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

Appropriation/Budget Activity 1319: <i>Research, Development, Test & Evaluation, Navy / BA 4: Advanced Component Development & Prototypes (ACD&P)</i>	R-1 Program Element (Number/Name) PE 0603207N / <i>Air/Ocean Tactical Applications</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	475.167	29.136	43.043	35.386	-	35.386	36.716	37.445	37.885	38.650	Continuing	Continuing
2341: <i>METOC Data Acquisition</i>	177.319	3.338	7.062	6.131	-	6.131	6.192	7.874	8.034	8.197	Continuing	Continuing
2342: <i>METOC Data Assimilation and Mod</i>	272.165	17.301	21.168	22.371	-	22.371	22.400	22.025	22.463	22.913	Continuing	Continuing
2344: <i>Precise Time and Astrometry</i>	20.525	4.381	2.467	2.466	-	2.466	3.628	3.345	3.102	3.168	Continuing	Continuing
2363: <i>Remote Sensing Capability Development</i>	1.886	0.312	0.327	0.328	-	0.328	0.328	0.000	0.000	0.000	0.000	3.181
3207: <i>Fleet Synthetic Training</i>	2.642	0.256	0.283	0.305	-	0.305	0.326	0.332	0.339	0.346	Continuing	Continuing
3404: <i>Tactical Environmental Support</i>	0.315	2.496	2.619	2.641	-	2.641	2.671	2.683	2.737	2.792	Continuing	Continuing
3405: <i>Decision Support Products & Dissemination</i>	0.315	1.052	1.117	1.144	-	1.144	1.171	1.186	1.210	1.234	Continuing	Continuing
9999: <i>Congressional Adds</i>	0.000	0.000	8.000	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	8.000

A. Mission Description and Budget Item Justification

Understanding and accurately predicting the maritime environment is a naval warfighting advantage. Effective meteorological and oceanographic modeling depends upon a network of advanced, reliable sensors below, on and above the world's oceans. Combined with state-of-the-art computational infrastructure, the Navy-Marine Corps Meteorological and Oceanographic (METOC) team delivers 24/7 observations, precise forecasts and operational recommendation to commanders. The Air Tactical Applications (AOTA) Program Element (PE) is aligned with the Navy's maritime strategy to enhance future METOC mission capabilities supporting naval warfighters worldwide. New state-of-the art government and commercial technologies are identified, transitioned, demonstrated and then integrated into Combat Systems and programs of record to provide capabilities that provide real-time and near-real-time operational effects of the physical environment on the performance of combat forces and their new and emerging platforms, sensors, systems and munitions. The AOTA program element focuses on sensing and characterizing and predicting the littoral and deep-strike battlespace in the context of regional conflicts and crisis response scenarios.

Projects in this PE transition state-of-the art sensing, assimilation, modeling and decision aid technologies from government and commercial sources. Unique project development efforts include atmospheric and oceanographic data assimilation techniques, forecast models, data base management systems and associated software for use in mainframe, desktop and laptop computers. Model data, products and services can be used by forward-deployed personnel or in a reach-back mode to optimize sensor placement and force allocation decisions. Global Geospatial Information and Services efforts within this program address the bathymetric needs of the Navy. Also developed are algorithms to process new satellite sensor data for integration into Navy and Marine Corps decision support systems and for display as part of the common operational and tactical pictures. In addition, the projects provide for demonstration and validation of specialized atmospheric and oceanographic

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instrumentation and measurement techniques, new sensors, communications and interfaces. Included are new capabilities to assess, predict and enhance the performance of current and emerging undersea warfare and mine warfare weapons systems. AOTA capabilities are designed to support the latest versions of the Global Command and Control System and specific unit-level combat systems. This PE develops technological upgrades for the U.S. Naval Observatory's Master Clock system to meet requirements of Department of Defense communications, cryptographic, intelligence, geolocation, and targeting systems; develops near-real-time earth orientation predictions; develops very precise determination of positions of both faint and bright stars; and supports satellite tracking and space debris studies.

Major emphasis areas include the Naval Integrated Tactical Environmental System Next Generation (NITES-Next) and the METOC Data Acquisition, the METOC Data Assimilation & Modeling, the Precise Timing and Astrometry, the Fleet Synthetic Training, the Tactical Environmental Support, Decision Support Products & Dissemination, the Earth System Prediction Capability projects, and the Remote Sensing Capability Development.

Advanced Component Development and Prototypes (ACD&P) efforts necessary to evaluate integrated technologies, representative modes or prototype systems in a high fidelity and realistic operating environment are funded in this PE. Most of the work in this PE can be classified between Technology Readiness Level (TRL) 6 (system/subsystem model or prototype demonstration in a relevant environment) and TRL 7 (system prototype demonstration in an operational environment).

Due to the number of efforts in this PE, the programs described herein are representative of the work included in this PE.

B. Program Change Summary (\$ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Previous President's Budget	29.747	32.643	36.157	-	36.157
Current President's Budget	29.136	43.043	35.386	-	35.386
Total Adjustments	-0.611	10.400	-0.771	-	-0.771
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	8.000			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-0.611	0.000			
• Program Adjustments	0.000	2.400	-0.777	-	-0.777
• Rate/Misc Adjustments	0.000	0.000	0.006	-	0.006

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

Project: 9999: *Congressional Adds*

Congressional Add: *Long duration autonomous hydrographic survey*

Congressional Add Subtotals for Project: 9999

	FY 2019	FY 2020
	0.000	8.000
	0.000	8.000

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

	FY 2019	FY 2020
Congressional Add Totals for all Projects	0.000	8.000

Change Summary Explanation

The FY 2021 funding request was reduced by \$0.777 million to account for the availability of prior year execution balances.

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy										Date: February 2020		
Appropriation/Budget Activity 1319 / 4					R-1 Program Element (Number/Name) PE 0603207N / <i>Air/Ocean Tactical Applications</i>				Project (Number/Name) 2341 / <i>METOC Data Acquisition</i>			
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
2341: <i>METOC Data Acquisition</i>	177.319	3.338	7.062	6.131	-	6.131	6.192	7.874	8.034	8.197	Continuing	Continuing
Quantity of RDT&E Articles		-	-	-	-	-	-	-	-	-		

A. Mission Description and Budget Item Justification

The major work of the Meteorology and Oceanography (METOC) Data Acquisition Project is to provide future mission capabilities to warfighters allowing them to detect and monitor the conditions of the physical environment throughout the entire battlespace. The most promising new sensor technologies (including unmanned vehicles, tactical sensor exploitation, in-situ sensors) are transitioned from the government's and commercial industry's technology base. These new sensor technologies are demonstrated, validated and integrated into operational programs for warfighters. These new sensor capabilities provide timely and accurate METOC data to operational and tactical commanders. METOC data requirements have evolved with emphasis on naval warfare shifting to littoral and deep strike battlespace. The need to accurately characterize dynamic conditions are crucial in planning and executing warfare operations and effectively allocating force weapon and sensor systems. Routinely available data sources, such as climatology, oceanographic and meteorological numerical models are necessary but not sufficient to support the littoral and deep strike regions. Operational sensors are deployed great distances from the target area of interest. The challenge is to collect and disseminate METOC data in variable and dynamic littoral environmental conditions or in denied, remote or inaccessible areas over extended periods of time.

This project: 1) provides the means to rapidly and automatically acquire a broad array of METOC data using off-board and on-board sensors; 2) provides an on-scene assessment capability for the tactical commander; 3) provides the tactical commander with real-time METOC data and products for operational use; 4) demonstrates and validates the use of tactical workstations and desktop computers for processing and display of METOC data and products; 5) demonstrates and validates techniques which employ data compression, connectivity and interface technologies to obtain, store, process, distribute and display these METOC data and products; 6) develops new charting and bathymetric survey techniques necessary to reduce hazards to navigation and improve forecast skill.

B. Accomplishments/Planned Programs (\$ in Millions, Article Quantities in Each)

	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Title: Meteorological and Oceanographic (METOC) Data Acquisition	3.338	7.062	6.131	0.000	6.131
Articles:	-	-	-	-	-
Description: Efforts falling within the Meteorology and Oceanography (METOC) Collections Project provide future scientific and technological warfighting capabilities that detect and continuously monitor environmental (atmospheric, sea surface, oceanographic and seabed) conditions throughout the battlespace. The Navy's mission continues to require focus on blue-water operations, littoral and deep-strike (inland) battlespaces. Each of these operating areas (and the transitions between them) has its own dynamic and complex environmental characteristics and behaviors that require modifying METOC Collections and associated sensing strategies and methodologies. Without reliable characterization of ocean and atmosphere in these operating areas, the Navy risks ineffective allocation and employment of warfighters and weapon systems, and the sensors that					

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Appropriation/Budget Activity 1319 / 4	R-1 Program Element (Number/Name) PE 0603207N / <i>Air/Ocean Tactical Applications</i>	Project (Number/Name) 2341 / <i>METOC Data Acquisition</i>

B. Accomplishments/Planned Programs (\$ in Millions, Article Quantities in Each)

	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
<p>fully enable them. Fleet Naval METOC has updated the definition and structure of the METOC program along the lines of operational mission needs. This update focuses on the operational characteristics of Tasking, Collection, Processing, Exploitation, and Dissemination (TCPED) of METOC data and information. Identified efforts supporting METOC are realigned to projects and activities that align to the TCPED updated program structure.</p> <p>FY 2020 Plans: Continue with implementing a "rapid innovation" weather-ocean capability that emphasizes observing systems.</p> <p>Continue assimilating satellite optical data streams into the Coupled Ocean-Atmosphere Mesoscale Prediction System ocean model component.</p> <p>The effort will also focus on each category as described below:</p> <p>Forward-based Navy coupled ocean data assimilation (NCODA). Emphasize Compression Integration, Integration of NCODA-Forward processing and algorithms, Modifications to bathythermograph (BT) Manager, integration of the BT-SSP (sound speed profile) and BT Manager modules, New Data Visualization.</p> <p>Develop automated mission planning and route selection aids in support of TRITON MQ-4C hazardous weather avoidance (Priority T-1a). Weather variables will include probability of icing, turbulence, thunderstorms, and cross-winds at air base for both takeoff and landing. Increases automation of Aerographers Mate (AG) mission planning, route selection, and weather briefing materials that will improve C2 and vehicle autonomy with greater platform-to-operator (AG) ratio, and automated planning (Priority T-1b). Improves platform-to-operator ratio supports guidance that many METOC billets supporting TRITON will not be renewed in FY 2019.</p> <p>Towed Array Ballasting System Construct prototype and integrate onto operational platform. Acoustic Towed Array Miniaturization Construct "build 2, 45mm footprint" into three prototype arrays with 3-different node spacings. Signal Processing Fully implement R-Theta algorithm. Remote Sea-Test Demonstrate technology in ONR-sponsored West Pacific sea-test.</p> <p>The capability delivered will be to provide operational high-resolution satellite visible/infrared (Vis/IR) and passive microwave (PMW) sea ice concentration retrievals for improved sea ice forecasts and safe navigation</p>					

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B. Accomplishments/Planned Programs (\$ in Millions, Article Quantities in Each)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
<p>in the Arctic. Users will be sea ice forecasters and personnel operating in the ice environment either surface or subsurface.</p> <p>The utility of SPIRE ionospheric data for modeling the ionosphere was evaluated in two parts split across fiscal year FY18 and FY19. In part 2 (FY19), a representative sample of SPIRE data (which includes at a minimum two contiguous days of data) acquired and ingested into an ionospheric data assimilative model. The performance of the model runs with SPIRE data will be compared to the performance of model runs without SPIRE data to demonstrate the overall impact of the data. Since it is anticipated that the volume of SPIRE data will grow substantially, the impact of the SPIRE data will be measured as a function of the density of SPIRE data samples in the vicinity of the independent ionospheric observations. This will provide for an estimation of the utility of larger constellations of SPIRE satellites with higher sample densities than the representative SPIRE data used in this study.</p> <p>Conclude the effort to Collect in-situ transmission loss (TL) from tactical platforms in support of Naval Oceanographic Office's (NAVOCEANO's) Low Frequency Bottom Loss (LFBL) database that developed efficient algorithm to perform inversion of TL data to produce geo-acoustic parameters of the local environment.</p> <p>FY 2021 Base Plans: On going Implementation of a "rapid innovation" weather-ocean capability that emphasizes observing systems.</p> <p>Further Assimilation of satellite optical data streams into the Coupled Ocean-Atmosphere Mesoscale Prediction System ocean model component.</p> <p>Maintain Forward-based Navy coupled ocean data assimilation (NCODA). Emphasize Compression Integration, Integration of NCODA-Forward processing and algorithms, Modifications to bathythermograph (BT) Manager, integration of the BT-SSP (sound speed profile) and BT Manager modules, New Data Visualization.</p> <p>Further Updates and expands applications of refractivity from radios (RFRs) projects</p> <p>Concluded Development of automated mission planning and route selection aids in support of TRITON MQ-4C hazardous weather avoidance (Priority T-1a).</p>					

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B. Accomplishments/Planned Programs (\$ in Millions, Article Quantities in Each)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Concluded the Delivery and environmental data collected by the P-8 to NAVOCEANO to be incorporated into prediction tools.					
Conduct METOC data acquisition methods for UxV platforms into the processing stream.					
Develop Expand satellite-based environmental monitoring (SBEM) data acquisition from domestic, commercial, and international partners as capabilities mature.					
<i>FY 2021 OCO Plans:</i> N/A					
<i>FY 2020 to FY 2021 Increase/Decrease Statement:</i> The FY 2021 funding decreases in PRJ 2341 METOC Data Acquisition by \$0.931 million due to the conclusion and delivery of environmental data collected by the P-8 to NAVOCEANO to be incorporated into prediction tools.					
Accomplishments/Planned Programs Subtotals	3.338	7.062	6.131	0.000	6.131

C. Other Program Funding Summary (\$ in Millions)											
<u>Line Item</u>	<u>FY 2019</u>	<u>FY 2020</u>	<u>FY 2021 Base</u>	<u>FY 2021 OCO</u>	<u>FY 2021 Total</u>	<u>FY 2022</u>	<u>FY 2023</u>	<u>FY 2024</u>	<u>FY 2025</u>	<u>Cost To Complete</u>	<u>Total Cost</u>
• RDTEN/0604218N/2345: <i>FLEET METOC EQUIPMENT</i>	0.672	0.217	0.620	-	0.620	0.577	0.487	0.497	0.000	Continuing	Continuing

Remarks

D. Acquisition Strategy
Acquisition, management and contracting strategies are to support the Meteorological and Oceanographic (METOC) Data Acquisition Project to develop, demonstrate, and validate METOC data collection methods and sensors, and to evolve the ability to provide timely and accurate METOC data and products to the Tactical Commander, all with management oversight by the Navy.

