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5 **Satellite Product Analysis and**
6 **Distribution Enterprise System**
7 **(SPADES)**

8
9 **Demonstration Project**

10
11 **Program Plan (PP)**

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16 **Date: September 24, 2014**



21
22 **U.S. Department of Commerce (DOC)**

23 **National Oceanic and Atmospheric Administration (NOAA)**

24 **National Environmental Satellite, Data, and Information Service (NESDIS)**

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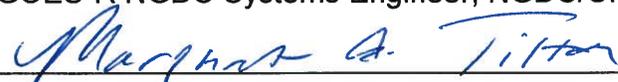
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CONCURRENCES



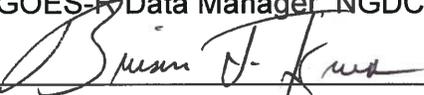
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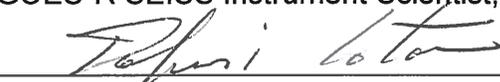
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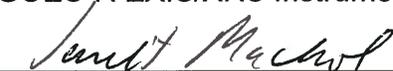
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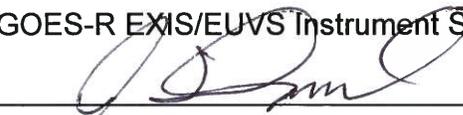
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Change Log

Revision	Date	Sections Changed	Author
0.1	7/20/14	Draft	Denig
0.2	9/2/14	All; Requirements renumbered	Denig
0.3	9/14/14	Pushed detailed requirements to L2	Denig
0.4	9/18/14	General clean-up	Denig
0.5	9/24/14	Response to Singer review	Denig

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1 INTRODUCTION

77 1.1 PURPOSE OF THIS DOCUMENT

78 The purpose of the Satellite Product Analysis and Distribution Enterprise System
 79 (SPADES) Program Plan (PP) is to provide the strategy for developing a demonstration
 80 capability for producing the GOES-R Level 2+ space weather products. This document
 81 includes separate sections for the SPADES program definition, system concept,
 82 success criteria, performance requirements, program management and developmental
 83 schedule. Throughout this document we refer to the demonstration system simply as
 84 SPADES wherein it is implicit that this is a non-operational capability that may
 85 nevertheless serve as the prototype for a follow-on operational system within the NWS.

86 1.2 SCOPE

87 The National Geophysical Data Center (NGDC) is developing SPADES to support a
 88 future research-to-operations (R2O) transition by National Weather Service (NWS) after
 89 FY15. SPADES is an internal developmental program within NGDC wherein NGDC will
 90 design, build and operate a demonstration system to 1) acquire GOES-R Level 1b (L1b)
 91 space weather products in real time, 2) produce the Level 2+ (L2+) space weather
 92 products, 3) visualize these products in graphical form, and 4) make these products
 93 available to the NWS Space Weather Prediction Center (SWPC) and other users. The
 94 current schedule allows for the SPADES to support an Initial Operational Capability
 95 (IOC) for GOES-R Post Launch Testing (PLT) in first quarter fiscal year 2016
 96 (1QFY2016) and a Final Operational Capability (FOC) in FY2017. To the maximum
 97 extent possible, SPADES will be developed as a stand-alone system to facilitate the
 98 aforementioned R2O transition and to support follow-on Operations and Maintenance
 99 (O&M) for the GOES-R space weather sensors and products. The NGDC Space
 100 Weather Team (SWT) has developed the Algorithm Theoretical Basis Documents
 101 (ATBDs) and supporting research-grade software codes for the full suite of L2+ space
 102 weather products in the three product sets listed in Table 1. The full set of L2+
 103 algorithms will be processed within SPADES.

104 **Table 1 – L2+ SWx Product Algorithms**

Product Set 1	Product Set 2	Product Set 3
SEISS.16 1-Minute Averages	SEISS.19 Moments and SC Charging	SEISS.20 Event Detection
SEISS.17 5-Minute Averages	MAG.10 Magnetopause Crossing	XRS.10 Flare Location
SEISS.18 Integral Flux	EUVS.03D Daily Averages	SUVI.13 Bright Regions
MAG.07 Coordinate Systems	EUVS.04 Event Detection	SUVI.14 Flare Location
MAG.08 1 Minute Averages	XRS.05 Channel Ratios	SUVI.15 Coronal Hole Boundaries
MAG.09 Quiet Fields	XRS.07 1-Minute Event Detection	
EUVS.03 1-Minute Averages	XRS.09 Daily Background	
XRS.04 1 Minute Averages	SUVI.19 Thematic Maps	
SUVI.07 Composite Images	SUVI.12 Coronal Hole Images	
SUVI.09 Fixed Difference Images		
SUVI.10 Running Difference Images		

105 1.3 APPLICABLE DOCUMENTS

106 Applicable Documents consist of documents that contain provisions or other pertinent
107 requirements directly related to and necessary for the performance of the activities
108 specified in this plan. Implementation of the requirements as stated in Section 5
109 assumes compliance with the version of these applicable documents effective on the
110 approval date of this plan.

