both)	Deletes requirement for additional instrumentation
3.0	09/23/10	1898	LIRD107, LIRD113, LIRD117, LIRD119, LIRD133, LIRD135, LIRD187, LIRD206, LIRD211, LIRD213	Relaxations of requirements – measurement accuracy: Cloud Ice Water Path, Cloud Liquid Water, Cloud Optical Depth; Cloud Particle Size Distribution, Enhanced “V”/Overshooting Top Detection, and Hurricane Intensity
3.0	04/26/11	2017	All	Rebaseline to V3.0
3.0	12/12/11	CMO Note	LIRD25, LIRD269-271,LIRD31, LIRD32, LIRD28,LIRD137	Corrected errors –capitalized East, make degree symbols consistent, annotated CCR-01842A as the applicable CCR, removed yellow highlight, LIRD28 – updated xxx to correct DIs, bolded “will”, revised footer to correct location in V3.
3.0	1/24/12	CMO Note	LIRD157	Also included as part of CCR-01842A
3.1	1/11/12	2154	Deviation: LIRD236	Deviation for LIRD236 (Geomagnetic Field Measurement Accuracy) to "2.3 nT after calibration, with 4 nT at end of life". Related to SCFPS CCR-02139.
3.1	1/11/12	2169	Deviation: LIRD31	This deviation captures the implementation recision of the products in Set 3 and 4.
3.2	5/15/12	2286	LIRD246	Changes Program Management Directive (PMD) to Program Commitment Agreement (PCA).
3.3	10/03/12	2164	LIRD242	Change name of product from Solar Imagery: X-ray to Solar Imagery: EUV.
3.3	10/03/12	2311	LIRD84	Clarify mission lifetime requirements.
3.3	10/03/12	2312	LIRD236	Change the Geomagnetic Field product Horizontal / Angular Resolution from +/- 0.25 degrees to N/A.

LEVEL 1 REQUIREMENTS DOCUMENT (L1RD)
DOCUMENT CHANGE RECORD (CONTINUED)

3.3	10/03/12	CMO Note	Cover	Revised GOES logo
3.4	10/24/13	2417	Deviation: LIRD198	Deviation to implementation of a baseline Snow Cover product
3.4	01/28/14	CMO Note	Header, Footer, DCR, LIRD3, LIRD249, LIRD250	* Revised footers to display new link for GOES-R portal from V3 to SharePoint. * Revised headers for document number to reflect the NASA code for GOES-R Program from P417 – to 410-. * Revised the Effective and Expiration dates to have consistent formats among GPO managed documents. * Revised DCR to clearly indicate which CCRs were deviations. * Revised document numbers from P417 to 410 for the MCP and CM Plan references.
3.5	05/02/17	3085	LIRD236	Add administrative note to Geomagnetic Field Product Measurement Accuracy.
3.6	05/17/19	3361C	Waiver: LIRD236	Geomagnetic Field Product Measurement Accuracy Waiver-G16 Related to Flight CCR 3307
3.6	05/17/19	3444	LIRD3, LIRD249, LIRD308, LIRD310, LIRD323 (new), LIRD324 (new), LIRD325 (new)	* Updated Applicable documents * Changed oversight from Program Management Directive (PMD) to Program Commitment Agreement PCA) * Additional of Compact Coronagraph

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Contents

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1 Introduction

1.1 Purpose

LIRD5 1.1.0-1

This document provides the Level I functional and performance requirements for developing the Geostationary Operational Environmental Satellite (GOES) System, R- Series (GOES-R). The purposes of this document are to:

a) Provide a brief summary of background, mission need, and fundamental objectives of the GOES-R Series.
b) Provide the top-level performance and functional requirements of the GOES-R Series for policy-level review, management control and generation of lower level requirements documents.

1.2 Scope

LIRD7 1.2.0-1

These Level I requirements reflect results obtained from system capabilities studies and document the GOES-R series requirements for the Acquisition and Operations Phase. They also serve as the basis for generation of lower-level, system requirements documents (e.g., Level II requirements documents).

1.3 Applicable Documents

LIRD3 1.3.0-1

- Consolidated User Observation Requirements List (COURL) housed in the NOAA Earth Observation Requirements Evaluation System (EORES). [The COURL was formerly the Consolidated Observational Requirements List (CORL) house in NOAA's CasaNOSA network. The current EORES link is https://eores.nesdis-hq.noaa.gov].
- Program Commitment Agreement, current Fiscal Year revision
- Memorandum for the Delegation of Key Decision Point Authority for the GOES-R Program, December 21, 2007
- GOES-R Program Management Control Plan, (MCP), 410-R-PLN-0067
- GOES-R Configuration Management Plan, 410-R-PLN-0084
- GOES-R Series Acronym & Glossary Document, 410-R-LIST-0142 *(CCR 03444)*

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LIRD8	2	# 2 GOES-R Series Background
LIRD9	2.1	## 2.1 System Need
LIRD10	2.1.0-1	The primary missions of NOAA are to understand and predict changes in climate, weather, oceans, and coasts, to share that knowledge and information with others, and to conserve and manage coastal and marine ecosystems and resources. GOES satellites meet current and near-term national operational environmental sensing requirements for continuous observation of weather, Earth's environment, and solar and space environment. To meet requirements and accomplish its mission, the geostationary satellites program performs three major functions: a) Provide continuous Geostationary Environmental Sensing. b) Provide Data Collection Service capability. c) Provide continuous relay of environmental data to distributed users and relay of distress signals from aircraft or marine vessels to search and rescue ground stations.
LIRD14	2.1.1	### 2.1.1 Observational Gap Addressed
LIRD15	2.1.1.0-1	There is no single environmental observing system that can meet the geographic coverage, vertical and horizontal resolution, measurement accuracy and timeliness requirements of the hundreds of environmental parameters needing to be sensed throughout our atmosphere, oceans, land and ice masses, and space and solar regimes to accomplish NOAA's mission. While NOAA's complementary polar-orbiting system of satellites provides data across the entire globe, its lower temporal coverage of four or more hours does not allow detection and monitoring of rapidly developing storms threatening US life and property. Similarly, nationwide radar systems, while able to continually detect precipitation areas, are unable to image the cloud systems and provide the 3-D fields of atmospheric temperature and moisture needed to predict the onset, intensity, duration and direction of these storms. Geosynchronous satellites are a vital, but not the only, part of this operational solution.
LIRD16	2.1.2	### 2.1.2 Ownership and Oversight
LIRD12	2.1.2.1	#### 2.1.2.1 Program Management
LIRD248	2.1.2.1.0-1	The GOES-R Series **shall** be established in accordance with NOAA/NASA Memorandum of Understanding (MOU).
LIRD249	2.1.2.1.0-2	The GOES-R Series Management and Oversight **shall** be conducted in accordance with the GOES-R Management Control Plan (MCP) (410-R-PLN-0067) and Program Commitment Agreement (PCA) as appropriate. *(CCR 03444)*
LIRD18	2.1.2.2	#### 2.1.2.2 Requirements
LIRD250	2.1.2.2.0-1	Level I requirements changes **shall** be approved by the NOAA Operating Systems Council (NOSC), after being vetted by the GOES-R Operational Requirements Working Group (GORWG). Detailed descriptions of the requirements change process is described in the GOES-R Configuration Management Plan (410-R-PLN-0084).
LIRD323	2.1.2.2.0-2	The GOES-R system **shall** collect coronal mass ejection observations utilizing the GOES-U spacecraft. *(CCR 03444)*
LIRD20	2.1.2.2.0-3	The GOES-R requirements documents **shall** be reviewed / approved as summarized in Table 1

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LIRD20	2.1.2.2.0-3	

Table 1 - GOES-R Requirements Documents Reviews and Approvals

Requirements Level	Baseline Document	Document Custodian and Control Process	Reviewing Body	Approving Body
NOAA Observing Systems Architecture (NOSA)	Consolidated Observational Requirements List (CORL)	NOAA Observing Systems Council (NOSC)	NOSC	NOAA Executive Council (NEC)
Level I	GOES-R Level I Requirements Document	Final: GOES-R Program	NOSC, NOAA PMC, NESDIS AA/DAAS	NOAA DUS
Level II	GOES-R Management Control Plan	Program Systems Engineering (PSE)	NESDIS AA/DAAS, NASA/Goddard Space Flight Center (GSFC) CMC	NESDIS AA, NASA/GSFC Center Director
Level IIa	Mission Requirements Document	PSE	GPO GORWG	GOES-R SPD
Level III	GOES-R Project Plans	GOES-R Projects	GOES-R Program	GOES-R SPD
Level IIIa	Project level Interface Documents & Functional Specifications	GOES-R Projects	GOES-R Program	GOES-R Project Managers