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Exhibit R-3, RDT&E Project Cost Analysis: PB 2021 Navy												Date: February 2020			
Appropriation/Budget Activity				R-1 Program Element (Number/Name)					Project (Number/Name)						
1319 / 4				PE 0603207N / Air/Ocean Tactical Applications					2341 / METOC Data Acquisition						
Product Development (\$ in Millions)				FY 2019		FY 2020		FY 2021 Base		FY 2021 OCO		FY 2021 Total			
Cost Category Item	Contract Method & Type	Performing Activity & Location	Prior Years	Cost	Award Date	Cost	Award Date	Cost	Award Date	Cost	Award Date	Cost	Cost To Complete	Total Cost	Target Value of Contract
METOC (DATA) Collections	WR	NRL : Washington, DC	81.363	0.430	Nov 2018	2.510	Dec 2019	0.575	Nov 2020	-		0.575	Continuing	Continuing	Continuing
METOC Future Mission Capabilities	WR	SSC PAC : California	23.063	0.000		0.050	Oct 2019	0.250	Nov 2020	-		0.250	Continuing	Continuing	Continuing
METOC Future Mission Capabilities	Various	Various : Various	45.516	0.000		0.000		0.000		-		0.000	Continuing	Continuing	Continuing
Tactical Oceanography Capabilities / Undersea Warfare (TOC USW)	Various	Various : Various	5.764	0.000		0.000		0.000		-		0.000	Continuing	Continuing	Continuing
Littoral Battlespace Sensing - Autonomous Undersea Vehicle	Various	Various : Various	8.422	0.000		0.000		0.000		-		0.000	Continuing	Continuing	Continuing
Tactical Oceanography Capabilities / Undersea Warfare (TOC USW)	WR	NSWC : Bethesda, MD	1.193	0.000		0.000		0.000		-		0.000	Continuing	Continuing	Continuing
METOC Future Mission Capabilities	C/FP	APPLIED SCIENCE ASSOCIATED : RHODE ISLAND	0.226	0.000		0.200	Oct 2019	0.040	Dec 2020	-		0.040	Continuing	Continuing	Continuing
METOC (DATA) Collections	C/FP	University of Washington : Seattle, WA	0.050	0.470	Nov 2018	0.102	Oct 2019	0.321	Oct 2020	-		0.321	Continuing	Continuing	Continuing
METOC (DATA) Collections	C/FP	METRON : Reston, VA	0.314	0.110	Dec 2018	0.300	Dec 2019	0.400	Oct 2020	-		0.400	Continuing	Continuing	Continuing
METOC Future Mission Capabilities	C/FP	SAIC : Virginia	1.781	0.000		0.000		0.000		-		0.000	Continuing	Continuing	Continuing
METOC Future Mission Capabilities	C/FP	CSC : Virginia	0.731	0.000		0.700	Dec 2019	0.400	Oct 2020	-		0.400	Continuing	Continuing	Continuing
METOC (DATA) Collections	WR	NRL : Monterey, CA Stennis Space Center, MS	1.689	0.915	Dec 2018	0.300	Dec 2019	1.435	Dec 2020	-		1.435	Continuing	Continuing	Continuing
METOC Future Mission Capabilities	C/CPFF	GDIT : Virginia	0.138	0.000		0.000		0.000		-		0.000	Continuing	Continuing	Continuing

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Exhibit R-3, RDT&E Project Cost Analysis: PB 2021 Navy												Date: February 2020			
Appropriation/Budget Activity				R-1 Program Element (Number/Name)					Project (Number/Name)						
1319 / 4				PE 0603207N / Air/Ocean Tactical Applications					2341 / METOC Data Acquisition						
Product Development (\$ in Millions)				FY 2019		FY 2020		FY 2021 Base		FY 2021 OCO		FY 2021 Total			
Cost Category Item	Contract Method & Type	Performing Activity & Location	Prior Years	Cost	Award Date	Cost	Award Date	Cost	Award Date	Cost	Award Date	Cost	Cost To Complete	Total Cost	Target Value of Contract
METOC (DATA) Collections	C/FP	Penn State University : PA	2.791	1.413	Dec 2018	0.000		0.000		-		0.000	Continuing	Continuing	Continuing
Subtotal			173.041	3.338		4.162		3.421		-		3.421	Continuing	Continuing	N/A
Support (\$ in Millions)				FY 2019		FY 2020		FY 2021 Base		FY 2021 OCO		FY 2021 Total			
Cost Category Item	Contract Method & Type	Performing Activity & Location	Prior Years	Cost	Award Date	Cost	Award Date	Cost	Award Date	Cost	Award Date	Cost	Cost To Complete	Total Cost	Target Value of Contract
METOC Future Mission Capabilities	C/CPIF	Various : Various	2.672	0.000		2.400	Nov 2019	1.900	Nov 2020	-		1.900	0.000	6.972	-
Littoral Battlespace Sensing - Autonomous Undersea Vehicle	C/FP	SAIC : Virginia	0.600	0.000		0.000		0.000		-		0.000	0.000	0.600	-
Tactical Oceanography Capabilities / Undersea Warfare (TOC USW)	WR	SSC PAC : California	0.247	0.000		0.000		0.000		-		0.000	0.000	0.247	-
METOC Future Mission Capabilities	C/CPFF	PSS/BAH : California	0.066	0.000		0.000		0.000		-		0.000	0.000	0.066	-
Subtotal			3.585	0.000		2.400		1.900		-		1.900	0.000	7.885	N/A
Test and Evaluation (\$ in Millions)				FY 2019		FY 2020		FY 2021 Base		FY 2021 OCO		FY 2021 Total			
Cost Category Item	Contract Method & Type	Performing Activity & Location	Prior Years	Cost	Award Date	Cost	Award Date	Cost	Award Date	Cost	Award Date	Cost	Cost To Complete	Total Cost	Target Value of Contract
METOC Future Mission Capabilities	Various	Various : Various	0.200	0.000		0.200	Nov 2019	0.460	Nov 2020	-		0.460	0.000	0.860	-
Subtotal			0.200	0.000		0.200		0.460		-		0.460	0.000	0.860	N/A

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Exhibit R-4, RDT&E Schedule Profile: PB 2021 Navy **Date:** February 2020

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METOC Collections - global and theater scales	FY 2019				FY 2020				FY 2021				FY 2022				FY 2023				FY 2024				FY 2025							
	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q				
Oceanographic and Ocean Acoustics Database Development																																
Satellite-based environmental monitoring for, analysis, assimilation and modeling																																

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Appropriation/Budget Activity 1319 / 4	R-1 Program Element (Number/Name) PE 0603207N / <i>Air/Ocean Tactical Applications</i>	Project (Number/Name) 2341 / <i>METOC Data Acquisition</i>
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METOC Collections - targeted and tactical scales	FY 2019				FY 2020				FY 2021				FY 2022				FY 2023				FY 2024				FY 2025							
	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q				
Emerging Air-Ocean Sensor Technology Test and Evaluation																																
Forward-based ocean and ocean acoustics modeling and data assimilation																																
Through-the-sensor environmental data collections																																

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

Events by Sub Project	Start		End	
	Quarter	Year	Quarter	Year
<i>METOC Collections - global and theater scales</i>				
Oceanographic and Ocean Acoustics Database Development: Deep Ocean Bottom Backscattering Database -- ARL-PSU	1	2020	4	2021
Oceanographic and Ocean Acoustics Database Development: Deep Ocean Bottom Backscattering Database -- NPS	1	2020	4	2023
Oceanographic and Ocean Acoustics Database Development: "Use of Mobile Acoustic Source for In-situ Transmission	1	2020	4	2021
Satellite-based environmental monitoring for, analysis, assimilation and modeling: Atmospheric Data Assimilation -- NRL-MRY	1	2020	4	2024
Satellite-based environmental monitoring for, analysis, assimilation and modeling: "DoD MW Sensors Special Sensor Microwave Imager Sounder (SSMIS),	1	2020	4	2021
Satellite-based environmental monitoring for, analysis, assimilation and modeling: Operational Satellite Sea Ice Products -- NRL-DC	1	2020	4	2022
Satellite-based environmental monitoring for, analysis, assimilation and modeling: Satellite Optical Data for Coupled Ocean-Atmosphere Models -- NRL-SSC	1	2020	4	2024
Satellite-based environmental monitoring for, analysis, assimilation and modeling: RTP: Flux Correction for Coupled System Extended Forecasts using Satellite Observations -- NRL-MRY	1	2020	4	2021
Satellite-based environmental monitoring for, analysis, assimilation and modeling: RTP: Flux Correction for Coupled System Extended Forecasts using Satellite Observations -- NRL-SSC	1	2020	4	2021
<i>METOC Collections - targeted and tactical scales</i>				
Emerging Air-Ocean Sensor Technology Test and Evaluation: ESTTE - LBS-G AN (Ambient Noise) -- SSC-PAC	1	2020	4	2020

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

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Events by Sub Project	Start		End	
	Quarter	Year	Quarter	Year
Emerging Air-Ocean Sensor Technology Test and Evaluation: ESTTE - SHARC RFR -- Various	1	2020	4	2020
Forward-based ocean and ocean acoustics modeling and data assimilation: NCODA-Forward Collaborative Integration -- METRON Scientific Solutions, Inc.	1	2020	4	2020
Forward-based ocean and ocean acoustics modeling and data assimilation: NCODA-Forward Collaborative Integration -- NRL-DC	1	2020	4	2022
Forward-based ocean and ocean acoustics modeling and data assimilation: NCODA-Forward Collaborative Integration -- NSWCCD / METRON	1	2020	4	2022
Forward-based ocean and ocean acoustics modeling and data assimilation: RTP: An NCODA-based Capability for Forward Ocean Data Assimilation -- NRL-SSC	1	2020	4	2021
Through-the-sensor environmental data collections: P-8 Environmental Data Sensing -- SSC-LANT	1	2020	4	2021

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy										Date: February 2020		
Appropriation/Budget Activity 1319 / 4					R-1 Program Element (Number/Name) PE 0603207N / <i>Air/Ocean Tactical Applications</i>				Project (Number/Name) 2342 / <i>METOC Data Assimilation and Mod</i>			
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
2342: <i>METOC Data Assimilation and Mod</i>	272.165	17.301	21.168	22.371	-	22.371	22.400	22.025	22.463	22.913	Continuing	Continuing
Quantity of RDT&E Articles		-	-	-	-	-	-	-	-	-		

A. Mission Description and Budget Item Justification

The Battlespace Data Assimilation and Prediction Project (2342) enables the future warfighter to leverage observed environmental data gathered under Project 2341 (METOC Data Acquisition) by assimilating data into and fusing them with sophisticated high-resolution (spatial and temporal) assessment and prediction models made possible by high-performance computing. These models gain increasing importance as weapons and sensors grow in sophistication and complexity, making them all the more sensitive to the effects of the natural environment. Meteorology and Oceanography (METOC) Processing enables full understanding of the limitations and constraints imposed by ocean and atmosphere, in space and time, thus quantifying and minimizing their impact on weapons, sensors, and mission. However, METOC Processing itself is limited by the temporal and spatial resolutions at which data are collected and numerically analyzed and predicted. Thus Projects 2341 and 2342 must remain aggressive in delivering higher and higher resolutions, demanding greater and greater computational and database capacities. METOC Processing efforts must also rise to the challenge of assimilating smaller-scale phenomena, particularly in the littorals, and predicting their spatial and temporal effects, as stated by Fleet and Force Commanders who require remote autonomous, clandestine, littoral battlespace sensing in near-shore areas to enable Sea Shield & Sea Basing. This next step in the Information Warfare (IW) Tasking, Collection, Processing, Exploitation and Dissemination (TCPED) continuum, METOC Processing, is critical to fully characterize the physical battlespace environment in real-time and in predictive/forecasting modes, and gives the warfighter a decisive advantage in the complex blue-water, littoral and deep-strike battlespaces.

B. Accomplishments/Planned Programs (\$ in Millions, Article Quantities in Each)

	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Title: Battlespace Data Assimilation and Prediction	8.373	21.168	22.371	0.000	22.371
Articles:	-	-	-	-	-
Description: The Battlespace Data Assimilation and Prediction Project (2342) enables the future warfighter to leverage observed environmental data gathered under Project 2341 (METOC Collections) by assimilating data into and fusing them with sophisticated high-resolution (spatial and temporal) assessment and prediction models made possible by high-performance computing. These models gain increasing importance as weapons and sensors grow in sophistication and complexity, making them all the more sensitive to the effects of the natural environment. METOC Processing enables full understanding of the limitations and constraints imposed by ocean and atmosphere, in space and time, thus quantifying and minimizing their impact on weapons, sensors and mission. However, METOC Processing itself is limited by the temporal and spatial resolutions at which data are collected and numerically analyzed and predicted. Thus Projects 2341 and 2342 must remain aggressive in delivering higher and higher resolutions, demanding greater and greater computational and database capacities.					

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy		Date: February 2020
Appropriation/Budget Activity 1319 / 4	R-1 Program Element (Number/Name) PE 0603207N / <i>Air/Ocean Tactical Applications</i>	Project (Number/Name) 2342 / <i>METOC Data Assimilation and Mod</i>

B. Accomplishments/Planned Programs (\$ in Millions, Article Quantities in Each)

	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
<p>METOC Processing efforts must also rise to the challenge of assimilating smaller-scale phenomena, particularly in the littorals, and predicting their spatial and temporal effects, as stated by Fleet and Force Commanders who require remote autonomous, clandestine, littoral battlespace sensing in near-shore areas to enable Sea Shield & Sea Basing. This next step in the TCPED continuum, METOC Processing, is critical to fully characterize the physical battlespace environment in real-time and in predictive/ forecasting modes, and gives the warfighter a decisive advantage in the complex blue-water, littoral and deep-strike battlespaces.</p> <p>FY 2020 Plans: The effort plans to focus on each category as described below :</p> <p>Complete: Reduce Navy Global Environmental Model's (NAVGEM) error in the calculations of the Effective Atmospheric Angular Momentum Functions (EAAMF), which are provided to the Naval Observatory for calculation of the changes in the length of day (LOD).</p> <p>Complete: Naval Research Laboratory (NRL) will transition the 3-grid WaveWatch3 real-time system to replace two existing operational global WaveWatch3 systems (one used now by Fleet Numerical Meteorology and Oceanography Center (FNMOC)-Monterey (MRY) and the other used now by FNMOC-John C. Stennis Space Center (SSC)). Transition will include a Validation Test Report. The majority of the required labor is associated with preparation of this report. NRL will also assist FNMOC with Operational Test (OPTTEST).</p> <p>Complete: Leverage a coupled ocean and atmospheric modeling and assimilation system based on Coupled Ocean/Atmosphere Mesoscale Prediction System (COAMPS), Navy Coastal Ocean Model (NCOM) and a range-dependent acoustic model (RAM). Operationalize the forward coupled ocean-acoustic system at Naval Oceanographic Office (NAVO)/FNMOC which will provide a number of advantages over current capabilities. Reduce runtime for acoustic simulations, reduce error due to the coupling of the models, reduce manpower due to the automation, and provide uncertainty estimates via uband.</p> <p>Complete: Develop and transition to the Fleet Numerical Meteorology and Oceanography Center (FNMOC) the Navy Ionosphere Model for Operations (NIMO), which consists of a physics-based model of the ionosphere and a data assimilation capability that will provide a real-time electron density specification on a global grid with the ability to specify high-resolution configurable regional grids. NIMO will also provide a 24-hour forecast of electron density climatology. The Ionospheric Data Assimilation 4-D (IDA4D) will be coupled with the Navy's Highly Integrated Thermosphere/Ionosphere Demonstration System (Navy-HITIDES) to form NIMO. NIMO and</p>					

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy		Date: February 2020
Appropriation/Budget Activity 1319 / 4	R-1 Program Element (Number/Name) PE 0603207N / <i>Air/Ocean Tactical Applications</i>	Project (Number/Name) 2342 / <i>METOC Data Assimilation and Mod</i>

B. Accomplishments/Planned Programs (\$ in Millions, Article Quantities in Each)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
<p>associated data preprocessors will be optimized to run efficiently on the Navy DoD Supercomputing Resource Centers (DSRC). NIMO will form the basis of a future Navy operational ionospheric forecasting system, running at multiple resolutions and fully coupled to operational atmospheric forecast models.</p> <p>Complete: Develop, test, and transition for operational implementation a strongly coupled ocean-atmosphere 4D-Var assimilation system for COAMPS. The new system will provide a unique capability that enables the observations from the atmosphere (ocean) to directly improve the analysis/forecast in the ocean (atmosphere). The US Navy will own the superior capability of accurately and efficiently characterizing the battlespace environment at the ocean-atmosphere interface once the proposed system becomes operational. The coupled DA system will be demonstrated in COAMPS-OS (on-scene) and verified with propagation products as well as traditional metrics.</p> <p>Complete: Substantially increase the skill of the COAMPS-TC (tropical cyclone) model in the prediction of rapid intensification (RI) events and inner-core structure (6.4), and to elucidate the nature of the relationship between inner-core structure and TC intensification prediction and predictability (6.2). Our approach includes (1) Model development Resolution increases and physics improvements for COAMPS-TC, (2) Data assimilation New capabilities for initializing COAMPS-TC, (3) TC structure guidance development structure assessment and prediction, (4) TC forecast post-processing exploiting statistically-corrected RI forecasts for increased skill. Through a synergistic combination of advancements to the COAMPS-TC model, the data assimilation system used to initialize the model, and the aids utilized by the operational warning centers to estimate TC inner-core structure characteristics (subsequently fed into the COAMPS-TC initial state), we aim to address the #1 research priority of both Joint Typhoon Warning Center (JTWC) and National Hurricane Center (NHC) Rapid intensification prediction.</p> <p>Complete: Develop and transition a global ensemble aerosol prediction system, including data assimilation, to FNMOC. This system will provide a new probabilistic aerosol prediction and product capability for enhanced aerosol data assimilation and downstream Electro-Optical (EO) attenuation modeling. This work leverages BA2 (budget activity 2) efforts that helped optimize the use of ensemble data assimilation methods for aerosol prediction. The Navy Aerosol Analysis Prediction System (ENAAPS) system and Data Assimilation Research Testbed (DART) were ported and tested on Navy DSRC machines as a near-real-time (NRT) system and implemented using Cylc (Cylc [pronounced silk] is a workflow engine for cycling systems - it orchestrates distributed suites of interdependent cycling tasks that may continue to run indefinitely). Under the Rapid Transition Project (RTP), the system will be thoroughly tested for NRT applications with a focus on how the</p>					