- 111 • GOES-R3 Proposal for the Satellite Product Analysis and Distribution System
112 project, dated 27 February 2014
- 113 • GOES-R Product Definition and Users' Guide (PUG), dated 06 December 2013
- 114 • Environmental Satellite Processing and Distribution System (ESPDS)
115 Development, Interface Control Document (ICD), ESPDS-SE6-EXT-DOC-2.4, 09
116 January 2014.
- 117 • NOAA Administrative Order (NAO) 216-108 "Requirements Management",
118 Effective: 24 October 2005.
- 119 • NAO 212-15, Management of Environmental Data and Information, Effective: 04
120 November 2010.
- 121 • ICD with NWS defining Integrated Dissemination Program (IDP) interface to
122 NGDC [TBD].

123 1.4 REFERENCE DOCUMENTS

124 Reference Documents consist of documents that provide supporting information needed
125 to facilitate the SPADES development.

- 126 • GOES-R L2+ space weather product ATBDs that were developed under the
127 GOES-R Risk Reduction and Algorithm Readiness programs and are available
128 from the NGDC/GOES-R Systems Engineer.

129 **2 PROGRAM DEFINITION**

130 2.1 OBSERVING SYSTEM NEED

131 The primary missions of NOAA are science, service and stewardship; 1) for a weather
132 ready nation, 2) healthy oceans, 3) climate adaptation and mitigation and 4) resilient
133 coastal communities and economies. Operating the Nation's system of environmental
134 satellites is one of the major responsibilities of the NOAA National Environmental
135 Satellite, Data, and Information Service (NESDIS). NESDIS operates the satellites and
136 manages the processing and distribution of the millions of bits of data and images these
137 satellites produce daily. The primary customer is the NWS which uses satellite data to
138 create forecasts for various weather advisory services and other customers. Space
139 weather data acquired by NOAA satellites used within SWPC also shared with other
140 Federal entities such as National Aeronautics and Space Administration (NASA) and
141 the Departments of Defense, Agriculture, Interior, and Transportation and with other
142 countries under the auspices of the International Space Environmental Service (ISES)
143 and the World Meteorological Organization (WMO).

144 2.2 Geostationary Operational Environmental Satellite, Series R (GOES-R)

145 Since 1974 NOAA has monitored the sun and the in-situ geosynchronous satellite
146 environment using data acquired from its fleet of Geostationary Operational
147 Environmental Satellites (GOES). The next-generation GOES-R program consists of 4
148 spacecraft, nominally GOES-R/S/T/U, that will provide continuity for NOAA's satellite-
149 based, space weather monitoring program through 2036. The first satellite in the series
150 will launch in early FY2016. Collectively, GOES-R refers to the 4 satellites in this series.

151 2.3 GOES-R Space Weather (SWx) Sensors

152 Manifested on GOES-R is a set of space weather sensors used to monitor the sun and
153 the local space environment. The GOES-R sensors offer improvements over earlier
154 GOES sensor capabilities while maintaining consistency with the historical
155 measurement record. Each of the GOES-R spacecraft consists of the set of SWx
156 sensors discussed in sections 2.3.1 through 2.3.4.

157 2.3.1 Space Environment In-situ Sensor Suite (SEISS)

158 SEISS is comprised of five (5) sensors to monitor proton, electron, and heavy ion fluxes
159 in the geosynchronous orbit location. SEISS consists of the low-energy and high-energy
160 Magnetospheric Particle Sensors (MPS-LO and MPS-HI), two Solar and Galactic Proton
161 Sensors (SGPS), and the Energetic Heavy Ion Sensor (EHIS). Information provided by
162 SEISS is critical for determining radiation risk factors to astronauts and commercial
163 airline passengers as well as potential impacts to satellite operations and high-
164 frequency (HF) communications.