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LIRD21	3	# 3 GOES-R Series Procurement Requirements
LIRD251	3.1	## 3.1 Segments
LIRD252	3.1.0-1	The GOES-R Series **shall** contain a space segment.
LIRD253	3.1.0-2	The GOES-R Series **shall** contain a ground segment.
LIRD254	3.2	## 3.2 Organization and Management
LIRD255	3.2.0-1	The GOES-R Series organization, program management, control and authority **shall** be in accordance with the GOES-R Management Control Plan.
LIRD245	3.2.1	### 3.2.1 Budget and Schedule Requirements *(CCR 1259)*
LIRD246	3.2.1.0-1	Budget and schedule milestones **shall** be managed in accordance with the annual Program Commitment Agreement (PCA) submitted by the GOES-R System Program Director (SPD) and approved by the NESDIS AA and the NOAA Deputy Under Secretary (DUS) for Oceans and Atmosphere. *(CCR 02286)*
LIRD256	3.2.1.1	#### 3.2.1.1 Regular Reporting
LIRD257	3.2.1.1.0-1	Regular reporting of the GOES-R Program **shall** be in accordance with the Management Control Plan.
LIRD258	3.2.1.2	#### 3.2.1.2 Deviation Reporting
LIRD259	3.2.1.2.0-1	GOES-R Series deviation reporting s**hall** be made as specified in the conditions outlined in the Department of Commerce Memorandum for the Delegation of Key Decision Point Authority for the GOES-R Program, and current Congressional and NOAA guidance.
LIRD260	3.3	## 3.3 Acquisition Strategy
LIRD261	3.3.0-1	The GOES-R Series instruments **shall** be procured by NASA/GSFC in accordance with the GOES-R Management Control Plan and applicable NASA/GSFC acquisition plan.
LIRD262	3.3.0-2	The GOES-R Series spacecraft **shall** be procured by NASA/GSFC in accordance with the GOES-R Management Control Plan and applicable NASA/GSFC acquisition plan.
LIRD263	3.3.0-3	The GOES-R Series launch services **shall** be procured by NASA/GSFC, in accordance with the GOES-R Management Control Plan and applicable NASA/GSFC acquisition plan.
LIRD264	3.3.0-4	The GOES-R Series ground segment **shall** be procured by NOAA, in accordance with the GOES-R Management Control Plan and applicable NOAA acquisition plan.

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LIRD265	4	# 4 Series System Requirements
LIRD266	4.0-1	The GOES constellation observes two operational coverage areas with the capacity to rapidly replace that coverage as needed. The development and launch of GOES assets prior and subsequent to the GOES-R series is assumed in order to maintain constellation availability.
LIRD267	4.1	## 4.1 Series Coverage
LIRD25	4.1.0-1	The GOES-R Series **shall** provide geosynchronous-viewed operational imagery of a minimum coverage area bounded by latitude 68° North to 68° South and longitude 150° East eastward to 2° West, as shown in Figure 1.

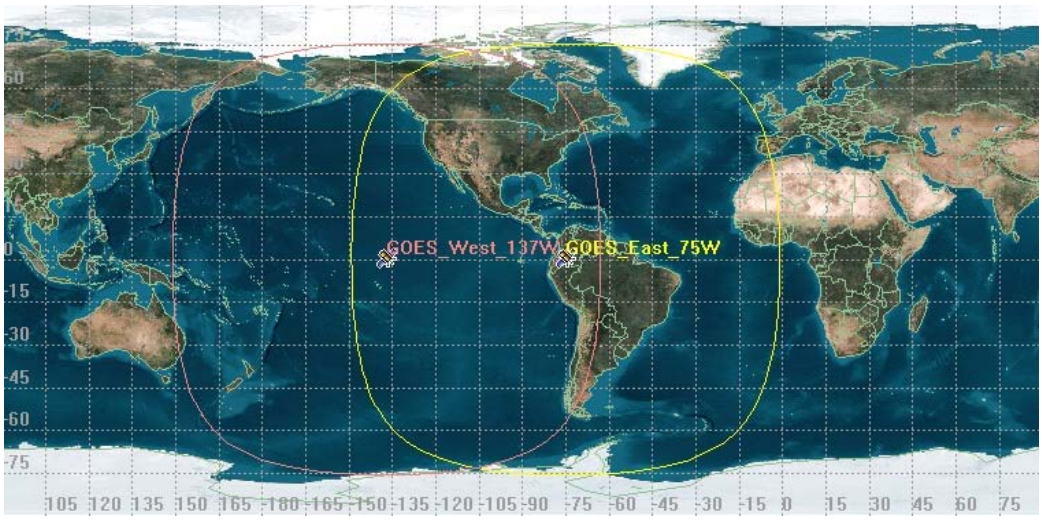

Figure 1 - GOES-R Series Imagery Coverage Area

LIRD269	4.1.0-2	The GOES-R Series **shall** have on-orbit geosynchronous operational locations designated as GOES-R West at 137° W longitude and GOES-R East at 75° W longitude.
LIRD270	4.1.0-3	The GOES-R Series Eastern operating zone (GOES East) **shall** be centered at 75° W longitude and cover an area bounded by 68° North and South latitudes, 148° West to 2° West longitudes.
LIRD271	4.1.0-4	The GOES-R Series Western operating zone (GOES West) **shall** be centered at 137° W longitude and cover an area bounded by 68° North and South latitudes, 150° East to 64° West longitudes.
LIRD272	4.2	## 4.2 GOES-R Series Facilities
LIRD43	4.2.0-1	The GOES-R Series **shall** implement communication interfaces to relay GOES-R sensor data in real time.
LIRD27	4.2.0-2	The GOES-R Series **shall** utilize existing NOAA primary ground operations locations.
LIRD275	4.2.0-3	The GOES-R Series **shall** utilize a Remote Backup facility for satellite terrestrial communications, command and control, and Key Performance Parameter (KPP) processing functionality as a secondary location.
LIRD276	4.2.0-4	The GOES-R Series Remote Backup location **shall** be located such that it is not susceptible to the same credible threat as the primary ground operations locations.
LIRD30	4.3	## 4.3 Observational Requirements

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LIRD31 4.3.0-1 The GOES-R Series Observational Requirements **will** be grouped into sets as described in Table 2. These sets are used to prioritize product implementation.

Table 2 - Observational Requirements Prioritization

Product Set	Comment
1	Includes the Cloud and Moisture Imagery Product (KPP) and highest priority products.
2	Includes next highest priority legacy and related products
3	Includes next highest priority and related products
4	Includes remaining products

(CCR 1842A)(CCR 02169 (RDW))

LIRD279 4.3.1

4.3.1 Terrestrial Weather

LIRD32 4.3.1.0-1 The GOES-R Series Atmospheric products are listed in Table 3 and detailed in Appendix Level I Requirements Document Product Performance Table.

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LIRD32 4.3.1.0-1

Table 3 - GOES-R Series System Atmospheric Products

Atmosphere	Product Set
AEROSOLS	
Aerosol Detection (including Smoke and Dust)	1
Aerosol Particle Size	3
Aerosol Optical Depth	1
Volcanic Ash Detection and Height	2
CLOUDS	
Aircraft Icing Threat	4
Cloud Ice Water Path	3
Cloud Layer Heights	3
Cloud Liquid Water	3
Cloud and Moisture Imagery	1
Cloud Optical Depth	1
Cloud Particle Size Distribution	1
Cloud Top Phase	1
Cloud Top Height	1
Cloud Top Pressure	1
Cloud Top Temperature	1
Cloud Type	3
Convective Initiation	3
Enhanced “V”/Overshoot Top Detection	4
Hurricane Intensity	2
Visibility	4
Low Cloud and Fog	3
Tropopause Folding Turbulence Prediction	3
Lightning Detection	2
PRECIPITATION	
Probability of Rainfall	4
Rainfall Potential	4
Rainfall Rate/QPE	2
PROFILES, INDICES, TOTAL WATER	
Legacy Vertical Moisture Profile	1
Legacy Vertical Temperature Profile	1
Derived Stability indices	2
Total Precipitable Water	1
RADIANCES	
Clear Sky Masks	1
Radiances	1
RADIATION	
Absorbed Shortwave Radiation: Surface	3
Downward Longwave Radiation: Surface	3
Downward Shortwave Radiation: Surface	2
Reflected Shortwave Radiation: TOA	2
Upward Longwave Radiation: Surface	3
Upward Longwave Radiation: TOA	3
TRACE GASES	
Ozone Total	3
SO2 Detection	3
WINDS	
Derived Motion Winds	2

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LIRD32 4.3.1.0-1 The GOES-R Series Land products are listed in Table 4 and detailed in Appendix Level I Requirements Document Product Performance Table.