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B. Accomplishments/Planned Programs (\$ in Millions, Article Quantities in Each)

	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
<p>ensemble performs in the forecast, including the ensemble mean and spread. Means for improving system performance will also be tested and implemented as part of NRT ENAAPS, including bias correction, new observations for assimilation, and evaluation of the NAVGEM ensemble impact on ENAAPS forecasts.</p> <p>Complete: Develop and test a Navy Coupled Ocean Data Assimilation (NCODA) -based capability for forward platforms (NCODA-forward) to assimilate collected oceanographic data (e.g. eXpendable BathyThermographs (XBTs), glider, etc./temperature, salinity, etc.) into an oceanographic model field (NCOM or Hybrid Coordinate Ocean Model (HYCOM)) in an acoustically consistent way for operational and tactical analysis and predictions. The proposed capability will provide an estimate of the uncertainty associated with the assimilation process that allows the user to know when the process is reliable and flag cases where the model data cannot be appropriately reconciled with respect to the observations. Production of such uncertainty fields will be used to derive sampling plans to confirm or exclude suspected outliers and reduce excessive uncertainty. Supporting capabilities must also be developed as part of the system to improve compression algorithms to allow more data (temperature, salinity, wind, model error estimates) to be sent to forward platforms and to provide capabilities to assess acoustic integrity of the assimilation process for frequencies of interest.</p> <p>Complete: Implement middle atmosphere processes into a fully coupled global atmosphere/wave/ocean/land/ice prediction system providing daily predictions out to 16 days, weekly predictions out to 32 days and weekly ensemble predictions to 90 days. Predictions will provide environmental information to meet Navy and Department of Defense (DoD) operations and planning needs throughout the globe from undersea to the upper atmosphere and from the tropics to the poles. The system will be implemented on Navy operational computer systems, and the necessary processing infrastructure will be put in place to provide products for Navy fleet user consumption.</p> <p>Develop an improved algorithm for estimating near-shore bathymetry from Synthetic Aperture Radar (SAR) imagery that would be incorporated into NAVO's operational implementation (using future Commander Naval Meteorology and Oceanography Command (CNMOC) funding). Algorithm improvements have been identified under previous work funded by NRL and CNMOC, and shown to perform significantly better than the existing operational capability on a small test set. The goal of this program is to incorporate those improvements into a single system suitable for transition and test it on a larger range of operational data. Specific tasks of this program, based on previously developed improvements, would be (1) incorporate a dynamic box capability based on instantaneous wave parameters; (2) incorporate an automated wave group amplitude metric to determine when to use bathymetry estimates within small spatial extents; (3) determine source and mitigation of</p>					

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B. Accomplishments/Planned Programs (\$ in Millions, Article Quantities in Each)

	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
<p>wave noise in new "Undispersion" algorithm; (4) perform validation studies using existing test sets; and (5) write report for NAVO implementation.</p> <p>Test assimilation of updated Naval Oceanographic Office (NAVOCEANO) derived swath ice concentration from NOAA-20 VIIRS and AMSR2 into the GOFS 3.1 system. Investigate ability to assimilate sea ice thickness observations and transition into NCODA system. Test sea ice thickness assimilation in GOFS 3.1 and GOFS 3.5 systems. Establish a geologically consistent physics-based seafloor prediction capability coupled with existing operational oceanic and atmospheric prediction systems. This seafloor prediction capability, based on the NRLs Global Predictive Seafloor Model (GPSM) foundation, will produce a geologically and geo-acoustically consistent replacement for the current high-frequency bottom loss (HFBL) values at any point on the seafloor for transition to NAVO. Characterize forecast dropouts, based on 500mb Anomaly Correlation (AC) methods, in the Navy Global Environmental Model (NAVGEN), including forecast statistics, common properties and causes. Develop and implement a fully coupled global atmosphere/wave/ocean/land/ice prediction system providing daily high- resolution deterministic 16-day and lower-resolution ensemble predictions at longer lead times. Optimize scripting for the deterministic and ensemble systems to better manage cycling tasks for model components and data assimilation, resulting in increased modularity, better parallelism, easier debugging through error trapping, and greater reuse. Develop an ensemble prediction system for a fully coupled global atmosphere/wave/ocean/land/sea ice coupled model for predictions out to 90 days. Develop a fully- coupled data assimilation capability to optimize the use of the observations across fluid interfaces, eliminating the transient inconsistencies, increasing forecast skill and representing coupled uncertainties. Evaluate and demonstrate the capabilities of a new generation of atmospheric dynamical systems that allow for variable resolution on the sphere, are highly scalable, and eliminate or mitigate spurious problems near the poles of the globe.</p> <p>Further develop, validate, and evaluate the capability of a fully coupled regional Arctic prediction system. Develop, integrate, and test improvements to the computational performance of models within the Navy global coupled forecast system as well as the coupling infrastructure to ensure that operational partners will meet their production schedules using available computational resources. Improve capabilities for supporting long range Navy planning (lead times of one week and longer). Develop and transition for operational implementation a high resolution global weather prediction system NAVGEN with resolution of approximately T1023L100 (13 km horizontal resolution and 100 vertical layers) that is highly competitive in predictive skill with other operational global numerical weather prediction (NWP) systems. Define, develop, and implement consistent quantitative skill metrics to assess the advancements in the Earth System Prediction Capability (ESPC), taking into account the applications and lead-times for which the ESPC environmental information will be used. Evaluate and</p>					

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B. Accomplishments/Planned Programs (\$ in Millions, Article Quantities in Each)

	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
<p>validate multi-model extended-range forecasts produced from interagency projects such as the North American Multi-model Ensemble (NMME). Develop the NAVGEM global model to include inline aerosols to simulate aerosol life cycle and perform aerosol direct radiative heating of the atmosphere. Participate in the NMME by re-forecasting the global coupled (NAVGEM-HYCOM- Los Alamos sea ice model (CICE)) Navy ESPC model for years 1999 to 2015. Accelerate the rate of improvement in the US National ESPC and National Unified Operational Prediction Capability (NUOPC), focusing primarily on the current and future generation global modeling enterprise. Develop the NAVGEM global model to address middle atmosphere processes associated with sudden stratospheric warming and extended range prediction.</p> <p>FY 2021 Base Plans: Maintain Development of Navy Earth System Prediction Capability (ESPC) systems towards final operating capability (FOC) estimated for FY22, including integration of improved aerosol, atmosphere, and land modeling systems, implementation of wave modeling, fully coupled data assimilation, improved spatial and temporal time scales, and ensemble prediction.</p> <p>Further Transition of merged atmospheric modeling capabilities towards transition from the current model (NAVGEM) into the next generation architecture (NEPTUNE).</p> <p>On-going Improvements to mesoscale modeling of hurricane forecasts, specifically targeting intensity and structure representations that inhibit prediction of realistic rates of rapid intensification.</p> <p>Maintain Leverage machine learning to better represent physical processes in specialty modeling systems, including ice, acoustics, and physics parameterizations.</p> <p>Further Improvements for ambient noise database usage, modeling, and integration into ocean modeling.</p> <p>Maintain Mature and integrate geologically consistent, physics-based seafloor prediction capability coupled with existing operational oceanic and atmospheric prediction systems.</p> <p>Further Expansion, validation, and verification of aerosol modeling to include greater chemistry capabilities, ensemble approaches, and in-line and offline capabilities.</p>					

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy		Date: February 2020
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B. Accomplishments/Planned Programs (\$ in Millions, Article Quantities in Each)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Starting in FY 2020, the Earth System Prediction Capability System is migrated into the Battlespace Data Assimilation and Prediction activity to more align with the modeling efforts for Air/Ocean Tactical Applications. FY 2021 Base Plans: N/A FY 2021 OCO Plans: N/A					
Accomplishments/Planned Programs Subtotals	17.301	21.168	22.371	0.000	22.371

C. Other Program Funding Summary (\$ in Millions)											
<u>Line Item</u>	<u>FY 2019</u>	<u>FY 2020</u>	<u>FY 2021 Base</u>	<u>FY 2021 OCO</u>	<u>FY 2021 Total</u>	<u>FY 2022</u>	<u>FY 2023</u>	<u>FY 2024</u>	<u>FY 2025</u>	<u>Cost To Complete</u>	<u>Total Cost</u>
• RDTEN/0604218N/2345: <i>FLEET METOC EQUIPMENT</i>	0.672	0.217	0.620	-	0.620	0.577	0.487	0.497	0.000	Continuing	Continuing

Remarks

D. Acquisition Strategy
Acquisition, management and contracting strategies are to support the Meteorological and Oceanographic (METOC) Data Assimilation and Modeling Project to develop, demonstrate, and validate METOC data assimilation and environmental prediction capabilities, enabling timely and accurate delivery of METOC prediction data and products to the Tactical Commander, all with management oversight by the Navy.

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Exhibit R-3, RDT&E Project Cost Analysis: PB 2021 Navy												Date: February 2020			
Appropriation/Budget Activity				R-1 Program Element (Number/Name)						Project (Number/Name)					
1319 / 4				PE 0603207N / Air/Ocean Tactical Applications						2342 / METOC Data Assimilation and Mod					
Product Development (\$ in Millions)				FY 2019		FY 2020		FY 2021 Base		FY 2021 OCO		FY 2021 Total			
Cost Category Item	Contract Method & Type	Performing Activity & Location	Prior Years	Cost	Award Date	Cost	Award Date	Cost	Award Date	Cost	Award Date	Cost	Cost To Complete	Total Cost	Target Value of Contract
METOC Future Mission Capabilities	WR	NRL : Washington DC	128.802	0.852	Nov 2018	3.450	Nov 2019	2.877	Nov 2020	-		2.877	Continuing	Continuing	Continuing
METOC Future Mission Capabilities	Various	Various : Various	46.068	0.000		0.000		0.000		-		0.000	0.000	46.068	-
METOC Space-Based Sensing Capabilities	WR	NRL : Washington, DC	17.092	0.000		0.000		0.000		-		0.000	Continuing	Continuing	Continuing
Tactical Oceanography Capabilities / Undersea Warfare	WR	NRL : Washington, DC	9.480	0.000		0.000		0.000		-		0.000	Continuing	Continuing	Continuing
Tactical Oceanography Capabilities / Undersea Warfare	C/FP	University of Texas : TX	1.263	0.000		0.150	Nov 2019	0.250	Oct 2020	-		0.250	0.000	1.663	-
Tactical Oceanography Capabilities / Undersea Warfare	WR	NSWC Carderock : West Bethesda, MD	2.090	0.000		0.150	Dec 2019	0.350	Oct 2020	-		0.350	Continuing	Continuing	Continuing
Tactical Oceanography Capabilities / Undersea Warfare	WR	NAVOCEANO : Mississippi	0.549	0.000		0.500	Mar 2020	0.000		-		0.000	0.000	1.049	-
Tactical Oceanography Capabilities / Undersea Warfare	C/FP	University of Washington : Seattle, WA	0.850	0.000		0.000		0.000		-		0.000	Continuing	Continuing	Continuing
Tactical Oceanography Capabilities / Undersea Warfare	C/FP	Johns Hopkins University : MD	0.431	0.000		0.030	Mar 2020	0.133	Oct 2020	-		0.133	Continuing	Continuing	Continuing
Tactical Oceanography Capabilities / Undersea Warfare	C/FP	SAIC/QNA : Various	1.876	0.000		0.000		0.000		-		0.000	Continuing	Continuing	Continuing
METOC Future Mission Capabilities	C/FP	SAIC/QNA : Various	3.096	0.000		0.000		0.000		-		0.000	Continuing	Continuing	Continuing
Tactical Oceanography Capabilities / Undersea Warfare	C/FP	Penn Sate University : Pennsylvania	0.125	0.000		0.000		0.000		-		0.000	0.000	0.125	-

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Exhibit R-3, RDT&E Project Cost Analysis: PB 2021 Navy												Date: February 2020			
Appropriation/Budget Activity				R-1 Program Element (Number/Name)					Project (Number/Name)						
1319 / 4				PE 0603207N / Air/Ocean Tactical Applications					2342 / METOC Data Assimilation and Mod						
Product Development (\$ in Millions)				FY 2019		FY 2020		FY 2021 Base		FY 2021 OCO		FY 2021 Total			
Cost Category Item	Contract Method & Type	Performing Activity & Location	Prior Years	Cost	Award Date	Cost	Award Date	Cost	Award Date	Cost	Award Date	Cost	Cost To Complete	Total Cost	Target Value of Contract
Tactical Oceanography Capabilities / Undersea Warfare	WR	SSC LANT : North Charleston	0.050	0.000		0.000		0.000		-		0.000	0.000	0.050	-
Tactical Oceanography Capabilities / Undersea Warfare	C/FP	SPA : Virginia	0.375	0.000		0.000		0.000		-		0.000	0.000	0.375	-
METOC SUPPORT SPACE-SOFTWARE DEVELOPMENT	WR	NRL : WASHINGTON DC	0.515	0.000		0.000		0.125	Dec 2020	-		0.125	Continuing	Continuing	Continuing
Tactical Oceanography Capabilities / Undersea Warfare	C/FP	METRON : Virginia	0.385	0.000		0.150	Oct 2019	0.150	Oct 2020	-		0.150	0.000	0.685	-
Tactical Oceanography Capabilities / Undersea Warfare	C/FP	Vencore : Virginia	0.239	0.000		0.000		0.000		-		0.000	0.000	0.239	-
METOC Battlespace Data Assimilation and Prediction	WR	NRL : Monterey, CAI Stennis Space Center,MS	7.695	7.054	Dec 2018	4.500	Nov 2019	6.234	Oct 2020	-		6.234	0.000	25.483	-
Earth Systems Prediction Capability (ONR)	WR	NRL : Washington DC	31.999	6.611	Dec 2018	8.569	Dec 2019	8.792	Oct 2020	-		8.792	Continuing	Continuing	Continuing
ESPC	Various	Various : Various	8.348	0.981	Dec 2018	0.000		0.000		-		0.000	Continuing	Continuing	Continuing
CHIEF OF NAVAL OPERATIONS SPEED TO FLEET INITIATIVE	WR	NRL : WASHINGTON DC	0.850	0.000		0.000		0.000		-		0.000	1.130	1.980	-
Subtotal			262.178	15.498		17.499		18.911		-		18.911	Continuing	Continuing	N/A
Support (\$ in Millions)				FY 2019		FY 2020		FY 2021 Base		FY 2021 OCO		FY 2021 Total			
Cost Category Item	Contract Method & Type	Performing Activity & Location	Prior Years	Cost	Award Date	Cost	Award Date	Cost	Award Date	Cost	Award Date	Cost	Cost To Complete	Total Cost	Target Value of Contract
METOC Future Mission Capabilities	Various	Various : Various	0.795	0.000		0.000		0.000		-		0.000	0.000	0.795	-

