Department of Defense
Fiscal Year (FY) 2017 President's Budget Submission

February 2016

Army

Justification Book of

Research, Development, Test & Evaluation, Army

RDT&E − Volume I, Budget Activity 1

RESEARCH, DEVELOPMENT, TEST AND EVALUATION, ARMY

APPROPRIATION LANGUAGE

For expenses necessary for basic and applied scientific research, development, test and evaluation, including maintenance, rehabilitation, lease, and operation of facilities and equipment, $7,615,921,000.00 to remain available for obligation until September 30, 2018.

The following Justification Books were prepared at a cost of $1,209,553: Aircraft (ACFT), Missile (MSLS), Weapons & Tracked Combat Vehicles (WTCV), Ammunition (AMMO), Other Procurement Army (OPA) 1 - Tactical & Support Vehicles, Other Procurement Army (OPA) 2 – Communications & Electronics, Other Procurement Army (OPA) 3 & 4 - Other Support Equipment & Spares, Research, Development, Test and Evaluation (RDTE) for: Budget Activity 1, Budget Activity 2, Budget Activity 3, Budget Activity 4, Budget Activity 5A, Budget Activity 5B, Budget Activity 6, and Budget Activity 7.

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FY 2017 RDT&E, ARMY
PROGRAM ELEMENT DESCRIPTIVE SUMMARIES

Introduction and Explanation of Contents

1. **General.** The purpose of this document is to provide summary information concerning the Research, Development, Test and Evaluation, Army program. The descriptive summaries are comprised of R-2 (Army RDT&E Budget Item Justification – program element level), R-2A (Army RDT&E Budget Item Justification – project level), R-3 (Army RDT&E Cost Analysis), R-4 (Schedule Profile Detail) and R-5 (Termination Liability Funding for MDAPs) Exhibits, which provide narrative information on all RDT&E program elements and projects through FY 2017.

2. **Relationship of the FY 2017 Budget Submitted to Congress to the FY 2016 Budget Submitted to Congress.** This paragraph provides a list of program elements/projects that are major new starts, restructures, developmental transitions, and terminated programs. Explanations for these changes can be found in the narrative sections of the Program Element R-2A Exhibits.

A. New Start Programs:

PE/Project	PE Title	Project Title
345251/FA8	Cyberspace Operations Forces and Force Support	Cyberspace Operations Forces and Force Support
363326/FA9	Security Initiatives	Security Initiatives
373150/EA5	Army Global Command & Control System	Strategic and Joint Mission Command
643308/EB7	Army Missile Defense Systems Integration	Army Space System Enhancement/Integration
643619/606	Close Combat Systems Adv Dev	Cntrmn/Barrier Adv Dev
643801/B47	Aviation Advanced Development	Future Vertical Lift Medium
654270/ET7	EW Development	Radio Frequency Interference Mitigation
654270/DX6	EW Development	Radio Frequency Interference Mitigation
654622/659	Family of Heavy Tactical Vehicles	Family of Hvy Tac Veh
654622/E40	Light Tactical Wheeled Vehicle	LTV Prototype
654645/EV8	Armored Systems Modernization on End Dev	Mobile Protected Firepower
654818/EW3	Army Tac Comm & Cont Hardware & Software	Unit Task Reorganization (UTR) Development
654822/EV4	General Fund Enterprise Business System (GFEBS)	General Fund Enterprise Business System Inc 2
664759/FA4	Major Test & Evaluation Investment	Warrior Injury Assessment Manikin (WIAMan)
675024/FB1	Anti-Tamper Technology Support	Anti-Tamper Technology Support
654818/EW3	Army Tac Comm &Cont Hardware & Software	Unit Task Reorganization (UTR) Development

B. Program Element/Project Restructures:

Old PE/Project	New Project Title	New PE/Project
0205778/EG2	Long Range Precision Fires (LRPF)	0607134/ES1
0303140/501	Army Key Mgmt System	0303140/DV4
0305204/D10	MQ-1C Gray Eagle	0203744/EB6
0601102/S14	Basic Resch in Clinical & Rehabilitative Med	0601102/ET6
0602787/874	Appl Resch in Clinical and Rehabilitative Med	0602787/ET4
0603002/840	Medical Advance Technology	0603002/ET5
0603827/S53	Personnel Airdrop System Development	0603827/ET8
0604120/ED5	Mounted	0604120/EH8
0604120/ED5	Dismounted	0604120/EJ2
0604280/DZ5	Manpack Radio	0605042/FA1
0604280/DZ5	Rifleman Radio	0605042/FA2
0604622/659	TWV Protection Kits	0604622/VR5
0604759/984	Range Radar Replacement Program (RRRP)	0604759/EY9
0604798/DY4	Network Integration Support	0604798/DY3
0604798/DY6	Brigade and Platform Integration Support	0604798/DY3
0604818/S75	Tactical Network Operations and Management	0604818/EK9
0604827/S75	Ground Soldier Ensemble	0604818/EQ8
0605031/EF5	Waveforms	0605031/EX6
0605457/DU4	FAAD C2 ED	0604741/126

C. Developmental Transitions:

Old PE/Project	New Project Title	New PE/Project
0204502/EF2	Integ/GrdSecSurv RespC	0605029/EQ2
0204502/EF2	Grnd-Based Opnl Surv Sys Expend (GBOSS-E)	0605033/EQ3
0303140/491	Defensive Cyber Operations	0605041/EV5
0603639/EC2	Adv Armor-Piercing (ADVAP)	0604802/EP5
0603639/EL8	Lightweight Cartridge Case for Small Caliber Ammo	0604802/EP6
0603639/656	120mm Cartridge (Advanced Multipurpose AMP)	0604802/ED7
0603782/372	Warfighter Information Network	0605535/EE8
0603827S54	Crew Served Weapons Engineering Development	0604601/EW4
0603850/472	Integrated Broadcast System	0305179/EF4
0605626/AC5	Enhanced Medium Alt Recon Surv Sys	0305206/EH3
0605898/M65	ATEC Joint	0605712/001
0606801/M46	AMCOM Cmd/Ctr Spt	0602705/H94
0606801/M46	AMCOM Cmd/Ctr Spt	0605024/FB1
0607865/DV8	Lower Tier Missile Defense (LTAMD) Capability	0604114/EX2
0604319/DU3	IFPC2	0605052/EY7

D. Program Terminations:

PE Title	PE/Project
Aircrew Integrated Sys Ad	0603827/152
PAC-3/MSE Missile	0605456/PA3

3. **Classification:** This document contains no classified data Appropriately cleared individuals can obtain further information on Classified/Special Access Programs by contacting the Department of the Army (ASA(ALT)) Special Programs Office.

Department of Defense
FY 2017 President's Budget
Exhibit R-1 FY 2017 President's Budget
Total Obligational Authority
(Dollars in Thousands)

14 Jan 2016

Appropriation	FY 2015 (Base & OCO)	FY 2016 Base Enacted	FY 2016 OCO Enacted	FY 2016 Total Enacted	FY 2017 Base	FY 2017 OCO	FY 2017 Total
Research, Development, Test & Eval, Army	6,744,134	7,562,170	1,500	7,563,670	7,515,399	100,522	7,615,921
Total Research, Development, Test & Evaluation	6,744,134	7,562,170	1,500	7,563,670	7,515,399	100,522	7,615,921

R-1C1: FY 2017 President's Budget (Published Version of PB Position), as of January 14, 2016 at 10:17:52

Department of Defense
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14 Jan 2016

Summary Recap of Budget Activities	FY 2015 (Base & OCO)	FY 2016 Base Enacted	FY 2016 OCO Enacted	FY 2016 Total Enacted	FY 2017 Base	FY 2017 OCO	FY 2017 Total
Basic Research	447,868	469,079		469,079	428,943		428,943
Applied Research	964,085	1,092,885		1,092,885	907,574		907,574
Advanced Technology Development	1,089,087	1,127,304		1,127,304	930,065		930,065
Advanced Component Development & Prototypes	298,467	506,123	1,500	507,623	550,635	9,375	560,010
System Development & Demonstration	1,604,756	2,085,147		2,085,147	2,265,094	84,043	2,349,137
RDT&E Management Support	1,166,015	1,070,581		1,070,581	1,136,134		1,136,134
Operational Systems Development	1,173,856	1,211,051		1,211,051	1,296,954	7,104	1,304,058
Total Research, Development, Test & Evaluation	6,744,134	7,562,170	1,500	7,563,670	7,515,399	100,522	7,615,921
Summary Recap of FYDP Programs							
General Purpose Forces	705,451	779,716		779,716	618,038		618,038
Intelligence and Communications	162,187	171,857		171,857	238,711	7,104	245,815
Research and Development	5,788,542	6,545,639	1,500	6,547,139	6,591,738	93,418	6,685,156
Central Supply and Maintenance	73,419	60,422		60,422	62,287		62,287
Administration and Associated Activities	233						
Classified Programs	14,302	4,536		4,536	4,625		4,625
Total Research, Development, Test & Evaluation	6,744,134	7,562,170	1,500	7,563,670	7,515,399	100,522	7,615,921

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14 Jan 2016

Appropriation: 2040A Research, Development, Test & Eval, Army

Line No	Program Element Number	Item	Act	FY 2015 (Base & OCO)	FY 2016 Base Enacted	FY 2016 OCO Enacted	FY 2016 Total Enacted	FY 2017 Base	FY 2017 OCO	FY 2017 Total	Sec
1	0601101A	In-House Laboratory Independent Research	01	13,125	13,018		13,018	12,381		12,381	U
2	0601102A	Defense Research Sciences	01	249,855	279,118		279,118	253,116		253,116	U
3	0601103A	University Research Initiatives	01	79,122	72,603		72,603	69,166		69,166	U
4	0601104A	University and Industry Research Centers	01	105,766	104,340		104,340	94,280		94,280	U
	Basic Research			447,868	469,079		469,079	428,943		428,943	
5	0602105A	Materials Technology	02	45,563	68,314		68,314	31,533		31,533	U
6	0602120A	Sensors and Electronic Survivability	02	45,792	58,374		58,374	36,109		36,109	U
7	0602122A	TRACTOR HIP	02	16,358	6,879		6,879	6,995		6,995	U
8	0602211A	Aviation Technology	02	62,046	56,884		56,884	65,914		65,914	U
9	0602270A	Electronic Warfare Technology	02	19,333	19,243		19,243	25,466		25,466	U
10	0602303A	Missile Technology	02	61,144	53,553		53,553	44,313		44,313	U
11	0602307A	Advanced Weapons Technology	02	37,464	38,028		38,028	28,803		28,803	U
12	0602308A	Advanced Concepts and Simulation	02	26,505	27,862		27,862	27,688		27,688	U
13	0602601A	Combat Vehicle and Automotive Technology	02	71,811	98,439		98,439	67,959		67,959	U
14	0602618A	Ballistics Technology	02	83,610	117,801		117,801	85,436		85,436	U
15	0602622A	Chemical, Smoke and Equipment Defeating Technology	02	3,865	3,866		3,866	3,923		3,923	U
16	0602623A	Joint Service Small Arms Program	02	6,633	5,487		5,487	5,545		5,545	U
17	0602624A	Weapons and Munitions Technology	02	62,131	83,340		83,340	53,581		53,581	U
18	0602705A	Electronics and Electronic Devices	02	72,442	64,301		64,301	56,322		56,322	U

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19	0602709A	Night Vision Technology	02	44,694	38,807		38,807	36,079		36,079	U
20	0602712A	Countermine Systems	02	28,597	36,568		36,568	26,497		26,497	U
21	0602716A	Human Factors Engineering Technology	02	23,434	23,681		23,681	23,671		23,671	U
22	0602720A	Environmental Quality Technology	02	15,288	20,850		20,850	22,151		22,151	U
23	0602782A	Command, Control, Communications Technology	02	33,117	36,160		36,160	37,803		37,803	U
24	0602783A	Computer and Software Technology	02	10,514	12,656		12,656	13,811		13,811	U
25	0602784A	Military Engineering Technology	02	66,582	80,909		80,909	67,416		67,416	U
26	0602785A	Manpower/Personnel/Training Technology	02	21,280	24,735		24,735	26,045		26,045	U
27	0602786A	Warfighter Technology	02	31,597	39,295		39,295	37,403		37,403	U
28	0602787A	Medical Technology	02	74,285	76,853		76,853	77,111		77,111	U
		Applied Research		964,085	1,092,885		1,092,885	907,574		907,574	
29	0603001A	Warfighter Advanced Technology	03	75,833	55,973		55,973	38,831		38,831	U
30	0603002A	Medical Advanced Technology	03	104,997	108,584		108,584	68,365		68,365	U
31	0603003A	Aviation Advanced Technology	03	99,762	103,136		103,136	94,280		94,280	U
32	0603004A	Weapons and Munitions Advanced Technology	03	72,176	82,663		82,663	68,714		68,714	U
33	0603005A	Combat Vehicle and Automotive Advanced Technology	03	143,606	135,571		135,571	122,132		122,132	U
34	0603006A	Space Application Advanced Technology	03	6,664	5,554		5,554	3,904		3,904	U
35	0603007A	Manpower, Personnel and Training Advanced Technology	03	11,677	12,636		12,636	14,417		14,417	U

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36	0603008A	Electronic Warfare Advanced Technology	03	43,416							U
37	0603009A	TRACTOR HIKE	03	7,492	7,502		7,502	8,074		8,074	U
38	0603015A	Next Generation Training & Simulation Systems	03	16,103	17,425		17,425	18,969		18,969	U
39	0603020A	TRACTOR ROSE	03	14,483	11,912		11,912	11,910		11,910	U
40	0603125A	Combating Terrorism - Technology Development	03	23,334	33,520		33,520	27,686		27,686	U
41	0603130A	TRACTOR NAIL	03	3,440	2,381		2,381	2,340		2,340	U
42	0603131A	TRACTOR EGGS	03	2,406	2,431		2,431	2,470		2,470	U
43	0603270A	Electronic Warfare Technology	03	27,238	32,874		32,874	27,893		27,893	U
44	0603313A	Missile and Rocket Advanced Technology	03	78,302	104,449		104,449	52,190		52,190	U
45	0603322A	TRACTOR CAGE	03	11,105	10,999		10,999	11,107		11,107	U
46	0603461A	High Performance Computing Modernization Program	03	214,614	222,159		222,159	177,190		177,190	U
47	0603606A	Landmine Warfare and Barrier Advanced Technology	03	12,795	13,966		13,966	17,451		17,451	U
48	0603607A	Joint Service Small Arms Program	03	7,055	5,105		5,105	5,839		5,839	U
49	0603710A	Night Vision Advanced Technology	03	46,056	40,929		40,929	44,468		44,468	U
50	0603728A	Environmental Quality Technology Demonstrations	03	11,311	14,727		14,727	11,137		11,137	U
51	0603734A	Military Engineering Advanced Technology	03	17,124	26,845		26,845	20,684		20,684	U
52	0603772A	Advanced Tactical Computer Science and Sensor Technology	03	38,098	38,147		38,147	44,239		44,239	U

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53	0603794A	C3 Advanced Technology	03		37,816		37,816	35,775		35,775	U
		Advanced Technology Development		1,089,087	1,127,304		1,127,304	930,065		930,065	
54	0603305A	Army Missle Defense Systems Integration	04	25,672	29,347		29,347	9,433		9,433	U
55	0603308A	Army Space Systems Integration	04	13,804	25,061		25,061	23,056	9,375	32,431	U
56	0603619A	Landmine Warfare and Barrier - Adv Dev	04		45,757		45,757	72,117		72,117	U
57	0603627A	Smoke, Obscurant and Target Defeating Sys-Adv Dev	04		13,426		13,426	28,244		28,244	U
58	0603639A	Tank and Medium Caliber Ammunition	04	25,317	46,749		46,749	40,096		40,096	U
59	0603747A	Soldier Support and Survivability	04	8,633	2,801	1,500	4,301	10,506		10,506	U
60	0603766A	Tactical Electronic Surveillance System - Adv Dev	04	9,255	13,472		13,472	15,730		15,730	U
61	0603774A	Night Vision Systems Advanced Development	04	3,521	7,292		7,292	10,321		10,321	U
62	0603779A	Environmental Quality Technology - Dem/Val	04	7,529	8,813		8,813	7,785		7,785	U
63	0603790A	NATO Research and Development	04	2,839	6,075		6,075	2,300		2,300	U
64	0603801A	Aviation - Adv Dev	04					10,014		10,014	U
65	0603804A	Logistics and Engineer Equipment - Adv Dev	04	13,188	21,233		21,233	20,834		20,834	U
66	0603807A	Medical Systems - Adv Dev	04	22,825	31,962		31,962	33,503		33,503	U
67	0603827A	Soldier Systems - Advanced Development	04	9,194	22,994		22,994	31,120		31,120	U
68	0604100A	Analysis Of Alternatives	04	9,685	9,805		9,805	6,608		6,608	U

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69	0604114A	Lower Tier Air Missile Defense (LTAMD) Sensor	04					35,132		35,132	U
70	0604115A	Technology Maturation Initiatives	04	43,083	35,917		35,917	70,047		70,047	U
71	0604120A	Assured Positioning, Navigation and Timing (PNT)	04	11,447	30,058		30,058	83,279		83,279	U
72	0604319A	Indirect Fire Protection Capability Increment 2-Intercept (IFPC2)	04	92,475	155,361		155,361				U
73	0305251A	Cyberspace Operations Forces and Force Support	04					40,510		40,510	U
		Advanced Component Development & Prototypes		298,467	506,123	1,500	507,623	550,635	9,375	560,010	
74	0604201A	Aircraft Avionics	05	39,583	18,639		18,639	83,248		83,248	U
75	0604270A	Electronic Warfare Development	05	5,792	18,843		18,843	34,642		34,642	U
76	0604280A	Joint Tactical Radio	05	9,454	4,546		4,546				U
77	0604290A	Mid-tier Networking Vehicular Radio (MNVR)	05	9,355	8,763		8,763	12,172		12,172	U
78	0604321A	All Source Analysis System	05	5,532	4,309		4,309	3,958		3,958	U
79	0604328A	TRACTOR CAGE	05	19,929	15,138		15,138	12,525		12,525	U
80	0604601A	Infantry Support Weapons	05	36,826	89,661		89,661	66,943		66,943	U
81	0604604A	Medium Tactical Vehicles	05	202							U
82	0604611A	JAVELIN	05	4,006	3,945		3,945	20,011		20,011	U
83	0604622A	Family of Heavy Tactical Vehicles	05	12,768				11,429		11,429	U
84	0604633A	Air Traffic Control	05	17,066	10,076		10,076	3,421		3,421	U
85	0604641A	Tactical Unmanned Ground Vehicle (TUGV)	05	2,663	15,374		15,374	39,282		39,282	U

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86	0604642A	Light Tactical Wheeled Vehicles	05					494		494	U
87	0604645A	Armored Systems Modernization (ASM) - Eng Dev	05					9,678		9,678	U
88	0604710A	Night Vision Systems - Eng Dev	05	58,997	67,582		67,582	84,519		84,519	U
89	0604713A	Combat Feeding, Clothing, and Equipment	05	2,983	1,763		1,763	2,054		2,054	U
90	0604715A	Non-System Training Devices - Eng Dev	05	8,775	27,155		27,155	30,774	33	30,807	U
91	0604741A	Air Defense Command, Control and Intelligence - Eng Dev	05	15,294	34,569		34,569	53,332		53,332	U
92	0604742A	Constructive Simulation Systems Development	05	4,394	23,364		23,364	17,887		17,887	U
93	0604746A	Automatic Test Equipment Development	05	10,685	8,960		8,960	8,813		8,813	U
94	0604760A	Distributive Interactive Simulations (DIS) - Eng Dev	05	9,699	9,138		9,138	10,487		10,487	U
95	0604780A	Combined Arms Tactical Trainer (CATT) Core	05	33,422	21,622		21,622	15,068		15,068	U
96	0604798A	Brigade Analysis, Integration and Evaluation	05	82,957	99,242		99,242	89,716		89,716	U
97	0604802A	Weapons and Munitions - Eng Dev	05	17,312	21,379		21,379	80,365		80,365	U
98	0604804A	Logistics and Engineer Equipment - Eng Dev	05	23,652	46,039		46,039	75,098		75,098	U
99	0604805A	Command, Control, Communications Systems - Eng Dev	05	5,116	2,683		2,683	4,245		4,245	U
100	0604807A	Medical Materiel/Medical Biological Defense Equipment - Eng Dev	05	29,441	45,412		45,412	41,124		41,124	U
101	0604808A	Landmine Warfare/Barrier - Eng Dev	05	53,579	55,215		55,215	39,630		39,630	U

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Appropriation: 2040A Research, Development, Test & Eval, Army

Line No	Program Element Number	Item	Act	FY 2015 (Base & OCO)	FY 2016 Base Enacted	FY 2016 OCO Enacted	FY 2016 Total Enacted	FY 2017 Base	FY 2017 OCO	FY 2017 Total	Sec
102	0604818A	Army Tactical Command & Control Hardware & Software	05	29,690	131,639		131,639	205,590		205,590	U
103	0604820A	Radar Development	05	5,022	12,309		12,309	15,983		15,983	U
104	0604822A	General Fund Enterprise Business System (GFEBS)	05	5,500	21,155		21,155	6,805		6,805	U
105	0604823A	Firefinder	05	22,587	2,967		2,967	9,235		9,235	U
106	0604827A	Soldier Systems - Warrior Dem/Val	05	5,942	18,776		18,776	12,393		12,393	U
107	0604854A	Artillery Systems - EMD	05	1,838	1,953		1,953	1,756		1,756	U
108	0605013A	Information Technology Development	05	64,982	60,358		60,358	74,236		74,236	U
109	0605018A	Integrated Personnel and Pay System-Army (IPPS-A)	05	62,831	121,011		121,011	155,584		155,584	U
110	0605028A	Armored Multi-Purpose Vehicle (AMPV)	05	88,797	226,210		226,210	184,221		184,221	U
111	0605029A	Integrated Ground Security Surveillance Response Capability (IGSSR-C)	05					4,980		4,980	U
112	0605030A	Joint Tactical Network Center (JTNC)	05	8,615	13,357		13,357	15,041		15,041	U
113	0605031A	Joint Tactical Network (JTN)	05	17,305	18,055		18,055	16,014		16,014	U
114	0605032A	TRACTOR TIRE	05		5,677		5,677	27,254		27,254	U
115	0605033A	Ground-Based Operational Surveillance System - Expeditionary (GBOSS-E)	05					5,032		5,032	U
116	0605034A	Tactical Security System (TSS)	05					2,904		2,904	U
117	0605035A	Common Infrared Countermeasures (CIRCM)	05	169,196	101,570		101,570	96,977	10,900	107,877	U
118	0605036A	Combating Weapons of Mass Destruction (CWMD)	05					2,089		2,089	U

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Line No	Program Element Number	Item	Act	FY 2015 (Base & OCO)	FY 2016 Base Enacted	FY 2016 OCO Enacted	FY 2016 Total Enacted	FY 2017 Base	FY 2017 OCO	FY 2017 Total	Sec
119	0605041A	Defensive CYBER Tool Development	05					33,836		33,836	U
120	0605042A	Tactical Network Radio Systems (Low-Tier)	05					18,824		18,824	U
121	0605047A	Contract Writing System	05					20,663		20,663	U
122	0605051A	Aircraft Survivability Development	05		78,112		78,112	41,133	73,110	114,243	U
123	0605052A	Indirect Fire Protection Capability Inc 2 - Block 1	05					83,995		83,995	U
124	0605350A	WIN-T Increment 3 - Full Networking	05	108,851	33,515		33,515				U
125	0605380A	AMF Joint Tactical Radio System (JTRS)	05	6,616	11,455		11,455	5,028		5,028	U
126	0605450A	Joint Air-to-Ground Missile (JAGM)	05	80,585	83,054		83,054	42,972		42,972	U
127	0605456A	PAC-3/MSE Missile	05	33,709	2,272		2,272				U
128	0605457A	Army Integrated Air and Missile Defense (AIAMD)	05	147,250	222,075		222,075	252,811		252,811	U
129	0605625A	Manned Ground Vehicle	05	47,265	39,247		39,247				U
130	0605626A	Aerial Common Sensor	05	20,328	2		2				U
131	0605766A	National Capabilities Integration (MIP)	05	18,254	10,599		10,599	4,955		4,955	U
132	0605812A	Joint Light Tactical Vehicle (JLTV) Engineering and Manufacturing Development Ph	05	43,302	32,486		32,486	11,530		11,530	U
133	0605830A	Aviation Ground Support Equipment	05	9,655	13,880		13,880	2,142		2,142	U
134	0210609A	Paladin Integrated Management (PIM)	05	77,210	152,288		152,288	41,498		41,498	U
135	0303032A	TROJAN - RH12	05	983	5,022		5,022	4,273		4,273	U