165 2.3.2 EUV and X-ray Irradiance Sensors (EXIS)

166 EXIS data are critical to monitoring incident solar x-ray and extreme ultraviolet
167 irradiance to the upper atmosphere, that is, the power and effect of the sun's
168 electromagnetic radiation per unit area. EXIS will detect solar flares that could interrupt
169 communications, reduce navigational accuracy and contribute to satellite drag.

170 2.3.3 Solar Ultraviolet Imager (SUVI)

171 SUVI is a telescope that monitors the sun in the extreme ultraviolet wavelength range.
172 By observing the sun, SUVI will be able to compile full-disk solar images around the
173 clock. It replaces the current GOES Solar X-ray Imager (SXI) instrument and represents
174 greater spectral coverage and improved spatial resolution over SXI.

175 2.3.4 Magnetometer (MAG)

176 MAG provides measurements of the local geomagnetic field within the space
177 environment that controls charged particle dynamics in the outer region of the
178 magnetosphere. These particles can be dangerous to spacecraft and human
179 spaceflight. The geomagnetic field measurements are important for providing alerts and
180 warnings to many customers, including satellite operators and power utilities. MAG
181 measurements are also essential inputs to the L2+ product, SEISS-19, Moments and
182 Spacecraft Charging. GOES magnetic data products are also important for validating
183 operational geospace models and used in research, being among the most widely used
184 spacecraft data by the national and international research communities.

185 2.4 GOES-R Space Weather Products

186 Space weather data from the GOES-R spacecraft will be used to create environmental
 187 products for NOAA operations and for other related purposes, including scientific
 188 research that often leads to improved space weather products. The set of GOES-R
 189 product levels range from Level 0 (L0) to Level 2+ (L2+) as generally defined by NASA,
 190 although within the GOES-R program the various product levels do not strictly comply
 191 with the NASA terminology. In general, the lowest level products are raw sensor data at
 192 full instrument resolution whereas higher level products correspond to sensor data
 193 records converted into more usable parameters and formats.

194 2.4.1 Level 0 (L0) *****INFORMATION ONLY*****

195

Table 2 – L1b SWx Products

196 L0 data products are reconstructed,
 197 unprocessed instrument/payload data at full
 198 resolution after removal of communications
 199 artifacts; e.g. synchronization frames,
 200 communications headers, duplicates. SWT
 201 access to GOES-R L0 data may leverage the
 202 SPADES infrastructure if it does not interfere
 203 with L2+ prototyping efforts. Any such
 204 leveraging is beyond the scope of this PP.

GOES-R Sensor	L1b Product Short Name
EXIS/EUV	EXIS-L1b-SFEU
EXIS/XRS	EXIS-L1b-SFXR
MAG	MAG-L1b-GEOF
SEISS/EHIS	SEIS-L1b-EHIS
SEISS/MPSL	SEIS-L1b-MPSL
SEISS/MPLH	SEIS-L1b-MPSH
SEISS/SGPS	SEIS-L1b-SGPS
SUVI/Fe093	SUVI-L1b-Fe093
SUVI/Fe131	SUVI-L1b-Fe131
SUVI/Fe171	SUVI-L1b-Fe171
SUVI/Fe195	SUVI-L1b-Fe195
SUVI/Fe184	SUVI-L1b-Fe284
SUVI/He303	SUVI-L1b-He303

205 2.4.2 Level 1a (L1a) ****INFORMATION
 206 ONLY*****

207 L1a data products are reconstructed,
 208 unprocessed instrument data at full resolution,
 209 time referenced and annotated with ancillary
 210 information, including radiometric and geometric
 211 calibration coefficients and geo-referencing
 212 parameters, e.g. platform ephemeris. Ancillary
 213 information is computed and appended but not
 214 applied to the L0 data. No access to GOES-R
 215 L1a products is available within SPADES.

216 2.4.3 Level 1b (L1b)

217 L1b data products are L1a data products that have been processed to sensor units. The
 218 GOES-R L1b space weather products are listed in Table 2. It is important to note that
 219 for GOES-R it is not possible to easily reverse-process all L1b products to their L1a
 220 equivalents.