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Exhibit R-3, RDT&E Project Cost Analysis: PB 2021 Navy												Date: February 2020			
Appropriation/Budget Activity				R-1 Program Element (Number/Name)					Project (Number/Name)						
1319 / 4				PE 0603207N / Air/Ocean Tactical Applications					2342 / METOC Data Assimilation and Mod						
Support (\$ in Millions)				FY 2019		FY 2020		FY 2021 Base		FY 2021 OCO		FY 2021 Total			
Cost Category Item	Contract Method & Type	Performing Activity & Location	Prior Years	Cost	Award Date	Cost	Award Date	Cost	Award Date	Cost	Award Date	Cost	Cost To Complete	Total Cost	Target Value of Contract
Littoral Battlespace Sensing - Autonomous Undersea Vehicle	C/FP	SAIC : Virginia	0.473	0.000		0.000		0.000		-		0.000	0.000	0.473	-
Tactical Oceanography Capabilities / Undersea Warfare	C/FP	SAIC : Virginia	0.634	0.000		0.000		0.000		-		0.000	0.000	0.634	-
METOC Future Mission Capabilities	C/FP	SAIC : VIRGINIA	0.215	0.100	Dec 2018	0.300	Feb 2020	0.300	Oct 2020	-		0.300	Continuing	Continuing	Continuing
METOC SUPPORT SPACE-PROGRAM SUPPORT	WR	SSC PACIFIC : SAN DIEGO, CA	0.190	0.100	Dec 2018	0.641	Feb 2020	0.425	Nov 2020	-		0.425	Continuing	Continuing	Continuing
Earth System Modeling Framework - Common Software Architecture	Various	Various : Boulder, CO; Various	0.660	0.660	Nov 2018	0.641	Nov 2019	0.731	Dec 2020	-		0.731	0.000	2.692	-
Program Support and Subject Matter Expertise	Various	UW-APL : Seattle, WA	1.921	0.358	Dec 2018	0.425	Dec 2019	0.380	Oct 2020	-		0.380	Continuing	Continuing	Continuing
Subtotal			4.888	1.218		2.007		1.836		-		1.836	Continuing	Continuing	N/A
Test and Evaluation (\$ in Millions)				FY 2019		FY 2020		FY 2021 Base		FY 2021 OCO		FY 2021 Total			
Cost Category Item	Contract Method & Type	Performing Activity & Location	Prior Years	Cost	Award Date	Cost	Award Date	Cost	Award Date	Cost	Award Date	Cost	Cost To Complete	Total Cost	Target Value of Contract
Data Analytics and Machine Learning	TBD	Charles River : Boston, MA	0.234	0.323	Dec 2018	0.500	Feb 2020	0.500	Nov 2020	-		0.500	0.000	1.557	-
Subtotal			0.234	0.323		0.500		0.500		-		0.500	0.000	1.557	N/A
Management Services (\$ in Millions)				FY 2019		FY 2020		FY 2021 Base		FY 2021 OCO		FY 2021 Total			
Cost Category Item	Contract Method & Type	Performing Activity & Location	Prior Years	Cost	Award Date	Cost	Award Date	Cost	Award Date	Cost	Award Date	Cost	Cost To Complete	Total Cost	Target Value of Contract
Acquisition Workforce	Various	Various : Various	0.090	0.000		0.000		0.000		-		0.000	0.000	0.090	-

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Exhibit R-4A, RDT&E Schedule Details: PB 2021 Navy		Date: February 2020
Appropriation/Budget Activity 1319 / 4	R-1 Program Element (Number/Name) PE 0603207N / <i>Air/Ocean Tactical Applications</i>	Project (Number/Name) 2342 / <i>METOC Data Assimilation and Mod</i>

Schedule Details

Events by Sub Project	Start		End	
	Quarter	Year	Quarter	Year
Proj 2342				
METOC Processing - global and theater scales: Numerical prediction in support of Precise Time and Astrometry: NAVGEM Upgrade for Improved Earth Orientation Parameters -- NRL-MRY	1	2020	4	2023
METOC Processing - global and theater scales: Oceanographic and Ocean Acoustics Database Development: Biological scattering and attenuation at tactical frequencies -- APL-JHU	1	2020	4	2021
METOC Processing - global and theater scales: Oceanographic and Ocean Acoustics Database Development: Boundary Interactions - TOTLOS Improvements -- APL-UW	1	2020	4	2022
METOC Processing - global and theater scales: Oceanographic and Ocean Acoustics Database Development: Cloud Enablement of Ocean and Atmospheric Master Library -- NRL-SSC	1	2020	4	2024
METOC Processing - global and theater scales: Oceanographic and Ocean Acoustics Database Development: "OAML Models and Database Verification, Validation and Enhancement	1	2020	4	2024
METOC Processing - global and theater scales: Oceanographic and Ocean Acoustics Database Development: The Improved Synthetic Ocean Profiles (ISOP), Version 2 -- NRL-SSC	1	2020	4	2023
METOC Processing - global and theater scales: Satellite-based environmental monitoring for, analysis, assimilation and modeling: Advanced Satellite Data Assimilation -- NRL-MRY	1	2020	4	2024
METOC Processing - global and theater scales: Satellite-based environmental monitoring for, analysis, assimilation and modeling: Aerosol observations for NAAPS validation -- NRL-MRY	1	2020	4	2024

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

Appropriation/Budget Activity 1319 / 4	R-1 Program Element (Number/Name) PE 0603207N / <i>Air/Ocean Tactical Applications</i>	Project (Number/Name) 2342 / <i>METOC Data Assimilation and Mod</i>
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Events by Sub Project	Start		End	
	Quarter	Year	Quarter	Year
METOC Processing - global and theater scales: Satellite-based environmental monitoring for, analysis, assimilation and modeling: Mean sea surface height for Sentinel -3A/B x -- NRL-SSC	1	2020	4	2021
METOC Processing - global and theater scales: Satellite-based environmental monitoring for, analysis, assimilation and modeling: Modeling, Sensing and Forecasting Ocean Optical Products	1	2020	4	2023
METOC Processing - global and theater scales: Satellite-based environmental monitoring for, analysis, assimilation and modeling: NFLUX: Ocean Surface Bias Detection and Correction Using Satellites	1	2020	4	2023
METOC Processing - global and theater scales: Satellite-based environmental monitoring for, analysis, assimilation and modeling: Operationally implementing sat-derived ice products	1	2020	4	2024
METOC Processing - global and theater scales: Satellite-based environmental monitoring for, analysis, assimilation and modeling: Radio occultations from commercial data providers -- NRL-MRY	1	2020	4	2021
METOC Processing - global and theater scales: Satellite-based environmental monitoring for, analysis, assimilation and modeling: Satellite Aerosol Data Assimilation -- NRL-MRY	1	2020	4	2024
METOC Processing - global and theater scales: Satellite-based environmental monitoring for, analysis, assimilation and modeling: Space METOC: Sea Surface Temp (SST) -- NRL-SSC	1	2020	4	2023
METOC Processing - global and theater scales: Satellite-based environmental monitoring for, analysis, assimilation and modeling: Validating and assimilating SAR	1	2020	4	2024
METOC Processing - global and theater scales: Unified, coupled and ensemble environmental numerical prediction, modeling and data assimilation: Large Scale Prediction -- NRL-SSC	1	2020	4	2024
METOC Processing - global and theater scales: Unified, coupled and ensemble environmental numerical prediction, modeling and data assimilation: National Unified Operational Prediction Capability	1	2020	4	2024

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

Appropriation/Budget Activity 1319 / 4	R-1 Program Element (Number/Name) PE 0603207N / <i>Air/Ocean Tactical Applications</i>	Project (Number/Name) 2342 / <i>METOC Data Assimilation and Mod</i>
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Events by Sub Project	Start		End	
	Quarter	Year	Quarter	Year
METOC Processing - global and theater scales: Unified, coupled and ensemble environmental numerical prediction, modeling and data assimilation: NAVGEM NRL-MRY	1	2020	4	2023
METOC Processing - global and theater scales: Unified, coupled and ensemble environmental numerical prediction, modeling and data assimilation: NCOM-4DVAR NRL-SSC	1	2020	4	2024
METOC Processing - global and theater scales: Unified, coupled and ensemble environmental numerical prediction, modeling and data assimilation: ESPC 1 : Coupled Global Prediction System -- NRL-MRY	1	2020	4	2024
METOC Processing - global and theater scales: Unified, coupled and ensemble environmental numerical prediction, modeling and data assimilation: ESPC 1 : Coupled Global Prediction System -- NRL-SSC	1	2020	4	2024
METOC Processing - global and theater scales: Unified, coupled and ensemble environmental numerical prediction, modeling and data assimilation: ESPC 1 B: High Resolution NAVGEM RTP NRL-MRY	1	2020	4	2024
METOC Processing - global and theater scales: Unified, coupled and ensemble environmental numerical prediction, modeling and data assimilation: ESPC 10 Coupled Model Data Assimilation -- NRL-MRY	1	2020	4	2024
METOC Processing - global and theater scales: Unified, coupled and ensemble environmental numerical prediction, modeling and data assimilation: ESPC 10 Coupled Model Data Assimilation -- NRL-SSC	1	2020	4	2024
METOC Processing - global and theater scales: Unified, coupled and ensemble environmental numerical prediction, modeling and data assimilation: ESPC 1D Middle Atmosphere NRL-DC	1	2020	4	2024
METOC Processing - global and theater scales: Unified, coupled and ensemble environmental numerical prediction, modeling and data assimilation: ESPC 1D Middle Atmosphere NRL-MRY	1	2020	4	2024
METOC Processing - global and theater scales: Unified, coupled and ensemble environmental numerical prediction, modeling and data assimilation: ESPC 2: NRL-MRY	1	2020	4	2024

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Exhibit R-4A, RDT&E Schedule Details: PB 2021 Navy			Date: February 2020	
Appropriation/Budget Activity	R-1 Program Element (Number/Name)	Project (Number/Name)		
1319 / 4	PE 0603207N / Air/Ocean Tactical Applications	2342 / METOC Data Assimilation and Mod		
Events by Sub Project	Start		End	
	Quarter	Year	Quarter	Year
METOC Processing - global and theater scales: Unified, coupled and ensemble environmental numerical prediction, modeling and data assimilation: ESPC 2: NRL-SSC	1	2020	4	2024
METOC Processing - global and theater scales: Unified, coupled and ensemble environmental numerical prediction, modeling and data assimilation: ESPC 3: Coupled Global Ensemble Prediction System	1	2020	4	2024
METOC Processing - global and theater scales: Unified, coupled and ensemble environmental numerical prediction, modeling and data assimilation: ESPC 4 :Next Generation Model NEPTUNE -- NRL-MRY	1	2020	4	2024
METOC Processing - global and theater scales: Unified, coupled and ensemble environmental numerical prediction, modeling and data assimilation: ESPC 4A - NexGen Ocean Model -- NRL-SSC	1	2020	4	2024
METOC Processing - global and theater scales: Unified, coupled and ensemble environmental numerical prediction, modeling and data assimilation: ESPC 6 Climate Analysis LR Forecasting (ACAF) Navy	1	2020	4	2022
METOC Processing - global and theater scales: Unified, coupled and ensemble environmental numerical prediction, modeling and data assimilation: ESPC 8: Extended range Ensemble Prediction NRL-MRY	1	2020	4	2024
METOC Processing - global and theater scales: Unified, coupled and ensemble environmental numerical prediction, modeling and data assimilation: ESPC 8: Extended range Ensemble Prediction NRL-SSC	1	2020	4	2024
METOC Processing - global and theater scales: Unified, coupled and ensemble environmental numerical prediction, modeling and data assimilation: ESPC 8a: Navy ESPC NRL-MRY	1	2020	4	2024
METOC Processing - global and theater scales: Unified, coupled and ensemble environmental numerical prediction, modeling and data assimilation: ESPC 8a: Navy ESPC -- NRL-SSC	1	2020	4	2024
METOC Processing - global and theater scales: Unified, coupled and ensemble environmental numerical prediction, modeling and data assimilation: ESPC 9 National ESPC Committee Support -- NRL-MRY	1	2020	4	2024

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Exhibit R-4A, RDT&E Schedule Details: PB 2021 Navy			Date: February 2020	
Appropriation/Budget Activity 1319 / 4	R-1 Program Element (Number/Name) PE 0603207N / <i>Air/Ocean Tactical Applications</i>	Project (Number/Name) 2342 / <i>METOC Data Assimilation and Mod</i>		
	Start		End	
Events by Sub Project	Quarter	Year	Quarter	Year
METOC Processing - global and theater scales: Unified, coupled and ensemble environmental numerical prediction, modeling and data assimilation: ESPC 9 National ESPC Committee Support -- NRL-SSC	1	2020	4	2024
METOC Processing - global and theater scales: Unified, coupled and ensemble environmental numerical prediction, modeling and data assimilation: ESPC-7 Regional Arctic (Prediction) System -- NRL-MRY	1	2020	4	2024
METOC Processing - global and theater scales: Unified, coupled and ensemble environmental numerical prediction, modeling and data assimilation: ESPC-7 Regional Arctic (Prediction) System -- NRL-SSC	1	2020	4	2024
METOC Processing - global and theater scales: Unified, coupled and ensemble environmental numerical prediction, modeling and data assimilation: ESPC-99 Naval Capabilities Development and R2O	1	2020	4	2024
METOC Processing - global and theater scales: Unified, coupled and ensemble environmental numerical prediction, modeling and data assimilation: RTP Hi-res NAVGEM -- NRL-MRY	1	2020	4	2021
MEOC Processing - assessments: Numerical predictions computational efficiency assessments and Skill Assessments: ESPC 5: Computational Efficiency of Earth System Models - NRL-MRY	1	2020	4	2024
MEOC Processing - assessments: Numerical predictions computational efficiency assessments and Skill Assessments: ESPC 5: Computational Efficiency of Earth System Models - NRL-SSC	1	2020	4	2024
MEOC Processing - assessments: Numerical predictions computational efficiency assessments and Skill Assessments: ESPC 11: Integrated skill diagnostics - NRL-MRY	1	2020	4	2024
MEOC Processing - assessments: Numerical predictions computational efficiency assessments and Skill Assessments: ESPC 11: Integrated skill diagnostics - NRL-SSC	1	2020	4	2024
MEOC Processing - assessments: Numerical predictions computational efficiency assessments and Skill Assessments: ESPC-11A: Characterization and Assessment of Forecast Dropouts in NAVGEM - NRL-MRY	1	2020	4	2021

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

Appropriation/Budget Activity 1319 / 4	R-1 Program Element (Number/Name) PE 0603207N / <i>Air/Ocean Tactical Applications</i>	Project (Number/Name) 2342 / <i>METOC Data Assimilation and Mod</i>
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Events by Sub Project	Start		End	
	Quarter	Year	Quarter	Year
METOC Processing - targeted and tactical scales: Forward-based ocean and ocean acoustics modeling and data assimilation: Acoustic Propagation and Uncertainty Model Upgrades: NSPE v6	1	2020	4	2024
METOC Processing - targeted and tactical scales: Numerical prediction in support of EM warfare and spectrum operations: Global Ensemble Aerosol Prediction (ENAAPS) -- NRL-DC	1	2020	4	2024
METOC Processing - targeted and tactical scales: Numerical prediction in support of EM warfare and spectrum operations: Navy Aerosol Analysis and Prediction System (NAAPS) -- NRL-MRY	1	2020	4	2024
METOC Processing - targeted and tactical scales: Numerical prediction in support of EM warfare and spectrum operations: ESPC 1 C NAVGEM Aerosol Model Development / NAVGEM In-Line NAAPS -- NRL-MRY	1	2020	4	2024
METOC Processing - targeted and tactical scales: Numerical prediction in support of EM warfare and spectrum operations: ASDEMRI RTP -- NRL-MRY	1	2020	4	2021
METOC Processing - targeted and tactical scales: Numerical prediction in support of EM warfare and spectrum operations: ASDEMRI RTP -- NSWCDD	1	2020	4	2021
METOC Processing - targeted and tactical scales: Numerical prediction in support of EM warfare and spectrum operations: RTP: Physics-based Ionosphere Model - NRL-DC / APL-JHU / ARL-UT	1	2020	4	2024
METOC Processing - targeted and tactical scales: Numerical prediction in support of Tropical Cyclone characterization: Environmental and Tropical NRL-MRY	1	2020	4	2024
METOC Processing - targeted and tactical scales: Through-the-sensor environmental data collections: Sphere Array Through-The-Sensor Bottom Loss Processing -- METRON Scientific Solutions, Inc.	1	2020	4	2023
METOC Processing - targeted and tactical scales: Through-the-sensor environmental data collections: Sphere Array Through-The-Sensor Bottom Loss Processing -- NRL-DC	1	2020	4	2023
METOC Processing - targeted and tactical scales: Through-the-sensor environmental data collections: COAMPS-OS -- NRL-MRY	1	2020	4	2022

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Exhibit R-4A, RDT&E Schedule Details: PB 2021 Navy		Date: February 2020
Appropriation/Budget Activity 1319 / 4	R-1 Program Element (Number/Name) PE 0603207N / <i>Air/Ocean Tactical Applications</i>	Project (Number/Name) 2342 / <i>METOC Data Assimilation and Mod</i>

Events by Sub Project	Start		End	
	Quarter	Year	Quarter	Year
METOC Processing - targeted and tactical scales: Through-the-sensor environmental data collections: Small Scale Atmospheric Models -- NRL-MRY	1	2020	4	2024
METOC Processing - targeted and tactical scales: Through-the-sensor environmental data collections: Small scale oceanography -- NRL-SSC	1	2020	4	2024

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy										Date: February 2020		
Appropriation/Budget Activity 1319 / 4					R-1 Program Element (Number/Name) PE 0603207N / <i>Air/Ocean Tactical Applications</i>				Project (Number/Name) 2344 / <i>Precise Time and Astrometry</i>			
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
2344: <i>Precise Time and Astrometry</i>	20.525	4.381	2.467	2.466	-	2.466	3.628	3.345	3.102	3.168	Continuing	Continuing
Quantity of RDT&E Articles		-	-	-	-	-	-	-	-	-		

A. Mission Description and Budget Item Justification

The Precise Timing and Astrometry (PTA) project funds research and development of improvements for the Master Clock (MC) System, the DoD Time Transfer capability, the Earth Orientation System, and the Astrometric Observation System. The MC System and Time Transfer provides precise time for use in modern military and National Technical Means (NTM) navigation, guidance, positioning, and tracking systems. The Earth Orientation System provides precise Earth Orientation Parameters (EOP) for use by the DoD and national civilian infrastructure to establish the specific orientation of the Earth and to provide input to the terrestrial reference frame. The Astrometric Observation System provides the basic data needed to generate the Celestial Reference Frame (CRF) which is the standard for calibrating all inertial navigation systems, satellite orbits, and earth rotation determinations. Improvement to the MC System, Time Transfer, Earth Orientation, and Astrometric Observation Systems are needed to ensure that new and upgraded DoD and NTM capabilities meet their performance requirements. The U.S. Naval Observatory (USNO), is responsible for coordinating Precise Time and Time Interval (PTTI) requirements and for maintaining a PTTI reference standard (astronomical and atomic) for use by all DoD, federal agencies, and related scientific laboratories. The Navy is also responsible for providing CRF data for military and NTM navigation, positioning, and guidance capabilities to all DoD.