Table 4 - GOES-R Series Land Products

Land	Product Set
Fire/Hot Spot Characterization	2
Flood/Standing Water	4
Ice Cover	4
Land Surface (Skin) Temperature	2
Snow Cover	2
Snow Depth (over Plains)	4
Surface Albedo	3
Surface Emissivity	3
Vegetation Fraction: Green	4
Vegetation Index	4

The GOES-R Series Ocean products are listed in Table 5 and detailed in Appendix Level I Requirements Document Product Performance Table.

Table 5 - GOES-R Series System Ocean Products

Ocean	Product Set
Currents	4
Currents: Offshore	4
Sea and Lake Ice: Age	4
Sea and Lake Ice: Concentration	4
Sea and Lake Ice: Motion	4
Sea Surface Temperature (skin)	2

(CCR 1385)(CCR 1419B)(CCR 1425)(CCR 1469)(CCR 1378)(CCR 1418)(CCR 1842A)

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LIRD283 4.3.2

4.3.2 Space Weather

LIRD284 4.3.2.0-1

The GOES-R Series Space and Solar Weather products are listed in Table 6 and detailed in Appendix Level I Requirements Document Product Performance Table.

Table 6 - GOES-R Series System Space and Solar Weather Products

Space and Solar	Product Set
Energetic Heavy Ions	2
Magnetospheric Electrons and Protons: Low Energy	2
Magnetospheric Electrons and Protons: Medium and High Energy	2
Solar and Galactic Protons	2
Geomagnetic Field	2
Solar Flux: EUV	2
Solar Flux: X-Ray	2
Solar Imagery: EUV	2

(CCR 2164)

LIRD285 4.4

4.4 Product Requirements

LIRD33 4.4.0-1

The GOES-R Series mission product data latency **shall** be less than or equal to the associated product refresh rate.

LIRD324 4.4.0-2

The GOES-R system **shall** make coronal mass ejection L0 data from the GOES-U Compact Coronagraph (CCOR) available to users. *(CCR 03444)*

LIRD46 4.4.1

4.4.1 Product Generation Requirements

LIRD47 4.4.1.0-1

The GOES-R Series **shall** ingest externally generated ancillary data and metadata from NOAA.

LIRD48 4.4.1.0-2

The GOES-R Series **shall** utilize internally generated environmental instrument data and externally generated ancillary as well as meta data required to produce the products listed in Table 3, Table 4, Table 5, and Table 6.

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LIRD49	4.4.1.0-3	The GOES-R Series **shall** maintain performance of generated environmental data products listed in Table 3, Table 4, Table 5 and Table 6.
LIRD50	4.4.2	**4.4.2 Product Distribution Requirements**
LIRD51	4.4.2.0-1	The GOES-R Series **shall** provide user access to all generated environmental data products.
LIRD293	4.4.3	**4.4.3 Product Data Archiving Requirements**
LIRD52	4.4.3.0-1	The GOES-R Series **shall** make products and associated supporting data available to the NOAA Archival Data Centers. *(CCR 1841A)*
LIRD295	4.5	**4.5 Availability Requirements**
LIRD28	4.5.0-1	The GOES-R Series **shall** maintain a mission availability of 0.80 over the operational lifetime for the combination of the specified operational coverage areas (as specified in LIRD270 and LIRD271).
LIRD297	4.5.0-2	In the event of a failure of a satellite requiring replacement, where an on-orbit replacement is available, the GOES-R Series Maximum Time to Restore Service (MaxTTRS) **shall** not exceed three weeks.
LIRD26	4.5.0-3	The GOES-R Series **shall** provide continuous (with outages less than 6 hours per year) sensor data for ground generation of the KPP.
LIRD299	4.5.0-4	In the event of a failure of one of the two GOES-R Series ground sites, the failover time to a backup site for those functions supporting the collection, generation and distribution of the KPP **shall** not exceed five minutes.
LIRD325	4.5.0-5	The GOES-R system **shall** provide continuous (with outages less than 75 hours per year) sensor data for ground generation of coronal mass ejection L0 data. *(CCR 03444)*
LIRD36	4.6	**4.6 Auxiliary Communication Services Requirements**
LIRD37	4.6.0-1	The GOES-R Series **shall** relay Earth-based Search and Rescue Satellite Aided Tracking (SARSAT) emergency beacon signals to Earth-based receivers.
LIRD38	4.6.0-2	The GOES-R Series **shall** relay Earth-based Emergency Managers Weather Information Network (EMWIN) data to Earth based receivers.
LIRD39	4.6.0-3	The GOES-R Series **shall** relay Earth-based High Rate Image Transmission (HRIT) data to Earth based receivers.
LIRD40	4.6.0-4	The GOES-R Series **shall** relay Earth-based Data Collection Platform (DCP) data to Earth based receivers.
LIRD305	4.6.0-5	The GOES-R Series **shall** relay Earth-based Data Collection Platforms' (DCP) commands to Earth based receivers.
LIRD41	4.6.0-6	The GOES-R Series **shall** relay ground-processed GOES Rebroadcast (GRB) data to Earth based receivers.
LIRD307	4.7	**4.7 On-orbit Checkout Location**
LIRD308	4.7.0-1	The GOES-R Series **shall** have a post-launch on-orbit geosynchronous check-out location of 89.5° W longitude for post launch testing. *(CCR 03444)*
LIRD309	4.8	**4.8 On-orbit Storage Location**

ID	Object Number	410-R-LIRD-0137, RM Version, Level I Requirements Document
LIRD310	4.8.0-1	The GOES-R Series **shall** have an on-orbit geosynchronous storage location of 105° W longitude capable of periodic check out in storage. *(CCR 03444)*
LIRD79	4.9	**4.9 Initial Operational Capability (IOC)**
LIRD80	4.9.0-1	The GOES-R Series **will** realize Initial Operating Capability (IOC) upon the successful generation and user availability of the KPP, following the Post Launch Test mission phase, as listed in Table 3 for either West or East coverage areas.
LIRD81	4.10	**4.10 System Full Operational Capability (FOC)**
LIRD82	4.10.0-1	The GOES-R Series **will** realize Full Operational Capability (FOC) upon the success of IOC for both the East and West on-orbit coverage areas, activation of Auxiliary Communications Services, and the production and availability to users of the full product set.
LIRD83	4.11	**4.11 Series Operational Lifetime** *(CCR 1259)*
LIRD84	4.11.0-1	Individual satellite lifetime of the GOES-R Series satellites **shall** consist of five years on-orbit storage and 10 years of operations. The GOES-R Series Operational Lifetime is dependent on the satellite lifetime and the launch schedule (defined in the Program Commitment Agreement (PCA)) and is defined as the period of time beginning with a GOES-R Series satellite operating at GOES-East or GOES-West and ending when the last GOES-R Series satellite is decommissioned. *(CCR 1259) (CCR 2311)*

ID	Object Number	410-R-LIRD-0137, RM Version, Level I Requirements Document
LIRD88	5	**5 MINIMUM PERFORMANCE SUCCESS CRITERIA**
LIRD313	5.0-1	The GOES-R Series minimum success criteria **will** be defined as the successful generation and availability to users of the Key Performance Parameter (KPP).
LIRD314	5.0-1.0-1	The GOES-R Series Key Performance Parameter (KPP) **will** be the Cloud and Moisture Imagery Product as listed in Table 3.

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LIRD92 6

6 Appendix: Level I Requirements Document Product Performance Table

LIRD93 6.1

6.1 Observational Requirements: Atmosphere

LIRD94 6.1.1

6.1.1 Aerosols

LIRD95 6.1.1.1

6.1.1.1 Aerosol Detection (including Smoke and Dust)

LIRD96 6.1.1.1.0-1 The GOES-R System **shall** produce Aerosol Detection (including Smoke and Dust) observational products in accordance with the table below.

Aerosol Detection (including Smoke and Dust)	Threshold
Primary Instrument	ABI
Geographic Coverage/Conditions	CONUS Full Disk Mesoscale
Vertical Resolution	Total column
Horizontal Resolution	2 km
Measurement Accuracy	Dust: 80% correct detection over land and ocean Smoke: 80% correct detection over land; 70% correct detection over ocean
Refresh Rate/Coverage Time	15 min

(CCR 1469)

LIRD97 6.1.1.2

6.1.1.2 Aerosol Particle Size

LIRD98 6.1.1.2.0-1 The GOES-R System **shall** produce an Aerosol Particle Size observational product in accordance with the table below.

Aerosol Particle Size	Threshold
Primary Instrument	ABI
Geographic Coverage/Conditions	Full Disk
Vertical Resolution	Total column
Horizontal Resolution	2 km
Measurement Accuracy	0.03 μm radius
Refresh Rate/Coverage Time	15 min

(CCR 1419B)(CCR 02169 (RDW))

LIRD99 6.1.1.3

6.1.1.3 Aerosol Optical Depth *(CCR 1469)*

LIRD100 6.1.1.3.0-1 The GOES-R System **shall** produce an Aerosol Optical Depth observational product in accordance with the table below.