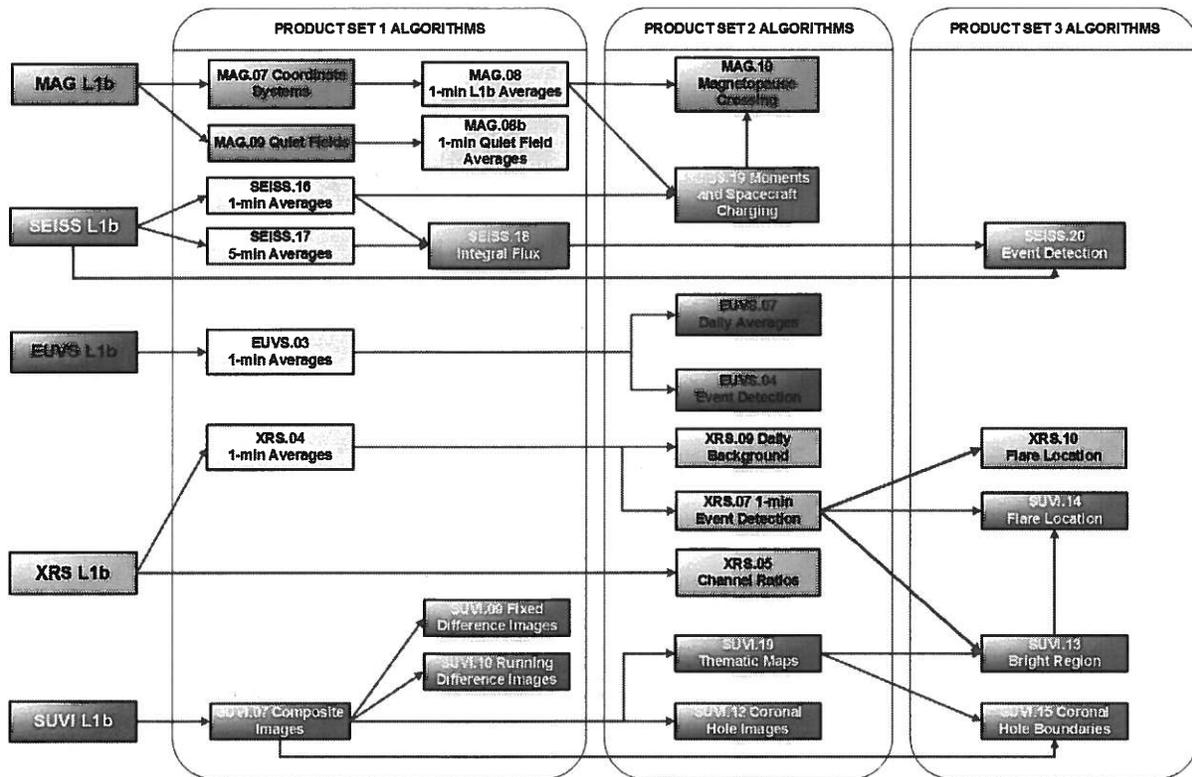
221 2.4.4 Level 2+ (L2+)

222 L2+ products are L1b data that have been processed to a higher level of utility. Within
 223 the context of this PP the GOES-R L2+ space weather products are those required by
 224 SWPC for NOAA space weather operations. The generation of L2+ products within a
 225 demonstration environment is the primary function of SPADES. The table in Section 1.2
 226 lists the 25 GOES-R L2+ space weather ATBDs developed by the SWT. Figure 1

227 provides a precedence chart for the L2+ space weather products that highlights
 228 algorithm interdependencies. Certain updates to the L2+ algorithms will be required for
 229 SPADES.

230 2.4.5 Auxiliary Data

231 Auxiliary data for SPADES are those data parameters other than the set of GOES-R
 232 L1b space weather data products (Table 2) that are produced internally by GOES-R and
 233 are required to produce the GOES-R L2+ space weather products. The set of required
 234 auxiliary data will be provided at the SPADES Preliminary Design Review (PDR).



235
 236 **Figure 1 – Precedence Chart**

237 2.4.6 Ancillary Data

238 Ancillary data is defined as any data which is not produced by GOES-R, but is acquired
 239 directly for SPADES from external providers and used within SPADES to produce the
 240 GOES-R L2+ space weather products. The set of required ancillary data will be
 241 provided at the SPADES PDR.

242 2.5 OWNERSHIP AND OVERSIGHT

243 Program Management

244 The SPADES program is managed and executed by NGDC with developmental
 245 oversight provided through the GOES-R Risk Reduction program.