The PTA research and development efforts are focused on several areas relating to timing and time transfer: (1) Fielding of Rubidium Fountain Atomic Clocks and development of improved Global Positioning System (GPS) Timing Receivers in order to meet the precise timing requirements for the GPS III system; (2) Research & development of the capability of distributing timing signals via Optical fiber lines, as an alternative and backup to GPS time distribution; and (3) Research & development into Optical Clock technology, which is expected to be required for future DoD systems. The PTA research and development effort is also focused on the following areas related to EOP determination: (1) Upgrade of the Very Long Baseline Interferometry (VLBI) data acquisition system / radio telescope at Kokee Park HI; (2) Development of a Software (SW) Correlator for processing of VLBI data, necessary for the generation of EOP data; (3) Development of the capability for electronic transmission of the VLBI data from remote VLBI sites to the USNO correlator. The new SW Correlator and VLBI infrastructure upgrades are necessary in order to support daily updates of EOP data required by GPS III; (4) Development of an automated end-to-end EOP processing system, which combines input from multiple data sets (e.g. VLBI data, GPS orbit data, and laser ranging data, etc.). Automation is necessary to meet future DoD and GPS requirements; (5) Modifications to the EOP system for compatibility with the new international standard. PTA research and development for astrometry focuses on 1) 1.8 meter telescope deployment 2) research into the development of a GPS-denied reference frame as a navigation solution 3) visible and infrared (IR) instrumentation development. These activities are necessary for producing CRF products in an era of new surveillance, targeting, intelligence, and reconnaissance technologies and instrumentation.

B. Accomplishments/Planned Programs (\$ in Millions, Article Quantities in Each)

	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Title: Precise Timing and Astronomy	4.381	2.467	2.466	0.000	2.466
Articles:	-	-	-	-	-

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy		Date: February 2020
Appropriation/Budget Activity 1319 / 4	R-1 Program Element (Number/Name) PE 0603207N / <i>Air/Ocean Tactical Applications</i>	Project (Number/Name) 2344 / <i>Precise Time and Astrometry</i>

B. Accomplishments/Planned Programs (\$ in Millions, Article Quantities in Each)

	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
<p>Description: Research and development of improvements for the Master Clock (MC) System, the DoD Time Transfer capability, the Earth Orientation System, and the Astrometric Observation System.</p> <p>FY 2020 Plans:</p> <ul style="list-style-type: none"> *Next Generation transceiver (modem) transition to operations *Further develop Two Way Satellite time transfer (TWSTT) enhancements *Further develop Optical time transfer: Fiber and Free Space Optical time transfer capability development *Initiate study for 1.8m robotic adaptive optics system *Optical Clock development: Assess calcium thermal-beam Clock stability, develop spectroscopy on laser-cooled beam *Transition Earth Orientation Parameters (EOP) automation products to operations (Final Operating Capability - FOC) *Transition GPS-denied reference frame data pipeline to operations*Further develop Solar Lunar Almanac Core (SLAC) Shapiro illuminance model study/upgrade <p>FY 2021 Base Plans:</p> <ul style="list-style-type: none"> *Critical Design Review (CDR) for transceiver for next generation time transfer *Two Way Satellite Time Transfer (TWSTT) enhancements *Optical Time Transfer: Fiber and Free Space optical time transfer capability development *Optical Clock Development: Assess calcium thermal-beam clock stability, develop spectroscopy on laser-cooled beam *Transition Earth Orientation Parameters(EOP)automation products to operations (Final Operating Capability - FOC) *Transition GPS-denied reference frame data pipeline to operations (Final Operating Capability - FOC) *Continue Solar Lunar Almanac Core (SLAC) Shapiro illuminance model study/upgrade *Begin development of the 1.8m robotic adaptive optics system <p>FY 2021 OCO Plans: N/A</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY21 decrease of \$0.001 million is due to planned transition to Full Operating Capability (FOC) and equipment for both the Two Way Satellite Time Transfer (TWSTT) enhancements and the development of Fiber and Free Space optical time transfer capability.</p>					

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy		Date: February 2020
Appropriation/Budget Activity 1319 / 4	R-1 Program Element (Number/Name) PE 0603207N / <i>Air/Ocean Tactical Applications</i>	Project (Number/Name) 2344 / <i>Precise Time and Astrometry</i>

B. Accomplishments/Planned Programs (\$ in Millions, Article Quantities in Each)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
The FY 2021 funding request was reduced by \$0.777 million to account for the availability of prior year execution balances.					
Accomplishments/Planned Programs Subtotals	4.381	2.467	2.466	0.000	2.466

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

N/A

Remarks

D. Acquisition Strategy

The included technology developments are primarily in-house with selected contractor participation.

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

Appropriation/Budget Activity 1319 / 4	R-1 Program Element (Number/Name) PE 0603207N / Air/Ocean Tactical Applications	Project (Number/Name) 2344 / Precise Time and Astrometry
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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			
Primary Hardware Development (NPOI) 1.8m Telescope Project (1)	SS/FFP	Lowell Observatory : Flagstaff, AZ	0.200	0.000		0.000		0.000		-		0.000	0.000	0.200	-
Primary Hardware Development (NPOI) 1.8m Telescope (2)	SS/FFP	AZ Embedded System : Not Specified	0.500	0.000		0.000		0.000		-		0.000	0.000	0.500	-
Ancillary Hardware Development 1	Various	U.S. Naval Observatory : Washington, DC	0.173	0.060	Dec 2018	0.058	Dec 2019	0.017	Dec 2020	-		0.017	0.000	0.308	-
Ancillary Hardware Development 2	Various	U.S. Naval Observatory : Washington, DC	0.172	0.060	Jan 2019	0.058	Jan 2020	0.058	Jan 2021	-		0.058	0.000	0.348	-
Ancillary Hardware Development 3	Various	U.S. Naval Observatory : Washington, DC	0.210	0.060	Apr 2019	0.058	Apr 2020	0.058	Apr 2021	-		0.058	0.000	0.386	-
Ancillary Hardware Development 4	Various	U.S. Naval Observatory : Washington, DC	0.115	0.060	Jul 2019	0.058	Jul 2020	0.098	Apr 2021	-		0.098	0.000	0.331	-
Primary Hardware Development for CTD (System Integration)	C/FP	Classified : Not Specified	0.000	0.000		0.000		0.000		-		0.000	0.000	0.000	-
Primary Hardware Development for CTD (RF Interface)	MIPR	Classified : Not Specified	5.640	0.000		0.000		0.000		-		0.000	0.000	5.640	-
Primary Hardware Development for CTD (Line Interface)	MIPR	Classified : Not Specified	3.049	0.000		0.000		0.000		-		0.000	0.000	3.049	-
Primary Hardware Development for CTD (Reference Upgrade)	C/FFP	Symmetricom : San Jose, CA	0.550	0.000		0.000		0.000		-		0.000	0.000	0.550	-
Next Generation Secure Time Transfer	C/FFP	Classified : Not Specified	1.207	0.500	Mar 2019	0.157	Mar 2020	0.155	Mar 2021	-		0.155	0.565	2.584	-
1.8 meter infrared camera development	C/FFP	Classified : Not Specified	0.000	0.931	Jan 2019	0.288	Jan 2020	0.540	Jan 2021	-		0.540	4.249	6.008	-

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

Appropriation/Budget Activity 1319 / 4	R-1 Program Element (Number/Name) PE 0603207N / <i>Air/Ocean Tactical Applications</i>	Project (Number/Name) 2344 / <i>Precise Time and Astrometry</i>
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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			
Primary Hardware Development (Site Prep)	SS/FFP	NASA/GSFC : HI	0.100	0.000		0.000		0.000		-		0.000	0.000	0.100	-
Primary Hardware Development (Antenna Receiver Electronics)	C/FFP	NASA : GSFC	1.000	0.000		0.000		0.000		-		0.000	0.000	1.000	-
1.8 meter Telescope Enclosure	C/FFP	NAVFAC SW : Not Specified	2.153	0.000		0.000		0.000		-		0.000	0.000	2.153	-
Advanced Time and Frequency Transfer Upgrade	C/FFP	Classified : Not Specified	0.000	0.500	Jul 2019	0.150	Jul 2020	0.150	Mar 2021	-		0.150	0.600	1.400	-
Optical Lattice Clocks	C/FFP	Classified : Not Specified	0.000	0.500	Jul 2019	0.150	Jul 2020	0.150	Mar 2021	-		0.150	0.600	1.400	-
Subtotal			15.069	2.671		0.977		1.226		-		1.226	6.014	25.957	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			
Development Support (All PTA - Labor) 1	Allot	U.S. Naval Observatory (Civilian Labor) : Washington, DC	0.528	0.115	Dec 2018	0.100	Dec 2019	0.100	Dec 2020	-		0.100	Continuing	Continuing	Continuing
Development Support (All PTA - Labor) 2	Allot	U.S. Naval Observatory (Civilian Labor) : Washington, DC	0.528	0.115	Mar 2019	0.100	Mar 2020	0.100	Mar 2021	-		0.100	Continuing	Continuing	Continuing
Development Support (All PTA - Labor) 3	Allot	U.S. Naval Observatory (Civilian Labor) : Washington, DC	0.528	0.115	Jun 2019	0.100	Jun 2020	0.100	Mar 2021	-		0.100	Continuing	Continuing	Continuing
Development Support (All PTA - Labor) 4	Allot	U.S. Naval Observatory (Civilian Labor) : Washington, DC	0.528	0.115	Jul 2019	0.100	Jul 2020	0.100	Mar 2021	-		0.100	Continuing	Continuing	Continuing

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

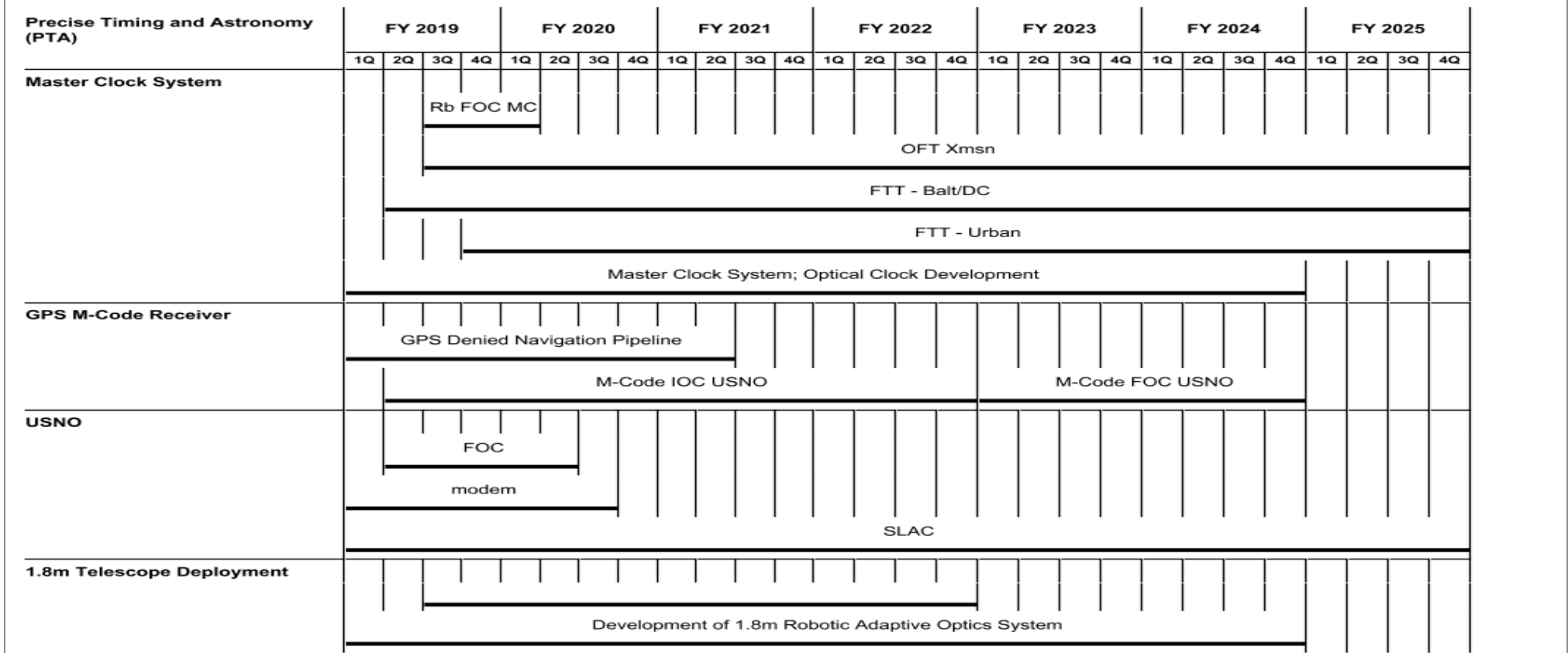
Appropriation/Budget Activity 1319 / 4	R-1 Program Element (Number/Name) PE 0603207N / <i>Air/Ocean Tactical Applications</i>	Project (Number/Name) 2344 / <i>Precise Time and Astrometry</i>
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Support (\$ in Millions)				FY 2019		FY 2020		FY 2021 Base		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			
		Labor) : Washington, DC													
Software Development (EOP Automation)	C/FFP	U.S. Naval Observatory (Civilian Labor) : Washington, DC	1.436	0.362	Jun 2019	0.250	Jun 2020	0.000		-		0.000	0.000	2.048	-
Travel 1	Allot	U.S. Naval Observatory (Civilian Travel) : Varies	0.043	0.000		0.000		0.000		-		0.000	0.000	0.043	-
Travel 2	Allot	U.S. Naval Observatory (Civilian Travel) : Varies	0.043	0.000		0.000		0.000		-		0.000	0.000	0.043	-
Travel 3	Allot	U.S. Naval Observatory (Civilian Travel) : Varies	0.044	0.000		0.000		0.000		-		0.000	0.000	0.044	-
Travel 4	Allot	U.S. Naval Observatory (Civilian Travel) : Varies	0.044	0.000		0.000		0.000		-		0.000	0.000	0.044	-
VLBI2010 Testing and Integration	MIPR	NASA : GSFC	0.905	0.000		0.000		0.000		-		0.000	0.000	0.905	-
Software Development (SW Correlator GUI)	C/FFP	U.S. Naval Observatory : Washington, DC	0.000	0.000		0.000		0.000		-		0.000	0.000	0.000	-
Astrometric Development	C/FFP	U.S. Naval Observatory : Washington, DC	0.487	0.261	Mar 2019	0.280	Mar 2020	0.280	Jan 2021	-		0.280	0.000	1.308	-
EOP Optimal Estimation	C/FFP	NASA : GSFC	0.000	0.125	Feb 2019	0.165	Feb 2020	0.125	Feb 2021	-		0.125	0.500	0.915	-
Foreign GNSS	C/FFP	Classified : Not Specified	0.000	0.125	Feb 2019	0.165	Feb 2020	0.125	Feb 2021	-		0.125	0.500	0.915	-
SLAC Software Upgrade	C/FFP	Classified : Not Specified	0.000	0.377	Mar 2019	0.230	Mar 2020	0.230	Jan 2021	-		0.230	0.690	1.527	-
Primary Hardware Development (NPOI) 1.8m Telescope Project (2)	SS/FFP	NASA : Varies	0.342	0.000		0.000		0.080	Mar 2021	-		0.080	0.000	0.422	-