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136	0304270A	Electronic Warfare Development	05	8,961	12,686		12,686	14,425		14,425	U
		System Development & Demonstration		1,604,756	2,085,147		2,085,147	2,265,094	84,043	2,349,137	
137	0604256A	Threat Simulator Development	06	21,691	27,535		27,535	25,675		25,675	U
138	0604258A	Target Systems Development	06	9,778	16,684		16,684	19,122		19,122	U
139	0604759A	Major T&E Investment	06	54,281	66,580		66,580	84,777		84,777	U
140	0605103A	Rand Arroyo Center	06	19,817	19,382		19,382	20,658		20,658	U
141	0605301A	Army Kwajalein Atoll	06	169,699	203,905		203,905	236,648		236,648	U
142	0605326A	Concepts Experimentation Program	06	18,757	19,430		19,430	25,596		25,596	U
143	0605502A	Small Business Innovative Research	06	172,658							U
144	0605601A	Army Test Ranges and Facilities	06	271,377	279,896		279,896	293,748		293,748	U
145	0605602A	Army Technical Test Instrumentation and Targets	06	43,961	51,550		51,550	52,404		52,404	U
146	0605604A	Survivability/Lethality Analysis	06	33,210	33,246		33,246	38,571		38,571	U
147	0605606A	Aircraft Certification	06	4,667	4,760		4,760	4,665		4,665	U
148	0605702A	Meteorological Support to RDT&E Activities	06	6,289	8,303		8,303	6,925		6,925	U
149	0605706A	Materiel Systems Analysis	06	20,578	20,403		20,403	21,677		21,677	U
150	0605709A	Exploitation of Foreign Items	06	8,418	10,396		10,396	12,415		12,415	U
151	0605712A	Support of Operational Testing	06	48,953	49,337		49,337	49,684		49,684	U
152	0605716A	Army Evaluation Center	06	54,468	52,694		52,694	55,905		55,905	U
153	0605718A	Army Modeling & Sim X-Cmd Collaboration & Integ	06	1,081	938		938	7,959		7,959	U
154	0605801A	Programwide Activities	06	63,687	60,319		60,319	51,822		51,822	U

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155	0605803A	Technical Information Activities	06	28,781	28,478		28,478	33,323		33,323	U
156	0605805A	Munitions Standardization, Effectiveness and Safety	06	62,168	64,604		64,604	40,545		40,545	U
157	0605857A	Environmental Quality Technology Mgmt Support	06	2,512	3,186		3,186	2,130		2,130	U
158	0605898A	Management HQ - R&D	06	48,951	48,955		48,955	49,885		49,885	U
159	0303260A	Defense Military Deception Initiative	06					2,000		2,000	U
160	0909999A	Financing for Cancelled Account Adjustments	06	233							U
	RDT&E	Management Support		1,166,015	1,070,581		1,070,581	1,136,134		1,136,134	
161	0603778A	MLRS Product Improvement Program	07	17,852	18,397		18,397	9,663		9,663	U
162	0603813A	TRACTOR PULL	07		9,461		9,461	3,960		3,960	U
163	0605024A	Anti-Tamper Technology Support	07					3,638		3,638	U
164	0607131A	Weapons and Munitions Product Improvement Programs	07		4,945		4,945	14,517		14,517	U
165	0607133A	TRACTOR SMOKE	07		7,569		7,569	4,479		4,479	U
166	0607134A	Long Range Precision Fires (LRPF)	07					39,275		39,275	U
167	0607135A	Apache Product Improvement Program	07	86,099	65,562		65,562	66,441		66,441	U
168	0607136A	Blackhawk Product Improvement Program	07	48,406	66,653		66,653	46,765		46,765	U
169	0607137A	Chinook Product Improvement Program	07	35,424	32,407		32,407	91,848		91,848	U
170	0607138A	Fixed Wing Product Improvement Program	07	819	1,151		1,151	796		796	U
171	0607139A	Improved Turbine Engine Program	07	49,328	51,164		51,164	126,105		126,105	U

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172	0607140A	Emerging Technologies from NIE	07	4,916	2,481		2,481	2,369		2,369	U
173	0607141A	Logistics Automation	07	3,513	1,673		1,673	4,563		4,563	U
174	0607665A	Family of Biometrics	07	1,332	13,237		13,237	12,098		12,098	U
175	0607865A	Patriot Product Improvement	07	57,962	89,816		89,816	49,482		49,482	U
176	0202429A	Aerostat Joint Project - COCOM Exercise	07	43,248	10,565		10,565	45,482		45,482	U
177	0203726A	Adv Field Artillery Tactical Data System	07	1,224							U
178	0203728A	Joint Automated Deep Operation Coordination System (JADOCS)	07	33,996	35,719		35,719	30,455		30,455	U
179	0203735A	Combat Vehicle Improvement Programs	07	297,423	354,667		354,667	316,857		316,857	U
180	0203740A	Maneuver Control System	07	43,453	15,408		15,408	4,031		4,031	U
181	0203744A	Aircraft Modifications/Product Improvement Programs	07	40				35,793		35,793	U
182	0203752A	Aircraft Engine Component Improvement Program	07	372	364		364	259		259	U
183	0203758A	Digitization	07	5,765	4,361		4,361	6,483		6,483	U
184	0203801A	Missile/Air Defense Product Improvement Program	07	4,917	3,154		3,154	5,122		5,122	U
185	0203802A	Other Missile Product Improvement Programs	07	40,468	35,951		35,951	7,491		7,491	U
186	0203808A	TRACTOR CARD	07	19,347	34,686		34,686	20,333		20,333	U
187	0205402A	Integrated Base Defense - Operational System Dev	07	4,196	10,750		10,750				U
188	0205410A	Materials Handling Equipment	07	802	402		402	124		124	U

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Line No	Program Element Number	Item	Act	FY 2015 (Base & OCO)	FY 2016 Base Enacted	FY 2016 OCO Enacted	FY 2016 Total Enacted	FY 2017 Base	FY 2017 OCO	FY 2017 Total	Sec
189	0205412A	Environmental Quality Technology - Operational System Dev	07	270							U
190	0205456A	Lower Tier Air and Missile Defense (AMD) System	07	78,720	64,159		64,159	69,417		69,417	U
191	0205778A	Guided Multiple-Launch Rocket System (GMLRS)	07	43,791	36,727		36,727	22,044		22,044	U
192	0208053A	Joint Tactical Ground System	07	10,209	20,515		20,515	12,649		12,649	U
194	0303028A	Security and Intelligence Activities	07	12,518	6,998		6,998	11,619		11,619	U
195	0303140A	Information Systems Security Program	07	13,627	31,154		31,154	38,280		38,280	U
196	0303141A	Global Combat Support System	07	5,225	21,574		21,574	27,223		27,223	U
197	0303142A	SATCOM Ground Environment (SPACE)	07	9,978	9,355		9,355	18,815		18,815	U
198	0303150A	WWMCCS/Global Command and Control System	07	2,493	7,034		7,034	4,718		4,718	U
201	0305179A	Integrated Broadcast Service (IBS)	07		750		750				U
202	0305204A	Tactical Unmanned Aerial Vehicles	07	20,290	13,225		13,225	8,218		8,218	U
203	0305206A	Airborne Reconnaissance Systems	07		22,870		22,870	11,799		11,799	U
204	0305208A	Distributed Common Ground/Surface Systems	07	20,155	25,592		25,592	32,284		32,284	U
205	0305219A	MQ-1C Gray Eagle UAS	07	46,472				13,470		13,470	U
206	0305232A	RQ-11 UAV	07					1,613		1,613	U
207	0305233A	RQ-7 UAV	07	16,389	11,797		11,797	4,597		4,597	U
208	0307665A	Biometrics Enabled Intelligence	07	1,973					7,104	7,104	U
209	0310349A	Win-T Increment 2 - Initial Networking	07	3,123	3,800		3,800	4,867		4,867	U

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Line No	Program Element Number	Item	Act	FY 2015 (Base & OCO)	FY 2016 Base Enacted	FY 2016 OCO Enacted	FY 2016 Total Enacted	FY 2017 Base	FY 2017 OCO	FY 2017 Total	Sec
210	0708045A	End Item Industrial Preparedness Activities	07	73,419	60,422		60,422	62,287		62,287	U
9999	9999999999	Classified Programs		14,302	4,536		4,536	4,625		4,625	U
		Operational Systems Development		1,173,856	1,211,051		1,211,051	1,296,954	7,104	1,304,058	
Total Research, Development, Test & Eval, Army				6,744,134	7,562,170	1,500	7,563,670	7,515,399	100,522	7,615,921	

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Appropriation 2040: Research, Development, Test & Evaluation, Army

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Exhibit R-2, RDT&E Budget Item Justification: PB 2017 Army											Date: February 2016	
Appropriation/Budget Activity 2040: *Research, Development, Test & Evaluation, Army I* BA 1: *Basic Research*					R-1 Program Element (Number/Name) PE 0601101A *I In-House Laboratory Independent Research*							
COST ($ in Millions)	**Prior Years**	**FY 2015**	**FY 2016**	**FY 2017 Base**	**FY 2017 OCO**	**FY 2017 Total**	**FY 2018**	**FY 2019**	**FY 2020**	**FY 2021**	**Cost To Complete**	**Total Cost**
Total Program Element	-	13.125	13.018	12.381	-	12.381	11.971	11.540	11.723	11.958	-	-
91A: *ILIR-AMC*	-	12.300	12.107	11.457	-	11.457	11.031	10.583	10.747	10.962	-	-
F16: *ILIR-SMDC*	-	0.825	0.911	0.924	-	0.924	0.940	0.957	0.976	0.996	-	-

A. Mission Description and Budget Item Justification

This program element (PE) supports basic research at the Army laboratories through the In-House Laboratory Independent Research (ILIR) program. Basic research lays the foundation for future developmental efforts by identifying fundamental principles governing various phenomena and appropriate pathways to exploit this knowledge. The ILIR program serves as a catalyst for major technology breakthroughs by providing laboratory directors flexibility in implementing novel research ideas, by nurturing promising young scientists and engineers, and is used to attract and retain top doctoral degreed scientists and engineers. The ILIR program also provides a source of competitive funds for peer reviewed efforts at Army laboratories to stimulate high quality, innovative research with significant opportunity for payoff to Army warfighting capability.

This Program Element (PE) supports ILIR at the Army Materiel Command's (AMC) six Research, Development, and Engineering Centers (Project 91A); at the six U.S. Army Medical Research and Material Command Laboratories (Project 91C); the seven laboratories within the Corps Of Engineers' U.S. Army Engineer Research and Development Centers (Project 91D); and at the U.S. Space and Missile Defense Command (SMDC) Technical Center (Project F16).

Work in the PE provides a foundation for applied research initiatives at the Army laboratories and research, development and engineering centers.

The cited work is consistent with the Assistant Secretary of Defense for Research and Engineering science and technology priority focus areas and the Army Modernization Strategy.

Work in this PE is performed by AMC, the Medical Research Materiel Command (MRMC), the Engineer Research and Development Center (ERDC) (multiple sites); and the SMDC Technical Center (Huntsville,AL).

Exhibit R-2, RDT&E Budget Item Justification: PB 2017 Army					Date: February 2016
Appropriation/Budget Activity 2040: *Research, Development, Test & Evaluation, Army* / BA 1: *Basic Research*		R-1 Program Element (Number/Name) PE 0601101A / *In-House Laboratory Independent Research*			
B. Program Change Summary ($ in Millions)	**FY 2015**	**FY 2016**	**FY 2017 Base**	**FY 2017 OCO**	**FY 2017 Total**
Previous President's Budget	13.427	13.018	12.381	-	12.381
Current President's Budget	13.125	13.018	12.381	-	12.381
Total Adjustments	-0.302	0.000	0.000	-	0.000
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-0.302	-			

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army			Date: February 2016
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601101A / *In-House Laboratory Independent Research*	Project (Number/Name) 91A / *ILIR-AMC*	

COST ($ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
91A: *ILIR-AMC*	-	12.300	12.107	11.457	-	11.457	11.031	10.583	10.747	10.962	-	-

Note

Not applicable for this item

A. Mission Description and Budget Item Justification

This project funds basic research within the Army Materiel Command's (AMC) Research, Development, and Engineering Centers (RDECs) and lays the foundation for future developmental efforts by identifying the fundamental principles governing various phenomena and appropriate pathways to exploit this knowledge.

The cited work is consistent with the Assistant Secretary of Defense, Research and Engineering Science and Technology focus areas and the Army Modernization Strategy.

Work in this project is performed by the Edgewood Chemical and Biological Center, Aberdeen Proving Grounds, MD within AMC, the Armaments Research, Development, and Engineering Center, Picatinny, NJ, the Tank and Automotive Research, Development, and Engineering Center, Warren, MI, the Natick Soldier Research, Development, and Engineering Center, Natick, MA, the Aviation and Missile Research, Development, and Engineering Center, Huntsville, AL, and the Communications and Electronics Research, Development, and Engineering Center, Ft. Monmouth, NJ.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
Title: Edgewood Chemical Biological Center	0.974	1.018	1.033
Description: Funds basic research in chemistry, biology, biotechnology, and aerosol for countering improvised explosive devices (IEDs), obscurants, and/or target defeat. Work in this project provides theoretical underpinnings for Program Element (PE) 0602622A (Chemical, Smoke, and Equipment Defeating Technologies). ***FY 2015 Accomplishments:*** Conducted fundamental research to develop an understanding of rational molecular and nano-system design, synthetic biology, nano-scale chemical and biological sensing and signaling, molecular toxicology, interfacial phenomena of particulate matter (solid/liquid) with chemical surfaces, and synthesis of new materials for protection, decontamination, and detection, and research the mathematics involved in data processing and interpretation. ***FY 2016 Plans:*** Further fundamental research to understand rational molecular and nano-system design, synthetic biology, nano-scale chemical and biological sensing and signaling, molecular toxicology, interfacial phenomena of particulate matter (solid/liquid) with chemical			

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601101A / *In-House Laboratory Independent Research*	**Project (Number/Name)** 91A / *ILIR-AMC*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
surfaces, and synthesis of new materials for protection, decontamination, and detection, and research the mathematics involved in data processing and interpretation. ***FY 2017 Plans:*** Will further fundamental research to understand rational molecular synthesis and novel materials, synthetic biology, nano-scale chemical and biological sensing, molecular toxicology, aerosol sciences, interfacial phenomena of particulate matter (solid/ liquid) with chemical surfaces, and synthesis of new materials for protection, decontamination, and detection, and research the mathematics involved in data processing and interpretation.			
Title: Armaments Research, Development and Engineering Center ***Description:*** Funds basic research in weapons component development, explosives synthesis/detection and area denial. Work in this project provides theoretical underpinnings for PE 0602307A (Advanced Weapons Technology). ***FY 2015 Accomplishments:*** Continued to solicit on a yearly basis new efforts to further basic research in areas such as advanced materials and nanotechnologies, more powerful energetics including those with insensitive munition properties, counter terrorism technologies, power and energy systems, smaller more lethal warheads and composite materials. ***FY 2016 Plans:*** Further basic research in areas such as advanced materials and nanotechnologies, more powerful energetics including those with insensitive munitions properties, counter terrorism technologies, power and energy systems, smaller more lethal warheads and composite materials. ***FY 2017 Plans:*** Will solicit new innovative research proposals to conduct fundamental research for developing technologies for lighter structural materials, nano-materials, area denial technologies, more powerful explosives, more lethal compact warheads, efficient thermal batteries and material coating technologies.	1.657	1.655	1.556
Title: Tank-Automotive Research, Development and Engineering Center ***Description:*** Funds basic research in ground vehicle technologies to include power, mobility, and unmanned systems. Work in this project provides theoretical underpinnings for PE 0602601A (Combat Vehicle and Automotive Technology). ***FY 2015 Accomplishments:*** Investigated shock wave localization and propagation in layered media; research the combustion properties of new fuels; investigated discrete element modeling for granular terrain – vehicle interaction; studied on-wafer microwave nonreciprocal devices (isolators and circulators) based on artificial magnetic metamaterials and naturally anisotropic ferrite materials;	1.463	1.452	1.350

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601101A / *In-House Laboratory Independent Research*	**Project (Number/Name)** 91A / *ILIR-AMC*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
researched manned/unmanned teaming and cooperative mobility behaviors; researched incremental learning for autonomous systems; and researched optical limiter techniques and materials for laser protection. ***FY 2016 Plans:*** Conduct research in off-road mobility and terramechanics, materials for shock wave mitigation, nano-lubricants, analytical framework for autonomy-enabled systems, combustion for military logistics fuels, and modeling of cognitive burdens. In-house research efforts address several Army-identified major research efforts for the future including materials science and multiscale modeling, intelligent/autonomous systems, and human sciences. ***FY 2017 Plans:*** Will solicit on a yearly basis new and continuing efforts to further basic research in Army-centric areas such as development of analytical methodologies for autonomous and autonomy-enabled systems such as latency compensation, shared control, modeling of human cognition, proprioception and perception, next-generation battery systems, advanced combustion, off-road mobility/terramechanics, materials and joining research as pertaining to lightweighting, armor materials/mechanisms, Big Data analytics, newtork security for autonomous systems, aeroacoustics computational fluid dynamics, bio-inspired approaches to waste-water treatment, multi-functional additives for fuels/lubricants, and pulse power applications to vehicle protection.			
Title: Natick Soldier Research, Development, and Engineering Center ***Description:*** Funds basic research in food sciences, textiles, and lightweight materials with potential for individual protection. Work in this project provides theoretical underpinnings for PE 0601102A (Defense Research Sciences), Project H52 (Equipment for the Soldier). ***FY 2015 Accomplishments:*** Explored the unique physics of photonic nanomaterials for revolutionizing the performance and size of systems such as infrared (IR) detectors, power generation, and remote imaging; continued to explore the relationship between peptide structure on tailored structures for controlling and optimizing the destructive efficacy of antimicrobial peptides for multiple applications. ***FY 2016 Plans:*** Create a new two-dimensional (2D) computational modeling approach to enhance understanding of interactions between fluids (e.g., airflow) and structural forces to provide a foundation for design of parachutes and fabric shelters; examine novel approaches to tailor textile surface chemistry and/or integration of advanced materials to allow creation of surfaces exhibiting true multifunctionality. ***FY 2017 Plans:***	1.365	1.350	1.246

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601101A / *In-House Laboratory Independent Research*	**Project (Number/Name)** 91A / *ILIR-AMC*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
Will assess newly modeled microrectenna arrays for their response to IR illumination; assess efficiency and adaptability of these microrectenna arrays for application in IR detectors, communication, and energy harvesting applications; explore the incorporation of bioactive peptides for increased stability of thin films.			
Title: Aviation and Missile Research, Development and Engineering Center: Missile Efforts	2.746	2.608	2.483
Description: Funds basic research in guided missile and rocket systems, directed energy weapons, unmanned vehicles, and related components. Work in this project provides theoretical underpinnings for PE 0602303A (Missile Technology). ***FY 2015 Accomplishments:*** Performed a pioneering demonstration of surface-enhanced analyte sensing and damage using plasmonic metal nanostructures; performed experimental test of analytic density matrix models in pump-probe spectroscopy; demonstrate chaotic dynamics in hybrid and non-smooth systems; pioneered innovative terahertz (THz) imaging techniques by combining state-of-the-art coherent imaging hardware and computational imaging methodologies; identified novel propagation phenomena that can dramatically modify/enhance linear and nonlinear interactions with artificial, metal-based plasmonic materials and semiconductors; and performed an experimental study of plasmonic nanostructures in the enhanced transmission regime for applications to beam steering. ***FY 2016 Plans:*** Continue experimental test of analytic density matrix models in precision pump-probe spectroscopy; demonstrate chaotic dynamics in hybrid and non-smooth systems; pioneer innovative THz imaging techniques by combining state-of-the-art coherent imaging hardware and computational imaging methodologies; and develop novel high performance signal processing techniques for chaotic waveforms in radar and communications. ***FY 2017 Plans:*** Will explore ultraviolet photocatalytic splitting of molecular bonds using plasmonic metal nanoparticles; investigate homomorphic encryption schemes (for tamper-proof signal processing); study new electromagnetic pulse propagation models that include nonlocal and quantum tunneling effects (to explore novel propagation phenomena and dramatically modify/enhance linear and nonlinear interactions with artificial, metal-based plasmonic materials and semiconductors); pioneer polarization-sensitive terahertz holographic imaging (for mapping strain in opaque materials); explore use of chaotic waveforms (for transformative high resolution radar and tactical data communications); develop microwave hyperbolic metamaterials (for subwavelength antennas and resonators); and study theoretically and experimentally linear and nonlinear optical properties of graphene-based layered and textured nanostructures.			
Title: Aviation and Missile Research, Development and Engineering Center: Aviation Efforts	1.560	1.553	1.453

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601101A / *In-House Laboratory Independent Research*	**Project (Number/Name)** 91A / *ILIR-AMC*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
Description: Funds basic research for aviation enabling technologies in the areas of aerodynamics, structural dynamics, and material science. Work in this project provides theoretical underpinnings for PE 0602211A (Aviation Technology). ***FY 2015 Accomplishments:*** Continued basic fluid dynamic research in the areas of vorticity dynamics, unsteady flow separation, and flow control to identify fundamental governing principles; completed analysis of wing/vortex interaction; conducted detailed measurements of boundary layer response to flow control; and continued work to increase control authority of plasma devices. ***FY 2016 Plans:*** Explore novel approaches to increase flow control authority for rotating wing applications using plasma; develop experimental techniques to better measure and understand flow structures in the wake of multi-rotor configurations and their performance in hover; and explore novel control allocation strategies to optimize pilot work load for future vertical lift configurations with redundant controls. ***FY 2017 Plans:*** Will combine visualization and measurements of the flow features in the wake of a wing interacting with a passing vortex (to better understand the structure and evolution of the trailing wake, and its relation to the lift distribution on the generating wing); apply novel fluidic actuators for adverse force reduction; and develop novel computational algorithms to dramatically speed up computations on newly emerging exascale computer architectures using techniques such as parallelization in both time and space.			
Title: Communications-Electronics Research, Development, and Engineering Center	2.535	2.471	2.336
Description: Funds basic research for communication and network enabling technologies in the areas of antenna design, network management, power generation and storage, and sensors. Work in this project provides theoretical underpinnings for PE 0602705A (Electronics and Electronic Devices). ***FY 2015 Accomplishments:*** Conducted research on a novel class of quasi-orthogonal waveforms that allow radar systems to perform their primary target detection mission while simultaneously allowing data sharing with other systems; investigated a new compressive sensing approach to adaptive target detection (can potentially ease antenna integration requirements for future multi-band/multi-aperture systems and improve the spatial resolution for target detection); investigated the fundamental distributed reformation reactions which affects species production, soot (coke) formation with more favorable reformed product gases; investigated the fundamental electrochemical properties of applied composite solid electrolyte interface for lithium electrochemical cells; investigated how Compressive Sensing (CS) affects image quality and develop metrics and model for CS; investigated how carrier transport			

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601101A / *In-House Laboratory Independent Research*	**Project (Number/Name)** 91A / *ILIR-AMC*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
phenomenology in epitaxial multilayer structures contribute to the performance of infrared focal plane arrays (FPAs); and investigated graph anomaly detection to identify network intrusions using traffic flow graph analysis and anomaly detection. ***FY 2016 Plans:*** Conduct research in data flow analysis as a supplemental theory for use in Satisfiability Modulo Theory (SMT) solvers to improve vulnerability detection by utilizing data-flow graphs coupled with SMT solvers; investigate an analytic method to calculate the probability and efficiency of message transmission via dynamic opportunistic devices across an undefined and uncooperative network; research the ability to perform signal processing by manipulating modes within a multi-mode optical fiber by utilizing the statistics of transmission properties and techniques for spatial division multiplexing to perform single and multi signal filtering within the optical fiber; investigate the performance of infrared detectors by researching high quantum efficiency Gallium-free long wave infrared nBn detectors grown on an aluminum antimonide (AlSb) lattice; research liquid phase heat transfer as a function of flow instability and vorticity intensity in microchannels with microcylinders with tip clearances to determine the optimum micro cylinder design in microchannels in three-dimensional (3D) stacked circuit architectures for electro-optics, radar, electronic warfare, communication and intelligence systems; investigate the fundamental electrochemical properties of applied composite solid electrolyte interface for lithium and divalent electrochemical cells; and investigate game theory based machine learning techniques to determine the feasibility of coordinating electronic warfare and tactical communications. ***FY 2017 Plans:*** Will conduct research focusing on the mathematical foundations of a pre-processing technique to facilitate fully homomorphic cryptosystems; research designs of packaging material used in solid state and bipolar batteries; investigate novel architectures that utilize photonic detection and beam forming concepts in the design of a highly capable beam-former/receiver (to alleviate the processing burden by exploring analog preprocessing and filtering techniques prior to digitization); create integratable thin film material heterostructures and explore novel process science techniques to enable high performance tunable filters for the next generation radar, electronic warfare and communications systems; research candidate target contrast metrics to improve parameters used in human vision model for high-contrast, low-contrast, and low-observable targets and investigate the psychophysics of noise in the Human Visual System (HVS) information processing chain by controlling “where” visual fusion takes place (e.g., temporal, left-right eye, or cognitive) to provide insight to how humans process fused image information and how the HVS filters information and noise; and research a planarization technique for infrared materials that yields a nearly flat surface with undamaged active layers.			
Accomplishments/Planned Programs Subtotals	12.300	12.107	11.457

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601101A / *In-House Laboratory Independent Research*	**Project (Number/Name)** 91A / *ILIR-AMC*

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army			Date: February 2016
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601101A / *In-House Laboratory Independent Research*	Project (Number/Name) F16 / *ILIR-SMDC*	

COST ($ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
F16: *ILIR-SMDC*	-	0.825	0.911	0.924	-	0.924	0.940	0.957	0.976	0.996	-	-

A. Mission Description and Budget Item Justification

This project provides In-house Laboratory Independent Research (ILIR) at the US Army Space and Missile Defense Command/Army Forces Strategic Command (USASMDC/ARSTRAT), Technical Center. This basic research on lasers and directed energy lays the foundation for future developmental efforts on high energy lasers and directed energy systems by identifying the fundamental principles governing various directed energy phenomena.