ID	Object Number	410-R-LIRD-0137, RM Version, Level I Requirements Document

LIRD100 6.1.1.3.0-1

Aerosol Optical Depth	Threshold
Primary Instrument	ABI
Geographic Coverage/Conditions	CONUS Full Disk
Vertical Resolution	Total column
Horizontal Resolution	2 km
Measurement Accuracy	Based on Aerosol Optical Depth ranges: Over land: < 0.04: 0.06 0.04 – 0.80: 0.04 > 0.80: 0.12 Over water: < 0.40: 0.02 > 0.40: 0.10
Refresh Rate/Coverage Time	CONUS: 5 min Full Disk: 15 min

(CCR 1469)

LIRD101 6.1.1.4

6.1.1.4 Volcanic Ash: Detection and Height

LIRD102 6.1.1.4.0-1 The GOES-R System **shall** produce a Volcanic Ash: Detection and Height observational product in accordance with the table below.

Volcanic Ash: Detection and Height	Threshold
Primary Instrument	ABI
Geographic Coverage/Conditions	Full Disk
Vertical Resolution	3 km (top height)
Horizontal Resolution	2 km
Measurement Accuracy	2 ton/km^2
Refresh Rate/Coverage Time	15 min

(CCR 1419B)

LIRD103 6.1.2

6.1.2 Clouds

LIRD104 6.1.2.1

6.1.2.1 Aircraft Icing Threat

LIRD105 6.1.2.1.0-1 The GOES-R System **shall** produce an Aircraft Icing Threat observational product in accordance with the table below.

Aircraft Icing Threat	Threshold
Primary Instrument	ABI
Geographic Coverage/Conditions	Full Disk
Vertical Resolution	Cloud top
Horizontal Resolution	10 km
Measurement Accuracy	50% correct classification
Refresh Rate/Coverage Time	60 min

(CCR 1425)(CCR 02169 (RDW))

ID	Object Number	410-R-LIRD-0137, RM Version, Level I Requirements Document

LIRD106 6.1.2.2

6.1.2.2 Cloud Ice Water Path

LIRD107 6.1.2.2.0-1 The GOES-R System **shall** produce a Cloud Ice Water Path observational product in accordance with the table below.

Cloud Ice Water Path	Threshold
Primary Instrument	ABI
Geographic Coverage/Conditions	CONUS – for limited cloudiness Full Disk – for limited cloudiness Mesoscale – for limited cloudiness
Vertical Resolution	Surface – 20 km
Horizontal Resolution	2 km
Measurement Accuracy	40% (Day); and Greater of 25 g/m^2 or 30% (Night)
Refresh Rate/Coverage Time	CONUS: 5 min Full Disk: 15 min Mesoscale: 5 min

(CCR 1419B)(CCR 1898)(CCR 02169 (RDW))

LIRD110 6.1.2.3

6.1.2.3 Cloud Layers/Heights *(CCR 1419B)*

LIRD111 6.1.2.3.0-1 The GOES-R System **shall** produce a Cloud Layers/Heights observational product in accordance with the table below.

Cloud Layers/Heights	Threshold
Primary Instrument	ABI
Geographic Coverage/Conditions	CONUS Full Disk Mesoscale
Vertical Resolution	1 cloud layer
Horizontal Resolution	CONUS: 10 km Full Disk: 10 km Mesoscale: 4 km
Measurement Accuracy	80% correct classification
Refresh Rate/Coverage Time	CONUS: 60 min Full Disk: 60 min Mesoscale: 5 min

(CCR 1419B)(CCR 02169 (RDW))

LIRD112 6.1.2.4

6.1.2.4 Cloud Liquid Water

LIRD113 6.1.2.4.0-1 The GOES-R System **shall** produce a Cloud Liquid Water observational product in accordance with the table below.

ID	Object Number	410-R-LIRD-0137, RM Version, Level I Requirements Document

LIRD113 6.1.2.4.0-1

Cloud Liquid Water	Threshold
Primary Instrument	ABI
Geographic Coverage/Conditions	CONUS Full Disk Mesoscale
Vertical Resolution	Total column
Horizontal Resolution	2 km
Measurement Accuracy	Greater of 50 g/m^2 or 30% (Day); and Greater of 25 g/m^2 or 15% (Night)
Refresh Rate/Coverage Time	CONUS: 5 min Full Disk: 30 min Mesoscale: 5 min

(CCR 1419B)(CCR 1898)(CCR 02169 (RDW))

LIRD114 6.1.2.5

6.1.2.5 Cloud and Moisture Imagery

LIRD115 6.1.2.5.0-1 The GOES-R System **shall** produce a Cloud and Moisture Imagery observational product in accordance with the table below.

Cloud and Moisture Imagery	Threshold
Primary Instrument	ABI
Geographic Coverage/Conditions	CONUS Full Disk Mesoscale
Vertical Resolution	N/A
Horizontal Resolution	2 km, with finer daytime observations
Measurement Accuracy	N/A
Refresh Rate/Coverage Time	CONUS: 5 min Full Disk: 15 min Mesoscale: 30 sec

LIRD116 6.1.2.6

6.1.2.6 Cloud Optical Depth

LIRD117 6.1.2.6.0-1 The GOES-R System **shall** produce a Cloud Optical Depth observational product in accordance with the table below.

ID	Object Number	410-R-LIRD-0137, RM Version, Level I Requirements Document

LIRD117 6.1.2.6.0-1

Cloud Optical Depth	Threshold
Primary Instrument	ABI
Geographic Coverage/Conditions	CONUS: optical depth > 1 Full Disk: optical depth > 1
Vertical Resolution	Total column
Horizontal Resolution	CONUS: 2 km Full Disk: 4 km
Measurement Accuracy	Liquid phase: Maximum of 2 or 20% (Day); and 30% (Night). Ice phase: Maximum of 3 or 30% (Day); and 30% (Night).
Refresh Rate/Coverage Time	CONUS: 30 min Full Disk: 15 min

(CCR 1419B)(CCR 1898)

LIRD118 6.1.2.7

6.1.2.7 Cloud Particle Size Distribution

LIRD119 6.1.2.7.0-1 The GOES-R System **shall** produce a Cloud Particle Size Distribution observational product in accordance with the table below.

Cloud Particle Size Distribution	Threshold
Primary Instrument	ABI
Geographic Coverage/Conditions	CONUS Full Disk Mesoscale
Vertical Resolution	Cloud Top
Horizontal Resolution	2 km
Measurement Accuracy	Liquid phase: 4 μm (Day); and maximum of 4 μm or 30% (Night). Ice phase: 10 μm (Day); and 10 μm (Night).
Refresh Rate/Coverage Time	CONUS: 5 min Full Disk: 15 min Mesoscale: 5 min

(CCR 1898)

LIRD120 6.1.2.8

6.1.2.8 Cloud Top Phase

LIRD121 6.1.2.8.0-1 The GOES-R System **shall** produce a Cloud Top Phase observational product in accordance with the table below.

ID	Object Number	410-R-LIRD-0137, RM Version, Level I Requirements Document

LIRD121 6.1.2.8.0-1

Cloud Top Phase	Threshold
Primary Instrument	ABI
Geographic Coverage/Conditions	CONUS Full Disk Mesoscale
Vertical Resolution	Cloud Top
Horizontal Resolution	2 km
Measurement Accuracy	80% correct classification
Refresh Rate/Coverage Time	CONUS: 5 min Full Disk: 15 min Mesoscale: 5 min

(CCR 1419B)

LIRD122 6.1.2.9

6.1.2.9 Cloud Top Height

LIRD123 6.1.2.9.0-1 The GOES-R System **shall** produce a Cloud Top Height observational product in accordance with the table below.

Cloud Top Height	Threshold
Primary Instrument	ABI
Geographic Coverage/Conditions	CONUS Full Disk Mesoscale
Vertical Resolution	Cloud top
Horizontal Resolution	CONUS: 10 km Full Disk: 10 km Mesoscale: 4 km
Measurement Accuracy	500 m for clouds with emissivity > 0.8
Refresh Rate/Coverage Time	CONUS: 60 min Full Disk: 60 min Mesoscale: 5 min

(CCR 1419B)

LIRD124 6.1.2.10

6.1.2.10 Cloud Top Pressure

ID	Object Number	410-R-LIRD-0137, RM Version, Level I Requirements Document

LIRD125 6.1.2.10.0-1 The GOES-R System **shall** produce a Cloud Top Pressure observational product in accordance with the table below.

Cloud Top Pressure	Threshold
Primary Instrument	ABI
Geographic Coverage/Conditions	CONUS Full Disk
Vertical Resolution	Cloud top
Horizontal Resolution	10 km
Measurement Accuracy	50 mb for clouds with emissivity > 0.8
Refresh Rate/Coverage Time	CONUS: 60 min Full Disk: 60 min

(CCR 1419B)

LIRD126 6.1.2.11 **6.1.2.11 Cloud Top Temperature**

LIRD127 6.1.2.11.0-1 The GOES-R System **shall** produce a Cloud Top Temperature observational product in accordance with the table below.