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Exhibit R-4, RDT&E Schedule Profile: PB 2021 Navy **Date:** February 2020

Appropriation/Budget Activity 1319 / 4	R-1 Program Element (Number/Name) PE 0603207N / <i>Air/Ocean Tactical Applications</i>	Project (Number/Name) 2344 / <i>Precise Time and Astrometry</i>
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Exhibit R-4A, RDT&E Schedule Details: PB 2021 Navy		Date: February 2020
Appropriation/Budget Activity 1319 / 4	R-1 Program Element (Number/Name) PE 0603207N / <i>Air/Ocean Tactical Applications</i>	Project (Number/Name) 2344 / <i>Precise Time and Astrometry</i>

Schedule Details

Events by Sub Project	Start		End	
	Quarter	Year	Quarter	Year
<i>Precise Timing and Astronomy (PTA)</i>				
Master Clock System: Rb Full Operational Capability (FOC) - AMC	3	2019	1	2020
Master Clock System: Optical Fiber Time (OFT) Transmission	3	2019	4	2025
Master Clock System: Fiber Time Transmission (FTT) in Baltimore/DC Area	2	2019	4	2025
Master Clock System: Fiber Time Transmission - Urban Demo	4	2019	4	2025
Master Clock System: Master Clock System; Optical Clock Development	1	2019	4	2024
GPS M-Code Receiver: GPS Denied Navigation Pipeline	1	2019	2	2021
GPS M-Code Receiver: M-Code IOC at USNO	2	2019	4	2022
GPS M-Code Receiver: M-Code FOC at USNO	1	2023	4	2024
GPS M-Code Receiver: Schedule Detail	1	2019	1	2025
USNO: Transition Earth Orientation Parameters (EOP) Automation software to operations (FOC)	2	2019	2	2020
USNO: Next Generation Time Transfer Transceiver (modem) CDR, transition to operations	1	2019	3	2020
USNO: Solar Lunar Almanac Core (SLAC); Illuminance Model study/upgrade	1	2019	4	2025
1.8m Telescope Deployment: FAC-D Development for Telescope Enclosure	3	2019	4	2022
1.8m Telescope Deployment: Development of 1.8m Robotic Adaptive Optics System	1	2019	4	2024

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy										Date: February 2020		
Appropriation/Budget Activity 1319 / 4					R-1 Program Element (Number/Name) PE 0603207N / <i>Air/Ocean Tactical Applications</i>				Project (Number/Name) 2363 / <i>Remote Sensing Capability Development</i>			
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
2363: <i>Remote Sensing Capability Development</i>	1.886	0.312	0.327	0.328	-	0.328	0.328	0.000	0.000	0.000	0.000	3.181
Quantity of RDT&E Articles		-	-	-	-	-	-	-	-	-		

A. Mission Description and Budget Item Justification

Remote Sensing Capability Development characterizes ocean environment using a variety of remote sensing techniques that provide that capability to discriminate atypical oceanographic phenomena from the natural environment that will greatly improve undersea dominance capabilities. The Naval Oceanographic Office will employ oceanographic data to refine and extend environmental characterization of the phenomena and disseminate data to the Fleet.

B. Accomplishments/Planned Programs (\$ in Millions, Article Quantities in Each)

	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Title: Remote Sensing Capability Dev.	0.312	0.327	0.328	0.000	0.328
Articles:	-	-	-	-	-
Description: Collect remote sensing and ground truth data in various weather and sea states to broaden the range of environmental conditions and reduce uncertainty in environmental prediction. Develop and enhance software algorithms to automatically detect oceanographic phenomena. Integrate algorithms for access over the network. Enhance existing toolsets to provide users robust applications to assist in their daily tasks. Develop training to provide the user community education on using the different tools and applications. (Details held at a higher classification)					
FY 2020 Plans: Invest in new technology that allows for an accelerated pace to detect oceanographic phenomena of ocean science transitions in the interest of national security for Task Force Ocean.					
FY 2021 Base Plans: Pursue technologies that continue an accelerated pace to detect oceanographic phenomena of ocean science transitions in the interest of national security for Task Force Ocean.					
FY 2021 OCO Plans: N/A					
FY 2020 to FY 2021 Increase/Decrease Statement: There is no significant change between FY2020 and FY 2021					
Accomplishments/Planned Programs Subtotals	0.312	0.327	0.328	0.000	0.328

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy		Date: February 2020
Appropriation/Budget Activity 1319 / 4	R-1 Program Element (Number/Name) PE 0603207N / <i>Air/Ocean Tactical Applications</i>	Project (Number/Name) 2363 / <i>Remote Sensing Capability Development</i>

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

N/A

Remarks

D. Acquisition Strategy

Remote Sensing Capability Development is being managed as a PEO Project leveraging the Rapid Development and Deployment (RDD) construct for rigor and discipline.

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Exhibit R-3, RDT&E Project Cost Analysis: PB 2021 Navy												Date: February 2020			
Appropriation/Budget Activity				R-1 Program Element (Number/Name)				Project (Number/Name)							
1319 / 4				PE 0603207N / Air/Ocean Tactical Applications				2363 / Remote Sensing Capability Development							
Product Development (\$ in Millions)				FY 2019		FY 2020		FY 2021 Base		FY 2021 OCO		FY 2021 Total			
Cost Category Item	Contract Method & Type	Performing Activity & Location	Prior Years	Cost	Award Date	Cost	Award Date	Cost	Award Date	Cost	Award Date	Cost	Cost To Complete	Total Cost	Target Value of Contract
REMOTE SENSING CAPABILITY DEVELOPMENT DATA COLLECTION	Various	VARIOUS : VARIOUS	0.268	0.312	Jan 2019	0.327	Nov 2019	0.328	Nov 2020	-		0.328	5.176	6.411	-
Subtotal			0.268	0.312		0.327		0.328		-		0.328	5.176	6.411	N/A
Test and Evaluation (\$ in Millions)				FY 2019		FY 2020		FY 2021 Base		FY 2021 OCO		FY 2021 Total			
Cost Category Item	Contract Method & Type	Performing Activity & Location	Prior Years	Cost	Award Date	Cost	Award Date	Cost	Award Date	Cost	Award Date	Cost	Cost To Complete	Total Cost	Target Value of Contract
Remote Sensing Capability Development Data Collection	WR	SSC Pacific : SAN DIEGO, CA	1.081	0.000		0.000		0.000		-		0.000	0.375	1.456	-
Subtotal			1.081	0.000		0.000		0.000		-		0.000	0.375	1.456	N/A
Management Services (\$ in Millions)				FY 2019		FY 2020		FY 2021 Base		FY 2021 OCO		FY 2021 Total			
Cost Category Item	Contract Method & Type	Performing Activity & Location	Prior Years	Cost	Award Date	Cost	Award Date	Cost	Award Date	Cost	Award Date	Cost	Cost To Complete	Total Cost	Target Value of Contract
Remote Sensing Capability Development Data Collection	C/FP	BAH : VA	0.537	0.000		0.000		0.000		-		0.000	0.374	0.911	-
Subtotal			0.537	0.000		0.000		0.000		-		0.000	0.374	0.911	N/A
Project Cost Totals			1.886	0.312		0.327		0.328		-		0.328	5.925	8.778	N/A
Remarks															

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Exhibit R-4, RDT&E Schedule Profile: PB 2021 Navy **Date:** February 2020

Appropriation/Budget Activity 1319 / 4	R-1 Program Element (Number/Name) PE 0603207N / <i>Air/Ocean Tactical Applications</i>	Project (Number/Name) 2363 / <i>Remote Sensing Capability Development</i>
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Remote Sensing Capability Dev.	FY 2019				FY 2020				FY 2021				FY 2022				FY 2023				FY 2024				FY 2025											
	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q								
Data Collection:																																				
Algorithm Development:																																				
System Integration:																																				
Testing:																																				
System Engineering:																																				

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Exhibit R-4A, RDT&E Schedule Details: PB 2021 Navy		Date: February 2020
Appropriation/Budget Activity 1319 / 4	R-1 Program Element (Number/Name) PE 0603207N / <i>Air/Ocean Tactical Applications</i>	Project (Number/Name) 2363 / <i>Remote Sensing Capability Development</i>

Schedule Details

Events by Sub Project	Start		End	
	Quarter	Year	Quarter	Year
<i>Remote Sensing Capability Dev.</i>				
Data Collection:: Schedule Detail	1	2019	2	2020
Algorithm Development:: Schedule Detail	1	2019	1	2021
System Integration:: Schedule Detail	3	2019	4	2019
Testing:: Schedule Detail	1	2020	4	2021
System Engineering:: Schedule Detail	1	2020	4	2021

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy										Date: February 2020		
Appropriation/Budget Activity 1319 / 4					R-1 Program Element (Number/Name) PE 0603207N / <i>Air/Ocean Tactical Applications</i>				Project (Number/Name) 3207 / <i>Fleet Synthetic Training</i>			
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
3207: <i>Fleet Synthetic Training</i>	2.642	0.256	0.283	0.305	-	0.305	0.326	0.332	0.339	0.346	Continuing	Continuing
Quantity of RDT&E Articles		-	-	-	-	-	-	-	-	-		

A. Mission Description and Budget Item Justification

Fleet Synthetic Training (FST) provides Naval Forces with an enhanced in-port training capability. Integrating embedded shipboard training devices, aircraft, and submarine simulators into an interoperable network with joint, coalition, and interagency partners will provide more effective training for our deploying naval forces.

A key factor in achieving this new way of training our Naval Forces is to ensure that the required training is based on realistic characterizations of the physical environment. This project develops and delivers software that characterizes the ocean and atmospheric environments; adjusts to meet fleet-required training scenarios; allows synthetic training to be conducted in areas of planned and contingency operations and provides sufficient detail to simulate the real-world conditions of the physical environment in those areas of interest.

B. Accomplishments/Planned Programs (\$ in Millions, Article Quantities in Each)

	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Title: Fleet Synthetic Training	0.256	0.283	0.305	0.000	0.305
Articles:	-	-	-	-	-
Description: Ballistic Missile Defense (BMD) Fleet Synthetic Training (FST) at sea effort will provide the capability to conduct integrated Live, Virtual, and Constructive (LVC) single or multi-ship exercises with ships at sea using the Navy Continuous Training Environment (NCTE). This capability will support BMD mission area Fleet training and mission rehearsal in theater, allow ships to participate in Combatant Command (CCMD) mandated BMD exercises while pier-side or underway, as well as enhance BMD training objective accomplishment in current Optimized Fleet Response Plan (O-FRP) underway training events such as Composite Training Unit Exercises (COMPTUEX) and Joint Task Force Exercises (JTFEX). The NCTE and FST directly support Fleet training readiness, strike group and BMD platform deployment certifications.					
FY 2020 Plans:					
*Complete on-demand cloud hosting to dynamically scale to workloads, thus making it more efficient, able to scale up for large jobs, and ultimately saving future operating costs					
*Further develop SensorSim to provide increased simulated sensor effects as an external service to provide standard and consistent sensor effect modeling across the Navy Continuous Training Environment (NCTE) and offer ease of extension and modification					

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy		Date: February 2020
Appropriation/Budget Activity 1319 / 4	R-1 Program Element (Number/Name) PE 0603207N / <i>Air/Ocean Tactical Applications</i>	Project (Number/Name) 3207 / <i>Fleet Synthetic Training</i>

B. Accomplishments/Planned Programs (\$ in Millions, Article Quantities in Each)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
<p>*Research a Search and Rescue (SAR) capability to provide the necessary environmental data in an executable format with existing capabilities or as an interactive tool to allow an end-user to provide inputs such as the location of the incident and entity in the water, then model the drift path of the object or person</p> <p>*Implement and execute a service around Advanced Propagation Model utilized by any simulation in the NCTE</p> <p>*Develop Fleet Synthetic Training (FST)/Live, Virtual, and Constructive (LVC) providing integrated LVC single or multi-ship exercises in support of Ballistic Missile Defense (BMD)</p> <p><i>FY 2021 Base Plans:</i></p> <p>*Further develop SensorSim to provide increased simulated sensor effects as an external service to provide standard and consistent sensor effect modeling across the NCTE and offer ease of extension and modification</p> <p>*Implement a SAR capability to provide the necessary environmental data in an executable format with existing capabilities or as an interactive tool to allow an end-user to provide inputs such as the location of the incident and entity in the water, then model the drift path of the object or person</p> <p>*Advance the capabilities of a service around Advanced Propagation Model utilized by any simulation in the NCTE *Implement FST/LVC capabilities providing integrated LVC single or multi-ship exercises in support of BMD.</p> <p><i>FY 2021 OCO Plans:</i> N/A</p> <p><i>FY 2020 to FY 2021 Increase/Decrease Statement:</i> Increase between FY20 and FY21 of \$0.022 million due to requirements for advanced technology development to support SensorSim and Advanced Propagation Modeling providing environmental data for integrated single or multi-platform exercises.</p>					
Accomplishments/Planned Programs Subtotals	0.256	0.283	0.305	0.000	0.305

C. Other Program Funding Summary (\$ in Millions)
N/A

Remarks

D. Acquisition Strategy
The included technology developments are primarily in-house with contractor participation through existing vehicles.

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Exhibit R-3, RDT&E Project Cost Analysis: PB 2021 Navy												Date: February 2020			
Appropriation/Budget Activity				R-1 Program Element (Number/Name)						Project (Number/Name)					
1319 / 4				PE 0603207N / Air/Ocean Tactical Applications						3207 / Fleet Synthetic Training					
Support (\$ in Millions)				FY 2019		FY 2020		FY 2021 Base		FY 2021 OCO		FY 2021 Total			
Cost Category Item	Contract Method & Type	Performing Activity & Location	Prior Years	Cost	Award Date	Cost	Award Date	Cost	Award Date	Cost	Award Date	Cost	Cost To Complete	Total Cost	Target Value of Contract
Development Support	C/FFP	AER : VA	0.641	0.000		0.106	Jan 2020	0.115	Jan 2021	-		0.115	Continuing	Continuing	Continuing
Software Development	C/FFP	AER : VA	0.243	0.000		0.053	Jan 2020	0.061	Jan 2021	-		0.061	Continuing	Continuing	Continuing
Configuration Management	C/FFP	AER : VA	0.408	0.000		0.043	Apr 2020	0.045	Jan 2021	-		0.045	0.000	0.496	-
Studies and Analysis	C/FFP	AER : VA	0.508	0.000		0.043	Jan 2020	0.045	Jan 2021	-		0.045	0.000	0.596	-
Award Fees	C/FFP	NAWC TSD (Orlando, FL) : FL	0.105	0.000		0.017	Jan 2020	0.018	Jan 2021	-		0.018	0.000	0.140	-
Technical Data	C/FFP	N/A : N/A	0.119	0.000		0.000		0.000		-		0.000	0.000	0.119	-
Subtotal			2.024	0.000		0.262		0.284		-		0.284	Continuing	Continuing	N/A
Test and Evaluation (\$ in Millions)				FY 2019		FY 2020		FY 2021 Base		FY 2021 OCO		FY 2021 Total			
Cost Category Item	Contract Method & Type	Performing Activity & Location	Prior Years	Cost	Award Date	Cost	Award Date	Cost	Award Date	Cost	Award Date	Cost	Cost To Complete	Total Cost	Target Value of Contract
Operational Test & Evaluation	C/FFP	AER : VA	0.321	0.000		0.000		0.000		-		0.000	0.000	0.321	-
Development Test and Evaluation	C/FFP	AER : VA	0.297	0.256	Jan 2019	0.021	Jan 2020	0.021	Jan 2021	-		0.021	0.000	0.595	-
Subtotal			0.618	0.256		0.021		0.021		-		0.021	0.000	0.916	N/A
Project Cost Totals			2.642	0.256		0.283		0.305		-		0.305	Continuing	Continuing	N/A
Remarks															

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Exhibit R-4, RDT&E Schedule Profile: PB 2021 Navy		Date: February 2020
Appropriation/Budget Activity 1319 / 4	R-1 Program Element (Number/Name) PE 0603207N / <i>Air/Ocean Tactical Applications</i>	Project (Number/Name) 3207 / <i>Fleet Synthetic Training</i>

FY 2019				FY 2020				FY 2021				FY 2022				FY 2023				FY 2024				FY 2025			
1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4