Work in this project is related to, and fully coordinated with, efforts in Program Element (PE) 0602307A (Advanced Weapons Technology).

The cited work is consistent with the Assistant Secretary of Defense for Research and Engineering science and technology priority focus areas and the Army Modernization Strategy.

Work is performed by the USASMDC/ARSTRAT, Technical Center, Huntsville, AL

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
Title: SMDC In-house Laboratory Independent Research (ILIR)	0.825	0.911	0.924
Description: Funds basic research to investigate laser propagation phenomenology for application in modeling and simulation and future directed energy weapons design. Activities in this proproject transition to High Energy Laser Technology in PE 0602307A (Advanced Weapons Technology).			
FY 2015 Accomplishments: Demonstrated a diode pumped rare earth gas laser and begin assessing scalability and potential for very high efficiency operation; completed spectroscope research on Xenon as a potential rare earth gas laser for transition to advanced beam control efforts; completed 1.06 micron laser atmospheric propagation research for transition to solid state laser effects; and completed initial assessment of all-weather tracker phenomenology for transition to advanced beam control efforts.			
FY 2016 Plans: Complete inductive radio frequency (RF) line widths, absorption, plasma control, and lifetimes investigations for an efficient Xenon laser; develop a Xenon high power laser scaling model; and complete comparison of different RF pumping mechanisms.			
FY 2017 Plans: Will conduct experiments to measure quenching of electron energy states of various buffer gas concentrations; investigate potential high power laser designs that use only efficient diode lasers without an additional laser gain media; and conduct			

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601101A / *In-House Laboratory Independent Research*	**Project (Number/Name)** F16 / *ILIR-SMDC*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
experiments to measure effects of different innovative adaptive optics techniques for laser propagation in the presence of particulates.			
Accomplishments/Planned Programs Subtotals	0.825	0.911	0.924

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2, RDT&E Budget Item Justification: PB 2017 Army											Date: February 2016	
Appropriation/Budget Activity 2040: *Research, Development, Test & Evaluation, Army* / BA 1: *Basic Research*					R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*							
COST ($ in Millions)	**Prior Years**	**FY 2015**	**FY 2016**	**FY 2017 Base**	**FY 2017 OCO**	**FY 2017 Total**	**FY 2018**	**FY 2019**	**FY 2020**	**FY 2021**	**Cost To Complete**	**Total Cost**
Total Program Element	-	249.855	279.118	253.116	-	253.116	256.042	264.693	272.327	276.863	-	-
305: *ATR Research*	-	1.970	2.029	2.057	-	2.057	2.093	2.130	2.172	2.215	-	-
31B: *Infrared Optics Rsch*	-	3.273	2.843	4.213	-	4.213	4.261	4.314	4.372	4.433	-	-
52C: *Mapping & Remote Sens*	-	1.990	2.030	2.057	-	2.057	2.092	2.130	2.172	2.215	-	-
53A: *Battlefield Env & Sig*	-	2.610	3.754	3.808	-	3.808	3.873	3.944	4.020	4.100	-	-
74A: *Human Engineering*	-	14.235	13.176	13.342	-	13.342	14.023	14.482	14.797	15.078	-	-
74F: *Pers Perf & Training*	-	5.131	5.459	5.540	-	5.540	5.635	5.737	5.852	5.969	-	-
ET6: *BASIC RESCH IN CLINICAL & REHABILITATIVE MED*	-	0.000	0.000	4.201	-	4.201	4.531	4.617	4.714	4.809	-	-
F20: *Adv Propulsion Rsch*	-	4.054	4.161	4.220	-	4.220	4.290	4.368	4.452	4.541	-	-
F22: *Rsch In Veh Mobility*	-	0.685	0.707	0.718	-	0.718	0.732	0.745	0.760	0.775	-	-
H42: *Materials & Mechanics*	-	9.054	8.603	8.731	-	8.731	8.879	9.040	9.218	9.402	-	-
H43: *Research In Ballistics*	-	8.602	8.410	8.531	-	8.531	8.676	8.834	9.007	9.187	-	-
H44: *Adv Sensors Research*	-	9.564	8.659	9.436	-	9.436	9.771	10.276	10.936	11.194	-	-
H45: *Air Mobility*	-	2.247	2.328	2.364	-	2.364	2.403	2.448	2.495	2.545	-	-
H47: *Applied Physics Rsch*	-	5.178	5.722	4.285	-	4.285	4.238	4.338	3.861	3.926	-	-
H48: *Battlespace Info & Comm Rsc*	-	24.596	25.463	28.276	-	28.276	28.668	29.105	29.624	30.168	-	-
H52: *Equip For The Soldier*	-	1.049	1.119	1.133	-	1.133	1.153	1.173	1.197	1.221	-	-
H57: *Single Investigator Basic Research*	-	78.575	87.001	94.519	-	94.519	94.284	99.007	102.166	103.423	-	-
H66: *Adv Structures Rsch*	-	2.000	2.033	2.061	-	2.061	2.095	2.133	2.174	2.217	-	-
H67: *Environmental Research*	-	0.901	0.913	0.928	-	0.928	0.943	0.961	0.979	0.999	-	-
S13: *Sci BS/Med Rsh Inf Dis*	-	10.924	11.181	11.318	-	11.318	11.503	11.722	11.952	12.191	-	-
S14: *Sci BS/Cbt Cas Care Rs*	-	10.183	9.758	5.699	-	5.699	5.540	5.636	5.743	5.857	-	-

Exhibit R-2, RDT&E Budget Item Justification: PB 2017 Army												Date: February 2016	
Appropriation/Budget Activity 2040: *Research, Development, Test & Evaluation, Army* / BA 1: *Basic Research*					R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*								
S15: *Sci BS/Army Op Med Rsh*	-	6.721	6.599	6.688	-	6.688	6.801	6.924	7.060	7.201	-	-
T14: *BASIC RESEARCH INITIATIVES - AMC (CA)*	-	18.250	40.000	0.000	-	0.000	0.000	0.000	0.000	0.000	-	-
T22: *Soil & Rock Mech*	-	5.537	4.456	4.520	-	4.520	4.597	4.681	4.773	4.868	-	-
T23: *Basic Res Mil Const*	-	2.045	1.722	1.747	-	1.747	1.777	1.809	1.844	1.881	-	-
T24: *Signature Physics And Terrain State Basic Research*	-	1.981	1.627	1.649	-	1.649	1.675	1.706	1.740	1.775	-	-
T25: *Environmental Science Basic Research*	-	7.061	6.980	7.081	-	7.081	7.202	7.336	7.480	7.630	-	-
T63: *Robotics Autonomy, Manipulation, & Portability Rsh*	-	6.730	7.233	8.764	-	8.764	8.988	9.680	11.242	11.407	-	-
T64: *Sci BS/System Biology And Network Science*	-	2.306	2.930	2.974	-	2.974	3.025	3.080	3.141	3.204	-	-
VR9: *Surface Science Research*	-	2.403	2.222	2.256	-	2.256	2.294	2.337	2.384	2.432	-	-

Note

In Fiscal Year (FY) 2015 and 2016 the funding for Clinical and Rehabilitative Medicine is in project S14. The Clinical and Rehabilitative Medicine basic research effort moves to project ET6 starting in FY17.

A. Mission Description and Budget Item Justification

This Program Element (PE) builds fundamental scientific knowledge contributing to the sustainment of United States (U.S.) Army scientific and technological superiority in land warfighting capability and to solving military problems related to long-term national security needs, investigates new concepts and technologies for the Army's future force, and provides the means to exploit scientific breakthroughs and avoid technological surprises. This PE fosters innovation in Army niche areas (e.g., lightweight armor, energetic materials, and night vision capability) and areas where there is no commercial investment due to limited markets (e.g., vaccines for tropical diseases). It also focuses university single investigator research on areas of high interest to the Army (e.g., high-density compact power and novel sensor phenomenologies). The in-house portion of the program capitalizes on the Army's scientific talent and specialized facilities to transition knowledge and technology into appropriate developmental activities. The extramural program leverages the research efforts of other government agencies, academia, and industry.

The cited work is consistent with the Assistant Secretary of Defense, Research and Engineering science and technology focus areas and the Army Modernization Strategy.

Exhibit R-2, RDT&E Budget Item Justification: PB 2017 Army	Date: February 2016
Appropriation/Budget Activity 2040: *Research, Development, Test & Evaluation, Army I* BA 1: *Basic Research*	**R-1 Program Element (Number/Name)** PE 0601102A *I Defense Research Sciences*

Work in this PE is performed by: the U.S. Army Research Laboratory (ARL), Adelphi, MD; the U.S. Research, Development and Engineering Command (RDECOM), Aberdeen, MD; the U.S. Army Medical Research and Materiel Command (MRMC), Ft. Detrick, MD; the U.S. Army Engineer Research and Development Center (ERDC), Vicksburg, MS; and the U.S. Army Research Institute for the Behavioral and Social Sciences (ARI), Arlington, VA.

B. Program Change Summary ($ in Millions)	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total
Previous President's Budget	248.283	239.118	242.896	-	242.896
Current President's Budget	249.855	279.118	253.116	-	253.116
Total Adjustments	1.572	40.000	10.220	-	10.220
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	40.000			
• Congressional Directed Transfers	-	-			
• Reprogrammings	8.000	-			
• SBIR/STTR Transfer	-6.428	-			
• Adjustments to Budget Years	-	-	10.220	-	10.220

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2015	FY 2016
Project: T14: *BASIC RESEARCH INITIATIVES - AMC (CA)*		
Congressional Add: *Program Increase*	8.000	40.000
Congressional Add: *Science, Technology, Engineering, and Math (STEM) Pilot Program*	2.250	-
Congressional Add Subtotals for Project: T14	10.250	40.000
Congressional Add Totals for all Projects	10.250	40.000

Change Summary Explanation

FY 2015: Congressional increase for University Research Initiatives, PE PE 0601103, Project D58 - totaled $20M. Army reprogrammed $8M of the congressional increase for proper execution of congressional intent - (i.e., for Single Investigator).

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army										Date: February 2016		
Appropriation/Budget Activity 2040 / 1					R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*				Project (Number/Name) 305 / *ATR Research*			
COST ($ in Millions)	**Prior Years**	**FY 2015**	**FY 2016**	**FY 2017 Base**	**FY 2017 OCO**	**FY 2017 Total**	**FY 2018**	**FY 2019**	**FY 2020**	**FY 2021**	**Cost To Complete**	**Total Cost**
305: *ATR Research*	-	1.970	2.029	2.057	-	2.057	2.093	2.130	2.172	2.215	-	-

A. Mission Description and Budget Item Justification

This project fosters research for automatic target recognition (ATR) concepts to enhance the effectiveness of Army systems while simultaneously reducing the workload on the Soldier. This project focuses on the fundamental underpinnings of aided and unaided target detection and identification techniques for land warfare scenarios including tagging, tracking, and locating (TTL) of non-traditional targets. This research enables Army systems that can act independently of the human operator to detect and track targets including clandestine tracking of non-cooperative targets. Such capabilities are needed for smart munitions, unattended ground sensors, and as replacements for existing systems. Critical technology issues include low depression angle, relatively short range, and highly competing background clutter. The resulting research will provide a fundamental capability to predict, explain, and characterize target and background signature content, and reduce the workload on the analyst. This research is aimed at determining the complexity and variability of target and clutter signatures and ultimately utilizing that knowledge to conceptualize and design advanced ATR paradigms to enhance robustness and effectiveness of land warfare systems. ATR research strategies include emerging sensor modalities such as spectral and multi-sensor imaging. Research in this project builds knowledge for several technology efforts including multi-domain smart sensors, third generation Forward Looking Infrared (FLIR), and advanced multi-function laser radar (LADAR).

Work in this project complements and is fully coordinated with the U.S. Army Armaments Research, Development, and Engineering Center (ARDEC); the U.S. Army Communications-Electronics Research, Development, and Engineering Center (CERDEC); and the U.S. Army Edgewood Chemical Biological Center (ECBC).

Work is this project supports key Army needs and provides the technical underpinnings to Program Element (PE) 0602270A (Electronic Warfare Technology)/Project 906 (Tactical Electronic Warfare Applied Research).

The cited work is consistent with the Assistant Secretary of Defense for Research and Engineering Science and Technology focus areas and the Army Modernization Strategy.

Work in this project is performed by the U.S. Army Research Laboratory (ARL), Adelphi, MD.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
Title: ATR Algorithms	1.970	2.029	2.057
Description: Investigate new algorithms to improve aided/unaided target detection and identification.			
FY 2015 Accomplishments:			

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** 305 / *ATR Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
Investigated methods for automatic human and vehicle activity detection and classification, and multimodal biometrics for improved situational understanding and reduced Soldier workload; researched methods to select relevant data for enhanced decision making; and developed machine learning algorithms for scene understanding. ***FY 2016 Plans:*** Expand investigation of human and vehicle activity detection methods to include joint exploitation of text and video data; extend biometric research techniques to enable automated face recognition using low resolution imagery and multimodal data sets; investigate methods for synthesizing scene understanding from multi viewpoint imagery including 3D models for face recognition; investigate image processing methods for detecting unmanned aerial systems (UAS) in electro-optical/infrared (EO/IR) data for use in counter-unmanned aerial systems (CUAS); and investigate algorithms for use in target detection and recognition. ***FY 2017 Plans:*** Will investigate methods for automatic object recognition from multi-perspective/multi-platform image data and assess their expected performance improvement over existing single perspective methods; investigate methods for improved vehicle tracking using three-dimensional (3D) scene reconstructions; research methods for multi-pose detection of humans in images which are expected to extend robustness of previous methods that have been demonstrated to work only on upright human postures; investigate methods for semantic classification of human actions in video; and investigate joint representations of polarimetric and visible face data for increased accuracy of face recognition using thermal data.			
Accomplishments/Planned Programs Subtotals	1.970	2.029	2.057

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army			Date: February 2016
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*	Project (Number/Name) 31B / *Infrared Optics Rsch*	

COST ($ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
31B: *Infrared Optics Rsch*	-	3.273	2.843	4.213	-	4.213	4.261	4.314	4.372	4.433	-	-

A. Mission Description and Budget Item Justification

This project supports Army research in materials and devices for active and passive infrared (IR) imaging systems; radio frequency (RF) photonics for radar, communications, and electronic warfare applications; and laser technology for missile threat countermeasure protection. This research aims to generate new technologies for unprecedented battlefield situational awareness and to continue the dominance of Army units during night operations. To achieve these objectives, IR focal plane arrays (FPAs) and lasers with significantly improved performance, lower cost, and increased operating temperatures are required. This research has direct application to Army ground vehicles, aviation platforms, weapon systems, and the individual Soldier. Research is focused on material growth, detector and laser design, and processing for large-area, multicolor IR FPAs, ultraviolet (UV) avalache photdiodes (APDs), and mid-wavelength IR and UV lasers. The principal efforts are directed towards novel materials for detectors and lasers, and investigating energy band-gap structures in semiconductor materials to enhance the performance of lasers, IR FPAs and UV APDs. In the area of RF Photonics, near-IR modeling and nanofabrication techniques are applied to the design and fabrication of IR photonic-crystal waveguide structures having customized IR properties. This research also is intended to lay the foundation for the development of integrated optoelectronic circuits using active and passive devices and components such as lasers, waveguides, and detectors in conjunction with fiber optic interconnects for the generation, distribution, processing, and control of microwaves. The fundamental physics of signal processing and noise generation as well as the conversion between the time and frequency domains and the optical and electrical domains in these opto-electronic circuits/systems will also be studied. The technical goals are to: 1) manage and control defects in the raw, unprocessed materials, maintaining quality control in the fabrication of the devices and arrays, 2) limiting introduction of impurities in the material, shielding device surfaces so that they are resistant to degradation over time and 3) thermal management, particularly as it applies to lasers. This work is coordinated with the U.S. Army Communications Electronics Research, Development, and Engineering Center (CERDEC). In the area of Advanced Materials, the research is to investigate the fundamental physics of energy, charge, and spin transport along and across active heterogeneous interfaces such as topological insulators, van der Waals heterostructures, solid/liquid interfaces, and bio/a-bio interfaces, and in new materials to achieve new electronic/optoelectronic device functionalities.

Work in this project supports key Army needs and provides the technical underpinning to PE 0602709A (Night Vision Technology)/Project H95 (Night Vision and Electro-Optic Technology).

The cited work is consistent with the Assistant Secretary of Defense for Research and Engineering Science and Technology focus areas and the Army Modernization Strategy.

Work in this project is performed by the Army Research Laboratory (ARL), Adelphi, MD.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
Title: Electro-Optic Materials Research, RF Photonics for Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance (C4ISR), and Photonics Research for Electronic Warfare	3.273	2.843	4.213

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** 31B / *Infrared Optics Rsch*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
Description: Conduct research into IR FPAs, RF photonics, and IR countermeasures to increase situational awareness in open and complex terrains; improve target detection, identification, and discrimination; and enhance missile threat IR countermeasure (IRCM) protection. ***FY 2015 Accomplishments:*** Grew and characterized new long-wave IR (LWIR) bulk semiconductor materials used in new detector designs with potential for low-cost, high performance applications; investigated the physical limitations in a variety of RF-photonic signal generation, transport, and processing schemes to optimize system resolution and bandwidth for C4ISR applications (e.g., position, navigation, and timing applications) that require very high phase precision; investigated optical and physical properties of novel semiconductor metamaterial and metastructure devices for applications such as chip scale chem/bio sensors and lighter and cheaper radios; and studied electro-optical (EO) modulator based on nano-crystal silicon for next generation high speed chip scale communication. ***FY 2016 Plans:*** Study engineered IR sensing semiconductor materials processed with micron-scale resonant surface features for improved single color, dual color, and higher operating temperature devices that add functionality in degraded visual environments and reduce system cost; study diode performance of semiconductor materials composed of indium arsenide antimonide (InAsSb) for improved long wavelength IR performance; research and advance opto-electronic oscillator technology for fiber-based acoustic sensor applications and better than global positioning system (GPS) clock precision; study photonics integration for biological and chemical sensing applications; and perform studies and develop/provide fundamental technologies to build ultraviolet (UV) sources (e.g., light emitting diode and laser) with increased output power. ***FY 2017 Plans:*** Will explore new concepts in heterojunction and superlattice design, growth, and fabrication for improved long-wave infrared detection; conduct studies of indium gallium nitride materials for use in achieving large area, high brightness, high power emitters in the near ultraviolet; pursue free-space optical time and frequency transfer using phase noise induced by air turbulence and other environmental effects; investigate techniques for improving the signal-to-noise ratio for standoff detection of chemical/ explosive hazards; and explore the modeling, growth, and fundamental physical properties of novel alloy heterostructures for topological insulators, low power/multifunctional electronics, and high performance thermoelectrics, as well as for highly efficient solar energy harvesting and fuel generation.			
Accomplishments/Planned Programs Subtotals	3.273	2.843	4.213

C. Other Program Funding Summary ($ in Millions)

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
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C. Other Program Funding Summary ($ in Millions)

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army									Date: February 2016			
Appropriation/Budget Activity 2040 / 1					R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*				Project (Number/Name) 52C / *Mapping & Remote Sens*			
COST ($ in Millions)	**Prior Years**	**FY 2015**	**FY 2016**	**FY 2017 Base**	**FY 2017 OCO**	**FY 2017 Total**	**FY 2018**	**FY 2019**	**FY 2020**	**FY 2021**	**Cost To Complete**	**Total Cost**
52C: *Mapping & Remote Sens*	-	1.990	2.030	2.057	-	2.057	2.092	2.130	2.172	2.215	-	-

A. Mission Description and Budget Item Justification

This project increases knowledge of terrain with a focus on improving the generation, management, analysis/reasoning, and modeling of geospatial data, and the exploitation of multi-sensor data. This fundamental knowledge forms the scientific "springboard" for the future development of applications, techniques, and tools to improve the tactical commander's knowledge of the battlefield. Results of this research are used to extract and characterize natural and man-made features from reconnaissance imagery in near-real time; to exploit terrain analysis and reasoning techniques; and to explore the potential of space technology and tactical geospatial sensor technology to provide real-time terrain intelligence, command and control, and targeting support. This research uses terrain and environmental data to improve situational awareness and enhance information dominance, leading to increased survivability, lethality, and mobility.

Work in this project provides theoretical underpinnings for Program element (PE) 0602784A (Military Engineering Technology), Project 855 (Topographical, Image Intel & Space).

The cited work is consistent with the Assistant Secretary of Defense, Research and Engineering science and technology focus areas and the Army Modernization Strategy.

