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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force **Date:** February 2020

Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 5: System Development & Demonstration (SDD)</i>	R-1 Program Element (Number/Name) PE 0604201F / <i>PNT Resiliency, Mods, and Improvements</i>
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COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
Total Program Element	-	45.363	142.782	38.564	0.000	38.564	50.923	10.980	0.000	0.000	0.000	288.612
651030: <i>GPS Receiver Development</i>	-	45.363	142.782	38.564	0.000	38.564	50.923	10.980	0.000	0.000	0.000	288.612
Quantity of RDT&E Articles	-	-	-	-	-	-	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

Positioning, Navigation and Timing (PNT) solutions are critical to defense operations, enabling delivery of precision fires, safe aerial navigation, and time coordination across multiple platforms and subsystems. PNT must be maintained in the face of emerging and continuously evolving electronic and cyber threats, requiring increased system resiliency and rapid adaptability similar to that historically required of electronic warfare systems. Evolving threats will drive upgrades such as Global Positioning System (GPS) receiver modernization, development of standard navigational system formats/interfaces, increased use of open system architecture design principles, incorporation of alternative navigation sources into navigational solutions, advanced anti-jam antennas, antenna electronics, radio frequency monitoring/locating/reporting capabilities, and precision clock improvements to maintain current and future force capabilities.

Project 651030 includes Embedded GPS/Inertial Navigation System (INS) Modernized (EGI-M), Miniaturized Airborne GPS Receiver 2000 Modernization (MAGR-2K-M), Resilient EGI (R-EGI) development, anti-jam antenna/antenna electronics development, situational awareness devices and other advanced/non-GPS PNT solutions. Activities also include, but are not limited to, current program planning, rapid prototyping/concept development, execution and future program planning and support to other GPS enabled systems as required. The PNT Resiliency, Mods, and Improvements (RMI) effort provides rapidly reprogrammable application space for Alternate Satellite Navigation Systems User Equipment (UE), enabling agile and resilient response to GPS threat environments. Funds may be used to address emerging and short-notice Diminishing Manufacturing Sources and Material Shortage (DMSMS) issues.

The FY 2021 funding request was reduced by \$6.364M to account for the availability of prior year execution balances.

This requirement supports performance of a full financial audit as required by title 10 U.S.C. Chapter 9A, Sec 240-D.

This program element may include necessary civilian pay expenses required to manage, execute, and deliver GPS receiver development capabilities. The use of such program funds would be in addition to the civilian pay expenses budgeted in program element 0605831F.

This program is in Budget Activity 5, System Development and Demonstration (SDD) because it has passed Milestone B approval and is conducting engineering and manufacturing development tasks aimed at meeting validated requirements prior to full rate production.

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B. Program Change Summary (\$ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Previous President's Budget	46.731	67.782	45.000	0.000	45.000
Current President's Budget	45.363	142.782	38.564	0.000	38.564
Total Adjustments	-1.368	75.000	-6.436	0.000	-6.436
• Congressional General Reductions	0.000	0.000			
• Congressional Directed Reductions	0.000	0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	0.000	75.000			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	0.000	0.000			
• SBIR/STTR Transfer	-1.368	0.000			
• Other Adjustments	0.000	0.000	-6.436	0.000	-6.436

Congressional Add Details (\$ in Millions, and Includes General Reductions)

Project: 651030: *GPS Receiver Development*

Congressional Add: *Program Increase - Embedded GPS/INS - Modernized (EGI-M)*

Congressional Add Subtotals for Project: 651030

Congressional Add Totals for all Projects

	FY 2019	FY 2020
	-	75.000
	-	75.000
	-	75.000

Change Summary Explanation

In FY 2019, decrease of \$1.368M for SBIR.

In FY 2020, Congressional Add for Unfunded requirement

In FY 2021, decrease of \$6.364M to account for the availability of prior year execution balances and decrease of \$0.072M for inflation adjustments.

C. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021
Title: Embedded GPS/INS - Modernized (EGI-M)	44.691	15.282	0.000
Description: EGI-M is a combined INS/GPS aircraft position, navigation, and timing system. Program upgrades EGI design to enhance resiliency against existing and emerging navigational warfare threats, incorporating design features (such as interface standardization and software modularity) to incorporate alternative navigation and timing sources, where cost effective, to reduce DoD cost and time lines to respond to newly identified threats and maintain current force capabilities. Incorporates M-Code and Automatic Dependent Surveillance-Broadcast (ADS-B) compliance capability into EGI receivers while addressing parts obsolescence, reducing configuration count from 260+ to a desired end-state of 16, and decreasing production and sustainment costs.			