Proj 3207	
Fleet Synthetic Training: Database Development:	
Fleet Synthetic Training: Architecture:	
Fleet Synthetic Training: Performance Surface Improvements:	
Fleet Synthetic Training: Development Work:	
Fleet Synthetic Training: Studies:	

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Exhibit R-4A, RDT&E Schedule Details: PB 2021 Navy		Date: February 2020
Appropriation/Budget Activity 1319 / 4	R-1 Program Element (Number/Name) PE 0603207N / <i>Air/Ocean Tactical Applications</i>	Project (Number/Name) 3207 / <i>Fleet Synthetic Training</i>

Schedule Details

Events by Sub Project	Start		End	
	Quarter	Year	Quarter	Year
<i>Proj 3207</i>				
Fleet Synthetic Training: Database Development:	1	2020	4	2025
Fleet Synthetic Training: Architecture:	1	2020	4	2025
Fleet Synthetic Training: Performance Surface Improvements:	1	2020	4	2025
Fleet Synthetic Training: Development Work:	1	2020	4	2025
Fleet Synthetic Training: Studies:	1	2020	4	2025

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy										Date: February 2020		
Appropriation/Budget Activity 1319 / 4					R-1 Program Element (Number/Name) PE 0603207N / Air/Ocean Tactical Applications				Project (Number/Name) 3404 / Tactical Environmental Support			
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
3404: <i>Tactical Environmental Support</i>	0.315	2.496	2.619	2.641	-	2.641	2.671	2.683	2.737	2.792	Continuing	Continuing
Quantity of RDT&E Articles		-	-	-	-	-	-	-	-	-		

A. Mission Description and Budget Item Justification

The Tactical Environmental Support Project (3404) enables the future warfighter to leverage environmental data gathered, assimilated and predicted under Projects 2341 (METOC Collections) and 2342 (METOC processing) by incorporating them into warfighting technological, net-centric applications that shape the way in which commanders engage the enemy, take full advantage of environmental conditions (and their impacts on systems and sensors) and complete the mission in the most efficient manner feasible. These software decision support tools complement the capabilities found in the Naval Integrated Tactical Environmental System Next Generation (NITES-Next) Program of Record, and provide platform, sensor, communications, and weapon systems performance assessments for littoral and deep-strike warfighters. The following warfighting disciplines benefit directly from these METOC Exploitation capabilities: (1) Undersea Warfare(USW), Anti-Submarine Warfare(ASW), Mine Warfare(MIW), Amphibious Warfare(AMW), Anti-Surface Warfare (ASUW), Anti-Air Warfare, (AAW), Strike Warfare(STW), Expeditionary Warfare(EXW), Electronic Warfare (EW), Information Operations (IO), Intelligence Operations(INT), Non-Combat Operations (NCO), Command, Control, Communication (CCC), and Naval Special Warfare(NSW).

B. Accomplishments/Planned Programs (\$ in Millions, Article Quantities in Each)

	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Title: Tactical Environmental Support	2.496	2.619	2.641	0.000	2.641
Articles:	-	-	-	-	-
Description: The Tactical Environmental Support Project (3404) enables the future warfighter to leverage environmental data gathered, assimilated and predicted under Projects 2341 (METOC Collections) and 2342 (METOC processing) by incorporating them into warfighting technological, net-centric applications that shape the way in which commanders engage the enemy, take full advantage of environmental conditions (and their impacts on systems and sensors) and complete the mission in the most efficient manner feasible. These software decision support tools complement the capabilities found in the Naval Integrated Tactical Environmental System Next Generation (NITES-Next) POR, and provide platform, sensor, communications, and weapon systems performance assessments for littoral and deep-strike warfighters.					
The following warfighting disciplines benefit directly from these METOC Exploitation capabilities (1) Undersea Warfare (USW), Anti-Submarine Warfare (ASW), Mine Warfare (MIW), Amphibious Warfare (AMW), Anti-Surface Warfare (ASUW), Anti-Air Warfare, (AAW), Strike Warfare (STW), Expeditionary Warfare (EXW), Electronic Warfare (EW), Information Operations (IO), Intelligence Operations (INT), Non-Combat Operations					

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy		Date: February 2020
Appropriation/Budget Activity 1319 / 4	R-1 Program Element (Number/Name) PE 0603207N / <i>Air/Ocean Tactical Applications</i>	Project (Number/Name) 3404 / <i>Tactical Environmental Support</i>

B. Accomplishments/Planned Programs (\$ in Millions, Article Quantities in Each)

(NCO), Command, Control, Communication (CCC), and Naval Special Warfare (NSW). Accomplishments and plans described below are examples for each effort category.

FY 2020 Plans:

In FY 2020 Tactical Environment Support will focus on the Improving the Builder software to include Bragg Line analysis, upgrades to the Ionospheric model and upgrades to output metadata. Leverage lessons learned from NAVSLaM to create a holistic approach to atmospheric boundary layer turbulence observation, data-basing and modeling, as they pertain to Navy tactical problems. Enhancements to newly fielded RF and EO capability that incorporates Fleet user feedback and tactical lessons learned. Explore synergies with other DoD ocean observation system initiatives in order to rapidly advance and scale-up Navy ocean observation systems, data exfiltration, data assimilation and forward modeling capabilities. Fully explore artificial intelligence (AI) and machine learning aspects of EPMA, to include optimization within private cloud and "big data analytics" architectures. Incorporate "mirrored" test and evaluation computational environments when fielding new EPMA capabilities.

Develop technologies that will improve NAVAIR's ability to quickly integrate newly developed NRLAAP capabilities.

Explore options in terms of long-term, state-of-the-art maintenance of and improvements to PE and ASW modeling.

Explore means of integrating STAPLE with newly developed cloud-based OAML software distribution capability.

Make additional modifications to TrueView/Builder in order to meet new Fleet operational and Cyber requirements in an agile manner.

Leverage lessons learned from remote sensing data algorithms for use in SmallSats and other newly emerging remote sensing technologies.

Develop and transition 4D performance surfaces and optimized suite of analyses and forecasts to identify hazardous weather and EM propagation forecasts along Triton UAS flight paths. Sensible weather variables that affect Triton and will be developed include cloud-free line-of-sight, improved turbulence probability, convection and lightning hazard probability, improved flight level winds, and cross-winds at the air base for both takeoff

FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy		Date: February 2020
Appropriation/Budget Activity 1319 / 4	R-1 Program Element (Number/Name) PE 0603207N / <i>Air/Ocean Tactical Applications</i>	Project (Number/Name) 3404 / <i>Tactical Environmental Support</i>

B. Accomplishments/Planned Programs (\$ in Millions, Article Quantities in Each)

	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
<p>and landing. Algorithms for more physically-based turbulence diagnosis will be developed, along with improve cloud microphysics capable of representing convection and lightning hazards. EM propagation routines will be developed to forecast probability of red detection areas (Priority T-1a, E-1c, and RTP Topic 5). Routines to forecast cloud-free line-of-sight will be developed to forecast EO/IR sensor effectiveness.</p> <p>Integrate Oceanographic and Atmospheric Model Library (OAML) model and database updates into the Scalable Tactical Acoustic Propagation Loss Engine (STAPLE) baseline. Work with the Sensor Optimization Working Group (SOWG) on suitability of OAML updates for Fleet implementation. Provide STAPLE update coordination. Maintain STAPLE configuration management and documentation</p> <p>Incorporate the latest in 6.1/6.2 research into the Navy's operational low-frequency passive acoustic models, Navy Standard Parabolic Equation (NSPE) and Uncertainty Band (uBand). Upgrades to NSPE include ice-covered sea surface elastic effects and a new variable depth grid finite-difference algorithm. Upgrades to uBand include cumulative uncertainty effects, a new input front-end, and several new surface duct treatment algorithms.</p> <p>Modifications to ray path calculations of GRAB-3D for vertical wall scenarios; convert the existing mathematical model to the proposed numerical model accounting for source bearing launch versus target bearing receiving angles; compute the acoustic pressure on a wave at the current source bearing launch angles with Caustic correction; refine/validate CASS-3D with MODSS SDSNE dataset (obtained in Phase I Base); convert validated FORTRAN model to C++ and multi-thread.</p> <p>6) Develop and document an OAML Submission Plan (OSP), file an ECP, and submit CASS-3D to OAML to begin the approval process</p> <p>Develop techniques to conduct near real-time RF channel estimation using distributed EW/IO receivers in combination with Blue Force emitters of opportunity, and an efficient operator interface and display for interpreting the complex and rapidly changing urface EW environment. PCAP will develop a system that combines previously-developed elements, namely Refractivty Data Fusion (RDF) and Refractivity from Radio (RFR), and makes the information available to an operator in real-time.</p> <p>Implement Variable Resolution (VR) BAGs into its survey and production workflow, which will require the development of tools for the exploitation of this new structure. The goal of this effort will be to provide this capability and toolset to NAVOCEANO. The Naval Research Laboratory's (NRL) effort will include</p>					

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy		Date: February 2020
Appropriation/Budget Activity 1319 / 4	R-1 Program Element (Number/Name) PE 0603207N / <i>Air/Ocean Tactical Applications</i>	Project (Number/Name) 3404 / <i>Tactical Environmental Support</i>

B. Accomplishments/Planned Programs (\$ in Millions, Article Quantities in Each)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
<p>the determination of the best approach for design/development of the tools, develop the tools, coordinate appropriate demonstrations to all required parties, and to provide software documentation to the customer.</p> <p>Improve the accuracy of Tactical Decision Aide (TDA) acoustic performance calculations in support of surface ship operations by reconciling Fleet sonar data with the OAML models and databases. Conversely, the Fleet data will be used to validate and upgrade the OAML models and databases.</p> <p>The objective of the effort is to improve the predicted performance of tactical weapon systems by measuring key environmental parameters in the battle space with tactical sensors. This is to be accomplished through the development, demonstration, and transition of new Through-the-Sensor data collection, extraction, processing, and dissemination techniques. System specifications to extract environmental data from tactical warfare sensors for use in on-scene decision aids will be developed. Sensors will include acoustic, oceanographic, and atmospheric environmental sensors. Data transformation goals include environmental data acquisition using advanced data processing techniques and rapid information dissemination capabilities. Data dissemination goals include integrating and exposing sensor data across Navy enclaves.</p> <p>Improve accuracy and efficacy of clutter extraction algorithms and processes utilized in the creation of Clutter databases for NAVO. Process currently utilizes AN/SQQ-89(A) recorded data. This task would also explore feasibility of future real time clutter extraction.</p> <p>Geospatially derived acoustic ground analysis has been shown to yield high correlation with acoustic signal excess range predictions generated from physics-based Transmission-Loss (TL) models. We propose to provide a high-performance tool implementing a promising method by which the integration of empirical geospatial acoustic high/low ground analysis may be used to optimized traditional physics-based sensor performance predictions. These optimizations range from narrowing choices on frequency performance, sensor performance, and range within which TL is computed.</p> <p>The goal of this proposed effort is to improve the accuracy and expand the capabilities of models, algorithms and databases that characterize atmospheric impacts on electromagnetic and electro-optical (EM/EO) sensors, weapons, EW/ES and communications systems. Ultimately, this effort will directly help in providing U.S. warfighters with enhanced battlespace awareness to optimize Electromagnetic Maneuver Warfare (EMW) decision making and planning for the current or predicted environmental conditions. These NPS-developed models, algorithms and databases (including NAVSLaM, EDC, UADC, VRPBA, RSMA-ED, Upper-Air Cn2</p>					

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy		Date: February 2020
Appropriation/Budget Activity 1319 / 4	R-1 Program Element (Number/Name) PE 0603207N / <i>Air/Ocean Tactical Applications</i>	Project (Number/Name) 3404 / <i>Tactical Environmental Support</i>

B. Accomplishments/Planned Programs (\$ in Millions, Article Quantities in Each)

	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
<p>models, Cn2 climatology and others) will be submitted to the CNMOC Oceanic and Atmospheric Master Library (OAML) in order to make fully tested, validated, documented and accredited products available "off the shelf" to U.S. DoD researchers and developers of EM/EO prediction TDAs and systems when and as needed. These NPS products are also disseminated to a multitude of U.S. DoD agencies and researchers prior to submission to OAML for research, development, testing and evaluation purposes.</p> <p>Optimize placement of unmanned oceanographic sensors for assimilation into numerical forecasts using technologies such as Guidance for Heterogeneous Observing SysTems (GHOST) developed and maintained by NRL 7300. Optimally integrate the sensor/vehicle allocation, model performance optimization, situational awareness and overall mission planning tasks into capabilities that can be transitioned to the Glider Operations center at NAVOCEANO for use with GHOST guidance. In addition, couple functionality with TOPSIDE software such that the tactical analyst can receive authoritative environmental information to inform operational decisions and to visualize mission definition input as well as platform instruction output from GHOST.</p> <p>Work towards transitioning a new probabilistic aerosol forecasting system, ensemble Navy Aerosol Analysis Prediction System (ENAAPS), to operations. ENAAPS was previously ported to the Navy DoD Supercomputing Resource Center (DSRC) computers and developed as a near-real-time (NRT) system run using Cylc with evaluation of the ensemble mean forecast. In the proposed work, new metrics will be developed for evaluating ensemble spread and used to evaluate the NRT 5 day forecasts, bias correction code for post-processing of the ensemble mean forecast will be added to the NRT system, and new probabilistic aerosol products will be developed.</p> <p>FY 2021 Base Plans: Tactical Environment Support will focus on the Improving the Builder software to include Bragg Line analysis, upgrades to the Ionospheric model and upgrades to output metadata. Leverage lessons learned from NAVSLaM to create a holistic approach to atmospheric boundary layer turbulence observation, data-basing and modeling, as they pertain to Navy tactical problems. Enhancements to newly fielded RF and EO capability that incorporates Fleet user feedback and tactical lessons learned. Explore synergies with other DoD ocean observation system initiatives in order to rapidly advance and scale-up Navy ocean observation systems, data exfiltration, data assimilation and forward modeling capabilities. Fully explore artificial intelligence (AI) and machine learning aspects of EPMA, to include optimization within private cloud and "big data analytics" architectures. Incorporate "mirrored" test and evaluation computational environments when fielding new EPMA capabilities.</p>					

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy		Date: February 2020
Appropriation/Budget Activity 1319 / 4	R-1 Program Element (Number/Name) PE 0603207N / <i>Air/Ocean Tactical Applications</i>	Project (Number/Name) 3404 / <i>Tactical Environmental Support</i>

B. Accomplishments/Planned Programs (\$ in Millions, Article Quantities in Each)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
<p>Develop technologies that will improve NAVAIR's ability to quickly integrate newly developed NRLAAP capabilities. Explore options in terms of long-term, state-of-the-art maintenance of and improvements to PE and ASW modeling.</p> <p>Explore means of integrating STAPLE with newly developed cloud-based OAML software distribution capability.</p> <p>Make additional modifications to TrueView/Builder in order to meet new Fleet operational and Cyber requirements in an agile manner.</p> <p>Leverage lessons learned from remote sensing data algorithms for use in SmallSats and other newly emerging remote sensing technologies.</p> <p>Develop and transition 4D performance surfaces and optimized suite of analyses and forecasts to identify hazardous weather and EM propagation forecasts along Triton UAS flight paths. Sensible weather variables that affect Triton and will be developed include cloud-free line-of-sight, improved turbulence probability, convection and lightning hazard probability, improved flight level winds, and cross-winds at the air base for both takeoff and landing</p> <p>Initiate: Improve oceanographic predictions by developing a system that automates the control of cooperative teams of unmanned maritime vehicles (UxVs).</p> <p>Continue: Explore options in terms of long-term, state-of-the-art maintenance of and improvements to PE and ASW modeling.</p> <p>Continue: Leverage lessons learned from remote sensing data algorithms for use in SmallSats and other newly emerging remote sensing technologies.</p> <p>Continue: Leverage lessons learned from NAVSLaM to create a holistic approach to atmospheric boundary layer turbulence observation, data-basing and modeling, as they pertains to Navy tactical problems.</p> <p>Continue: Explore synergies with other DoD ocean observation system initiatives in order to rapidly advance and scale-up Navy ocean observation systems, data exfiltration, data assimilation and forward modeling capabilities.</p>					

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy		Date: February 2020
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B. Accomplishments/Planned Programs (\$ in Millions, Article Quantities in Each)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Complete: Fully explore artificial intelligence (AI) and machine learning aspects of EPMA, to include optimization within private cloud and "big data analytics" architectures. Incorporate "mirrored" test and evaluation computational environments when fielding new EPMA capabilities.					
Complete: Enhancements to newly fielded RF and EO capability that incorporates Fleet user feedback and tactical lessons learned.					
Complete: Develop technologies that will improve NAVAIR's ability to quickly integrate newly developed NRLAAP capabilities.					
Complete: Make additional modifications to TrueView/Builder in order to meet new Fleet operational and Cyber requirements in an agile manner.					
Complete: Explore means of integrating STAPLE with newly developed cloud-based OAML software distribution capability.					
Complete: Provide a new ashore (reach back) radar/radio frequency (RF) and electro-optical (EO) performance products system that is modular, extensible, and high fidelity environmental model-driven that can serve as a replacement for the current tactical decision aids (TDAs) for RF: AREPS (Advanced Refractive Effects Prediction System), and EO: TAWS					
<i>FY 2021 OCO Plans:</i> N/A					
<i>FY 2020 to FY 2021 Increase/Decrease Statement:</i> There is no significant change between FY 2020 and FY 2021					
Accomplishments/Planned Programs Subtotals	2.496	2.619	2.641	0.000	2.641

C. Other Program Funding Summary (\$ in Millions) N/A
Remarks

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy		Date: February 2020
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D. Acquisition Strategy

Acquisition, management and contracting strategies are to support the Tactical Environmental Support Project to develop, demonstrate and validate products and decision aids to understand and predict the impact of the environment on military operations.