Work in this project is performed by the Army Engineer Research and Development Center (ERDC), Vicksburg, MS.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
Title: Sensor Phenomenology and Spatial-Temporal Pattern Discovery	1.990	2.030	2.057
Description: Funding provided for the following research. ***FY 2015 Accomplishments:*** Investigated aerosol effects on the integrity of Light Detection and Ranging (LiDAR) signals to improve signal and data collection capabilities; explored methods of describing objects in massive unstructured datasets through novel machine learning techniques to advance Big Data capabilities; investigated multi-source signal decomposition and characterization from single acoustic sensors to increase monitoring capabilities; and theorized metrics for the quantification of adaptive capacity of human populations resulting from environmental change to monitor instability. ***FY 2016 Plans:*** Investigate algorithms to index and query massive amounts of data with spatial and temporal context; theorize and explore framework of pattern learning tasks to rapidly analyze geospatial and temporal data; investigate quantifiable relationships between plant physiology and soil crust biology; explore relationship between biogeochemistry of permafrost in arctic soils and remote			

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** 52C / *Mapping & Remote Sens*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
sensing signatures; and explore uncertainty in seismic signatures due to both the source and propagation mediums (i.e., soil and rock). ***FY 2017 Plans:*** Will investigate remotely measurable signatures of polysaccharide content of biological soil crusts for assessment of soil stability and potential of dust lofting; investigate the observable biogeochemical and remote sensing signals from permafrost wetlands to understand the impact of these unique terrain attributes on military training (e.g., sensor performance, operational mobility), and infrastructure stability; and investigate novel statistical approaches to characterize uncertainty for seismic wave propagation due to military activity of interest in regions where detailed local ground characterization is not possible.			
Accomplishments/Planned Programs Subtotals	1.990	2.030	2.057

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army			Date: February 2016
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*	Project (Number/Name) 53A / *Battlefield Env & Sig*	

COST ($ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
53A: *Battlefield Env & Sig*	-	2.610	3.754	3.808	-	3.808	3.873	3.944	4.020	4.100	-	-

A. Mission Description and Budget Item Justification

This project focuses on research to seek an in-depth understanding of the complex atmospheric boundary layer associated with high-resolution meteorology; the transport, dispersion, optical properties and characterization of chemical and biological aerosols; and the propagation of full-spectrum electro-magnetic and acoustic energy. The future Army will operate in very complex environments (e.g., urban, mountainous, forested and jungle terrain) requiring new approaches to understand, characterize, and depict environmental phenomena and their effects on military systems, personnel and operations. The lack of a complete understanding of the meteorological aspects of the complex microscale boundary layer in which the Army operates continues to impact our ability to provide predictable, actionable, accurate and timely tactical environmental intelligence to battlefield commanders and small Soldier units. This project focuses on producing the foundational environmental science research to characterize the atmospheric boundary layer and deliver novel capabilities and techniques including urban turbulence characterization for its effects on micro platforms and sensor payloads, high resolution urban wind flow modeling for more efficient and accurate prediction of the transport and dispersion of obscurants and chemicals, battlefield aerosol characterization and the interaction between aerosols and meteorological processes for Soldier health initiatives, characterization and detection of bio-warfare agent aerosols, environmental effects on acoustic and electromagnetic signal propagation in urban and other complex domains for improved target location and imaging, exploration of previously unexploited regions of the acoustic and electro-magnetic spectrum, and formulation of objective analysis tools that can assimilate on-scene all-source weather observations, atmospheric composition, and fuse this information with forecasts to provide immediate Nowcast products and actionable information. These capabilities will have a direct impact on ensuring Soldier survivability, weapon system lethality, effective surveillance and reconnaissance, and the mobility required for future warfighter mission planning and execution operations.

Work in this project supports key Army needs and provides the theoretical underpinnings for Program Element (PE) 0602784A (Military Engineering Technology)/Project H71 (Meteorological Research for Battle Command).

The cited work is consistent with the Assistant Secretary of Defense for Research and Engineering Science and Technology priority focus areas and the Army Modernization Strategy.

Work in this project is performed by the Army Research Laboratory (ARL), Adelphi, MD and White Sands Missile Range, NM.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
Title: Predictive Modeling of the Boundary Layer	2.610	3.754	3.808
Description: Increase survivability and improve situational awareness for a variety of sensors, optics and flying objects (e.g., projectiles, unmanned aircraft systems, etc.) through research to enhance accuracy of predictive modeling of the atmospheric boundary layer and improve the ability to function effectively in adverse conditions.			
FY 2015 Accomplishments:			

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** 53A / *Battlefield Env & Sig*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
Finalized and implemented an experimental hybrid data assimilation approach into microscale and mesoscale numerical weather prediction models to improve fine-scale weather forecast performance; researched options for implementing a computationally efficient Weather Research and Forecasting-based Weather Running Estimate-Nowcast (WRE-N) model to produce localized probabilistic forecast grids suitable for tactically-deployed unit hosting; explored novel approaches for developing an agile feedback loop that incorporates model-driven sensing and collection, and uses boundary layer sensing for near real-time model adaptation and corrected predictions; and determined feasibility of atmospheric energy harvesting for small scale applications. ***FY 2016 Plans:*** Investigate boundary layer aerosol fate chemistry (i.e., how an aerosol moves and transforms in the atmosphere/environment) in support of chem/bio detection methods, transport and dispersion; investigate boundary layer aerosol effect on surface energy budget; use the field observed data to improve both the WRE-N and the microscale numerical model accuracy for complex terrain, especially for thermal driven flows due to differential heating; initiate research of large turbulent eddies in the atmospheric boundary layer using the microscale model so that turbulent transport of momentum, energy and moisture between the boundary layer and the free atmosphere can be predicted and parameterized better in microscale and mesoscale models; develop a data assimilation approach for WRE-N and extend finest mesh to hundreds-of-meters grid spacing; begin efforts to integrate WRE-N and Atmospheric Boundary Layer Environment (ABLE), and develop improved surface energy budget and multi-scale turbulence models that will enhance the accuracy of predictive diurnal and vertical profile models of optical and mechanical turbulence in the boundary layer. ***FY 2017 Plans:*** Will research active and passive sensing methodologies for microscale boundary layer modeling to predict and correct turbulent image distortion; combine ultra-high-resolution microscale modeling methodologies into ABLE (to provide a full-physics microscale predictive system); conduct experiments using WRE-N/ABLE mesoscale-microscale modeling system with varying forecast resolutions (ranging from hundreds down to tens of meters); develop model enhancements for urban and complex terrain flows, and new data assimilation capabilities (to improve accuracy in battlefield domains); research novel computational methods for fielding on small, tactical computer platforms and Soldier-hosted mobile handheld devices; research the transport and diffusion of atmospheric aerosols, to include background haze, that potentially confounds chemical and biological sensors/detectors/warning systems; research chemical and biological fate when exposed to various naturally-occurring ambient atmospheric aerosols, using both single-particle and bulk sample spectroscopic techniques; and research acoustic and electro-optical propagation for use in characterizing the atmospheric state of the atmospheric boundary layer using both in situ and remote sensing techniques.			
Accomplishments/Planned Programs Subtotals	2.610	3.754	3.808

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** 53A / *Battlefield Env & Sig*

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army										Date: February 2016		
Appropriation/Budget Activity 2040 / 1					R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*				Project (Number/Name) 74A / *Human Engineering*			
COST ($ in Millions)	**Prior Years**	**FY 2015**	**FY 2016**	**FY 2017 Base**	**FY 2017 OCO**	**FY 2017 Total**	**FY 2018**	**FY 2019**	**FY 2020**	**FY 2021**	**Cost To Complete**	**Total Cost**
74A: *Human Engineering*	-	14.235	13.176	13.342	-	13.342	14.023	14.482	14.797	15.078	-	-

Note

Not applicable for this item

A. Mission Description and Budget Item Justification

This project focuses on research that improves Soldier-system performance in future force environments by looking at key phenomena underlying Soldier performance such as auditory spatial orientation (e.g., perception of azimuth, elevation and distance of sounds) within uncertain, degraded acoustic conditions; extending and protecting auditory and cognitive performance; human performance in automated, mixed-initiative (human control-machine control) environments; communications in hearing-degraded conditions; visual scanning and target detection; Soldier emotion and fatigue states; integration across multiple sensory modalities; perceptual-motor behavior; collaborative (team) and independent multi-task, multi-modal, multi-echelon Soldier-system performance - all cast against the influx of emerging transformation-driven technological solutions and opportunities. Technical barriers include lack of methods for describing, measuring, modeling analyzing and managing the interplay of these phenomena due to the dynamic nature of human behavior and to the situational complexity and ambiguity that characterize operations in the future force. Technical solutions are being pursued in the areas of data generation and algorithm development in these emerging environments in order to update and improve our understanding of performance boundaries and requirements and enable neuroengineering. These solutions include multi-disciplinary partnerships, metrics, simulation capabilities, and modeling tools for characterizing Soldier-system performance, and provide a shared conceptual and operational framework for militarily relevant research on cognitive and perceptual processes. In the area of translational neuroscience, which is the transition of basic neuroscience research to relevant applications, research is carried out to examine leading edge methodologies and technologies to improve the measurement and classification of neural states and behavior in operationally-relevant environments, to examine the potential application of neuroscience theories to autonomous systems to improve Soldier-system interactions, to model the relationship between brain structure and cognitive performance for understanding individual differences and injury, and to assess how neural pathways implicated in functional processing can be enhanced through dynamic system interface technologies for improving in-theatre performance and training. In the area of cybernetics, which is a scientific discipline that bridges the fields of control theory and communication theory for the study and modeling of behavior in complex systems, research is carried out to examine the complex human-system-environment relationships that define, constrain, and influence the interactions between Soldier and system. Research efforts are pursued to advance theory, models, and methodological approaches that capture the dynamic and multidimensional nature of human behavior, including the temporal dependencies inherent to human behavior, through an integrated program of research efforts focused on: novel cybernetic models of human multisensory integration and human-system communication; neuro-inspired, bio-inspired, and engineering approaches to computational algorithms for multisensory integration and multi-sensor fusion to enable enhanced and augmented Soldier perception in human-system interactions; new methodological approaches for the design of multisensory displays and human-system communications; and multisensory test bed platforms for examining experimental hypotheses driven by model predictions and proof-of-principle applications of identified algorithms and methods.

Work in this project supports key Army needs and provides the technical underpinnings to several Program Elements (PEs) to include PE 0601104A (University and Industry Research Centers)/Project H09 (Robotics Collaborative Technology Alliance) and PE 0602716A (Human Factors Engineering Technology)/H70 (Human Factors Engineering System Development).

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Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** 74A / *Human Engineering*

The cited work is consistent with the Assistant Secretary of Defense for Research and Engineering Science and Technology focus areas and the Army Modernization Strategy.

Work in this project is performed by the U.S. Army Research Laboratory (ARL), Human Research and Engineering Directorate, Aberdeen Proving Ground, MD.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
Title: Research to Characterize and Enhance Soldier Performance	1.686	1.628	-
Description: Characterize and enhance human auditory performance of the dismounted warrior in complex environments while protecting the hearing of the Soldier. ***FY 2015 Accomplishments:*** Conducted Soldier-oriented research to understand the auditory conditions that lead to misinterpretation of auditory events in a complex sensory environment; quantified and described spatial range across which detection of auditory location changes are unlikely to be detected; and characterized the environmental elements and contexts that may be vulnerable to misinterpretation. ***FY 2016 Plans:*** Conduct Soldier-oriented research to understand the auditory conditions that determine recognition and identification of relevant auditory events; and expand basic psychophysical research paradigms by incorporating elements that reflect the complexity of the military context, such as sound class categories and semantic assessments of relevance.			
Title: Soldier Performance	1.686	1.629	-
Description: Conduct fundamental research on human performance in military-relevant environments to include operations, command, and training. Use approaches such as computational cognitive modeling and social network analyses to investigate the factors affecting the information flow, situational understanding and prediction, and technology-mediated collaboration under conditions of stress and uncertainty. Determine the environmental and context factors affecting performance, learning, and retention in immersive and simulated environments; establish realism/fidelity boundary conditions for perceptual, cognitive, and physical parameters for experimentation and for training. ***FY 2015 Accomplishments:*** Further developed the human performance information processing models addressing network challenges using formal mathematical approaches and task-network modeling and simulation to integrate information across network layers for better information management and planning; established a theoretical foundation for human networking behavior yielding testable predictions for laboratory experiments (modeling effort); continued the development of object recognition of places and objects (cognitively-inspired intelligent robotic technology); leveraged the results of industry efforts in shape recognition features; conducted experiments in realistic contexts with human interaction; conducted experiments to fill data voids and developed models describing and able to predict the key simulation parameters affecting perception, cognition, and physical performance independently (simulation and training); and outlined experimentation required to determine simulation parameters affecting			

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** 74A / *Human Engineering*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
the interactions across perception, cognition, and physical performance. Included preliminary Training and Soldier performance research to identify and evaluate performance models, metrics and environments for determining Soldier behavior. This work will be continued under a new R2 bullet beginning in Fiscal Year (FY) 2016. ***FY 2016 Plans:*** Continue to investigate integrative aspects of key psychosocial factors of cyber security to understand behaviors of attackers, defenders, and users in operational settings; create a scientific experimental infrastructure of game-modeling and empirical studies to examine risk to operation completeness and to study strategic decision-making for responding to human-machine attacker units; and enhance basic understanding of big data implications on distributed team communications and decision making by refining task network models to study the feasibility of the doctrinal tenets surrounding network-enabled warfare (e.g., more data leads to enhanced situational awareness).			
Title: Translational Neuroscience ***Description:*** Integrating neuroscience with traditional approaches to understanding Soldier behavior to enable systems designs that maximize Soldier performance. ***FY 2015 Accomplishments:*** Developed and refined active machine learning algorithms for improving the task performance of brain-based technologies that combine neural signals extracted from the Soldier with semi-autonomous computer systems; examined effects of environmental context on cognitive brain state assessments; explored analytical approaches for interpreting brain activity in unstructured tasks; and investigated how different signal processing approaches affect the detection of brain network signal estimates in order to support future development of brain-based technologies. ***FY 2016 Plans:*** Develop algorithms to detect changes in brain state during long-term performance of a task for a non-invasive brain-computer interface; collect novel neurophysiological datasets based on real-world measurements of stress and fatigue; collect innovative structural imaging data from a large cohort (N>100) of participants to quantify sensitivity of measurement and variability between individuals; and investigate signatures of brain networks that capture changes in task performance. ***FY 2017 Plans:*** Will develop adaptive algorithms to enable semi-supervised learning of brain states in support of human-in-the-loop systems; analyze the reliable relationships between objective physiological measurements and subjective assessments of fatigue; assess the sensitivity in the structural topology or shape of connections between brain regions in a large cohort (N<100) to characterize human variability.	4.398	3.579	3.639
Title: Human System Integration – Cybernetics	4.828	5.119	5.157

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** 74A / *Human Engineering*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017

Description: Apply a cybernetic approach (theoretical study and comparison of communication and control processes in biological and artificial systems) to human systems integration to achieve tighter control of devices and communication among humans and between machines and humans. Use social, computational, and information approaches to extend the scope of interaction beyond individual systems to the full network context.

FY 2015 Accomplishments:
Determined areas of convergence for cognitive, social, information and computational sciences to develop and apply the cybernetic approach to human centered design of complex systems; invoked neural, information, and social-cybernetic modeling approaches to identify and begin to address the human system integration gaps that exist at the millisecond time scales and/or in the team- level interactions; examined issues in the design and implementation of cybernetic systems that will enable leveraging of the human nervous system's abilities to integrate, interpret, and utilize multimodal information in the sensory-perceptual-motor decision-making cycle; conducted research using novel paradigms, such as wearable computing and augmented reality technologies to identify key temporal and context parameters in multi-sensory integration; and laid the foundation for scaling up to societal-level cybernetics.

FY 2016 Plans:
Examine computational models consistent with cybernetic principles, including feedback models of adaptive mechanisms in human multisensory integration for sensor and motor systems control; implement and study novel neuro-inspired and bio-inspired architectures for cybernetic models that can be applied to the critical challenge of multisensory integration across sensory features that cannot be measured on the same metric dimensions; design a multimodel platform to support human multisensory basic and applied research efforts in augmented reality and perception; examine critical parameters of multisensory displays to enhance and support human perceptual performance in human-system interactions; explore novel methodologies for identifying and integrating variables in cybernetic models to improve human-system communication; explore novel methods for the design of novel, dynamic, and adaptive human-system interactions through methods for mutual human-system communication that leverage information and social science approaches.

FY 2017 Plans:
Will advance conceptual, theoretical, and computational closed-loop models (such as neuro-inspired and bio-inspired models) of adaptive behavior and multisensory integration; develop and assess statistical and computational methods to account for variability in and improve prediction of human performance by leveraging temporal dependencies inherent to human neural, physiological, and/or behavioral data; advance display and multi-aspect measurement capabilities for highly-mobile, immersive, multimodal platforms to support human performance research efforts in augmented perception in real-world contexts; develop and extend novel methodologies for metrics to capture the complex interrelationships in dynamic unisensory and multisensory

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
parameters that drive human adaptive behavior; implement and assess novel, cybernetic approaches to human-system communication and interaction that induce or support adaptive and/or mutually adaptive behavior to improve human performance.			
Title: Continuous Multi-Faceted Soldier Characterization for Adaptive Technologies ***Description:*** This effort will investigate technologies that provide the foundation for future Army systems to adapt to individual Soldier's states, behaviors, and intentions in real-time. Enable high fidelity, continuous prediction that can account for continuous changes in Soldier's physical, cognitive, and social states, such as stress, fatigue, task difficulty, trust, and situational awareness. ***FY 2017 Plans:*** Will advance theories for dynamically integrating asynchronously recorded data from multiple sources with different temporal resolution and time-varying levels of information quality; understand relationships between behavioral, physiological, environmental, and task-based factors and human variability in task performance in real-world environments; and characterize quality of information recorded from behavioral, physiological, environmental, and task-based sensors continuously used in real-world environments.	-	-	3.306
Title: Training and Soldier Performance ***Description:*** Research relationship between training environment fidelity/level of immersion and Soldier performance & behavior. Determine the level of physical, perceptual, and cognitive interaction necessary for a simulated environment to effect performance similar to the operational environment. Characterize the appropriate use of different classes of simulated environments to ensure valid results. Develop guidelines for using mobility platforms in simulators to induce physical and cognitive stress that is representative of the operational environment. Implementation of the guidelines will enhance training effectiveness. ***FY 2015 Accomplishments:*** Explored the varying levels of immersive environments (real environment, first person game, fully immersive) and varying levels of physical and cognitive stress (induced by varying levels of physical and cognitive stimuli) to determine ability of Soldiers to perceive and act on information. Used results from these studies to augment models of Soldier performance and behavior as a function of training environment. If those models are insufficient, begin development of new models, based on empirical data, predicting Soldier behavior based on training environment. ***FY 2016 Plans:*** Explore effects of mobility platform and training environment on route selection during training scenarios; manipulate level of information in the environment to determine how information influences route selection, traversal time, and other Soldier performance parameters; use results from these studies to augment current models or develop new models of Soldier performance and behavior (using empirical data to predict Soldier behavior based on training environment). ***FY 2017 Plans:***	1.637	1.221	1.240

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** 74A / *Human Engineering*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
Will explore state-of-the-art techniques in immersion, presence, and fidelity with regard to simulation-based training effectiveness to identify appropriate theories of how these factors might be used to predict training outcomes; and develop conceptual-based models that can predict training outcomes.			
Accomplishments/Planned Programs Subtotals	14.235	13.176	13.342

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army										Date: February 2016		
Appropriation/Budget Activity 2040 / 1					R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*				Project (Number/Name) 74F / *Pers Perf & Training*			
COST ($ in Millions)	**Prior Years**	**FY 2015**	**FY 2016**	**FY 2017 Base**	**FY 2017 OCO**	**FY 2017 Total**	**FY 2018**	**FY 2019**	**FY 2020**	**FY 2021**	**Cost To Complete**	**Total Cost**
74F: *Pers Perf & Training*	-	5.131	5.459	5.540	-	5.540	5.635	5.737	5.852	5.969	-	-

A. Mission Description and Budget Item Justification

This project provides the funding to develop innovative theories, models, and methods to improve personnel assessment, training, and leader development, as well as provide a better understanding of individual, unit, and organizational behavior and performance within the context of complex organizational and operational environments. The research within these domains will enable advances in psychometrics to support the development of the next generation of psychological assessments for selection, classification, and assignment. The research also will target how to improve the assessment of difficult-to-measure skills and enable theoretical advances to inform and support the accelerated development of complex cognitive and social skills. This research lays the foundation for future applications that address the behavioral and organizational dynamics that impact Army flexibility, effectiveness, and resilience.

Work in this project complements and is fully coordinated with Program Element (PE) 0602785A (Project 790) and PE 0603007A (Project 792).

The cited work is consistent with the Assistant Secretary of Defense, Research and Engineering Science and Technology focus areas and the Army Human Capital Strategy.

Work in this project is performed by the Army Research Institute for the Behavioral and Social Sciences (ARI), Ft. Belvoir, VA.

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2015**	**FY 2016**	**FY 2017**
Title: Personnel Measures (previously Human Behavior)	1.800	1.834	1.900
Description: Funding is provided for basic research to develop innovative theories, models, and methods to improve personnel assessment, training, and leader development. ***FY 2015 Accomplishments:*** Initiated the development of measurement theory and performance-based measurement methods to improve selection, classification, and assignment. ***FY 2016 Plans:*** Investigating the integration of psychological and neurometric approaches for improving individual difference assessment and personnel testing methods. ***FY 2017 Plans:*** Will initiate research to develop assessment methods for difficult to measure skills & attributes related to complex organizational behaviors.			
Title: Climate, Readiness, and Resilience (previously Human in Complex Organizations)	3.331	3.625	3.640

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** 74F / *Pers Perf & Training*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
Description: Funding is provided for basic research that will provide a better understanding of individual, unit, and organizational behavior and performance within the context of complex organizational and operational environments. ***FY 2015 Accomplishments:*** Initiated research to develop group and organizational measures of organizational cohesion, resilience, and effectiveness. ***FY 2016 Plans:*** Investigating integrated approaches to understanding and assessing systematic contextual moderators of behavior in organizations with primary emphasis on improving prediction of mistreatment and inclusion. ***FY 2017 Plans:*** Will initiate research to develop models to better understand organizational processes needed to achieve maximal organizational flexibility, effectiveness, and resilience.			
Accomplishments/Planned Programs Subtotals	5.131	5.459	5.540

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army			Date: February 2016
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*	Project (Number/Name) ET6 / *BASIC RESCH IN CLINICAL & REHABILITATIVE MED*	

COST ($ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
ET6: *BASIC RESCH IN CLINICAL & REHABILITATIVE MED*	-	0.000	0.000	4.201	-	4.201	4.531	4.617	4.714	4.809	-	-

Note

In Fiscal Year (FY) 2015 and 2016 the funding for Clinical and Rehabilitative Medicine was in project S14. The Clinical and Rehabilitative Medicine basic research effort moves to project ET6 starting in FY17. This is not a new start.

A. Mission Description and Budget Item Justification

This project supports basic research on experimental models that are developed to support in-depth trauma research studies. This project includes studies to understand the healing of burned or traumatically injured tissues i.e. eye and facial tissues, and transplant technology. Such efforts will minimize lost duty time and provide military medical capabilities for post-evacuation restorative and rehabilitative care.

Research conducted in this project focuses on Clinical and Rehabilitative Medicine.

The cited work is consistent with the Assistant Secretary of Defense for Research and Engineering Science and Technology, priority focus areas and the Army Modernization Strategy.