Cloud Top Temperature	Threshold
Primary Instrument	ABI
Geographic Coverage/Conditions	Full Disk Mesoscale
Vertical Resolution	At cloud tops
Horizontal Resolution	2 km
Measurement Accuracy	3 K for clouds with emissivity > 0.8
Refresh Rate/Coverage Time	Full Disk: 15 min Mesoscale: 5 min

(CCR 1419B)

LIRD128 6.1.2.12 **6.1.2.12 Cloud Type**

LIRD129 6.1.2.12.0-1 The GOES-R System **shall** produce a Cloud Type observational product in accordance with the table below.

ID	Object Number	410-R-LIRD-0137, RM Version, Level I Requirements Document

LIRD129 6.1.2.12.0-1

Cloud Type	Threshold
Primary Instrument	ABI
Geographic Coverage/Conditions	CONUS Full Disk Mesoscale
Vertical Resolution	N/A
Horizontal Resolution	CONUS: 10km Full Disk: 2km Mesoscale: 2 km
Measurement Accuracy	60% correct classification
Refresh Rate/Coverage Time	CONUS: 30 min Full Disk: 15 min Mesoscale: 15 min

(CCR 1419B)(CCR 02169 (RDW))

LIRD130 6.1.2.13

6.1.2.13 Convective Initiation

LIRD131 6.1.2.13.0-1 The GOES-R System **shall** produce a Convective Initiation observational product in accordance with the table below.

Convective Initiation	Threshold
Primary Instrument	ABI
Geographic Coverage/Conditions	CONUS Mesoscale
Vertical Resolution	N/A
Horizontal Resolution	2 km
Measurement Accuracy	70% correct detection
Refresh Rate/Coverage Time	CONUS: 5 min Mesoscale: 5 min

(CCR 1346)(CCR 1425)(CCR 02169 (RDW))

LIRD132 6.1.2.14

6.1.2.14 Enhanced "V"/Overshooting Top Detection

LIRD133 6.1.2.14.0-1 The GOES-R System **shall** produce an Enhanced "V"/Overshooting Top Detection observational product in accordance with the table below.

Enhanced “V”/Overshooting Top Detection	Threshold
Primary Instrument	ABI
Geographic Coverage/Conditions	CONUS Mesoscale
Vertical Resolution	N/A
Horizontal Resolution	2 km
Measurement Accuracy	75% correct detection (in terms of 1 – False Alarm Rate)
Refresh Rate/Coverage Time	5 min

(CCR 1425)(CCR 1898)(CCR 02169 (RDW))

LIRD134 6.1.2.15

6.1.2.15 Hurricane Intensity

ID	Object Number	410-R-LIRD-0137, RM Version, Level I Requirements Document

LIRD135 6.1.2.15.0-1 The GOES-R System **shall** produce a Hurricane Intensity observational product in accordance with the table below.

Hurricane Intensity	Threshold
Primary Instrument	ABI
Geographic Coverage/Conditions	Full Disk
Vertical Resolution	N/A
Horizontal Resolution	2 km
Measurement Accuracy	6.5 m/s over ocean
Refresh Rate/Coverage Time	30 min

(CCR 1898)

LIRD136 6.1.2.16 **6.1.2.16 Lightning Detection**

LIRD137 6.1.2.16.0-1 The Product **will** include the collection of Lightning Events, identification of contiguous Events as "Lightning Groups" and events having discrete time and space continuity as "Lightning Flashes."

The GOES-R System **shall** produce a Lightning Detection observational product in accordance with the table below.

Lightning Detection	Threshold
Primary Instrument	GLM
Geographic Coverage/Conditions	Full Disk
Vertical Resolution	Surface to cloud top
Horizontal Resolution	10 km
Measurement Accuracy	70% total flashes detection
Refresh Rate/Coverage Time	20 sec

(CCR 1419B)(CCR 1437)

LIRD138 6.1.2.17 **6.1.2.17 Low Cloud and Fog**

LIRD139 6.1.2.17.0-1 The GOES-R System **shall** produce a Low Cloud and Fog observational product in accordance with the table below.

Low Cloud and Fog	Threshold
Primary Instrument	ABI
Geographic Coverage/Conditions	Full Disk
Vertical Resolution	0.5 km (depth)
Horizontal Resolution	2 km
Measurement Accuracy	70% correct detection
Refresh Rate/Coverage Time	15 min

(CCR 1425)(CCR 02169 (RDW))

LIRD140 6.1.2.18 **6.1.2.18 Tropopause Folding Turbulence Prediction *(CCR 1425)***

ID	Object Number	410-R-LIRD-0137, RM Version, Level I Requirements Document

LIRD141 6.1.2.18.0-1 The GOES-R System **shall** produce a Tropopause Folding Turbulence Prediction observational product in accordance with the table below.

Tropopause Folding Turbulence Prediction	Threshold
Primary Instrument	ABI
Geographic Coverage/Conditions	Full Disk Mesoscale
Vertical Resolution	Surface – 100mb
Horizontal Resolution	2 km
Measurement Accuracy	50% correct detection of Moderate or Greater turbulence
Refresh Rate/Coverage Time	Full Disk: 15 min Mesoscale: 5 min

(CCR 1419B)(CCR 1425)(CCR 02169 (RDW))

LIRD142 6.1.2.19 **6.1.2.19 Visibility**

LIRD143 6.1.2.19.0-1 The GOES-R System **shall** produce a Visibility observational product in accordance with the table below.

Visibility	Threshold
Primary Instrument	ABI
Geographic Coverage/Conditions	Full Disk
Vertical Resolution	N/A
Horizontal Resolution	10 km
Measurement Accuracy	80% correct classification
Refresh Rate/Coverage Time	60 min

(CCR 1425)(CCR 02169 (RDW))

LIRD144 6.1.3 **6.1.3 Precipitation**

LIRD145 6.1.3.1 **6.1.3.1 Probability of Rainfall**

LIRD146 6.1.3.1.0-1 The GOES-R System **shall** produce a Probability of Rainfall observational product in accordance with the table below.

Probability of Rainfall	Threshold
Primary Instrument	ABI
Geographic Coverage/Conditions	Full Disk
Vertical Resolution	N/A
Horizontal Resolution	2 km
Measurement Accuracy	25%
Refresh Rate/Coverage Time	15 min

(CCR 02169 (RDW))

LIRD147 6.1.3.2 **6.1.3.2 Rainfall Potential**

ID	Object Number	410-R-LIRD-0137, RM Version, Level I Requirements Document

LIRD148 6.1.3.2.0-1 The GOES-R System **shall** produce a Rainfall Potential observational product in accordance with the table below.

Rainfall Potential	Threshold
Primary Instrument	ABI
Geographic Coverage/Conditions	Full Disk
Vertical Resolution	N/A
Horizontal Resolution	2 km
Measurement Accuracy	5 mm for pixels designated as raining
Refresh Rate/Coverage Time	15 min

(CCR 1426A)(CCR 02169 (RDW))

LIRD149 6.1.3.3 **6.1.3.3 Rainfall Rate/QPE**

LIRD150 6.1.3.3.0-1 The GOES-R System **shall** produce a Rainfall Rate/QPE observational product in accordance with the table below.

Rainfall Rate/QPE	Threshold
Primary Instrument	ABI
Geographic Coverage/Conditions	Full Disk
Vertical Resolution	N/A
Horizontal Resolution	2 km
Measurement Accuracy	6 mm/hr at 10 mm/hr rate with higher values at higher rates
Refresh Rate/Coverage Time	15 min

(CCR 1426A)

LIRD151 6.1.4 **6.1.4 Profiles, Indices, Total Water**

LIRD152 6.1.4.1 **6.1.4.1 Legacy Vertical Moisture Profile**

ID	Object Number	410-R-LIRD-0137, RM Version, Level I Requirements Document

LIRD153 6.1.4.1.0-1 The GOES-R System **shall** produce a Legacy Vertical Moisture Profile observational product in accordance with the table below.

Legacy Vertical Moisture Profile	Threshold
Primary Instrument	ABI
Geographic Coverage/Conditions	CONUS Full Disk Mesoscale
Vertical Resolution	Reflects layering of numerical weather prediction models; Inherent vertical resolution is only 3 to 5 km
Horizontal Resolution	10 km
Measurement Accuracy	20% relative humidity
Refresh Rate/Coverage Time	Full Disk: 60 min CONUS: 30min Mesoscale: 5 min

(CCR 1346)(CCR 1417)

LIRD154 6.1.4.2 **6.1.4.2 Legacy Vertical Temperature Profile**

LIRD155 6.1.4.2.0-1 The GOES-R System **shall** produce a Legacy Vertical Temperature Profile observational product in accordance with the table below.