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Exhibit R-4, RDT&E Schedule Profile: PB 2021 Navy **Date:** February 2020

Appropriation/Budget Activity 1319 / 4	R-1 Program Element (Number/Name) PE 0603207N / <i>Air/Ocean Tactical Applications</i>	Project (Number/Name) 3404 / <i>Tactical Environmental Support</i>
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Proj 3404	FY 2019				FY 2020				FY 2021				FY 2022				FY 2023				FY 2024				FY 2025			
	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q
METOC Exploitation - targeted and tactical scales																												
Forward-based ocean and ocean acoustics modeling and data assimilation																												
Numerical prediction in support of atmospheric acoustics characterization																												
Numerical prediction in support of EM warfare and spectrum operations																												
Oceanographic and Ocean Acoustics Database Development																												
Satellite-based environmental monitoring for, analysis, assimilation and modeling																												
Scalable, distributed and adaptive ocean data collections methodologies																												

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Exhibit R-4A, RDT&E Schedule Details: PB 2021 Navy		Date: February 2020
Appropriation/Budget Activity 1319 / 4	R-1 Program Element (Number/Name) PE 0603207N / <i>Air/Ocean Tactical Applications</i>	Project (Number/Name) 3404 / <i>Tactical Environmental Support</i>

Schedule Details

Events by Sub Project	Start		End	
	Quarter	Year	Quarter	Year
Proj 3404				
Forward-based ocean and ocean acoustics modeling and data assimilation: STAPLE Transitions -- NSWCCD	1	2020	4	2024
Forward-based ocean and ocean acoustics modeling and data assimilation: TOPSIDE Acoustics Support / Sonar Performance Engine (SPE)/ RAM-Seahawk Upgrade 1.1 (was FY17-TES-09-N) -- OASIS, Inc.	1	2020	4	2021
Numerical prediction in support of atmospheric acoustics characterization: Atmospheric Acoustic Propagation (AAP) -- NRL-MRY	1	2020	4	2020
Numerical prediction in support of EM warfare and spectrum operations: RTP: Electromagnetic Spectrum Performance Products Ashore -- NRL-MRY / NRL-DC / SSC-PAC	1	2020	4	2024
Numerical prediction in support of EM warfare and spectrum operations: Improved Atmospheric Models for Electromagnetic Maneuver Warfare -- NPS	1	2020	4	2024
Numerical prediction in support of EM warfare and spectrum operations: Navy Electro-Optical Sensor Performance Prediction -- NRL-MRY	1	2020	4	2024
Numerical prediction in support of EM warfare and spectrum operations: NEOSPP and EMSPPA and SSCPAC Code 55280 TrueView team efforts -- SSC-PAC	1	2020	4	2024
Oceanographic and Ocean Acoustics Database Development: Environmental Post-Mission Analysis - TTS ocean and atmosphere data collection -- NRL-SSC	1	2020	4	2024
Satellite-based environmental monitoring for, analysis, assimilation and modeling: Preparing Tactical Optical Ocean Products from Satellite Sensors -- NRL-SSC	1	2020	4	2024
Scalable, distributed and adaptive ocean data collections methodologies: CAST: Cooperative Autonomous Sensing Team -- APL-UW	1	2020	4	2022
Scalable, distributed and adaptive ocean data collections methodologies: Guidance for Heterogeneous Observation Systems (GHOST) -- NRL-SSC	1	2020	4	2024

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy										Date: February 2020		
Appropriation/Budget Activity 1319 / 4					R-1 Program Element (Number/Name) PE 0603207N / Air/Ocean Tactical Applications				Project (Number/Name) 3405 / Decision Support Products & Dissemination			
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
3405: Decision Support Products & Dissemination	0.315	1.052	1.117	1.144	-	1.144	1.171	1.186	1.210	1.234	Continuing	Continuing
Quantity of RDT&E Articles		-	-	-	-	-	-	-	-	-		

A. Mission Description and Budget Item Justification

Decision Support Products & Dissemination efforts enable the future warfighter to leverage environmental data gathered, assimilated, predicted and exploited by optimizing data formatting, compression, packaging, depiction, data-basing and transfer methodologies that permit the rapid dissemination of actionable battlespace environmental (METOC) information over tactical and reach-back networks. This project ensures warfighters, commanders and those who support them are fully synchronized in terms of environmental data products shared among a multitude of platforms, systems and common operating pictures (COPs). METOC information is highly dynamic. Just as time synchronization is essential to navigation principles, timely METOC knowledge and information are vital to battlespace environmental exploitation, placing the warfighter and support elements in spatial and temporal synchronization, and at a collective advantage, in terms of the current and predicted states of the ocean and atmosphere.

B. Accomplishments/Planned Programs (\$ in Millions, Article Quantities in Each)

	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Title: Decision Support Products and Dissemination	1.052	1.117	1.144	0.000	1.144
Articles:	-	-	-	-	-
Description: The Decision Support Products and Dissemination Project (3405) enables the future warfighter to leverage environmental data gathered, assimilated, predicted and exploited under Projects 2341 (METOC Collections), 2342 (METOC processing) and 3404 (METOC exploitation) by optimizing data formatting, compression, packaging, depiction, data-basing and transfer methodologies that permit the rapid dissemination of actionable battlespace environmental (METOC) information over tactical and reach-back networks. This project ensures warfighters, commanders and those who support them are fully synchronized in terms of environmental data products shared among a multitude of platforms, systems and common operating pictures (COPs). METOC information is highly dynamic. Just as time synchronization is essential to navigation principles, timely METOC knowledge and information synchronization is vital to battlespace environmental exploitation, placing the warfighter and all of those who support him on the "same sheet of music" and at a collective advantage, in terms of the current and predicted states of the ocean and atmosphere.					
Accomplishments and plans described below are examples for each effort category.					
FY 2020 Plans:					

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy		Date: February 2020
Appropriation/Budget Activity 1319 / 4	R-1 Program Element (Number/Name) PE 0603207N / <i>Air/Ocean Tactical Applications</i>	Project (Number/Name) 3405 / <i>Decision Support Products & Dissemination</i>

B. Accomplishments/Planned Programs (\$ in Millions, Article Quantities in Each)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Evaluate global ocean analyses and forecasts from different national/international centers, with respect to both hydrographic and acoustic properties.					
Complete Develop ship routing and base preparedness algorithms so that they can be employed on the following systems the Automated Tropical Cyclone Forecast System (ATCF), the Joint METOC Viewer (JMV), and the Advanced Weather Interactive Processing System Version II (AWIPS II).					
Explore the use of oceanographic confidence estimates derived from model/data comparisons to improve Navy ocean and acoustic models and tactical decision aids. Initiate Leverage lessons learned from ocean analysis and forecast evaluations in order to improve databases, data assimilation techniques and ocean and acoustic models in a more synergistic way.					
Leverage lessons learned from A3PET to create a holistic approach to realtime ASW mission planning and retasking by exploring machine learning, highperformance computing, cloud computing and "big data analytics" aspects of the ASW mission planning and associated ocean environment problem.					
Develop a divisionwide system for verification and validation that includes access to statistics for model runs by authorized external users. By leveraging community based tools, we can build a unified verification framework which is consistent across the suite of models and also consistent with our operational partners. Such a framework would allow us to make use of more modern, feature based verification metrics that can assist with identification and diagnosis of specific sources of model error. In addition, this modern framework would allow NRL to better tailor our verification products to inform data assimilation and model development, as well as the needs of the end user. Finally, a consistent model verification framework would aid in collaboration with other U.S. partners (e.g. NCEP, JEDI) who are employing the same community tools.					
The goal of this project is to create a framework and supporting technologies that will enable sharing and coordination of METOC data across multiple providers, enclaves, and domains. This includes creating a realtime master index of all model output products across multiple providers and domains, a grid generalization system that is able to pull and transform gridded model outputs from multiple sources, and a modular dissemination system that will support a wide variety of METOC data consumers. Each of these components can exist and operate at multiple nodes across agencies and network domains. extend the Adaptive Air ASW Planning and Evaluation Tool (A3PET) realtime ASW missionplanning tool to incorporate critical capabilities request by Fleet Users. This effort will develop additional capability to the existing tool, including modeling of					

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy		Date: February 2020
Appropriation/Budget Activity 1319 / 4	R-1 Program Element (Number/Name) PE 0603207N / <i>Air/Ocean Tactical Applications</i>	Project (Number/Name) 3405 / <i>Decision Support Products & Dissemination</i>

B. Accomplishments/Planned Programs (\$ in Millions, Article Quantities in Each)

	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
<p>Active Sonobuoys, modeling buoy drift and buoy deployment latency, as well as adding in overlay import/export functionality for more efficient MPRA mission planning. This effort extends the A3PET MPRA mission planning tool capability delivered in FY18.migrate the OAML library, administrative, and management functions to a cloud based approach. This will provide more efficient maintenance and distribution of the databases, algorithms and models. It will also provide better compatibility with future programs.Implement wind probabilities for Southern Hemisphere, SMOS winds and fixes, RI aid upgrades or consensus upgraded into ATCF; Evaluation of FNMOC version of WAVEWATCH ensemble based on JTWC forecasts.Apply and develop machine learning methods to modeling efforts to help identify model environments and scenarios that help validate the model against measured acoustics and/or reconstruct active acoustic events.</p> <p>FY 2021 Base Plans: Initiate: Develop a unified framework for verification of prediction models across atmosphere, ocean, ice, and space at all spatial and temporal scales, including partnering with other domestic forecast centers to leverage tool suites and infrastructure.</p> <p>Initiate: Deliver capability to access all geospatial information contained within regularly spaced, or Variable Resolution (VR) data files within common GIS software.</p> <p>Initiate: Develops a framework and supporting technologies that will enable sharing and coordination of METOC data across multiple providers, enclaves, and domains.</p> <p>Continue: Evaluate global ocean analyses and forecasts from different national/international centers, with respect to both hydrographic and acoustic properties.</p> <p>Continue: Explore the use of oceanographic confidence estimates derived from model/data comparisons to improve Navy ocean and acoustic models and tactical decision aids.</p> <p>Continue: Leverage lessons learned from A3PET to create a holistic approach to real-time ASW mission planning and re- tasking by exploring machine learning, high-performance computing, cloud computing and "big data analytics" aspects of the ASW mission planning and associated ocean environment problem.</p>					

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy				Date: February 2020	
Appropriation/Budget Activity 1319 / 4		R-1 Program Element (Number/Name) PE 0603207N / <i>Air/Ocean Tactical Applications</i>		Project (Number/Name) 3405 / <i>Decision Support Products & Dissemination</i>	
B. Accomplishments/Planned Programs (\$ in Millions, Article Quantities in Each)					
Complete: Leverage lessons learned from ocean analysis and forecast evaluations in order to improve databases, data assimilation techniques and ocean and acoustic models in a more synergistic way.					
FY 2021 OCO Plans: N/A					
FY 2020 to FY 2021 Increase/Decrease Statement: There is no significant change from FY2020 to FY2021.					
Accomplishments/Planned Programs Subtotals					
	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
	1.052	1.117	1.144	0.000	1.144
C. Other Program Funding Summary (\$ in Millions) N/A					
Remarks					
D. Acquisition Strategy Acquisition, management and contracting strategies are to support the Decision Support Products & Dissemination Project to develop, demonstrate and validate products and decision aids to provide environmentally based recommendations to commanders at the Strategic, Operational, and Tactical levels of military operations.					

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Exhibit R-4, RDT&E Schedule Profile: PB 2021 Navy **Date:** February 2020

Appropriation/Budget Activity 1319 / 4	R-1 Program Element (Number/Name) PE 0603207N / <i>Air/Ocean Tactical Applications</i>	Project (Number/Name) 3405 / <i>Decision Support Products & Dissemination</i>
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METOC Decisions and Dissemination - assessments	FY 2019				FY 2020				FY 2021				FY 2022				FY 2023				FY 2024				FY 2025							
	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q				
Numerical predictions skill assessments																																

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Exhibit R-4, RDT&E Schedule Profile: PB 2021 Navy **Date:** February 2020

Appropriation/Budget Activity 1319 / 4	R-1 Program Element (Number/Name) PE 0603207N / <i>Air/Ocean Tactical Applications</i>	Project (Number/Name) 3405 / <i>Decision Support Products & Dissemination</i>
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METOC Decisions and Dissemination - targeted and tactical scales	FY 2019				FY 2020				FY 2021				FY 2022				FY 2023				FY 2024				FY 2025							
	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q				
Forward-based ocean and ocean acoustics modeling and data assimilation Numerical prediction in support of Navy Resource protection																																
Numerical prediction in support of EM warfare and spectrum operations																																

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

Events by Sub Project	Start		End	
	Quarter	Year	Quarter	Year
<i>METOC Decisions and Dissemination - assessments</i>				
Numerical predictions skill assessments: Global Ocean Multi-Model Comparison -- NRL-SSC	1	2020	4	2024
Numerical predictions skill assessments: Ocean model performance indicators for operational Navy ocean and acoustic model assessment -- NRL-SSC	1	2020	4	2022
<i>METOC Decisions and Dissemination - targeted and tactical scales</i>				
Forward-based ocean and ocean acoustics modeling and data assimilation: Adaptive Air ASW Planning and Evaluation Tool	1	2020	4	2024
Forward-based ocean and ocean acoustics modeling and data assimilation: Numerical prediction in support of Navy Resource protection: ship routing and base preparedness algorithms	1	2020	4	2024
Numerical prediction in support of EM warfare and spectrum operations: Environmental Performance Surfaces for OTH Radars and HF Communications (AKA, Pearman OTH RADAR Exploitation) -- NRL-SSC	1	2020	4	2023

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy **Date:** February 2020

Appropriation/Budget Activity 1319 / 4	R-1 Program Element (Number/Name) PE 0603207N / <i>Air/Ocean Tactical Applications</i>	Project (Number/Name) 9999 / <i>Congressional Adds</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
9999: <i>Congressional Adds</i>	0.000	0.000	8.000	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	8.000
Quantity of RDT&E Articles		-	-	-	-	-	-	-	-	-		

A. Mission Description and Budget Item Justification

Congressional Interest Items not included in other Projects.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020
Congressional Add: Long duration autonomous hydrographic survey	0.000	8.000
FY 2019 Accomplishments: N/A		
FY 2020 Plans: Conduct advanced technology development research in Long Duration autonomous hydrographic surveys.		
Congressional Adds Subtotals	0.000	8.000

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

N/A

Remarks

D. Acquisition Strategy

N/A

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Exhibit R-4, RDT&E Schedule Profile: PB 2021 Navy **Date:** February 2020

Appropriation/Budget Activity 1319 / 4	R-1 Program Element (Number/Name) PE 0603207N / <i>Air/Ocean Tactical Applications</i>	Project (Number/Name) 9999 / <i>Congressional Adds</i>
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Long duration autonomous hydrographic survey	FY 2019				FY 2020				FY 2021				FY 2022				FY 2023				FY 2024				FY 2025							
	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q				

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

Events by Sub Project	Start		End	
	Quarter	Year	Quarter	Year
<i>Long duration autonomous hydrographic survey</i>				
Milestone A : Long Duration Autonomous Survey TBD	1	2020	4	2020