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C. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021
<p>FY 2020 Plans: Finalize baseline requirements for initial platforms in order to develop Prime Item Development Specification (PIDS) and Interface Control Document (ICD). Receive qualification test procedures approval to begin test & evaluation (T&E). Complete Critical Design Review (CDR) and begin the production engineering development models (EDM).</p> <p>FY 2021 Plans: N/A</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: Funding decreased in conjunction with planned receiver development activities for all systems.</p>				
<p>Title: Miniaturized Airborne GPS Receiver 2000 - Modernized (MAGR-2K-M)</p> <p>Description: MAGR-2K-M is an aircraft GPS receiver. Program increases MAGR-2K-Legacy resiliency against existing and emerging navigational warfare threats while reducing cost and time lines to incorporate agile capabilities to respond to newly identified threats. Incorporates M-Code capability into MAGR-2K-Legacy receivers while addressing parts obsolescence and providing a pathway to ADS-B Out implementation. Performs appropriate trade studies and incorporates additional resiliency features, such as alternate navigation inputs, where cost effective. The Air Force and the Navy are the primary users of the MAGR-2K-M system.</p> <p>FY 2020 Plans: Complete full qualification testing, Production Readiness Unit (PRU) integration and flight test support. Conduct anomaly resolution.</p> <p>FY 2021 Plans: N/A</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: Funding decreased in conjunction with planned receiver development activities for all systems.</p>		0.521	1.000	0.000
<p>Title: PNT Resiliency, Mods, and Improvements (RMI)</p> <p>Description: Conduct studies and analysis of PNT systems and requirements, develop and evaluate alternative courses of action, identify, plan and conduct PNT technology transition projects, conduct prototype and acquisition program planning, and provide recommended solutions to DoD and Air Force decision makers relative to navigation warfare threat evolution and technology emergence. This includes work for more flexible Secure Software Defined Receiver User Equipment to capture other than GPS signals like Multi-Global Navigation Satellite Systems to include Navigation Technology Satellite-III.</p>		0.121	0.500	0.000

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C. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021
<p>FY 2020 Plans: Develop M-code prototypes</p> <p>FY 2021 Plans: N/A</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: Funding decreased in conjunction with planned development activities for all systems.</p>				
<p>Title: Resilient EGI (R-EGI)</p> <p>Description: Establishes a Government Reference Architecture (GRA) embodying open systems architecture concepts, enabling and accelerating the transition of future resilient PNT DoD systems. Enables design and development of various aircraft PNT Line Replaceable Units (LRUs) that are rapidly upgradeable to counter evolving threats. Demonstrates the GRA through prototyping of an open R-EGI LRU. Program matures, prototypes, and tests promising PNT technologies/systems and develops transition paths to flow new technologies into new and/or existing PNT systems. Provides improved PNT resiliency to counter navigational warfare threats through the design, development, test, and transition of science and technology efforts to PNT systems.</p> <p>FY 2020 Plans: Continue the R-EGI LRU prototyping effort, fabricating, and testing initial proof-of-concept prototypes and beginning design on functional demonstration prototypes. Continue development of hardware standards and software navigation protocols, aircraft data/communication networking protocols and advanced receiver designs. Continue to mature resilient hardware and software technologies into new and/or existing PNT systems.</p> <p>FY 2021 Plans: Converge Phase I R-EGI LRU prototypes into Phase II R-EGI LRU "Best of Breed" prototypes while refining fabrication, testing, and design on functional demonstration prototypes. Continue development of hardware standards and software navigation protocols, aircraft data/communication networking protocols and advanced receiver designs. Continue to mature resilient hardware and software technologies into new and/or existing PNT systems.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: Funding decreased due to the transition between phases of the R-EGI LRU prototyping effort and associated contractual implementations.</p>		0.030	51.000	38.564
Accomplishments/Planned Programs Subtotals		45.363	67.782	38.564

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	FY 2019	FY 2020
Congressional Add: Program Increase - Embedded GPS/INS - Modernized (EGI-M)	-	75.000
FY 2020 Plans: EGI-M development, testing, and production engineering development models (EDM).		
Congressional Adds Subtotals	-	75.000

D. Other Program Funding Summary (\$ in Millions)

N/A

Remarks

E. Acquisition Strategy

Modify and modernize existing legacy PNT systems to incorporate major enhancements such as GPS M-Code, ADS-B out, and alternative PNT solutions to GPS while reducing lifecycle costs through common sustainment practices and economies of scale. Design, development, and testing efforts, to include the development of government owned reference architectures for rapid capability insertion, share a common PE to allow flexibility in funding and planning. Integration and operational testing of completed PNT solutions are accomplished by individual platforms and weapons systems. This approach uses a combination of cost-plus and fixed-price contract types based on acquisition phase and risk with a mix between competition and sole-source strategies. Modifications to legacy receivers are acquired via Engineering Change Proposals (ECP)/Task Orders on existing contracts. Other Transaction Authorities (OTA) and industry consortiums are used to support prototyping and open standards development for new PNT solutions.