Work in this project is performed by the Army Institute of Surgical Research (USAISR), Joint Base San Antonio, TX; and the Armed Forces Institute of Regenerative Medicine (AFIRM), Multiple Institutions across the US.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
Title: Clinical and Rehabilitative Medicine	-	-	4.201
Description: This effort conducts basic studies of mechanisms of tissue growth and traumatic injury to gain an understanding that will assist or facilitate the healing or transplantation process. The focus is placed on severe blast trauma to the limbs, head, face (including eye), and genitalia (organs of reproduction), abdomen and burns.			
FY 2017 Plans: Will characterize and define the post-injury cellular mechanisms resulting in functional deficits of the eyes; will formulate concepts and identify promising novel therapies and strategies to treat traumatically injured eyes; will assess and characterize the future threats and battlefield logistics impacting eye injuries and treatments; and will continue to define innovative strategies to regenerate and reconstruct hard (e.g. bone) and soft (e.g. skin, muscle, nerve, vascular) tissues to enable promising approaches to advance into the applied research phase through directed experimentation in the laboratory to address injuries of the			

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** ET6 / *BASIC RESCH IN CLINICAL & REHABILITATIVE MED*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
extremities, face (including eyes), genital, and abdominal body regions. Will identify novel immunomodulation (modification of the immune response / immune system functioning) technologies as well as vascular technologies that reduce the requirement for vein harvest and nerve regeneration technologies that address nerve gap injuries.			
Accomplishments/Planned Programs Subtotals	-	-	4.201

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army			Date: February 2016
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*	Project (Number/Name) F20 / *Adv Propulsion Rsch*	

COST ($ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
F20: *Adv Propulsion Rsch*	-	4.054	4.161	4.220	-	4.220	4.290	4.368	4.452	4.541	-	-

A. Mission Description and Budget Item Justification

This project fosters research to increase the performance of small air-breathing engines and power-trains to support improved system mobility, reliability, and survivability for air and/or ground vehicles; and ultimately serves to reduce the logistics cost burden for the future force. Problems addressed include the need for greater fuel efficiency and reduced weight in these propulsion systems. Technical barriers to advanced propulsion systems are the inadequacy of existing materials to safely withstand higher temperature demands, the lack of capability to accurately simulate the flow physics and the mechanical behavior of these systems, including the engine and drive train. The Army is the lead Service in these technology areas and performs basic research in propulsion, as applicable to rotorcraft as well as tracked and wheeled vehicles. Technical solutions are being pursued through analysis, code generation, and evaluations to improve engine and drive train components and investigate advanced materials. Component level investigations include compressors, combustors, turbines, energy sources and conversion, injectors, pistons, cylinder liners, piston rings, gears, seals, bearings, shafts, and controls.

Work in this project provides the technical underpinnings for Program Element (PE) 0602211A (Aviation Technology).

The cited work is consistent with the Assistant Secretary of Defense for Research and Engineering Science and Technology focus areas and the Army Modernization Strategy.

Work in this project is performed by the Army Research Laboratory (ARL) at Aberdeen Proving Ground, MD.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
Title: Thermal Materials	2.376	2.431	4.220
Description: Investigate new materials needed to withstand the higher temperature regimen of advanced high performance engines, and evaluate improved tools and methods that will accurately simulate the flow physics and the mechanical behavior of future engines and drive trains, which will contribute to the design of more fuel efficient and reliable propulsion systems.			
FY 2015 Accomplishments: Conducted thermo-mechanical fatigue experiments on new bulk ceramic materials, polymer composites, and metal alloys to enable reduced production/maintenance costs, and to achieve increased performance factors with improved temperature capability; developed advanced computational damage models; and conducted mechanical diagnostics experiments to improve the understanding of failure progression and diagnostics in drive train mechanical components, such as gears and bearings.			
FY 2016 Plans: Formulate and validate physics-based model of 1) calcium–magnesium–alumino-silicate (CMAS) degradation on thermal barrier coating in a gas turbine environment, and 2) the thermal softening and oxidation degradation on advanced gear steel			

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** F20 / *Adv Propulsion Rsch*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
surfaces. This work provides the foundation for developing physics-based full-length scale concept-to-design of high-speed thermomechanical turbomachinery and mechanical energy transfer for future rotorcraft. ***FY 2017 Plans:*** Will formulate and validate physics-based model of 1) CMAS degradation on thermal barrier coating in a gas turbine environment, and 2) the thermal softening and oxidation degradation on advanced gear steel surfaces. This work will provide the foundation for developing physics-based full-length scale concept-to-design of high-speed thermomechanical turbomachinery and mechanical energy transfer for future rotorcraft.			
Title: Reliable Small Engines for Unmanned Systems ***Description:*** Develop improved tools and methods to enhance the reliability and fuel efficiency of small engines for air and ground vehicles and to enable the use of heavy fuels. ***FY 2015 Accomplishments:*** Evaluated transient spray and combustion characteristics of heavy fuel injectors under simulated engine conditions to optimize engine combustion, performance, and efficiency; and developed more accurate and reliable modeling and simulation tools to predict spray and combustion characteristics under complex fluid dynamics conditions that enable effective design of small engines for a range of Army applications. ***FY 2016 Plans:*** Evaluate liquid and vapor partitioning in transient spray phenomenon to discover injection-kinetic dependency of spray and combustion events, analyze droplet size distributions in transient spray, and assess ignition, combustion intensity and radical dependency on transient spray; characterize spray and combustion processes of JP-8, Jet A, and alternative jet fuels for fuel property correlation with spray and combustion parameters; and research modeling and simulation methodologies (both semi-empirical and physics-based) that predict spray and combustion characteristics under complex fluid dynamics conditions.	1.678	1.730	-
Accomplishments/Planned Programs Subtotals	4.054	4.161	4.220

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** F20 / *Adv Propulsion Rsch*

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army			Date: February 2016
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*	Project (Number/Name) F22 / *Rsch In Veh Mobility*	

COST ($ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
F22: *Rsch In Veh Mobility*	-	0.685	0.707	0.718	-	0.718	0.732	0.745	0.760	0.775	-	-

A. Mission Description and Budget Item Justification

This project conducts research in support of advanced military vehicle technology with emphasis on advanced propulsion, sophisticated vehicle dynamics and simulation, vehicle-terrain interaction, vehicle control, and advanced track and suspension concepts. Advanced propulsion research will dramatically improve power density, performance and thermal efficiency for advanced engines, transient heat transfer, high temperature materials and thermodynamics. This project also supports state-of-the-art simulation technologies to achieve a more fundamental understanding of advanced mobility concepts. The subject research is directed at unique, state-of-the-art phenomena in specific areas such as: non-linear ground vehicle control algorithms, using off-road terrain characteristics; and unique mobility approaches, using advanced analytical and experimental procedures.

Work in this project provides the theoretical underpinnings for Program Element 0602601A (Combat Vehicle and Automotive Technology).

Work in this project is performed by the Tank and Automotive Research, Development and Engineering Center (TARDEC).

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
Title: Advanced Mathematical Algorithms for Improved Vehicle Efficiency	0.685	0.707	0.718
Description: Funding is provided for the following effort: ***FY 2015 Accomplishments:*** Researched new physics based analytical tools for more accurately and rapidly predicting vehicle terrain interaction effects; and explored new methodologies/relationships for improving intelligent mobility including latency. ***FY 2016 Plans:*** Research development of North Atlantic Treaty Organization (NATO) Reference Mobility Model mobility metrics using new physics-based analytical tools for more accurately and rapidly predicting vehicle terrain interaction effects (off-road mobility); continue to explore new methodologies/relationships for improving autonomous mobility including latency; and research math modeling human driver actions/responses critical to predicting vehicle dynamics and interactions with the environment. ***FY 2017 Plans:*** Will continue to develop the framework for the next-generation NATO Reference Mobility Model methodology, a tool-agnostic solution which can be tailored by the various NATO nations based on their software tools of choice; adapt National Aeronautics Space Administration (NASA) Jet Propulsion Laboratory's Rover Analysis Modeling and Simulation methodology to autonomous and tele-operated ground vehicles; develop detailed models for different off-road terrains (sand, loam, clay) using Discrete Elements Method, finite elements analysis and mesh-free method approaches; develop multi-scale computational algorithms that			

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** F22 / *Rsch In Veh Mobility*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
can model both large ground vehicle systems and fine soil particles in an integrated mobility simulation; and investigate high-speed mobility of tele-operated vehicles in transcontinental scenarios.			
Accomplishments/Planned Programs Subtotals	0.685	0.707	0.718

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army										Date: February 2016		
Appropriation/Budget Activity 2040 / 1					R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*				Project (Number/Name) H42 / *Materials & Mechanics*			
COST ($ in Millions)	**Prior Years**	**FY 2015**	**FY 2016**	**FY 2017 Base**	**FY 2017 OCO**	**FY 2017 Total**	**FY 2018**	**FY 2019**	**FY 2020**	**FY 2021**	**Cost To Complete**	**Total Cost**
H42: *Materials & Mechanics*	-	9.054	8.603	8.731	-	8.731	8.879	9.040	9.218	9.402	-	-

A. Mission Description and Budget Item Justification

This project conducts basic research in materials science, which includes research into key phenomena enabling the creation and production of revolutionary materials that will provide higher performance, lighter weight, lower cost, improved reliability, and environmental compatibility for Army unique applications. The current methodology of using materials to gain added functionality for Army systems is to use a layered approach, whereby each layer provides added capability (e.g., ballistic, chemical/biological, signature, etc.), but ultimately makes the system too heavy and too expensive. Technical solutions are being pursued through understanding the fundamental aspects of chemistry and microstructure that influence the performance and failure mechanisms of ceramics, advanced polymer composites, and advanced metals, with the goal of creating hierarchically organized materials systems that possess multifunctional attributes at greatly reduced weight and cost. These advanced materials will enable revolutionary lethality and survivability technologies for the future.

Work in this project supports key Army needs and provides the technical underpinnings for several Program Elements (PE) to include PE 0602105A (Materials Technology)/ Project H84 (Materials) and PE 0602786A (Warfighter Technology)/H98 (Clothing & Equipment Technology).

The cited work is consistent with the Assistant Secretary of Defense for Research and Engineering Science and Technology focus areas and the Army Modernization Strategy.

Work in this project is performed by the Army Research Laboratory (ARL), Aberdeen Proving Ground, MD.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
Title: Microscopic/Nanostructural Materials	2.348	2.341	2.375
Description: Devise new materials and design capabilities based upon fundamental concepts derived at the microscopic and nanostructural levels for the future force.			
FY 2015 Accomplishments: Created numerical models and experimental techniques to design energy-absorbing, adaptive, damage-tolerant nanocomposites; developed new paradigms for thermodynamically stable nanostructured materials systems that overcome traditional property trade-offs; and pursued revolutionary new polymeric building block materials for structural, membrane, sensor, and power/energy applications.			
FY 2016 Plans:			

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** H42 / *Materials & Mechanics*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
Develop computational capabilities and methods to explore grain boundary structure-property relationships for predicting the strength and failure response of metals and ceramics; and continue thermodynamic stability research of micro/nanomaterials including synthesis of new nanocrystalline iron-based alloys that employ novel particulate oxide strengthening mechanisms. ***FY 2017 Plans:*** Will advance development of computational methods to discover and exploit interfacial structure-property relationships at grain boundaries in metals and ceramics to improve strength and fracture resistance; and develop a series of model fibers to investigate structure-property relationships as a function of processing.			
Title: High Deformation Rate Materials ***Description:*** Develop fundamental understanding necessary to design, process and characterize materials specifically intended for high loading rate applications, as in armor and armaments.. ***FY 2015 Accomplishments:*** Developed multiscale, multidisciplinary models and related experimental techniques to elucidate fundamental physics of materials response to include: thermoelastic, yield, failure, and fracture behavior at high deformation rates; created novel experimental research tools to enable the study of these high deformation rate phenomena with greater resolution; incorporated microstructural and high deformation response into robust multiscale computational codes; and began to create new materials specifically designed to enhance performance at high deformation rates in applications ranging from armor to new armaments. ***FY 2016 Plans:*** Enhance multiscale, multidisciplinary materials research to include 1) investigation of methods that couple electromagnetic and continuum mechanics (i.e., modeling behaviors of materials as a continuous mass rather than discrete particles) theories and algorithms that transition microcracks at small length scales to macrocracks at larger scales and 2) experimental and modeling capabilities to capture the high rate response and failure of polymer materials under extreme loading conditions. ***FY 2017 Plans:*** Will advance multiscale, multidisciplinary materials research by developing 1) computational methods to link electromagnetics and continuum mechanics theories and bridge length scales to model crack growth, and 2) experimental and modeling capabilities to capture the high rate and pressure-dependent response of polymer materials.	3.407	3.107	3.153
Title: Materials Research and Processing at Small Scale ***Description:*** Elucidate and exploit unique structure, processing, and property relationships that occur in materials at small length scales and develop methods to tailor the physical, chemical and mechanical response of these materials to enable unprecedented performance improvements in materials properties. ***FY 2015 Accomplishments:***	3.299	3.155	1.089

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** H42 / *Materials & Mechanics*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
Developed an integrated computational materials science capability that clarifies relevant physical mechanisms and enables the rational design of small scale (nanoscale) and bio-inspired building blocks; utilized thermodynamic and kinetic studies of self-assembly processes to design, create, and characterize nanostructured surfaces and interfaces; and created and utilized small scale materials characterization techniques to further the fundamental understanding of small scale materials and processes. ***FY 2016 Plans:*** Explore fundamental effects of alloying elements on atomic level structure and resulting properties and dynamic (high-rate) response to enable new lightweight alloys; develop novel modeling capabilities to capture physics at small scales in protective fibers and composite materials; and begin new foundational research on next-generation protective fibers with controlled nano/ microscale structure. ***FY 2017 Plans:*** Will perform research into high energy processing techniques to consolidate metal powders to form thermodynamically stable, nano-grained alloy materials, that exhibit high strength, ductility, and toughness.			
Title: Materiel Research and Processing Using High Energy Fields ***Description:*** Explore interactions between materials and intense energy fields (magnetic, electric, pressure, etc.) to discover new pathways and mechanisms for controlling and altering material structure, enabling the development of new materials with unique property combinations and abilities to respond adaptively to battlefield conditions. ***FY 2017 Plans:*** Will develop new models and experimental capabilities to understand effects of electromagnetic (EM) fields on multiscale structure of armor ceramics during processing, including using EM fields to control engineer grain boundaries for enhanced energy dissipation and fracture resistance under high-rate loading.	-	-	2.114
Accomplishments/Planned Programs Subtotals	9.054	8.603	8.731

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army										Date: February 2016		
Appropriation/Budget Activity 2040 / 1					R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*				Project (Number/Name) H43 / *Research In Ballistics*			
COST ($ in Millions)	**Prior Years**	**FY 2015**	**FY 2016**	**FY 2017 Base**	**FY 2017 OCO**	**FY 2017 Total**	**FY 2018**	**FY 2019**	**FY 2020**	**FY 2021**	**Cost To Complete**	**Total Cost**
H43: *Research In Ballistics*	-	8.602	8.410	8.531	-	8.531	8.676	8.834	9.007	9.187	-	-

A. Mission Description and Budget Item Justification

This project seeks to improve the understanding of the chemistry and physics controlling the propulsion, launch, and flight of gun-launched projectiles and missiles, and to understand the interaction of these weapons with armored targets. This research results in basic new knowledge, which allows the formulation of more energetic propellants, more accurate and non-lethal (NL)/lethal projectiles and missiles, and advanced armors for increased survivability of Army combat systems. This effort supports the Office of the Secretary of Defense Advanced Energetics Initiative to mature the fundamental technologies required to transition the next generation of energetic materials into field use.

Work in this project supports key Army needs and provides the theoretical underpinnings for Program Element (PE) 0602618A (Ballistics Technology)/Project H80 (Survivability and Lethality Technology).

The cited work is consistent with the Assistant Secretary of Defense for Research and Engineering Science and Technology focus areas and the Army Modernization Strategy.

Work in this project is performed by the Army Research Laboratory (ARL), Aberdeen Proving Ground, Adelphi, MD, and Research Triangle Park, NC.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
Title: Advanced Energetics Initiative	3.516	3.155	3.203
Description: Expand and confirm physics based models and validation techniques to enable design of novel insensitive propellants/explosives with tailored energy release for revolutionary future force survivability and weapons effectiveness. ***FY 2015 Accomplishments:*** Exploited material micro/nanostructure, high pressure synthesis, and managed energy release mechanisms to develop energetic materials with two to ten times the energy content of conventional explosives; further advanced theory required to develop accurate descriptions and models of condensed phase processes, quantum mechanical reactive potential energy surfaces, shock impact, initiation and detonation phenomena, and ignition and combustion; and further developed synthetic capabilities to produce high-nitrogen containing materials. ***FY 2016 Plans:*** Explore novel high-nitrogen carbon, hydrogen, nitrogen and oxygen (CHNO) synthesis methodologies to create unique energetic molecular structures while maintaining stability of reactive properties; expand investigation and explore novel extended solid energetic materials, in particular poly-carbon monoxide (CO), including alternatives to high pressure synthesis methods; and			

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** H43 / *Research In Ballistics*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
develop predictive models and associated experimental methods to enable precise control of energy release in shear-mediated acceleration of solid-solid chemical reactions. ***FY 2017 Plans:*** Will develop novel small scale experimental strategies to release and measure the energy and power stored in structural bond energy release materials (e.g., nanodiamonds), extended solids (e.g., poly-CO), and other types of disruptive energetic materials; and develop computational models to guide understanding of potential materials, methods and mechanisms to enable release of energy to be converted to work, both in terms of propulsion of a flight body and lethal effects on a target.			
Title: Launch and Flight of Gun Launched Projectiles as well as Missiles ***Description:*** Improve the fundamental understanding of the mechanisms controlling the launch and flight of gun launched projectiles and missiles, and understand the interaction of these weapons with armored targets. ***FY 2015 Accomplishments:*** Further developed computational aerodynamics capabilities, coupled with the development of next-generation guidance, navigation, and control solutions to enable new paradigms in maneuverability to achieve ultrahigh precision. ***FY 2016 Plans:*** Investigate dynamics and controls of extreme aerodynamic maneuvers and assess transient effects and potential for maneuver without the use of sensors; and begin to explore and create capabilities for prescribing favorable forces and moments on flight bodies across multiple Mach regimes. ***FY 2017 Plans:*** Will develop unique modeling and experimental capabilities to predict and characterize the flight physics associated with complex rapid maneuvering of a flight body as well as the nonlinear control algorithms required for navigation in constrained environments (e.g., global positioning system denied).	1.659	1.730	2.020
Title: Armor Research ***Description:*** Develop fundamental knowledge of mechanisms that can be exploited to ensure the next generation of lightweight and efficient armor technologies. ***FY 2015 Accomplishments:*** Established capabilities to extract electron temperature data from time resolved imaging spectroscopy measurements of shaped charge jet induced plasma for comparison to numerical simulation predictions; developed hierarchical multiscale methodology for transfer of relevant information from mesoscale computation to macroscale constitutive and failure models; and developed	3.427	3.525	2.558

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** H43 / *Research In Ballistics*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
coupled finite element and physiological numerical modeling methods to evaluate the dynamic response of the human head as a structure under short-time blast loading to enable effective design of protection concepts. ***FY 2016 Plans:*** Develop analytic and numerical methods and associated experiments for rigorous coupling of electro-magnetics and solid dynamics models; explore the validity of phase-field methods to track coupled deformation mechanisms in polycrystalline solids under rapid deformation; and assess accuracy and ability of multi-scale computations that account for material-scale mechanisms during penetration events. ***FY 2017 Plans:*** Will develop computational methods to capture multiple deformation and failure mechanisms occurring simultaneously that occur under ballistic and blast loading conditions; and develop novel experiments to probe and quantify high-rate deformation mechanisms at small length scales to improve multi-scale computations.			
Title: Humans in Extreme Ballistic Environments Research ***Description:*** Provide physics-based discovery of novel protection mechanisms through increased understanding of wave propagation through tissue and the resulting deformation and damage of tissue during ballistic and blast events. ***FY 2017 Plans:*** Will develop novel experimental techniques to explore cell-level response of neuronal tissue as a function of various potential high-rate loading variables.	-	-	0.750
Accomplishments/Planned Programs Subtotals	8.602	8.410	8.531

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army										Date: February 2016		
Appropriation/Budget Activity 2040 / 1					R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*				Project (Number/Name) H44 / *Adv Sensors Research*			
COST ($ in Millions)	**Prior Years**	**FY 2015**	**FY 2016**	**FY 2017 Base**	**FY 2017 OCO**	**FY 2017 Total**	**FY 2018**	**FY 2019**	**FY 2020**	**FY 2021**	**Cost To Complete**	**Total Cost**
H44: *Adv Sensors Research*	-	9.564	8.659	9.436	-	9.436	9.771	10.276	10.936	11.194	-	-

A. Mission Description and Budget Item Justification

This project supports basic research to produce future generations of sensors with capabilities beyond those currently being employed. Technical barriers include the fundamental speed and bandwidth limitations of current materials and devices, the efficiency of current algorithms, current computing architectures, organic material lifetimes, the understanding of the fundamental concepts of quantum cryptography, and the spatial resolution of current radio frequency (RF) sensors. The technical approach is to exploit large-scale electromagnetic (EM) models to predict and explain target and clutter scattering behavior, and research new digital and image processing modules and algorithms, beam propagation and material models of nonlinear optical effects, remote sensing and intelligent system distributive interactive simulations, and battlefield acoustic signal processing algorithms for improved, hazardous material detection and sensor data feature and information fusion under the Data-to-Decisions (D2D) concept, unique sensor development, and survivable sensor systems. This project also funds research in the development of biologically inspired materials for use as sensors as well as for power generation and storage; and physics-based multi-scale models for electronic, optical, mechanical, and chemical materials. Payoffs include high-data-rate military communications, improved radar signal processing techniques that will allow existing systems to improve spatial resolution, improved ultra wideband radar technology for detection of explosives including mine detection, through-the-wall sensing and improved robotics perception, improved sensor approaches and signal processing techniques for enhanced acoustic/seismic sensing systems in noisy environments, distributed sensor data fusion in ad hoc networks, improved cryptography techniques, improved understanding of the physics and atomic properties of materials, and improved capabilities in hazardous material and event sensing.

Work in this project supports key Army needs and provides the theoretical underpinnings to Program Element (PE) 0602786A (Warfighter Technology)/Project H98 (Clothing & Equipment Technology).

Work in this project complements and is fully coordinated with research at the Army Armaments Research, Development, and Engineering Center (ARDEC); the Army Communications Electronics Research, Development, and Engineering Center (CERDEC), the Army Natick Soldier Research, Development, and Engineering Center (NSRDEC) and the Army Edgewood Chemical Biological Center (ECBC).

The cited work is consistent with the Assistant Secretary of Defense for Research and Engineering Science and Technology focus areas and the Army Modernization Strategy.