246 Requirements

247 This document specifies the L1 requirements for the prototype SPADES. The L1
248 requirements are the highest level requirements from which a conceptual basis for the
249 prototype system can be formulated. Section 5 lists the specific L1 requirements
250 needed to design and develop the SPADES system although other derived
251 requirements may be included in the list of Applicable Documents in Section 1.3. The
252 Reference Materials in Section 1.4 includes additional requirements derived from each
253 of the L2+ products with regard to, for example, programming language, latency and
254 output format as specified in the associated ATBDs.

255 **3 SYSTEM CONCEPT**

256 The overarching goal of the prototype SPADES effort is to develop a prototype system
257 for producing the GOES-R L2+ space weather products with consideration given to
258 supporting the R2O transition to NWS systems. Figure 2 is a schematic of the SPADES
259 prototype. The SPADES architecture consists of the following functional segments:

- 260 • Ingest Segment (IS) – Acquires GOES-R L1b space weather products and
261 auxiliary data [TBD].
- 262 • Storage Segment (SS) – Provides for local storage of GOES-R L1b space
263 weather products and auxiliary data [TBD].
- 264 • Processing Segment (PS) – Responsible for processing all L2+ space
265 weather algorithms and for acquiring ancillary data [TBD]
- 266 • Controller Segment (CS) – Provides for automatic algorithm queuing and
267 system monitoring.
- 268 • Monitor Segment (MS) – Monitors critical functions and provides alerts for
269 non-standard operations.
- 270 • Visualization Segment (VS) – Provides visualization capabilities for all L1b
271 and L2+ space weather products.

272 3.1 System Access

273 The following describes the system access provided to various users of SPADES aside
274 from system administrators and authorized information technology (IT) staff.

275 3.1.1 Internal Authorized Users

276 Internal authorized users are those users operating entirely within the SPADES
277 environment. Internal authorized users are typically members of the SWT directly
278 involved with implementing L2+ algorithms within the SPADES. Access to SPADES is
279 subject to standard login protocols.

280 3.1.2 External Authorized Users

281 External authorized users are those users requiring access to the GOES-R L1b
282 products. External authorized users are typically members of the SWT needing access
283 to L1b space weather products for offline instrument calibration/validation and sensor

284 performance monitoring/maintenance. An external authorized user will typically require
 285 a password to access L1b products and auxiliary data.