Legacy Vertical Temperature Profile	Threshold
Primary Instrument	ABI
Geographic Coverage/Conditions	CONUS Full Disk Mesoscale
Vertical Resolution	Reflects layering of numerical weather prediction models; Inherent vertical resolution is only 3 to 5 km
Horizontal Resolution	10 km
Measurement Accuracy	1 K below 400 hPa and above boundary layer
Refresh Rate/Coverage Time	Full Disk: 60 min CONUS: 30 min Mesoscale: 5 min

(CCR 1346)(CCR 1417)

LIRD156 6.1.4.3 **6.1.4.3 Derived Stability Indices**

LIRD157 6.1.4.3.0-1 The GOES-R System **shall** produce a Derived Stability Indices observational product in accordance with the table below.

ID	Object Number	410-R-LIRD-0137, RM Version, Level I Requirements Document

LIRD157 6.1.4.3.0-1

Derived Stability Indices	Threshold
Primary Instrument	ABI
Geographic Coverage/Conditions	Full Disk CONUS Mesoscale
Vertical Resolution	N/A
Horizontal Resolution	Full Disk:10km CONUS: 10 km Mesoscale: 10 km
Measurement Accuracy	Lifted Index: 2.0K CAPE: 1000 J/kg Showalter index: 2 Total totals Index: 1 K-index: 2
Refresh Rate/Coverage Time	Full Disk: 60 min CONUS: 30 min Mesoscale: 5 min

(CCR 1346)(CCR 1417)(CCR 1842A)

LIRD158 6.1.4.4

6.1.4.4 Total Precipitable Water

LIRD159 6.1.4.4.0-1 The GOES-R System **shall** produce a Total Precipitable Water observational product in accordance with the table below.

Total Precipitable Water	Threshold
Primary Instrument	ABI
Geographic Coverage/Conditions	Full Disk CONUS Mesoscale
Vertical Resolution	N/A
Horizontal Resolution	Full Disk = 10 km CONUS = 10 km Mesoscale = 10 km
Measurement Accuracy	1 mm
Refresh Rate/Coverage Time	Full Disk = 60 min CONUS = 30 min Mesoscale = 5 min

(CCR 1314)(CCR 1419B)(CCR 1417)

LIRD162 6.1.5

6.1.5 Radiances

LIRD163 6.1.5.1

6.1.5.1 Clear Sky Masks

LIRD164 6.1.5.1.0-1 The GOES-R System **shall** produce a Clear Sky Masks observational product in accordance with the table below.

ID	Object Number	410-R-LIRD-0137, RM Version, Level I Requirements Document

LIRD164 6.1.5.1.0-1

Clear Sky Masks	Threshold
Primary Instrument	ABI
Geographic Coverage/Conditions	CONUS Full Disk Mesoscale
Vertical Resolution	N/A
Horizontal Resolution	2 km
Measurement Accuracy	87% correct detection
Refresh Rate/Coverage Time	CONUS: 15 min Full Disk: 15 min Mesoscale: 5 min

(CCR 1419B)

LIRD165 6.1.5.2

6.1.5.2 Radiances

LIRD166 6.1.5.2.0-1 The GOES-R System **shall** produce a Radiances observational product in accordance with the table below.

Radiances	Threshold
Primary Instrument	ABI
Geographic Coverage/Conditions	CONUS Full Disk Mesoscale
Vertical Resolution	N/A
Horizontal Resolution	Individual channel resolutions (0.5 km, 1.0 km, and 2.0 km)
Measurement Accuracy	1.0 K equivalent when converted into brightness temperature units for known emissivity
Refresh Rate/Coverage Time	Full Disk: 15 min CONUS: 15 min Mesoscale: 5 min

(CCR 1346)

LIRD167 6.1.6

6.1.6 Radiation

LIRD168 6.1.6.1

6.1.6.1 Absorbed Shortwave Radiation: Surface

LIRD169 6.1.6.1.0-1 The GOES-R System **shall** produce an Absorbed Shortwave Radiation: Surface observational product in accordance with the table below.

ID	Object Number	410-R-LIRD-0137, RM Version, Level I Requirements Document

LIRD169 6.1.6.1.0-1

Absorbed Shortwave Radiation: Surface	Threshold
Primary Instrument	ABI
Geographic Coverage/Conditions	Mesoscale
Vertical Resolution	N/A
Horizontal Resolution	5 km
Measurement Accuracy	90 W/m^2 at low value (100 W/m^2); 45 W/m^2 at mid value (400 W/m^2); 55 W/m^2 at high value (800 W/m^2)
Refresh Rate/Coverage Time	60 min

(CCR 1385)(CCR 02169 (RDW))

LIRD170 6.1.6.2

6.1.6.2 Downward Longwave Radiation: Surface

LIRD171 6.1.6.2.0-1 The GOES-R System **shall** produce a Downward Longwave Radiation: Surface observational product in accordance with the table below.

Downward Longwave Radiation: Surface	Threshold
Primary Instrument	ABI
Geographic Coverage/Conditions	CONUS Full Disk
Vertical Resolution	N/A
Horizontal Resolution	CONUS: 25 km Full Disk: 100 km
Measurement Accuracy	25 W/m^2
Refresh Rate/Coverage Time	60 min

(CCR 02169 (RDW))

LIRD172 6.1.6.3

6.1.6.3 Downward Shortwave Radiation: Surface *(CCR 1385)*

ID	Object Number	410-R-LIRD-0137, RM Version, Level I Requirements Document

LIRD173 6.1.6.3.0-1 The GOES-R System **shall** produce a Downward Shortwave Radiation: Surface observational product in accordance with the table below.

Downward Shortwave Radiation: Surface	Threshold
Primary Instrument	ABI
Geographic Coverage/Conditions	CONUS Full Disk Mesoscale
Vertical Resolution	N/A
Horizontal Resolution	CONUS: 25 km Full Disk: 50 km Mesoscale: 5 km
Measurement Accuracy	85 W/m^2 at high end of range (1000 W/m2); 65 W/m^2 at typical value/midpoint (350 W/m^2); 110 W/m^2 at low end of range (100 W/m^2)
Refresh Rate/Coverage Time	60 min

(CCR 1385)

LIRD174 6.1.6.4 **6.1.6.4 Reflected Shortwave Radiation: TOA *(CCR 1385)***

LIRD175 6.1.6.4.0-1 The GOES-R System **shall** produce a Reflected Shortwave Radiation: TOA observational product in accordance with the table below.

Reflected Shortwave Radiation: TOA	Threshold
Primary Instrument	ABI
Geographic Coverage/Conditions	CONUS Full Disk
Vertical Resolution	N/A
Horizontal Resolution	CONUS: 25 km Full Disk: 100 km
Measurement Accuracy	85 W/m^2 at high end of range (1000 W/m^2); 65 W/m^2 at typical value/midpoint (350 W/m^2); 110 W/m^2 at low end of range (100 W/m^2)
Refresh Rate/Coverage Time	60 min

(CCR 1385)

LIRD176 6.1.6.5 **6.1.6.5 Upward Longwave Radiation: Surface**

LIRD177 6.1.6.5.0-1 The GOES-R System **shall** produce an Upward Longwave Radiation: Surface observational product in accordance with the table below.

ID	Object Number	410-R-LIRD-0137, RM Version, Level I Requirements Document

LIRD177 6.1.6.5.0-1

Upward Longwave Radiation: Surface	Threshold
Primary Instrument	ABI
Geographic Coverage/Conditions	CONUS Full Disk
Vertical Resolution	N/A
Horizontal Resolution	CONUS: 25 km Full Disk: 100 km
Measurement Accuracy	30 W/m^2
Refresh Rate/Coverage Time	60 min

(CCR 1385)(CCR 02169 (RDW))

LIRD178 6.1.6.6

6.1.6.6 Upward Longwave Radiation: TOA

LIRD179 6.1.6.6.0-1 The GOES-R System **shall** produce an Upward Longwave Radiation: TOA observational product in accordance with the table below.

Upward Longwave Radiation: TOA	Threshold
Primary Instrument	ABI
Geographic Coverage/Conditions	CONUS Full Disk
Vertical Resolution	N/A
Horizontal Resolution	25 km
Measurement Accuracy	20 W/m^2
Refresh Rate/Coverage Time	60 min

(CCR 02169 (RDW))

LIRD180 6.1.7

6.1.7 Trace Gases

LIRD181 6.1.7.1

6.1.7.1 Ozone Total

LIRD182 6.1.7.1.0-1 The GOES-R System **shall** produce an Ozone Total observational product in accordance with the table below.