Work in this project is performed by the Army Research Laboratory (ARL), Adelphi, MD.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
Title: Adaptive, Active, and Intelligent Optical Systems	1.755	-	-

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** H44 / *Adv Sensors Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
Description: Adaptive, active, and intelligent optical systems for high-data-rate military communications and directed energy applications. ***FY 2015 Accomplishments:*** Completed the optimization of the pointing, acquisition, and tracking sub-systems of the Free-Space Optical (FSO) networked multi-gigabit communication system; conducted a performance evaluation of the FSO and its related control software; and developed a visible light multispectral quantum imager capable of imaging through turbulence and demonstrate its capability in turbulence and low light field experiments to beyond one kilometer.			
Title: Improving Sensor and Photonics Research (Nano) ***Description:*** Create more survivable and secure sensors and displays; improve hazardous material monitoring; and investigate new magnetic- and electric-field sensor technologies for personnel, activity, and improvised explosive device (IED) detection. ***FY 2015 Accomplishments:*** Researched methods to improve acoustic classification robustness in diverse environments; studied a physics-based tracker algorithm for extremely long-range infrasound (low-frequency sound) detections; researched methods to improve magnetic tunnel junction sensor sensitivity and interface for reading non-erasable magnetic permeability bits of stored information; and investigated signal processing algorithms for exploiting flexible and adaptable low frequency ultra-wideband (UWB) waveforms that support stepped frequency radar technology. ***FY 2016 Plans:*** Research design of electrically-small antennas using adaptive metamaterials and adaptive surfaces; develop foliage penetrating (FOPEN) tree clutter model; develop low-frequency acoustic transducers to enhance signatures for improved tracking and classification algorithms that also compensate for signature variances due to channel and target motion effects; investigate enhanced performance magnetic tunnel junctions for low-frequency noise rejection and increased detection bandwidth and range; research distributed processing and fusion of gunfire signatures from disparate sensors; and examine the efficacy of surface-enhanced Raman scattering (SERS) sensor elements based on paper and flexible substrates impregnated with noble metal nano-photonic materials. ***FY 2017 Plans:*** Will investigate detection and tracking algorithms using a high fidelity foliage penetrating radar target and clutter model; develop radio frequency interference mitigation algorithms; investigate low-frequency, quasi-static, magnetic-, and electric-field interactions between a sensor and its environment to improve overall sensor performance; investigate sensor and algorithmic methodologies to differentiate infrasound from wind-turbulence to better understand the phenomenology of noise generation and develop strategies for mitigating the effects of wind-turbulence; research distributed processing and fusion methods using shared decision-	2.925	2.850	2.393

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** H44 / *Adv Sensors Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
making processes over low-power, short-lifetime sensors with limited communication capabilities for efficient battlefield situational awareness to the dismounted Soldiers; and examine efficacy of a hybrid, surface-enhanced biosensor.			
Title: Multi-scale Modeling for Novel Materials ***Description:*** Explore and develop multi-scale modeling techniques to support fundamental studies of electronic and structural materials properties from the atomistic to the continuum. Resulting models will be used to design and develop materials for more efficient, longer lifetime sensors and power and energy devices, and lighter materials for vehicle and soldier protection. This effort includes research that leverages two 5-year Collaborative Research Alliances (CRAs): the Materials in Extreme Dynamic Environments CRA and the Multi-scale/Multidisciplinary Modeling of Electronic Materials CRA. These CRAs are funded under PE 0601104A/Project VS2 (Multi-scale Materials Modeling Centers). ***FY 2015 Accomplishments:*** Continued to perform fundamental studies to identify and model the physics and atomic interactions that define their structural, mechanical, electronic, and optical properties and characteristics and control material deformation, progressive/catastrophic failure, and phase response across length scales; validated multi-scale experimental techniques and characterization methods; continued to develop advanced computational models for multiscale modeling of electrochemical systems; investigated and develop scalable interdisciplinary data models to address spatial one-way coupling of software on massively parallel petaflop systems, and multi-core computing systems; and conducted research in multi-scale computational sciences and coupled different modeling paradigms at the algorithm level. ***FY 2016 Plans:*** Develop algorithms/theories that further advance the state of the art and understanding of electronic materials with regards to interactions of electrons, photons, phonons, defects and impurities; evaluate the comprehensive set of material characteristics and properties at length and time scales that govern high-rate deformation; evaluate the modeling of fracture and failure phenomena in metallic, polymeric, ceramic, and composite material systems through both computational and experimental techniques; and expand computational modeling methods to exploit newly emerging high performance computing capability. ***FY 2017 Plans:*** Will create validation methods for new state-of-the-art algorithms developed for the understanding of electronic materials with regards to interactions of electrons, photons, phonons, defects, and impurities; investigate methods to quantify uncertainty for a comprehensive set of material characteristics and properties at length and time scales that govern high-rate deformation; develop scalable numerical algorithms for modeling of failure, fracture, and fragmentation phenomena in metallic, polymeric, ceramic, and composite material systems through computational and experimental techniques; and implement multi-scale computational material modeling methods on massively parallel computers.	2.925	2.795	2.840
Title: Biological and Bio-inspired Materials and Devices Research	1.959	3.014	4.203

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** H44 / *Adv Sensors Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
Description: Create synthetic biological materials for devices and sensors that can be used by the Army to improve force protection and reduce logistical burden. ***FY 2015 Accomplishments:*** Investigated the underlying biology that enables natural and synthetic biological materials and systems to monitor, control, enhance, and predict bacterial metabolism and products for improved logistics and force protection; studied novel synthetic recognition reagents in response to new and emerging threats that possess superior performance, stability and adaptability; and researched hybrid biological/electronic/photonic materials capabilities based on bio-engineered cellular machinery or specific properties of bio-interfacial chemistry. ***FY 2016 Plans:*** Develop computational models of bacterial metabolism that include synthetically engineered pathways and use synthetic biology to manipulate that metabolism for production of commodity chemicals necessary for waste to energy applications; and study and develop fundamental synthetic biology tools enabling biomaterials discovery with enhanced features (e.g., integrated reporting and high temperature discovery) to allow for understanding and control of biological material interfaces for sensor and electronic integration, bioadhesives and other applications. ***FY 2017 Plans:*** Will investigate the addition of complementary natural microorganisms to current experimental protocols for microbial-derived fuels (i.e., a microbial consortium), with the goal of improving system stability over time and robustness to food source variability for waste-to-energy applications; establish models of cell membrane potential to better understand its role in controlling and optimizing biological reactions; create advanced computational protocols to model synthetic peptides for material discovery and maturation for improved biosensors; investigate the diversity of synthetic peptide libraries and develop first generation bioinformatic and modeling tools for genetically engineered peptides for inorganics and multifunctional materials; and extend peptide material discovery with integrated optical reporting to new material sets to enable active bio/abio heterogeneous interfaces.			
Accomplishments/Planned Programs Subtotals	9.564	8.659	9.436

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** H44 / *Adv Sensors Research*

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army			Date: February 2016
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*	Project (Number/Name) H45 / *Air Mobility*	

COST ($ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
H45: *Air Mobility*	-	2.247	2.328	2.364	-	2.364	2.403	2.448	2.495	2.545	-	-

A. Mission Description and Budget Item Justification

This project supports basic research in aerodynamics for manned and unmanned rotary wing aircraft. The goal of this effort is to develop improved tools and methods to analyze, evaluate, and assess rotorcraft-unique aerodynamic properties in conventional helicopter and tilt-rotor aircraft. The efforts in this project will result in a better understanding of rotorcraft aeromechanics and will result in improved performance, safety and, ultimately, improved combat effectiveness of the manned and unmanned rotorcraft in the future force. This project supports the future force by providing research into technologies that can improve tactical mobility, reduce logistics footprint, and increase survivability for rotary wing aircraft.

Work in this project provides the theoretical underpinnings for Program Element 0602211A (Aviation Technologies).

The cited work is consistent with the Assistant Secretary of Defense for Research and Engineering Science and Technology priority focus areas and the Army Modernization Strategy.

Work in this project is performed by the Army Aviation & Missile Research, Development and Engineering Center, Aeroflightdynamics Directorate at the National Aeronautics and Space Administration (NASA) Ames Research Center, CA and Langley Research Center, VA.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
Title: Rotary Wing Aerodynamics	2.247	2.328	2.364
Description: Funding is provided for the following effort			
FY 2015 Accomplishments: Continued computational aero-science investigations aimed at developing novel numerical methods for rotorcraft unique flow phenomena and continue fundamental aeromechanics experiments; conducted an experimental investigation of rotor wake physics including worm-like flow instabilities; investigated flow phenomena in unsteady flow separation; and developed and improve testing techniques for aerodynamics/fluid flow such as pressure sensitive paint and particle image velocimetry.			
FY 2016 Plans: Continue fundamental research in rotary-wing aeromechanics to lay the foundation for technologies with long-term relevance to future vertical lift encompassing areas such as automation; exploit high-performance computing to research three-dimensional structural dynamics and advanced flow control techniques; and conduct experimental and computational investigations to better understand interactional aerodynamics of multi-rotor configurations by developing pioneering flow measurement techniques and novel numerical algorithms/methods.			
FY 2017 Plans:			

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** H45 / *Air Mobility*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
Will leverage knowledge gained from earlier computational aero-science investigations (aimed at developing novel numerical methods) for rotorcraft blade structural load investigations; conduct experimental investigation of rotor blade structural loads; develop and improve flow measurement techniques such as infra-red thermography for transition, pressure sensitive paint for surface loads, and particle image velocimetry for flow field velocities; and explore interactional aerodynamic effects on multi-rotor configurations including the rotor downwash/outwash.			
Accomplishments/Planned Programs Subtotals	2.247	2.328	2.364

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army			Date: February 2016
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*	Project (Number/Name) H47 / *Applied Physics Rsch*	

COST ($ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
H47: *Applied Physics Rsch*	-	5.178	5.722	4.285	-	4.285	4.238	4.338	3.861	3.926	-	-

A. Mission Description and Budget Item Justification

This project performs basic research on electronic materials and structures as well as technologies in energy harvesting and energetic materials, batteries and fuel cells to enable higher performance and more efficient electronic systems. This includes nanoelectronic devices for low-power and high-frequency applications; sensors, emissive nonlinear and nanophase electrodes, and electronic materials; advanced battery materials, thermoelectric devices, photovoltaic devices, as well as more efficient fuel cells for hybrid power; and the manipulation of cold atoms on a chip for improved gyroscopes and accelerometers for inertial navigation units in global positioning system (GPS)-denied environments, very sensitive gravitational sensors for detecting underground facilities, low-phase noise precision oscillators for low-velocity Doppler radar, and ultra-stable atomic clocks for GPS-denied environments, as well as for future space-based timing applications. These investigations will also impact the development of power sources and specialty electronic materials for the Army's future force, including improved wide band gap semiconductor performance for more electric platforms, nanomaterials for batteries and fuel cells, quantum dots for increased photovoltaic efficiency and advanced radar systems. Technical barriers affecting performance, weight, cost, and power consumption will be addressed.

Work in this project supports key Army needs and provides the technical underpinnings to Program Elements (PE) 0602705A (Electronics and Electronic Devices)/ Project H94 (Electronics & Electronic Devices). Work in this project complements and is fully coordinated with research at the Army Armaments Research, Development, and Engineering Center (ARDEC); the Army Communications Electronics Research, Development, and Engineering Center (CERDEC); and the Army Natick Soldier Research, Development, and Engineering Center (NSRDEC).

The cited work is consistent with the Assistant Secretary of Defense for Research and Engineering Science and Technology priority focus areas and the Army Modernization Strategy.

Work in this project is performed by the Army Research Laboratory (ARL), Adelphi, MD.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
Title: Nanoelectronic Devices and Sensors	2.934	3.326	1.836
Description: Conducts research for advanced battery materials; fuel cells and reformers for Soldier and vehicle power; electronic materials structures and defects of high-temperature, wide-bandgap semiconductors for high-power electronic applications; materials for advanced nano and micro devices; cold-atom chip devices for advanced sensors and ultra-stable atomic clocks; and integration of nanoenergetics and Micro-Electro-Mechanical Systems (MEMS) for fusing and micro-robotic applications. ***FY 2015 Accomplishments:*** Investigated transport of cold atoms along chip-scale wires for applications in inertial navigation in GPS denied environments and for applications in environmental sensing, including magnetometry; investigated integration of three-dimensional (3D) piezoelectric materials and processes with flexible substrate and circuit technologies for radio frequency (RF) MEMS and millimeter scale			

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** H47 / *Applied Physics Rsch*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
robotics; studied and characterize the growth and electrical properties of stacked two-dimensionalo (2D) electronic materials for application to RF and/or logic devices; refined the early development of on-chip energetic materials and processing for supplying slow, high temperature thermal sources; and investigated composition and effect of additives on solid-electrolyte interphase formation on silicon anodes for lithium ion batteries. ***FY 2016 Plans:*** Construct an ultrafast laser spectroscopy experimental testbed to detect surface contamination by hazardous materials; investigate detection method based on photothermal vibrometry using tunable quantum cascade laser (QCL) sources for surface contamination detection and conduct ongoing investigations of other promising candidate spectroscopic detection technologies; analyze processes and materials for the realization of thin film deposited 3D piezoelectric materials for novel and high performance MEMS actuators; develop processes and characterize on-chip energetic materials for optimization of slow reaction rates for energy generation and thermal source applications; develop growth techniques and fabrication processes for stacked 2D materials, optimization for RF electronic properties and use of flexible substrates to enable vertical RF active devices resulting in higher frequency RF circuits (to increase performance with less size, weight and power); characterize devices and integrated circuits made using 2D electronic materials such as transition metal dichalcogenides in order to enable conformable, high performance electronics; assess performance prospects for application of such materials for high frequency and low power analog, RF, and digital electronics for communication and sensing; and research one-dimensional (1D)/2D novel phenomena for alternative device architectures for operation in extreme environments. ***FY 2017 Plans:*** Will investigate the viability of photoacoustic sensing using tunable quantum cascade laser sources for chemical hazard detection at standoff distances; investigate electrical performance of stacked 2-D materials and develop 2-D flexible integrated circuit analysis methodologies for the design of low-power and flexible RF and electronic circuits; develop and validate thermal models for the design of on-chip, energetic thermal sources and other thermally responsive on-chip materials for zero-power actuation applications; and analyze the integration of high performance piezoelectric materials with multi-layer structures to enable tunable, adaptable RF MEMS devices and inertial sensors.			
Title: Advanced Energy Efficient Science Research ***Description:*** Conduct materials, components, and multi-scale modeling research that will lead to advances in energy storage, harvesting, conversion, and efficiency for a wide range of Army applications such as Soldier and vehicle power, microgrids, communications, radar and electronic warfare. ***FY 2015 Accomplishments:*** Studied the physical limits of wide-band gap materials for direct photoelectrochemical production of hydrogen for use as fuel; investigated the effect of plasmonic arrays on the catalysis of oxygen reduction and ethanol oxidation as alternative methods	2.244	2.396	2.449

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** H47 / *Applied Physics Rsch*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
for fuel production; and developed advanced superconducting materials by metal organic chemical vapor deposition (MOCVD) processes to aid in energy conversion. ***FY 2016 Plans:*** Investigate plasmonic arrays and effect of array structure on catalysis of oxygen reduction, carbon dioxide electroreduction and ethanol oxidation as routes to producing fuel on the battlefield; investigate the effect of electromagnetic radiation (EM) at several frequencies on catalysis rate and selectivity to determine impact on power generation; and investigate the use of metamaterials to enhance EM effects on catalysis for higher conversions to useful fuels. ***FY 2017 Plans:*** Will investigate structures that have plasmonic resonance in the infrared; fabricate aluminum gallium nitride (AlGaN) structures that are bandgap-matched with ultraviolet phosphors; investigate 3D GaN structures for beta-voltaic and beta-photovoltaic power sources; develop understanding of failure mechanisms and methods of assessing wide bandgap device reliability in extreme operating regimes that will enable reliable Army sub-systems with improved power, weight and size efficiencies; study robustness and long-term reliability and related failure mechanisms of the AlGaN/GaN metal-insulator-semiconductor interface under accelerated electric fields and elevated temperatures; use multi-scale modeling to improve battery energy density and fuel cell performance; investigate electronic materials classes showing high potential for improved efficiency and frequency response through modeling, simulation, and characterization of electronic performance and metrology; investigate materials growth and fundamental device fabrication processes for energy efficiency and reduced parasitic losses; and develop new thermodynamic cycles for increased power and energy density in pyroelectrics, and determine effective acoustic energy transfer modes for wireless power transfer.			
Accomplishments/Planned Programs Subtotals	5.178	5.722	4.285

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army									Date: February 2016			
Appropriation/Budget Activity 2040 / 1					R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*				Project (Number/Name) H48 / *Battlespace Info & Comm Rsc*			
COST ($ in Millions)	**Prior Years**	**FY 2015**	**FY 2016**	**FY 2017 Base**	**FY 2017 OCO**	**FY 2017 Total**	**FY 2018**	**FY 2019**	**FY 2020**	**FY 2021**	**Cost To Complete**	**Total Cost**
H48: *Battlespace Info & Comm Rsc*	-	24.596	25.463	28.276	-	28.276	28.668	29.105	29.624	30.168	-	-

A. Mission Description and Budget Item Justification

This project supports basic research to enable intelligent and survivable command and control, communication, computing, and intelligence (C4I) systems for the future force. As the combat force structure decreases and operates in more dispersed formations, information systems must be more robust, intelligent, interoperable, and survivable if the Army is to retain both information and maneuver dominance. This research supports the Army's Network Science initiative and addresses the areas of information assurance, signal processing for wireless battlefield communications, document and speech machine translation, and intelligent systems for C4I. Major barriers to achieving the goals are the inherent vulnerabilities associated with using standardized protocols and commercial technologies while addressing survivability in a unique hostile military environment that includes highly mobile nodes and infrastructure, bandwidth-constrained communications at lower echelons, resource-constrained sensor networks, diverse networks with dynamic topologies, high-level multi-path interference and fading, jamming and multi-access interference, levels of noise in speech signals and document images, new low-density languages, and information warfare threats. These C4I technologies must accommodate heterogeneous security infrastructures and information exchange/security mechanisms between multiple levels of security. The intelligent systems for C4I research focuses on providing the agent technology capabilities that will produce highly relevant tactical events for mounted or dismounted commanders, leaders and Soldiers; improve the timeliness, quality and effectiveness of actions; and speed the decision-making process of small teams operating in complex natural or urban terrain.

Work in this project supports key Army needs and provides the technical underpinnings to Program Element (PE) 0602783A (Computer and Software Technology) / Project Y10 (Computer/Information Science Technology).

The cited work is consistent with the Assistant Secretary of Defense for Research and Engineering Science and Technology priority focus areas and the Army Modernization Strategy.

Work in this project is performed by the Army Research Laboratory (ARL), Adelphi, MD.

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2015**	**FY 2016**	**FY 2017**
Title: Communications for Tactical Networks	1.816	1.934	1.963
Description: Perform research to provide communications capability for a fully-mobile, fully-communicating, and situationally-aware force operating in a highly dynamic, wireless, mobile networking environment populated by hundreds to thousands of networked nodes. ***FY 2015 Accomplishments:*** Conducted analysis, simulations, and experiments to develop new communications networking capability in harsh tactical environments (e.g., exploitation of low frequency communications, mobility and autonomy to maintain connectivity, and mapping connectivity regions to blend with mobility planning and sensing); developed quality of information (QoI) theories based upon			

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** H48 / *Battlespace Info & Comm Rsc*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
human-in-the-loop analysis; and developed mathematical representations for the QoI of static and dynamic data and its effectiveness for situational awareness. ***FY 2016 Plans:*** Research theories, models and experimental approaches towards new communications networking capability (e.g., control and signal processing algorithms for adaptive hybrid networks comprised of microwave and lower very high frequency (VHF) frequencies with active adaptations) in harsh tactical environments; investigate approaches to integrated agent-based node relocation and communications planning that enhances network connectivity; and develop modeling and analysis methods that support the design of hybrid networks able to maintain communications in highly disruptive, hostile environments. ***FY 2017 Plans:*** Will investigate and create theories, models, and adaptive algorithms for robust and efficient communications under varied conditions using cognitive and dynamic spectrum access techniques in a hostile tactical environment; research new modeling and analysis methods for hybrid networks that support mobile networking infrastructures to ensure communications in highly disruptive and hostile environments; and define analytical tradeoffs between different performance metrics for multi-modal communications.			
Title: Data-to-Knowledge to Support Decision-Making	2.392	2.545	4.503
Description: Design and implement a laboratory-scale common information processing infrastructure, inclusive of cloud computing, for networking processes that aids the transformation of data into actionable intelligence to support decision-making under uncertainty. Perform research to utilize real-time, tactical, soldier-centric information for improved decision-making and situational awareness. ***FY 2015 Accomplishments:*** Researched the effect of context-dependent information exploitation on the situation awareness of intelligence analyst and soldiers at the edge by constraining the problem domain in an effort to reduce computational complexity and increase accuracy of specific baseline algorithms; experimentally validated the value of information construct within a tactical military decision support system; and investigated algorithms for intelligent exploration and focused data collection in relevant environments using collaborative mobile platforms. ***FY 2016 Plans:*** Develop a framework and algorithms for multi-modal information fusion of representative tactical elements from text, video and imagery; investigate the impact to situational awareness when using integrated multi-modal analytics versus independent analytics; study the value of information construct as a measure of the contribution of multimodal analytics; and investigate algorithms for intelligent mission planning and task allocation for heterogeneous teams of mobile platforms in tactical environments. ***FY 2017 Plans:***			

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** H48 / *Battlespace Info & Comm Rsc*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
Will study and evaluate the effectiveness of multi-media information processing techniques on user understanding while adapting the presentation of information to various user parameters, including mission and physiological measures; experiment with methods for integrating user/mission concepts (e.g., user fatigue or humanitarian versus mine-clearing missions) to adapt how and when information is provided to the user. Measures of effectiveness will include decrease in communications delay and increase in situational awareness.			
Title: Information Protection for Mobile Ad-Hoc Networks (MANETs) ***Description:*** Perform research on protecting information in highly mobile, wireless tactical environments, where networks must operate under severe bandwidth, energy, and processing constraints, and without reliance on centralized security services. Beginning in fiscal year 2015, includes work previously conducted under Network Science for MANETs and Tactical Communications. ***FY 2015 Accomplishments:*** Developed security processes and techniques to provide information protection in mobile dynamic environments, where mobile devices are connected to coalition networks serving as forward-deployed devices at the edge; developed techniques to minimize energy required to support security functions; developed security protocols and processes for using tactical cloudlets as a shared resource among Warfighters and coalition forces; and developed and characterized algorithms for detection and analysis of adversarial malicious operations on networks that involve the above mentioned complexity of mobility, resource constraints, inconsistency and shared resources. ***FY 2016 Plans:*** Investigate techniques for novel, stealthy communications that are less likely to be detected and intercepted by the adversary than conventional radio frequency communications; investigate methods for mission-focused, network analysis and prediction of cyber risks; and design innovative techniques to collect, detect and actively mitigate low-observable, highly sophisticated cyber threats in complex heterogeneous networks comprised of wireless and wired technologies. ***FY 2017 Plans:*** Will investigate emerging technologies and their underlying communication protocols focusing on computational complexity; establish techniques to empirically quantify the complexity of a protocol for future application in network security risk assessments; research and derive fundamental methods to automatically generate provably-secure networking protocols that are suitable for deployment on resource-constrained devices and wireless/wired networks; and explore machine learning and statistical methods to improve situational awareness through event and data reasoning.	5.836	5.902	5.992
Title: Multi-Lingual Computing Research ***Description:*** Establishes formal methods for bridging language barriers in tactical environments, incorporating state-of- the-art techniques in machine translation and natural language processing.	1.053	1.120	1.136

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** H48 / *Battlespace Info & Comm Rsc*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
FY 2015 Accomplishments: Identified and extracted event-based information from large amounts of text written in different genres in different languages and dialects to support temporal and spatial relation analyses in situational awareness; and examined the extension of linguistics analysis techniques to image processing. ***FY 2016 Plans:*** Identify tractable elements of social meaning reflected in text, based on sociolinguistic theory, and develop algorithms to extract basic elements from social media; examine contribution of social information to entity and event-based information extracted from text; evaluate and extend Natural Language Processing (NLP) semantic underpinnings for spatial and temporal representation and link with logical formalisms for reasoning and action planning; and investigate role of pragmatics in both supporting language interaction with autonomous systems and interpreting social meaning extracted from text. ***FY 2017 Plans:*** Will explore techniques for extending NLPconcepts to social media analytics for author/programmer identification, summarization, and enhanced video analytics.			
Title: Advanced Computing	3.499	3.562	4.116
Description: Investigate advanced computing and high performance computing (HPC) networking architectures, memory/storage architectures, algorithms and visualization techniques to support advanced battle command applications for Command, Control, Communications, Computer, and Intelligence (C4I) systems. ***FY 2015 Accomplishments:*** Explored novel models to represent advanced computing/networking coupled with real-time battlefield information processing while meeting tactically relevant turn-around and scheduling requirements and constraints; and extended models to include power and performance metrics as part of the wider knowledge base in forming an application signature-processor pairing that can be used to perform intelligent processor selection on a case-by-case basis. ***FY 2016 Plans:*** Develop novel programming models using emerging programming languages for dynamically evolving mobile heterogeneous computing/networking architectures to solve high fidelity battle command applications; and develop validation methods for these mobile heterogeneous computing/networking devices ***FY 2017 Plans:*** Will develop programming methods to support the next generation of computing hardware systems (e.g., heterogeneous, parallel, and non-traditional computing architectures such as neuro-synaptic); research new algorithmic methods for tactical HPC to address power, performance, and portability in emerging computational resources; research and create novel capabilities			