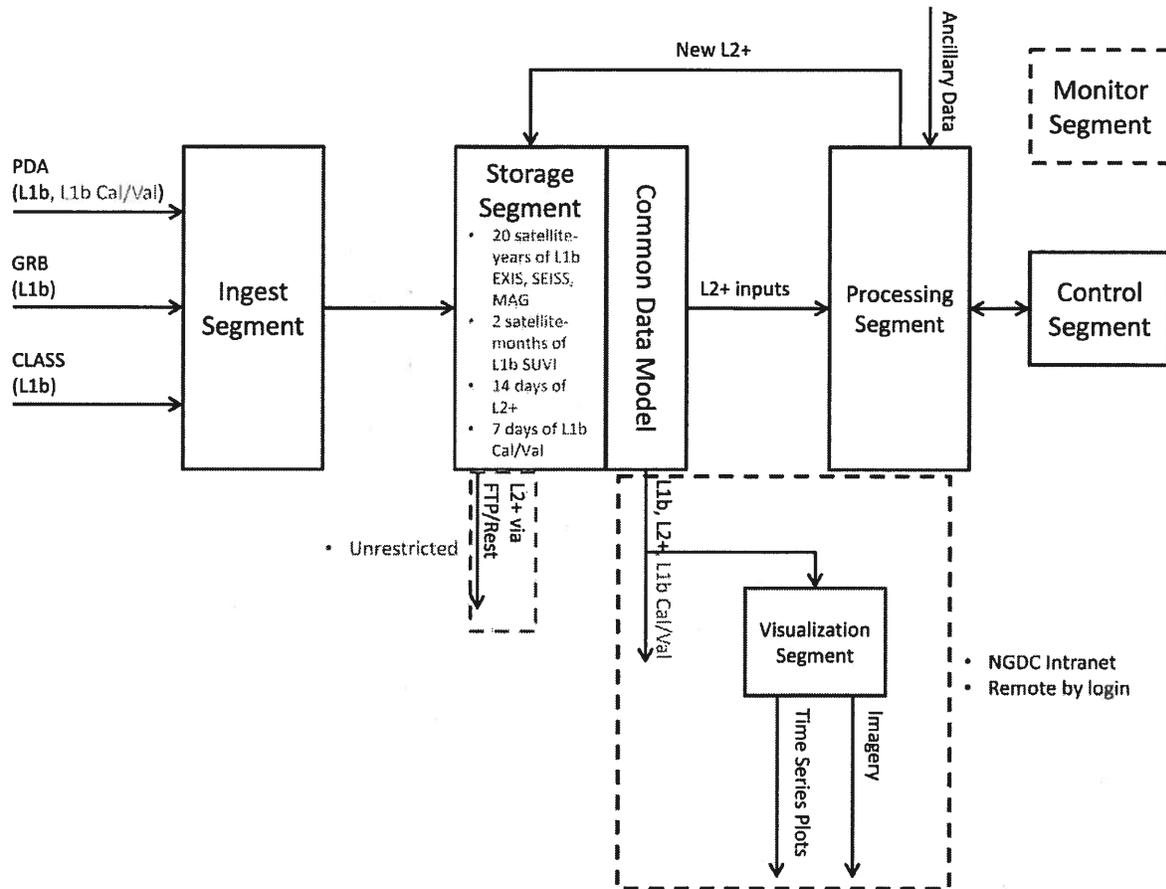


Figure 2 – SPADES Functional Architecture

286 3.1.3 Constituents

287 Constituents are those users requiring access to GOES-R L2+ space weather products.
 288 Examples of constituents include space weather operators and scientists within the
 289 NWS/SWPC and engineering staff from the Office of Satellite and Product Operations
 290 (OSPO). Constituents will not require passwords for access to L2+ products.

291 3.2 Data Access

292 The following describes the various data access channels for GOES-R L1b space
 293 weather products and auxiliary data required by SPADES.

294 3.2.1 Product Analysis and Distribution (PDA)

295 PDA is an internet-based channel providing near real-time access to GOES-R L1b
 296 space weather products and auxiliary data. PDA data is available to authorized users
 297 having internet access. PDA is part of the NESDIS Environmental Satellite Processing
 298 and Distribution System (ESPDS) development effort.

299 3.2.2 GOES-R ReBroadcast (GRB)

300 GRB is a direct broadcast channel providing real-time access to GOES-R L1b space
301 weather products and auxiliary data. The NWS manages the antenna and software
302 capable of receiving the GOES direct broadcast downlink in Boulder, CO. The NWS
303 GRB channel will be leveraged for SPADES.

304 3.2.3 Comprehensive Large Array-data Stewardship System

305 CLASS is NOAA's official archive for GOES-R retrospective L1b space weather
306 products and auxiliary data. SPADES access to CLASS is subscription based. NGDC
307 manages the Boulder CLASS.

308 3.2.4 Level 0 Storage System (LZSS) *****INFORMATION ONLY*****

309 The LZSS is a service provided by GOES-R to ensure that authorized users have
310 access to GOES-R L0 products. Beyond the scope of this PP, SPADES may be
311 leveraged to access GOES-R L0 data in support of L1b and L2+ product calibration and
312 validation if doing so does not interfere with L2+ algorithm prototyping.

313 3.3 System Developmental Phases

314 This section describes the various SPADES developmental phases.

315 3.3.1 Concept Definition Phase

316 The concept development phase includes development of a PP that is reviewed and
317 accepted by the SPADES developmental team. A preliminary set of Level 2
318 requirements will exist at the end of the concept development phase.

319 3.3.2 Preliminary Design Phase

320 At the completion of the preliminary design phase all SPADES segments will be
321 functionally defined and the intra-segment interfaces well specified. The final Level 2
322 requirements will be approved and a preliminary set of Level 3 will be in draft form. An
323 Interface Control Document (ICD) exists in draft form specifying all external interfaces
324 for SPADES. A high-level architecture for SPADES exists.

325 3.3.3 Critical Design Phase

326 At the completion of the critical design phase SPADES is sufficiently designed to allow
327 for initial build and roll-out. Level 3 requirements are approved. The SPADES ICD is in
328 final form with all TBDs/TBRs closed.

329 3.3.4 Initial Operational Capability (IOC)

330 IOC represents the initial release of SPADES. Near real-time GOES-R L1b data are
331 acquired from the Product Distribution and Access (PDA) system, and the subset of the
332 L2+ space weather products specified in Table 1 are available for provisional use by
333 constituents.

334 3.3.5 Final Operational Capability (FOC)

335 FOC represents the final release of SPADES. Real-time L1b data are acquired from the
336 GOES ReBroadcast (GRB) system and from CLASS. Access to the final L2+ space
337 weather products is provided to constituents.