Ozone Total	Threshold
Primary Instrument	ABI
Geographic Coverage/Conditions	CONUS Full Disk
Vertical Resolution	Total column
Horizontal Resolution	10 km
Measurement Accuracy	15 Dobson Units
Refresh Rate/Coverage Time	60 min

(CCR 1469)(CCR 02169 (RDW))

LIRD183 6.1.7.2

6.1.7.2 SO_2 Detection

ID	Object Number	410-R-LIRD-0137, RM Version, Level I Requirements Document

LIRD184 6.1.7.2.0-1 The GOES-R System **shall** produce an SO_2 Detection observational product in accordance with the table below.

SO_2 Detection	Threshold
Primary Instrument	ABI
Geographic Coverage/Conditions	Full Disk
Vertical Resolution	Total column
Horizontal Resolution	5 km
Measurement Accuracy	70% correct detection
Refresh Rate/Coverage Time	60 min

(CCR 1425)(CCR 02169 (RDW))

LIRD185 6.1.8 ## 6.1.8 Winds

LIRD186 6.1.8.1 ### 6.1.8.1 Derived Motion Winds

LIRD187 6.1.8.1.0-1 The GOES-R System **shall** produce a Derived Motion Winds observational product in accordance with the table below.

Derived Motion Winds	Threshold
Primary Instrument	ABI
Geographic Coverage/Conditions	CONUS Full Disk Mesoscale
Vertical Resolution	Cloud motion vector winds: At cloud tops; Clear-Sky water vapor winds: 200mb
Horizontal Resolution	CONUS: 38 km Full Disk: 38 km Mesoscale: 38 km
Measurement Accuracy	Mean Vector Difference: 7.5 m/s
Refresh Rate/Coverage Time	CONUS: 15 min Full Disk: 60 min (based on a single set of 3 sequential images 5 or more minutes apart) Mesoscale: 5 min

(CCR 1346)(CCR 1386A)(CCR 1898)

LIRD188 6.2 # 6.2 Observational Requirements: Land

LIRD189 6.2.1 ## 6.2.1 Fire/Hot Spot Characterization

LIRD190 6.2.1.0-1 The GOES-R System **shall** produce a Fire/Hot Spot Characterization observational product in accordance with the table below.

ID	Object Number	410-R-LIRD-0137, RM Version, Level I Requirements Document

LIRD190 6.2.1.0-1

Fire/Hot Spot Characterization	Threshold
Primary Instrument	ABI
Geographic Coverage/Conditions	CONUS Full Disk
Vertical Resolution	N/A
Horizontal Resolution	2 km
Measurement Accuracy	2.0 K within dynamic range
Refresh Rate/Coverage Time	CONUS: 5 min Full Disk: 15 min

LIRD191 6.2.2

6.2.2 Flood/Standing Water

LIRD192 6.2.2.0-1 The GOES-R System **shall** produce a Flood/Standing Water observational product in accordance with the table below.

Flood/Standing Water	Threshold
Primary Instrument	ABI
Geographic Coverage/Conditions	Full Disk Mesoscale
Vertical Resolution	N/A
Horizontal Resolution	10 km
Measurement Accuracy	60% correct classification
Refresh Rate/Coverage Time	60 min

(CCR 1383)(CCR 02169 (RDW))

LIRD193 6.2.3

6.2.3 Ice Cover *(CCR 1418)*

LIRD194 6.2.3.0-1 The GOES-R System **shall** produce an Ice Cover observational product in accordance with the table below.

Ice Cover	Threshold
Primary Instrument	ABI
Geographic Coverage/Conditions	Full Disk
Vertical Resolution	N/A
Horizontal Resolution	2 km
Measurement Accuracy	85% correct detection
Refresh Rate/Coverage Time	180 min

(CCR 1418)(CCR 02169 (RDW))

LIRD195 6.2.4

6.2.4 Land Surface (Skin) Temperature

LIRD196 6.2.4.0-1 The GOES-R System **shall** produce a Land Surface (Skin) Temperature observational product in accordance with the table below.

ID	Object Number	410-R-LIRD-0137, RM Version, Level I Requirements Document

LIRD196 6.2.4.0-1

Land Surface (Skin) Temperature	Threshold
Primary Instrument	ABI
Geographic Coverage/Conditions	CONUS Full Disk Mesoscale
Vertical Resolution	N/A
Horizontal Resolution	CONUS: 2 km Full Disk: 10 km Mesoscale: 2 km
Measurement Accuracy	2.5 K with known emissivity, known atmospheric correction, and 80% channel correlation; 5 K otherwise
Refresh Rate/Coverage Time	60 min

LIRD197 6.2.5

6.2.5 Snow Cover

LIRD198 6.2.5.0-1

The GOES-R System **shall** produce a Snow Cover observational product in accordance with the table below.

Snow Cover	Threshold
Primary Instrument	ABI
Geographic Coverage/Conditions	CONUS Full Disk Mesoscale
Vertical Resolution	N/A
Horizontal Resolution	2 km
Measurement Accuracy	0.30
Refresh Rate/Coverage Time	60 min

(CCR 1418)(CCR 2417 (RDW))

LIRD199 6.2.6

6.2.6 Snow Depth (over Plains)

LIRD200 6.2.6.0-1

The GOES-R System **shall** produce a Snow Depth (over Plains) observational product in accordance with the table below.

ID	Object Number	410-R-LIRD-0137, RM Version, Level I Requirements Document

LIRD200 6.2.6.0-1

Snow Depth (over Plains)	Threshold
Primary Instrument	ABI
Geographic Coverage/Conditions	CONUS - tall grassy plains only Full Disk - tall grassy plains only Mesoscale - tall grassy plains only
Vertical Resolution	N/A
Horizontal Resolution	2 km
Measurement Accuracy	9 cm
Refresh Rate/Coverage Time	60 min

(CCR 1418)(CCR 02169 (RDW))

LIRD201 6.2.7

6.2.7 Surface Albedo

LIRD202 6.2.7.0-1 The GOES-R System **shall** produce a Surface Albedo observational product in accordance with the table below.

Surface Albedo	Threshold
Primary Instrument	ABI
Geographic Coverage/Conditions	Full Disk
Vertical Resolution	N/A
Horizontal Resolution	2 km
Measurement Accuracy	0.08 (albedo units)
Refresh Rate/Coverage Time	60 min

(CCR 02169 (RDW))

LIRD203 6.2.8

6.2.8 Surface Emissivity

LIRD204 6.2.8.0-1 The GOES-R System **shall** produce a Surface Emissivity observational product in accordance with the table below.

Surface Emissivity	Threshold
Primary Instrument	ABI
Geographic Coverage Conditions	CONUS
Vertical Resolution	N/A
Horizontal Resolution	10 km
Measurement Accuracy	0.05
Refresh Rate/Coverage Time	60 min

(CCR 1419B)(CCR 1417)(CCR 02169 (RDW))

LIRD205 6.2.9

6.2.9 Vegetation Fraction: Green

LIRD206 6.2.9.0-1 The GOES-R System **shall** produce a Vegetation Fraction: Green observational product in accordance with the table below.

ID	Object Number	410-R-LIRD-0137, RM Version, Level I Requirements Document

LIRD206 6.2.9.0-1

Vegetation Fraction: Green	Threshold
Primary Instrument	ABI
Geographic Coverage/Conditions	CONUS Full Disk
Vertical Resolution	N/A
Horizontal Resolution	2 km
Measurement Accuracy	0.10 (SZA <55 degrees), 0.20 (55 degrees < SZA< 70 degrees)
Refresh Rate/Coverage Time	60 min

(CCR 1898)(CCR 1842A)(CCR 02169 (RDW))

LIRD207 6.2.10

6.2.10 Vegetation Index

LIRD208 6.2.10.0-1 The GOES-R System **shall** produce a Vegetation Index observational product in accordance with the table below.

Vegetation Index	Threshold
Primary Instrument	ABI
Geographic Coverage/Conditions	CONUS Full Disk
Vertical Resolution	N/A
Horizontal Resolution	2 km
Measurement Accuracy	0.04 NDVI Units
Refresh Rate/Coverage Time	60 min

(CCR 1842A)(CCR 02169 (RDW))

LIRD209 6.3

6.3 Observational Requirements: Ocean

LIRD210 6.3.1

6.3.1 Currents

LIRD211 6.3.1.0-1 The GOES-R System **shall** produce a Currents observational product in accordance with the table below.

Currents	Threshold
Primary Instrument	ABI
Geographic Coverage/Conditions	Full Disk Mesoscale
Vertical Resolution	Surface
Horizontal Resolution	2 km
Measurement Accuracy	Speed: 1.0 km/hr (0.3 m/s) in both meridional and zonal directions
Refresh Rate/Coverage Time	6 hr

(CCR 1384)(CCR 1898)(CCR 02169 (RDW))

LIRD212 6.3.2

6.3.2 Currents: Offshore

ID	Object Number	410-R-LIRD-0137, RM Version, Level I Requirements Document

LIRD213 6.3.2.0-1 The GOES-R System **shall** produce a Currents: Offshore observational product in accordance with the table below.