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** H48 / *Battlespace Info & Comm Rsc*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
based on increased computing capacity; and explore and evaluate novel, soldier-centric distributed computing and information architectures at the tactical edge for real-time human uniqueness assessment applications.			
Title: Quantum Information Sciences	4.802	5.277	5.359
Description: Perform research to enable new techniques for ultra-precise navigation, timing, communications and imaging using atomtronics and spintronics, which are quantum measurement and sensing devices based upon atoms and spin respectively, instead of electrons. Conventional techniques for sensing magnetic fields, gravity, and timing have reached a plateau in their performance, and will be severely impacted in future contested-battlefield environments. This research brings new insights regarding the use of quantum science to enhance Warfighter effectiveness. ***FY 2015 Accomplishments:*** Studied physics of compact (i.e., wrist-watch scale) atom chips (an atom chip uses quantum properties of atoms to sense gravity and acceleration) needed for a precise position/navigation/timing (PNT) sensor; studied fundamental atomic physics of quantum repeaters, for an eventual hybrid quantum communication system, based on transmission of single photons that are quantum mechanically entangled with quantum memories; and obtained new insights into "writing" and "reading" laser-cooled rubidium atoms to store and later retrieve a single photon from the atomic ensemble over long haul optical fiber. ***FY 2016 Plans:*** Investigate quantum node-to-node communication along optical fibers and free-space via entangled single photon generation and capture; evaluate the quantum effects and entanglement (i.e., two particles together describe a single quantum state and can't be independently measured or the state of the whole changes) processes of laser- cooled atoms and study and characterize unique trapping processes to hold and exploit the quantum properties of ions; and study frequency conversion processes to link disparate quantum systems that generate single photons at different wavelengths of light (e.g., microwave or ultraviolet to visible or infrared). Regardless of the mode of communications, quantum tagging and/or encryption may be used to provide robust information security and viability. ***FY 2017 Plans:*** Will investigate use of integrated photonics and nanotechnology as potentially highly compact components in a quantum network; investigate solid-state systems for controlled, high-rate photon emission, and hybrid ion/neutral atom, solid-state entangled systems as potential interfaces between mixed quantum state systems, which is essential to realizing noise reduction in networked quantum sensors relative to classical systems; establish network protocols with enhanced quantum capacities and rates that integrate classical networking, and assess associated fidelities and the role of error correction in a distributed entangled system; investigate a versatile quantum controller for managing input and output of quantum memory and nodes; and pursue on-chip, Bell-state measurements between quantum memories and repeaters for distributed quantum information systems.			
Title: Network Science Technology Experimental Center	5.198	5.123	5.207

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
Description: Supports in-house Network Science studies in conjunction with the Network Sciences Collaborative Technology Alliance (PE 0601104A) ***FY 2015 Accomplishments:*** Expanded the wireless emulation capabilities to include the interactions among communication, social, and information networks; developed techniques for modeling the performance of hybrid networks; and developed, analyzed and validated composite trust management techniques and metrics that consider the interactions between social, information and communication networks. These efforts provided improved understanding of tactical network behaviors, improved network designs, secure information flows and enhanced decision-making. ***FY 2016 Plans:*** Conduct experimental and theoretical investigations of novel in-network information discovery, storage, pre-processing, integration and routing approaches that enhance quality and trust in information, in the presence of disruptions and kinetic and cyber attacks; characterize and develop theoretical models of behaviors of heterogeneous networks that combine traditional radio frequency communication links with novel channels that are more stealthy and exhibit different propagation features; develop theoretical foundations for security properties in complex heterogeneous networks; and extend and refine mathematical methods and models that anticipate dynamic changes in collaboration and decision making in networks comprised of human and artificial agents. ***FY 2017 Plans:*** Will investigate novel techniques to model, characterize, and control information delivered through multi-genre networks (e.g., communications, information, or socio-cognitive) based on the semantics and context of information requests, and requisite composite quality-of-information measures; derive theories, representations, and models for discovering patterns in network data, to include inferring new phenomena from incomplete and noisy network data, and predicting properties of multi-genre networks; research methods to measure and enhance human trust in decision-making contexts involving information provided by networked sources, both human and automated systems, and experimentally verify them; explore methods for simulating and emulating the impact of quality-of-information on decision-making in networks comprised of humans and physical and virtual agents; and create models and tools for the formal study, verification, and analysis of software-defined, information-centric algorithms that support interoperability, adaptability, and resilience of heterogeneous networks.			
Accomplishments/Planned Programs Subtotals	24.596	25.463	28.276

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

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D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army			Date: February 2016
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COST ($ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
H52: *Equip For The Soldier*	-	1.049	1.119	1.133	-	1.133	1.153	1.173	1.197	1.221	-	-

Note

Not applicable for this item

A. Mission Description and Budget Item Justification

This project supports basic research to achieve technologies for the Soldier of the future. This research is focused on core technology areas which include mathematical modeling, physical and cognitive performance, polymer science/textile technology, nanotechnology, biotechnology, and combat ration research. Research efforts are targeted at enhancing the mission performance, survivability, and sustainability of the Soldier by advancing the state-of-the-art in the sciences underlying human performance, clothing, and protective equipment to defend against battlefield threats and hazards such as ballistics, chemical agents, lasers, environmental extremes, and ration shortfalls.

Work in this project provides theoretical underpinnings for Program Element 0602786A (Warfighter Technology).

The cited work is consistent with the Assistant Secretary of Defense, Research and Engineering Science and Technology focus areas and the Army Modernization Strategy.

Work is performed and managed by the Army Natick Soldier Research, Development, and Engineering Center (NSRDEC), Natick, MA.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
Title: Equipment for the Soldier	1.049	1.119	1.133
Description: This project supports basic research to achieve technologies that support the Soldier of the future. Research areas include mathematical modeling, physical and cognitive performance, polymer science/textile technology, nanotechnology, biotechnology, and combat rations.			
FY 2015 Accomplishments: Examined thermal degradation mechanisms in selected natural materials as basis for potential flame/fire protection approaches; created nonwoven electrospun composites of unique composition and examined their properties and material behavior to provide foundation for robust, Soldier-based sensing of pathogens in food and ambient environment.			
FY 2016 Plans: Explore enhancement of cognitive skills via trans-cranial direct current stimulation (t-DCS) and examine associated neural mechanisms responsible for skill improvement, with the goal of understanding whether t-DCS can complement Soldier training in improving cognitive and motor skills required for enhanced battle space awareness; examine a novel in-vitro gut fermentation			

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
model to gain fundamental understanding of dietary component influence on gut health as it relates to improving Soldier performance through nutrition. ***FY 2017 Plans:*** Will explore the feasibility of creating materials with seemingly dissimilar functionalities such as water-requiring catalysis and water repellency; understand the effects of a three-dimensional (3D) surface structure on material multifunctional performance via the use of nanoparticles and nanoparticulate films; explore the thermal responsive behavior of silver nanowire enhanced hydrogels to determine the feasibility of integration into protective materials that manage thermal properties such as body heat loss.			
Accomplishments/Planned Programs Subtotals	1.049	1.119	1.133

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army			Date: February 2016
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COST ($ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
H57: *Single Investigator Basic Research*	-	78.575	87.001	94.519	-	94.519	94.284	99.007	102.166	103.423	-	-

A. Mission Description and Budget Item Justification

This project fosters extramural basic research to create and exploit new scientific discoveries and technology breakthroughs, primarily from universities, that will improve the Army's transformational capabilities. The Army Research Office of the Army Research Laboratory (ARL) maintains a strong peer-reviewed scientific research program through which leap-ahead technological solutions may be discovered, matured, and transitioned to overcome the technological barriers associated with next generation capabilities. Included are research efforts for increasing knowledge and understanding in fields related to long-term future force needs in the physical sciences (i.e., physics, chemistry and life sciences), the engineering sciences (i.e., mechanical sciences, electronics, materials science and environmental science (i.e., atmospheric and terrestrial sciences)), and information sciences (i.e., mathematical sciences, computing sciences, and network sciences). Targeted research programs in nanotechnology, training and simulation, smart structures, multifunctional and micro-miniature sensors, intelligent systems, countermine, compact power, and other mission-driven areas will lead to a future force that is more strategically deployable, more agile, more lethal, and more survivable. The breadth of this basic research program covers approximately 900 active, ongoing research grants and contracts with leading academic researchers and approximately 1,600 graduate students yearly, supporting research at nearly 250 institutions in 50 states.

Work is this project supports key Army needs and provides the technical underpinnings to Program Elements (PE) 0602618A (Ballistics Technology)/Project H80 (Survivability and Lethality Technology).

The cited work is consistent with the Assistant Secretary of Defense for Research and Engineering Science and Technology priority focus areas and the Army Modernization Strategy.

Work in this project is performed extramurally by ARL, Adelphi, MD.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
Title: Basic Research in Life Sciences	8.004	9.782	8.868
Description: Pursues fundamental discoveries in life sciences with the ultimate goal of facilitating the development of novel biomaterials to greatly enhance Soldier protection and performance. More specifically, i) molecular genetics research pursues fundamental studies in molecular and systems biology, and genetics, ii) neurosciences research investigating the physiology underlying perception, neuro-motor output, and potential methods of monitoring cognitive states during activity, iii) biochemistry research focuses on studies in structural and cell biology, metabolic processes, and biophysics, iv) research in microbiology pursues studies in microbial physiology, ecology, and evolution, v) social science research aims to elucidate the social, cultural, and other influences to human actions, and vi) auditory and signal processing research to map the cognitive implications of multisensory information integration.			

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017

FY 2015 Accomplishments:

Identified the genetic networks and epigenetic factors that enable the survival of bacteria in extreme stress conditions, which may reveal new insight into stress resilience and survival in eukaryotic organisms, and ultimately enable the engineering of microorganisms better suited to rugged industrial production conditions; expanded studies of previously-demonstrated DNA assembly method to determine whether diverse nanostructured shapes can be carved from a common 3D DNA block, which may provide a future template for generating hybrid materials with the advantages of both biological and synthetic systems; characterized the molecular dynamics and evolution of associative memory in bacteria, which will be an important step towards understanding microbial adaptation potential for use as a potential tool to be exploited for microbial forensics analyses; and devised a model for the automated synthesis of neuro-cognitive computational models derived from brain activity to determine whether it is possible to mathematically link functional brain data to cognitive states, which could ultimately lead to new applications for assessing and improving Soldier mental performance such as battlefield training, and treatment of disorders such as post-traumatic stress disorder (PTSD).

FY 2016 Plans:

Research and design neuro-cognitive computational models that detect a single-sound source(amongst multiple audible stimuli) to determine whether it is possible to link brain data to the segregated/isolated sound sources from noisy environments (may lead to new applications for effective auditory prostheses, automatic speech recognition, and other tools for enhanced Soldier auditory situational awareness in distracting environments); screen analogs of cellular cyclic diguanylate to identify and characterize a key potential pathway that mediates the formation of bacterial persister cells, a unique state that is known to allow bacteria to survive exposure to antibiotics or environmental changes (may lead to new methods for the rapid and efficient treatment of wounds or systemic infections, particularly those caused by antibiotic-resistant bacteria); determine whether damage after acute myocardial infarction can be reduced by modulating oxygen demand (may lead to a metabolic-reduction strategy to reduce mortality on the battlefield); and evolve artificial enzymes, synthesized by assembling metal catalysts on protein scaffolds, to provide site-selectivity and precision not possible with traditional chemical catalysts (may provide new synthetic routes for advanced, well-defined materials including functionalized polymers and responsive materials, such as new fabrics to protect the Soldier and coatings to strengthen materiel).

FY 2017 Plans:

Will develop an analytical method to non-invasively characterize and predict the adaptation of neural circuits (may provide the critical and fundamental groundwork for improved rehabilitation from traumatic brain injury); explore the relationships between ApoE (a protein critical for cholesterol metabolism), mitochondrial function, and brain function (may have implications in the prevention and treatment of traumatic brain injury); investigate mechanisms of protein repair and maintenance that enables some organisms to produce hydrogen continuously in the presence of light (may enable improved hydrogen-producing engineered systems that could ultimately could be used to convert hydrogen to electricity through field-ready hydrogen fuel cells); and characterize and modify bacterial micro-compartments for potential use as an engineered organelle (specialized structure within

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
a cell) (may provide a platform for the production of polymers or antimicrobials that normally require significant infrastructure to produce synthetically).			
Title: Basic Research in Environmental Sciences ***Description:*** Basic research in the environmental sciences is needed for the Army to operate effectively because terrestrial and atmospheric conditions and processes affect virtually all aspects of Army activities. The earth's surface environment is a multifaceted and dynamic system, and there is an increasing need for multidisciplinary approaches to address important research questions within the atmospheric and terrestrial sciences. ***FY 2015 Accomplishments:*** Exploited recent theoretical and experimental advances in soft-matter physics to isolate and examined the granular dynamics of fluid-driven sediment transport, focusing on bed load transport in rivers. ***FY 2016 Plans:*** Perform analysis of hill slopes using high-resolution topography to test the hypothesis that sharp breaks in topographic scaling metrics exist across climate and erosion rate gradients to generate high resolution information about terrain, vegetation, drainage, and erosion and have implications for change detection. ***FY 2017 Plans:*** Will develop a novel micro-optical sensor platform for the characterization and monitoring of atmospheric gases and aerosols (may lead to new methods for the characterization of aerosol particle shape and composition for rapidly identifying biological warfare agents); and explore and demonstrate a valid approach for short-term dating of heated structures and sediment burial events based on natural mineral luminescence (may provide a crucial tool for calibrating various detection methods for Improvised Explosive Devices (IEDs) and tunnels).	1.450	1.527	1.550
Title: Basic Research in Chemical Sciences ***Description:*** Basic research to achieve advanced energy control, improved threat detection, and novel responsive materials for Soldier protection. Research efforts will lead to: light-weight, reliable, compact power sources, more effective, lower vulnerability propellants and explosives for tailored precision strikes with minimum collateral damage, new approaches for shielding the Soldier and Army platforms from ballistic, chemical, and biological threats, and reducing signatures for identification by the enemy, and advance warning of explosive, chemical, and biological weapons and dangerous industrial chemicals. ***FY 2015 Accomplishments:*** Investigated and characterized the ionic states of energetic compounds (will enable the design of safer (e.g. during transport and storage), more powerful explosives and propellants); identified fundamental mechanisms and properties that control the assembly and dissociation of supramolecular systems upon influence of external stimuli, such as toxic chemicals, enzymes, or changes in pH (will lead to new capabilities for protection from, and inactivation of, chemical and biological warfare agents and toxic industrial	7.736	9.567	12.950

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
chemicals); synthesized polymeric materials employing unique building motifs with the goal of creating a self-assembled complex ensemble - the ensemble's response to a variety of conditions that are used to determine how the state of the system can be controlled in a nonlinear manner (may lead to new materials or coatings that can detect and repair defects); and probe transport processes in confined media to reveal an improved understanding of ion transport (will provide new long-term applications such as fuel cell membranes with higher ionic conductivity to provide the Soldier with more effective portable power systems). ***FY 2016 Plans:*** Investigate and characterize the decomposition mechanisms in methyl nitrate, an important high-energy material, which may lead to the engineering of explosives that are safer for transport and use by the Soldier; elucidate the basic mechanisms by which ion concentration and ion type affect the ordering and properties of micrometer-sized droplets of liquid crystals and the potential for these mechanisms to provide large-scale measurable changes (may lead to new capabilities for sense-and-respond chemical systems including self-healing, self-cleaning, and adaptive materials); synthesize new polymers composed of functional block copolymer membranes containing a high density of tailored pores and characterize the kinetics of the membrane transport properties to changes in external stimuli (may enable new applications in sensing, water purification, and breathable chem/bio protective clothing); and identify and characterize the active sites and intermediates in the electrochemical and photocatalytic reactions that occur in metal / semiconductor electrodes (may improve energy generation and storage). ***FY 2017 Plans:*** Will explore the fundamental aspects of oxygen and hydrogen transport gas diffusion electrodes (may enable new higher-performing power generation and energy storage technologies); devise new methods to synthesize infinite coordination polymers, that are a class of materials that possess tailorable properties and high surface areas (may provide novel materials with applications in sensing and catalysis); evaluate the role of the recently-discovered chemical reaction pathway termed “roaming mechanisms” in the decomposition of energetic molecules such as explosives (may enable improved control and development of next-generation propellants and explosives); and push the current boundaries of mechanical-chemical reactivity by designing and demonstrating new modes for activating molecules called mechanophores, which convert mechanical to chemical energy using pre-defined mechanisms (may lead to regenerative materials and controlled drug delivery).			
Title: Basic Research in Physics ***Description:*** Focuses on research in many subfields of physics, including condensed matter physics, optical physics, atomic and molecular physics and quantum information, with an emphasis on discovering new realms of quantum and optical phenomena. Pursuit of fundamental physics in these subfields provides new opportunities for future developments in superior optics, ultra-sensitive sensors, and novel electronic architectures for classical and quantum computing. ***FY 2015 Accomplishments:*** Explored the infrared and optical responses of electrostatically-induced effects in correlated oxides, such as metal-to-insulator transitions (may lead to advanced electronic technologies for sensing and computational hardware); investigated new synthetic	14.091	16.262	18.678

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
physics in cold quantum gases (will contribute to the development of cold-atom interferometers for ultra-accurate navigation and quantum computing applications for secure communication); detected single molecular ion spectra using laser-cooled atomic ions by exploiting previous research on trapped ions for quantum information science (may lead to capabilities beyond what is possible with classical systems, such as resource optimization, optimal wargaming, efficient and secure command, control, communications, computers, intelligence, surveillance and reconnaissance (C4ISR) that will greatly benefit the Department of Defense (DoD), airline, financial, and telecommunications industries); and demonstrated and characterize microjoule-level laser pulse energies for 150 attosecond pulses in the 30-70 eV photon energy range (>1,000 times higher than the current world record) (may enable future applications in standoff explosives detection and sensing through obscurants). ***FY 2016 Plans:*** Develop new imaging methods such as non-linear optical spectroscopies for detecting spin-orbit coupling in advanced materials (may lead to new electronic technologies for sensors and computational hardware); investigate novel photon-photon interactions in a strongly-interacting cold atomic gas (may enable the first observation of the crystallization of a gas of strongly interacting photons, and in the long term, may lead to improvements in computation, measurement, and sensing); develop robust techniques for quantum sensing and measurement to overcome the fragility of quantum information due to unwanted environmental interactions (may provide unprecedented computation and communication capabilities); and characterize the unique electron dynamics of a particular class of magnetic materials known as ferroplasmons and develop theories to effectively model this behavior (may lead to lighter and smaller electronic components). ***FY 2017 Plans:*** Will characterize and devise methods to control the unique structural, orbital, and magnetic order in a particular structure of oxygen-containing compounds called isovalent oxide superlattices (may lead to unique advances in computing, passive sensors, and low-power electronics); systematically study and simulate the long-range interaction of quantum defects in materials (may lead to the development of new materials with properties previously inaccessible by traditional synthesis methods); utilize recently developed quantum algorithms for quantum chemistry to investigate new algorithms (may provide tools for the next-generation of communication devices); and develop a comprehensive theoretical framework of photonic metamaterials that control light in ways impossible with any natural material (may lead to a new class of lightweight electronics and photonics, such as low-power lasers and new imaging techniques).			
Title: Basic Research in Electronics and Photonics	10.541	11.094	11.260
Description: Pursues discoveries in electronic sensing, optoelectronics, solid state and high frequency science, electromagnetics, microwaves, and power electronics for situational awareness, communications, information processing, electro-magnetic warfare, and power efficiency.			
FY 2015 Accomplishments:			

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
Showed independent tuning of the temperature coefficient of resistance and noise in bolometers to improve signal to noise ratio of room temperature infrared detectors; showed electrically injected, high-speed 1.55 μm nanoscale lasers on a silicon platform for potential gains in energy efficiency of computational and sensor systems; demonstrated that plasmonic antennas can mitigate efficiency degradation of conventional antennas at terahertz and optical frequencies to investigate the potential of free-space interconnects for efficient data communications and energy harvesting; and created and investigated a novel sensor based on optical dark modes in nanorods for use in biomolecule, chemical sensing, and near-field imaging. ***FY 2016 Plans:*** Establish infrared and optical response in a carbon nanotube-oxide-metal rectenna for room temperature infrared detection; show coaxial nanolasers scalable to deep-subwavelength dimensions suitable for on-chip interconnects; initiate metasurface control of THz radiation emission (direction and beam width) without external antenna, using variable surface wave propagation for chemical and biological agent sensing; and create a novel gallium nitride graphene hot electron transistor structure with THz frequency response for high data rate communications capable of transmitting greater amounts of data in a similar timeframe. ***FY 2017 Plans:*** Will show that thermal field gradients can be used to create additional stress in flexoelectric materials for improved energy harvesting and self-powered wireless sensors; show route to high modulation bandwidth surface emitting lasers with oxide-free vertical cavity approaches for high bandwidth photonic circuits; demonstrate radio frequency filters with unmatched quality factors nearing 400 (a factor of 5 better than the best previously reported, for ground mobile wireless communications); and create a gallium nitride based semiconductor/biomolecular platform for investigating guided growth of neuronal cells and hybrid functional neural circuits with both regular electronics and artificial neuronal circuit components for brain/machine interfaces.			
Title: Basic Research in Materials Sciences	6.868	7.227	7.334
Description: Research that provides innovations in materials design and process through the elucidation of fundamental relationships linking composition, microstructure, defect structure, processing and properties of materials. Revolutionary materials provide support for the Army in firepower, mobility, communications, personnel protection, infrastructure and installations, and will directly affect virtually all mission areas. ***FY 2015 Accomplishments:*** Elucidated the molecular mechanisms by which living cells regulate intracellular biochemical activity with mechanical force and designed novel materials with force-activated control; provided novel functional materials with unprecedented physical properties through strongly linked multi-scale models developed specific to the materials systems; and completed a vigorous investigation of two-dimensional non-graphitic atomic layers and heterostructures and identified advanced material properties and capabilities. ***FY 2016 Plans:*** nable control of chemical and electrochemical reactions through the rational design of material architectures that control the spatial and temporal pathways of precursors, intermediates, and products in order to achieve dramatically enhanced efficiency			