338 **4 SUCCESS CRITERIA**

339 System success for the prototype SPADES development requires meeting or exceeding
340 the following criteria:

- 341 Acquiring GOES-R L1b space weather products and auxiliary data from PDA.
- 342 Acquiring GOES-R L1b space weather products and auxiliary data from GRB.
- 343 Acquiring GOES-R L1b space weather products and auxiliary data from CLASS.
- 344 Producing the set of GOES-R L2+ space weather products listed in Table 1.
- 345 Providing GOES-R L2+ space weather products to constituents.

346 **5 PERFORMANCE REQUIREMENTS**

347 5.1 Level 1 Requirements

348 L1-SPADES-100 SPADES shall be developed as a real-time demonstration system
349 for GOES-R L2+ product generation and dissemination.

350 L1-SPADES-110 SPADES shall have a design mission lifetime of 20 years.

351 L1-SPADES-120 SPADES shall have a System Availability of greater than or equal
352 to 98% over any 30-day period for the mission lifetime.

353 L1-SPADES-130 SPADES hardware and system software elements (operating
354 system and software languages) shall be Commercial Off-The-Shelf (COTS).

355 L1-SPADES-140 SPADES shall be built in a modular fashion consisting of the
356 following functional segments; Ingest Segment (IS), Storage Segment (SS), Processing
357 Segment (PS), Control Segment (CS) and Visualization Segment(VS).

358 **6 PROGRAM MANAGEMENT**

359 6.1 Program Management

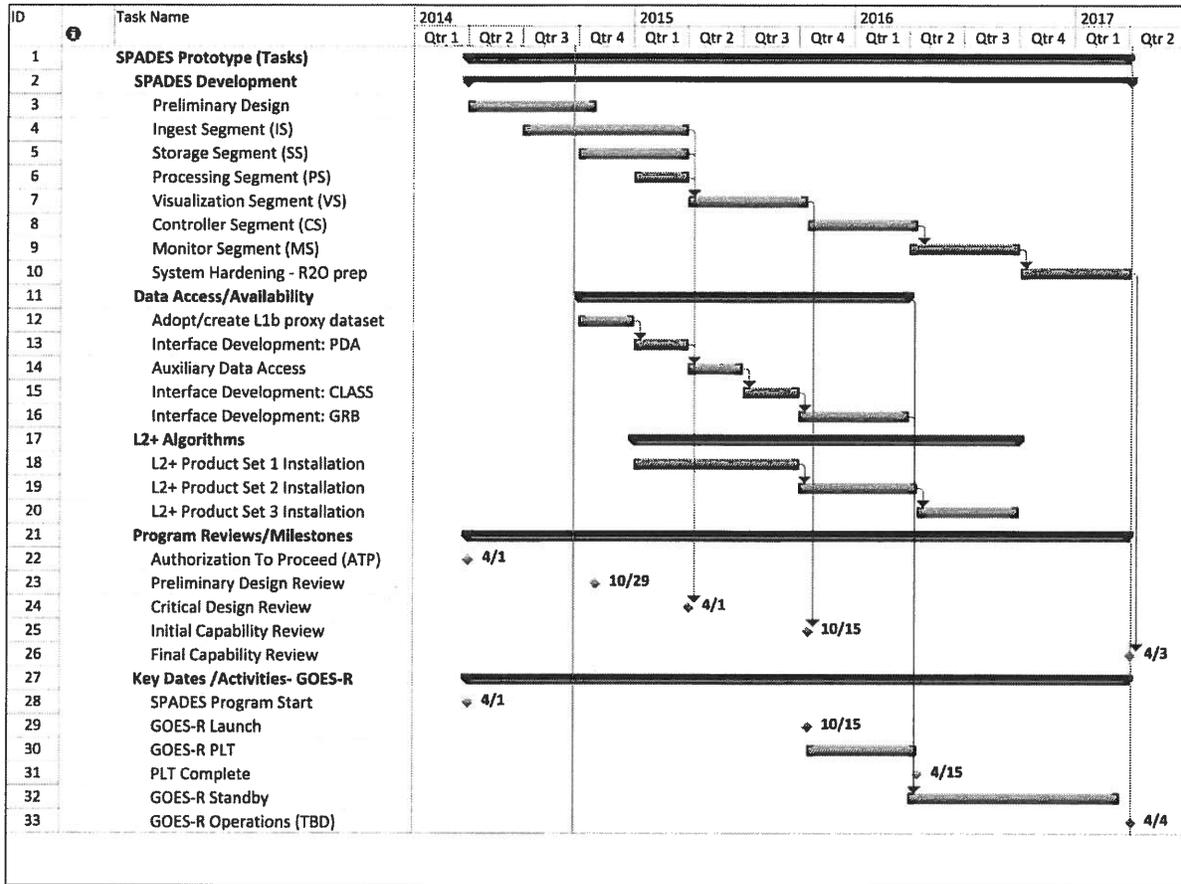
360 The SPADES prototype project shall be managed by NGDC with oversight provided by
361 the GOES-R Risk Reduction program. Participation by members of the NWS and OSPO
362 is highly encouraged.