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Exhibit R-3, RDT&E Project Cost Analysis: PB 2021 Air Force **Date:** February 2020

Appropriation/Budget Activity 3600 / 5	R-1 Program Element (Number/Name) PE 0604201F / PNT Resiliency, Mods, and Improvements	Project (Number/Name) 651030 / GPS Receiver Development
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Product Development (\$ in Millions)				FY 2019		FY 2020		FY 2021 Base		FY 2021 OCO		FY 2021 Total	Cost To Complete	Total Cost	Target Value of Contract
Cost Category Item	Contract Method & Type	Performing Activity & Location	Prior Years	Cost	Award Date	Cost	Award Date	Cost	Award Date	Cost	Award Date	Cost			
EGI-M #1 EMD	C/CPAF	Honeywell : Clearwater, FL	-	-		34.976	Apr 2020	-		-		-	Continuing	Continuing	-
EGI-M #2 EMD	SS/CPFF	Northrop Grumman : Woodland Hills, CA	-	40.276	Nov 2018	38.732	Mar 2020	-		-		-	Continuing	Continuing	-
MAGR-2K-M	SS/CPFF	Raytheon : El Segundo, CA	-	0.000	May 2019	1.000	Jul 2020	-		-		-	Continuing	Continuing	-
PNT RMI	SS/CPFF	Collins Aerospace : Des Moines, IA	-	0.121	Jul 2019	0.500	Oct 2019	-		-		-	Continuing	Continuing	-
R-EGI	C/CPFF	IS4S : Huntsville, AL	-	0.000	May 2019	51.000	Oct 2019	35.383	Oct 2020	-		35.383	Continuing	Continuing	-
Subtotal			-	40.397		126.208		35.383		-		35.383	Continuing	Continuing	N/A

Support (\$ in Millions)				FY 2019		FY 2020		FY 2021 Base		FY 2021 OCO		FY 2021 Total	Cost To Complete	Total Cost	Target Value of Contract
Cost Category Item	Contract Method & Type	Performing Activity & Location	Prior Years	Cost	Award Date	Cost	Award Date	Cost	Award Date	Cost	Award Date	Cost			
EGI-M FFRDC	Various	MITRE Corp. : Bedford, MA	-	1.142	Oct 2018	0.263	Oct 2019	-		-		-	Continuing	Continuing	-
R-EGI FFRDC	Various	MITRE Corp. : Bedford, MA	-	-		1.663	Oct 2019	1.925	Oct 2020	-		1.925	Continuing	Continuing	-
EGI-M Lab	PO	Integrated Spt Facility : GA	-	-		-		-		-		-	Continuing	Continuing	-
Subtotal			-	1.142		1.926		1.925		-		1.925	Continuing	Continuing	N/A

Test and Evaluation (\$ in Millions)				FY 2019		FY 2020		FY 2021 Base		FY 2021 OCO		FY 2021 Total	Cost To Complete	Total Cost	Target Value of Contract
Cost Category Item	Contract Method & Type	Performing Activity & Location	Prior Years	Cost	Award Date	Cost	Award Date	Cost	Award Date	Cost	Award Date	Cost			
EGI-M	PO	Various : TBD	-	0.000	Mar 2019	0.500	Oct 2019	-		-		-	Continuing	Continuing	-
MAGR-2K-M	PO	Various : TBD	-	0.000	Mar 2019	0.400	Oct 2019	-		-		-	Continuing	Continuing	-
R-EGI	PO	Various : TBD	-	0.030		0.030	Oct 2019	0.500	Oct 2020	-		0.500	Continuing	Continuing	-

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Exhibit R-4A, RDT&E Schedule Details: PB 2021 Air Force		Date: February 2020
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Schedule Details

Events by Sub Project	Start		End	
	Quarter	Year	Quarter	Year
<i>PNT</i>				
EGI-M #1 EMD (NGC)	1	2019	1	2021
EGI-M #2 EMD (HI)	2	2020	1	2021
MAGR-2K-M EMD	1	2019	4	2020
MAGR-2K-M Testing	1	2019	4	2020
R-EGI Prototyping	4	2019	4	2023