Currents: Offshore	Threshold
Primary Instrument	ABI
Geographic Coverage/Conditions	CONUS and US navigable waters through EEZ Full Disk
Vertical Resolution	Surface
Horizontal Resolution	2 km
Measurement Accuracy	1.0 km/hr (0.3 m/s) in both meridional and zonal directions
Refresh Rate/Coverage Time	180 min

(CCR 1898)(CCR 02169 (RDW))

LIRD214 6.3.3

6.3.3 Sea and Lake Ice: Age

LIRD215 6.3.3.0-1 The GOES-R System **shall** produce a Sea and Lake Ice: Age observational product in accordance with the table below.

Sea and Lake Ice: Age	Threshold
Primary Instrument	ABI
Geographic Coverage/Conditions	Full Disk
Vertical Resolution	Ice surface
Horizontal Resolution	1 km
Measurement Accuracy	80% correct detection
Refresh Rate/Coverage Time	6 hr

(CCR 1418)(CCR 02169 (RDW))

LIRD216 6.3.4

6.3.4 Sea and Lake Ice: Concentration

LIRD217 6.3.4.0-1 The GOES-R System **shall** produce a Sea and Lake Ice: Concentration observational product in accordance with the table below.

ID	Object Number	410-R-LIRD-0137, RM Version, Level I Requirements Document

LIRD217 6.3.4.0-1

Sea and Lake Ice: Concentration	Threshold
Primary Instrument	ABI
Geographic Coverage/Conditions	CONUS/Regional – Great Lakes and US coastal waters containing sea ice hazards to navigation Full Disk – Sea ice covered waters in Northern and Southern Hemispheres
Vertical Resolution	Ice surface
Horizontal Resolution	CONUS: 3 km Full Disk: 10 km
Measurement Accuracy	Ice concentration – 10%
Refresh Rate/Coverage Time	CONUS: 180 min Full Disk: 6 hr

(CCR 02169 (RDW))

LIRD220 6.3.5

6.3.5 Sea and Lake Ice: Motion

LIRD221 6.3.5.0-1

The GOES-R System **shall** produce a Sea and Lake Ice: Motion observational product in accordance with the table below.

Sea and Lake Ice: Motion	Threshold
Primary Instrument	ABI
Geographic Coverage/Conditions	Great Lakes and Chesapeake and Delaware Bays Full Disk – Sea ice covered waters in northern and southern hemispheres
Vertical Resolution	N/A
Horizontal Resolution	CONUS: 5 km Full Disk: 15 km
Measurement Accuracy	Direction: 22.5°; Speed: 3 km/day
Refresh Rate/Coverage Time	CONUS: 3 hr Full Disk: 6 hr

(CCR 1418)(CCR 02169 (RDW))

LIRD222 6.3.6

6.3.6 Sea Surface Temperature (skin) *(CCR 1378)*

LIRD223 6.3.6.0-1

The GOES-R System **shall** produce a Sea Surface Temperature (skin) observational product in accordance with the table below.

ID	Object Number	410-R-LIRD-0137, RM Version, Level I Requirements Document

LIRD223 6.3.6.0-1

Sea Surface Temperature (skin)	Threshold
Primary Instrument	ABI
Geographic Coverage/Conditions	Full Disk
Vertical Resolution	N/A
Horizontal Resolution	2 km
Measurement Accuracy	2.1 K with known emissivity, known atmospheric correction, and 80% channel correlation; 3.1 K otherwise
Refresh Rate/Coverage Time	Full Disk: 60 min

(CCR 1346)(CCR 1378)

LIRD224 6.4

6.4 Observational Requirements: Space and Solar

LIRD225 6.4.1

6.4.1 Energetic Particles *(CCR 1419B)*

LIRD226 6.4.1.1

6.4.1.1 Energetic Heavy Ions

LIRD227 6.4.1.1.0-1 The GOES-R System **shall** produce an Energetic Heavy Ions observational product in accordance with the table below.

Energetic Heavy Ions	Threshold
Primary Instrument	SEISS
Orthogonality/Coverage	1 direction
Vertical Resolution	N/A
Horizontal/Angular Resolution	N/A
Measurement Accuracy	25%
Refresh Rate/Coverage Time	5 min

LIRD228 6.4.1.2

6.4.1.2 Magnetospheric Electrons and Protons: Low Energy

LIRD229 6.4.1.2.0-1 The GOES-R System **shall** produce a Magnetospheric Electrons and Protons: Low Energy observational product in accordance with the table below.

Magnetospheric Electrons and Protons: Low Energy	Threshold
Primary Instrument	SEISS
Orthogonality/Coverage	5 directions
Vertical Resolution	N/A
Horizontal/Angular Resolution	N/A
Measurement Accuracy	25%
Refresh Rate/Coverage Time	30 sec

ID	Object Number	410-R-LIRD-0137, RM Version, Level I Requirements Document

LIRD230 6.4.1.3

6.4.1.3 Magnetospheric Electrons and Protons: Medium and High Energy

LIRD231 6.4.1.3.0-1 The GOES-R System **shall** produce a Magnetospheric Electrons and Protons: Medium and High Energy observational product in accordance with the table below.

Magnetospheric Electrons and Protons: Medium and High Energy	Threshold
Primary Instrument	SEISS
Orthogonality/Coverage	5 directions
Vertical Resolution	N/A
Horizontal/Angular Resolution	N/A
Measurement Accuracy	25%
Refresh Rate/Coverage Time	30 sec

LIRD232 6.4.1.4

6.4.1.4 Solar and Galactic Protons

LIRD233 6.4.1.4.0-1 The GOES-R System **shall** produce a Solar and Galactic Protons observational product in accordance with the table below.

Solar and Galactic Protons	Threshold
Primary Instrument	SEISS
Orthogonality/Coverage	2 directions
Vertical Resolution	N/A
Horizontal/Angular Resolution	N/A
Measurement Accuracy	25%
Refresh Rate/Coverage Time	1 min

LIRD234 6.4.2

6.4.2 Magnetic Field

LIRD235 6.4.2.1

6.4.2.1 Geomagnetic Field

LIRD236 6.4.2.1.0-1 The GOES-R System **shall** produce a Geomagnetic Field observational product in accordance with the table below.

Geomagnetic Field	Threshold
Primary Instrument	Magnetometer
Orthogonality/Coverage	3-axis 0.5°
Vertical Resolution	N/A
Horizontal/Angular Resolution	N/A
Measurement Accuracy	1.0 nT (per axis)
Refresh Rate/Coverage Time	2 samples/sec

(CCR 02154 (RDW))(CCR 2312) (Note: LIRD236 Geomagnetic Field Product Measurement Accuracy values in existing LIRD CCR-2154 (RDW) reflect currently known and uncorrected bias plus three standard deviations about that bias. LIRD236 applies to a 250 nT field. Measurement accuracy at a 100 nT field will be ≤ 1.7 nT. Accuracy performance scales between the 100 nT and 250 nT field. (CCR 03085)) (CCR 03361C (RDW))

ID	Object Number	410-R-LIRD-0137, RM Version, Level I Requirements Document

LIRD237 6.4.3

6.4.3 Solar

LIRD238 6.4.3.1

6.4.3.1 Solar Flux: EUV

LIRD239 6.4.3.1.0-1 The GOES-R System **shall** produce a Solar Flux: EUV observational product in accordance with the table below.

Solar Flux: EUV	Threshold
Primary Instrument	EXIS
Orthogonality/Coverage	Solar Disk (40 arcmin)
Vertical Resolution	N/A
Horizontal/Angular Resolution	N/A
Measurement Accuracy	± 20%
Refresh Rate/Coverage Time	30 sec

LIRD240 6.4.3.2

6.4.3.2 Solar Flux: X-Ray

LIRD241 6.4.3.2.0-1 The GOES-R System **shall** produce a Solar Flux: X-Ray observational product in accordance with the table below.

Solar Flux: X-Ray	Threshold
Primary Instrument	EXIS
Orthogonality/Coverage	Solar Disk (40 arcmin)
Vertical Resolution	N/A
Horizontal/Angular Resolution	N/A
Measurement Accuracy	± 20%
Refresh Rate/Coverage Time	10 sec

LIRD242 6.4.3.3

6.4.3.3 Solar Imagery: EUV *(CCR 2164)*

LIRD243 6.4.3.3.0-1 The GOES-R System **shall** produce a Solar Imagery: EUV observational product in accordance with the table below.

Solar Imagery: EUV	Threshold
Primary Instrument	SUVI
Orthogonality/Coverage	0.0 - 1.3 Solar Radii
Vertical Resolution	N/A
Horizontal/Angular Resolution	7.0 arcsec
Measurement Accuracy	± 40% in radiance
Refresh Rate/Coverage Time	Image: < 2 min

(CCR 1766)(CCR 2164)