363 **7 BUDGET AND SCHEDULE**

364 7.1 Budget

365 The prototype SPADES program is being developed using funds provided via the
366 GOES-R Risk Reduction program. Costs for development of SPADES is capped at
367 \$1.525 M in accordance with an investment schedule of \$625K in Year 1, \$650K in Year
368 2 and 250K in year 3. The period of performance is 01 Apr 14 to 31 Mar 17.

369 7.2 Schedule



370

371 **Figure 3 – Schedule**

APPENDICES

372

373 A. ACRONYMS

374	ATBD	Algorithm Theoretical Basis Document
375	CI	Common Ingest
376	CIRES	Cooperative Institute for Research in Environmental Sciences
377	CLASS	Comprehensive Large Array-data Stewardship System
378	COTS	Commercial Off The Shelf
379	CDR	Critical Design Review
380	CS	Control Segment
381	DOC	U.S. Department of Commerce
382	DoD	Department of Defense
383	DS	Distribution Segment
384	EHIS	Energetic Heavy Ion Sensor
385	ESPDS	Environmental Satellite Processing and Distribution System
386	EUV	Extreme UltraViolet (sensor)
387	EXIS	EUV and X-ray Irradiance Sensors
388	Fe	Iron (Chemical Symbol)
389	FITS	Flexible Image Transport System
390	FOC	Final Operational Capability
391	FY	Fiscal Year
392	GOES	Geostationary Operational Environmental Satellite
393	GOES-R	Geostationary Operational Environmental Satellite, Series R
394	GRB	GOES ReBroadcast
395	He	Helium (Chemical Symbol)
396	HF	High Frequency
397	ICD	Interface Control Document
398	IDP	Integrated Dissemination Program
399	IOC	Initial Operational Capability
400	ISES	International Space Environmental Service
401	IS	Ingest Segment
402	IT	Information Technology
403	L0	Level 0 (data product level)
404	L1	Level 1 (requirement designation)

405	L1a	Level 1a (data product level)
406	L1b	Level 1b (data product level)
407	L2	Level 2 (requirements designation)
408	L2+	Level 2 Plus (data product level)
409	LZSS	Level 0 Storage System
410	MAG	Magnetometer
411	MOU	Memorandum of Understanding
412	MPSL	Magnetospheric Particle Sensor Low
413	MPSH	Magnetospheric Particle Sensor High
414	NAO	NOAA Administrative Order
415	NASA	National Aeronautics and Space Administration
416	NetCDF	Network Common Data Form
417	NGDC	National Geophysical Data Center
418	NESDIS	National Environmental Satellite, Data, and Information Service
419	NOAA	National Oceanic and Atmospheric Administration
420	NWS	National Weather Service
421	O&M	Operations and Maintenance
422	OSPO	Office of Satellite and Product Operations
423	PDA	Product Distribution and Access
424	PDR	Preliminary Design Review
425	PLT	Post Launch Testing
426	PP	Program Plan
427	PS	Processing Segment
428	PUG	Payload Users Guide
429	R2O	Research To Operations
430	SC	Storage Segment
431	SEISS	Space Environment In-Situ Suite
432	SGPS	Solar and Galactic Particle Sensor
433	SPADES	Satellite Product Analysis and Distribution Enterprise System
434	SS	Storage Segment
435	SUVI	Solar UltraViolet Imager
436	SWPC	Space Weather Prediction Center
437	SWT	Space Weather Team

438	SWx	Space Weather
439	SXI	Solar X-ray Imager
440	TBD	To Be Determined
441	USAF	United States Air Force
442	VS	Visualization Segment
443	WMO	World Meteorological Organization
444	XRS	X-Ray Sensor