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
and extraordinary energy production and storage; create stable free-standing single monomer thick novel two-dimensional (2D) crystalline organic polymer nanosheets and covalent organic frameworks with unprecedented physical properties to enable tunable band gaps and high carrier mobility and enable polymer electronics; and develop a fundamental understanding of how to propagate a molecular-level detection event to a macroscopic material property change across multiple length and time scales to achieve revolutionary sensors with record sensitivity and selectivity. ***FY 2017 Plans:*** Will establish a new generation of spin-based devices based on optimized spin-orbit coupling heterostructures, such as nanoscale terahertz oscillators and ultrafast, low power spin logic/memory (for potential applications in non-volatile memory, high-speed logic and information processing, chemical sensing, and high-frequency communications); and utilize driven periodic excitation to systematically explore, demonstrate, and stabilize hidden phases of materials with unique physics and properties, enable the theoretical predictive capacity for such hidden phases, and synthesize strongly correlated (thin film) materials based upon these phases (for disruptive electrical, optical, thermal and magnetic applications).			
Title: Basic Research in Computing Sciences	7.543	7.938	8.558
Description: Provides the backbone for performing complex, multi-system analysis, modeling and simulation for understanding information systems. Advancements in computer sciences have a direct impact on enhancing the Warfighters' decision-making, situation awareness, command and control, as well as on the overall performance of weapon, intelligence, transportation and logistics systems. ***FY 2015 Accomplishments:*** Established new knowledge in acquiring, computing, and analyzing big data in a trusted fashion, and investigate novel techniques for processing multi-modal data that may be in the form of text, photo, video, and audio so that actionable intelligence and timely information can be extracted and derived for better situation awareness and better decision making; investigated new concepts such as value of information, and invest in new research opportunity areas such as social informatics; and pursued efforts on information assurance with a special focus on hardware based resilient techniques. ***FY 2016 Plans:*** Establish novel representations, non-commutative information theory, and dimensionality reduction of multimodal data that enable effective large scale multimodal data analyses, particularly image/video data analytics to extract actionable intelligence to support C4ISR; create new techniques for the optimal realization of real-time multi-core systems as well as future hybrid and exascale systems through the asymptotic analysis of scheduling approaches and new energy efficient algorithms and architectures for efficient and timely processing of Army big data analytics and timely field information processing; investigate metrics for determining information trustworthiness and for detecting deception in social data; and establish new analytical models that quantify the resiliency of computing systems. ***FY 2017 Plans:***			

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
Will create methods to allow message-passing distributed applications to efficiently solve problems in which data and/or memory requirements far exceed the amount of physical memory available in the underlying computer system (for efficient and timely processing of Army big data analytics, and efficiently solving large Army problems on computer clusters); establish unified visual data representation and methods for face recognition using low quality images and videos taken from unconstrained and multi-spectrum visual sources to achieve reliable performance of face recognition; establish guiding principles for cyber system maneuvering; and establish models and quantification metrics to analyze and evaluate the effectiveness of cyber system adaptation for better defense.			
Title: Basic Research In Network Sciences	8.123	8.549	10.578
Description: Focuses on gaining an understanding of the fundamental aspects of how networks develop, function, and adapt to the environment and the rate of information flow in man-made and naturally occurring networks. This understanding will have a direct impact on net-centric force operations, such as better communication system design and operations, and more efficient logistics or communications support.			
FY 2015 Accomplishments: Studied interconnected networks and how failure in a network spreads to other networks; investigated rigorous mathematical theories that bring together statistical mechanics, operations research, game theory and reliability theory to predict how failures propagate and when/how failures could be controlled; explored new game theory inspired models for how economic and social factors lead to large societal changes, such as Arab spring style revolutions; and studied tensor decomposition of spectral graphs that arise from big data in social networks with a view towards automatically learning the structure of networks and their properties.			
FY 2016 Plans: Research design mechanisms for deriving consensus, for use in crowd-sourcing based solutions for resource allocation problems; study how to design teams to optimize performance and diversify capabilities by building mathematical models that explain and predict how teams organize, exchange information, build knowledge, influence, adapt, learn, and build consensus, resulting in actionable findings that create effective teams; study how information from social networks can be used to design and build adaptive, predictive solutions for managing load, mobility, and connectivity of communication networks; develop new control theory to facilitate task allocation and efficient exploration by autonomous teams; and develop spectral methods to determine important properties of random graphs and different classes of dynamics on networks related to flows/advection and consensus processes to enable the shaping and manipulation of networks to achieve dynamically reconfigurable desired information processing and energy distribution properties.			
FY 2017 Plans: Will investigate traffic flows under various conditions of communications service degradation to determine effect on the message throughput and delay; research interactions between systems requiring finite delay to improve real-time video and facilitate			

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
robotic control over disadvantaged communications networks; research modeling and control of finite-sized, far-from-equilibrium systems and bio-inspired information for perception and sensory motor control; research quantifiable informative models of team behavior as dynamical systems interacting over multiple networks to advance the network science of teams, and examination of the antecedents and effects of knowledge hoarding on team performance; and research modeling and detection of spurious and deceptive data in decisions based on crowd-sourcing.			
Title: Basic Research in Mechanical Sciences	6.578	6.913	6.977
Description: Focuses on improved understanding of propulsion and combustion for improved efficiency and fuel flexibility, energetics initiation for insensitive munitions, fluid dynamics for rotorcraft, complex dynamic systems for novel sensors, energy generation and multi-dimensional systems, and solid mechanics especially at high strain rates in composite materials for novel armor and protection systems. ***FY 2015 Accomplishments:*** Gained an understanding of oxidizer behavior in energetic materials via determination of how the morphology and phase behavior evolved during the heating and reaction process; demonstrated new capabilities to actively control entropy production and free energy exchange in arrays of molecular motors; developed a reduced-order methodology suitable for the study of the large parameter design space associated with "dynamic stall"; and developed a numerical modeling approach capable of quantifying the formation of shear bands and dynamic crack propagation of structural materials under high strain rate loading. ***FY 2016 Plans:*** Gain understanding of dynamic responses of reactive metallic alloys (RMA) -- how they deform, fracture and combust to enable novel energetic material behaviors; develop microstructure-failure-strength relationships at mesoscales in lightweight metallic systems under dynamic loading conditions and bridge the gap between atomistic and continuum simulations for fundamental understanding of the processes governing the strength and toughness properties of solids; determine effectiveness of near-Kolmogorov & Kolmogorov scale forcing of shear layers for re-distributing energy from large scale turbulent structures to small scales dominated by viscous dissipation for improved understanding of flow separation and control; and determine the biophysical principles underlying muscle's capability to store, dissipate, generate, and transfer energy. ***FY 2017 Plans:*** Will develop scientific principles for a new framework to enable new capabilities for programming deformable structures to perform dexterous interactions (deformable structures provide more accurate modeling); perform experimental measurements and develop theoretical models for the dynamics of anisotropic (i.e., non-spherical) particles in turbulent flows in order to elucidate and describe small-scale vorticity (i.e., curl of the velocity field) mechanisms in large-scale flows; develop reduced models for the combustion of alkane based fuels using a novel computational approach based on the synergy between atomistic simulations and network analysis of complex systems; and develop conceptual and analytical-computational models, based on the energy			

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** H57 / *Single Investigator Basic Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
dissipated by interface fracture simulated by artificial equivalent shear viscosity and capable of effectively representing failure in complex composite materials subjected to high-strain rate dynamic loading.			
Title: Basic Research in Mathematical Sciences ***Description:*** Pursue the creation of new mathematical tools and methods for performing complex, multi-system analysis and modeling to enhance soldier and weapon-system performance. More specifically, the focus is on creating mathematical principles and practical algorithms for stochastic analysis and control, analysis and control of biological systems, numerical computation of infinite-dimensional systems, and modeling of irregular geometric and social phenomena. ***FY 2015 Accomplishments:*** Conducted innovative basic research in statistical analysis, infinite-dimensional stochastics and control, multiscale procedures that transfer information among multiple sets of scales, identification and quantification of fundamental principles of biological dynamics often through multiscale modeling, representation of three-dimensional (3D) terrain and new metrics for small-group social and sociolinguistic phenomena. This mathematical science research led to improved conventional and quantum information networks and information processing, soldier health and performance, decision making, training, simulation and mission planning. ***FY 2016 Plans:*** Initiate basic research efforts to develop a theory of information at the quantum level, to develop advanced geometric models of social processes as an alternative to network models, and to develop mathematical models that can achieve a two-way flow of information in the computational modeling of materials. These new mathematical areas will bring new modeling capabilities in secure communications, the prediction of collective behavior, and enable designer materials. ***FY 2017 Plans:*** Will conduct basic research efforts to outline the major areas of the fundamental laws of quantitative biology, and develop fractional-order mathematical models (used in the study of anomalous behavior of dynamical systems) and corresponding computational methods for sharply-featured flows. Development of these new mathematical areas is expected to bring new modeling and predictive capabilities into biology, littoral flows, and in fluid-structure applications, such as turbines and windmills.	5.804	6.106	5.700
Title: Basic Research in Simulation and Training ***Description:*** Advances in simulation and training require basic research to understand neuronal changes that occur in the brain during successful and unsuccessful simulations and training. An interdisciplinary approach involving chemistry, computer science, engineering, mathematics, physics, and network science will be required to understand the molecular, cellular, developmental, structural, functional, and computational aspects of the brain during learning, simulation, and training. It will be necessary to determine how neural circuits develop and are arranged physiologically in individuals to produce cognitive computations during	1.837	2.036	2.066

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** H57 / *Single Investigator Basic Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
simulation and training. This research will also include extensive studies to discover and map the neural circuitry that enables cognitive adaptation, and the dynamic mechanisms of neural network modification need to be established. ***FY 2015 Accomplishments:*** Conducted basic research efforts related to the design of mathematical models and experimental methods to map the cognitive implications of multisensory information integration, including neurobiology studies to elucidate the mechanisms of synaptic signaling that underlies perception, network science studies to characterize the functional connectivity and information processing, and computer science studies to design models to accurately represent these systems. ***FY 2016 Plans:*** Further the research in the design of mathematical models and experimental methods that map how the brain processes and integrates data received from all senses simultaneously (e.g., auditory, visual, olfactory), and determine the implications of this process in human decision making. In the long term, this research will provide tools to select individuals best suited for particular tasks and the development of more rapid and cost-effective methods to train warfighters for a range of complex tasks. ***FY 2017 Plans:*** Will elucidate the neural mechanisms underlying the perception of camouflaged objects (may provide new simulation methods for camouflaging personnel and material, and new training methods to help observers detect hidden objects); and research the neural code underlying auditory attention by mapping activity in multiple auditory-related sites simultaneously (may provide a new paradigm for enhancing Warfighter performance and caring for injured personnel).			
Accomplishments/Planned Programs Subtotals	78.575	87.001	94.519

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army			Date: February 2016
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*	Project (Number/Name) H66 / *Adv Structures Rsch*	

COST ($ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
H66: *Adv Structures Rsch*	-	2.000	2.033	2.061	-	2.061	2.095	2.133	2.174	2.217	-	-

A. Mission Description and Budget Item Justification

This project funds basic research for improved tools and methods to advance structural health monitoring capabilities and enable condition-based maintenance for sustainment of rotorcraft and ground vehicles. This research also enables the design and use of composite structures that can better address the cost, weight, performance, and dynamic interaction requirements of future platforms identified by the Army Modernization Strategy. Ultimately, these technologies result in safer, more affordable vehicles with a greatly reduced logistics footprint. This project is a joint Army/National Aeronautics and Space Administration (NASA) effort that includes structures technology research into: structural integrity analyses; failure criteria; inspection methods which address fundamental technology deficiencies in both metallic and composite Army rotorcraft structures; use of composite materials in the design and control of structures through structural tailoring techniques; rotorcraft aeroelastic modeling and simulation; helicopter vibration (rotating and fixed systems); and the design and analyses of composite structures with crashworthiness as a goal. The problems in structural modeling are inaccurate structural analysis and validation methods to predict durability and damage tolerance of composite and metallic rotorcraft structures and inadequate structural dynamics modeling methods for both the rotating and fixed system components to address reliability issues for future aircraft. The technical barriers include a lack of understanding of failure mechanisms, damage progression, residual strength, high-cycle fatigue, the transfer of aerodynamic loads on the rotor to the fixed system, and impact of these unknown loads on aircraft components. Technical solutions are focused on: advanced fatigue methodologies for metallic structures, improved composites technology throughout the vehicle, long-term investigation of integrated stress-strength-inspection, advanced methods for rotor system vehicle vibratory loads prediction, improved methods to predict vehicle stability, and improved analyses to address Army Aviation requirements. These advancements will extend service life, reduce maintenance costs, enhance durability, and reduce the logistics footprint of existing and future Army vehicles. This is the only basic research project supporting investigations for rotorcraft and ground vehicle structures within the Department of Defense.

Work in this project supports key Army needs and provides the technical underpinnings to Program Element (PE) 0602211A (Aviation Technology).

The cited work is consistent with the Assistant Secretary of Defense for Research and Engineering Science and Technology priority focus areas and the Army Modernization Strategy.

Work in this project is performed by the Army Research Laboratory (ARL), using facilities located at NASA Langley Research Center, Hampton, VA, and at Aberdeen Proving Ground, MD.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
Title: Structural Analysis and Vibration Methods	2.000	2.033	2.061
Description: This research explores new structural analyses and validation methods to achieve more accurate predictions of durability and damage tolerance in composite and metallic rotorcraft structures and evaluates structural dynamics modeling methods to address critical reliability issues in the rotating and fixed system components of future aircraft.			
FY 2015 Accomplishments:			

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** H66 / *Adv Structures Rsch*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
Investigated strategies for improving the durability of vehicle platforms through the introduction of novel composite materials; developed and demonstrated a probabilistic tool for the development of novel composite materials to address specific structural performance requirements; developed the capability to capture and quantify precursors to damage in structural components that will enhance the operation and sustainability of future vehicle systems; and demonstrated three-dimensional (3D) printing of multifunctional structural components for air and ground vehicle applications. ***FY 2016 Plans:*** Investigate (experimentally and theoretically) the electrical, thermal, magnetic, and mechanical property changes for structural materials and composites under complex loading conditions for the purpose of assessing the practicality of damage-detection sensing modes, and for developing damage progression models; and research novel processes to enhance the electrical, thermal, mechanical and magnetic performance. ***FY 2017 Plans:*** Will develop innovative theoretical models that accurately predict material crack growth and structural fatigue life for use in increasing the fatigue-failure resistance of metallic and composite structural components for Army platforms; and investigate and identify materials damage precursors in structures by utilizing material electrical, thermal, mechanical, and/or magnetic response to enable strategies to extend the life of critical structural components by tailoring usage based upon early damage detection.			
Accomplishments/Planned Programs Subtotals	2.000	2.033	2.061

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army			Date: February 2016
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*	Project (Number/Name) H67 / *Environmental Research*	

COST ($ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
H67: *Environmental Research*	-	0.901	0.913	0.928	-	0.928	0.943	0.961	0.979	0.999	-	-

A. Mission Description and Budget Item Justification

This project focuses basic research on innovative technologies for industrial pollution prevention (P2) that directly supports the Army production base and weapon systems and also addresses non-stockpile chemical warfare (CW) site remediation. Work in pollution prevention invests in next generation manufacturing, maintenance, and disposal methods that will result in significantly reducing the usage of hazardous and toxic substances and their associated costs. The goal is to decrease the overall life-cycle costs of Army systems by 15-30% through the application of advanced pollution prevention technologies. Non-stockpile CW efforts include establishing the ecotoxicity of CW compounds, environmental fate and effect of CW compounds in soils and biodegradation of CW compounds. Pollution prevention thrusts include: environmentally acceptable, advanced, non-toxic processes to manufacture lightweight alternative structural materials to enhance weapon system survivability; clean synthesis of more powerful and improved energetic compounds to eliminate the use of hazardous materials and minimize the generation of wastes; and surface protection alternatives to hazardous paints, cadmium, chromium, and chromate conversion metal and composite surfaces.

Work in this project complements and is fully coordinated with the Army Environmental Requirements Technology Assessment (AERTA) requirements and contains no duplication with any effort within the Military Departments.

The cited work provides the technical underpinnings for Program Element 0602618A (Ballistics Technology).

Work in this project is performed by the Army Armament, Research, Development and Engineering Center, Picatinny, NJ.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
Title: Industrial Pollution Prevention	0.901	0.913	0.928
Description: This effort conducts research on innovative environmentally-friendly technologies that support the warfighter (focusing on pollution prevention technologies).			
FY 2015 Accomplishments: Researched green technologies for new energetics/propellants, airborne lead reduction in Army weapon systems, and environmentally friendly technologies to support Army soldier systems; selected projects to support the Army Environmental Requirements and Technology Assessments (AERTA).			
FY 2016 Plans: Perform research involving hazardous materials and wastes generated from production of energetic materials, additive manufacturing, and weapon systems; investigate efforts to enhance technologies to support Soldier systems; and investigate selected projects to comply with the Office of the Secretary of the Army's environmental initiatives.			
FY 2017 Plans:			

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** H67 / *Environmental Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
Will investigate and perform basic research for the reduction of hazardous materials generated from energetic materials formulations, additive manufacturing, and weapon systems designs focusing on pollution prevention technologies. This includes investigating new innovative energetic materials, as well as analyzing selected projects and their respective technologies for their compliance to the Office of the Secretary of the Army's environmental initiatives.			
Accomplishments/Planned Programs Subtotals	0.901	0.913	0.928

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army			Date: February 2016
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*	Project (Number/Name) S13 / *Sci BS/Med Rsh Inf Dis*	

COST ($ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
S13: *Sci BS/Med Rsh Inf Dis*	-	10.924	11.181	11.318	-	11.318	11.503	11.722	11.952	12.191	-	-

Note

In Fiscal Year (FY) 2017: Prevention/Treatment of Parasitic (organism living in or on another organism) Diseases research area and the Vaccines for Prevention of Malaria research area are merged into one task area titled Parasitic Diseases – Drugs and Vaccines

A. Mission Description and Budget Item Justification

This project fosters basic research leading to medical countermeasures for naturally occurring diseases impacting military operations. Basic research for this project provides an understanding of the mechanisms that make organisms infectious and mechanisms that render the human body response effective, preventing diseases caused by infectious agents. Understanding the biological characteristics of infectious organisms also enables the development of point-of-care and laboratory-based diagnostic tools (used to identify the nature and cause of a particular disease). Understanding of disease transmission by insects and other organisms helps in developing new interventions to prevent transmission of such diseases. Infectious disease threats from malaria, diarrhea, and dengue (a severe debilitating disease transmitted by mosquitoes), common where Warfighters are stationed across all Unified Combatant Commands, are the highest priorities for basic research.

Research conducted in this project focuses on the following four areas:

(1) Prevention/Treatment of Parasitic (organism living in or on another organism) Diseases
(2) Bacterial Disease Threats
(3) Viral Disease Threats
(4) Vector Identification and Control

Work is managed by the Medical Research Materiel Center (MRMC) in coordination with the Naval Medical Research Center (NMRC). The Army is responsible for programming and funding all Department of Defense naturally occurring infectious disease research requirements, thereby precluding duplication of effort within the Military Departments.

Work in this project complements and is fully coordinated with Program element (PE) 0602787A (Medical Technology).

The cited work is consistent with the Assistant Secretary of Defense, Research and Engineering Science and Technology, focus areas and the Army Modernization Strategy.

Work in this project is performed by the Walter Reed Army Institute of Research (WRAIR) and NMRC, Silver Spring, MD, and their overseas laboratories.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
Title: Prevention/Treatment of Parasitic (organism living in or on another organism) Diseases	3.871	3.997	-

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** S13 / *Sci BS/Med Rsh Inf Dis*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
Description: This effort is to better understand the biology of malaria and leishmaniasis (a skin-based disease transmitted by sand flies predominantly exhibited as skin sores) parasites and to gain the necessary foundation for discovering medical countermeasures to protect military personnel from infection. Malaria, which can cause fatal and chronic disease, is the most significant military infectious disease threat. Because the malaria parasite becomes resistant to drugs over time, it is necessary to continually search for parasite weaknesses that can be exploited by different drugs and vaccines. In FY17 this research area and the Vaccines for Prevention of Malaria research area are merged into one task area titled Parasitic Diseases – Drugs and Vaccines. ***FY 2015 Accomplishments:*** Continued to identify new lead candidate drugs and combinations to stay ahead of emerging drug resistance in malaria parasite; and identified new technologies to deliver drugs into the human body by using novel formulations. ***FY 2016 Plans:*** Optimize the safety and effectiveness of next generation malarial prophylaxis (measures taken to prevent health problems) candidate drugs based on lead candidates identified in FY15, through structural modifications of selected compounds (Triazine and Pyrimidinylguanidine); and will identify new lead candidates.			
Title: Vaccines for Prevention of Malaria ***Description:*** This effort is to better understand and identify new proteins in the design of candidate vaccines for various types of malaria including the severe form of malaria (Plasmodium falciparum) and the less severe but relapsing form (Plasmodium vivax). A highly effective vaccine could reduce/eliminate the use of anti-malarial drugs and also reduce the development of drug resistance to current/future drugs. In FY17 this research area and the Drugs to Prevent/Treat Parasitic Diseases research area are merged into one task area titled Parasitic Diseases – Drugs and Vaccines. ***FY 2015 Accomplishments:*** Identified and characterized mechanism of protective immunity; continued to assess immunogenicity of new vaccine candidates in small-animal models to determine suitability in formulations of multiple antigen vaccines and identified and characterized new technologies to deliver candidate vaccine into the human body by using novel formulations. ***FY 2016 Plans:*** Continue to identify and characterize mechanisms of protective immunity elicited by new candidate malaria protein-based antigens; define a strategy to develop a candidate vaccine against falciparum malaria that contains several different kinds of antigens, to improve vaccine effectiveness; and identify new recombinant (artificially produced via genetic engineering) protein-based vaccine candidate(s) against vivax malaria.	2.482	2.530	-
Title: Basic Research on drugs and vaccines against parasitic diseases	-	-	6.583

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** S13 / *Sci BS/Med Rsh Inf Dis*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
Description: Malaria, which can cause fatal and chronic disease, is the most significant military infectious disease threat. This effort seeks to better understand the biology of malaria and leishmaniasis (a skin-based disease transmitted by sand flies predominantly exhibited as skin sores) parasites and to gain the necessary foundation for discovering medical countermeasures to protect military personnel from infection. Because the malaria parasite becomes resistant to drugs over time, it is necessary to continually search for parasite weaknesses that can be exploited by different drugs and vaccines. This effort seeks to better understand small molecule therapeutics and prophylactics, to overcome drug resistant organisms and identify new proteins in the design of candidate vaccines for various types of malaria including the severe form (caused by Plasmodium falciparum) and the less severe but relapsing form (caused by Plasmodium vivax). In FY17 the Prevention/Treatment of Parasitic Diseases research area and the Vaccines for Prevention of Malaria research area are merged into one task area titled Parasitic Diseases – Drugs and Vaccines. ***FY 2017 Plans:*** Will identify new formulations (increase/decrease drug quantity in single administered dose, change chemical structure to increase circulating dose) of selected compounds Will identify new lead candidates from the 8-aminoquinoline class of compounds used to treat malaria. Will continue to identify and select additional methods to formulate new recombinant (artificially produced via genetic engineering) protein-based vaccine candidate(s) against vivax malaria (the most common of four types of malaria species) to initiate assessment of its immunogenicity (ability to provoke an immune response) in small animals.			
Title: Bacterial Disease Threats ***Description:*** This effort is to better understand the biology of bacterial organisms and their effects on humans, how to prevent wound infections, prevent/treat diarrhea (a significant threat during initial deployments), and scrub typhus (a debilitating mite-borne disease that has in recent history been the leading rickettsial disease to impact US military operations and is developing resistance to currently available antibiotics). ***FY 2015 Accomplishments:*** Explored common adjuvants and routes of delivery for a combination vaccine against the major diarrheal causing bacterial impacting Warfighters: Campylobacter (leading bacterial cause of food borne disease in many developed countries), Shigella (bacteria that causes diarrhea, similar to salmonella), and enterotoxigenic E. coli (leading bacterial cause of diarrhea). Identified epidemiologic (study of the causes, distribution, and control of disease) importance of enteric (gastrointestinal) pathogens to develop strategies for preventing diarrhea in deployed Warfighters. Identified correlates of protection (indicator of effectiveness) in animal models; identified new techniques and tools for improved infection control and wound healing; and identified and evaluated novel methods for prevention of trauma-associated infection by highly antibiotic-resistant bacteria. ***FY 2016 Plans:***	1.527	1.517	1.532

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** S13 / *Sci BS/Med Rsh Inf Dis*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
Continue to identify and explore various methods to develop a combination vaccine against three bacterial agents (Campylobacter, Shigella, and enterotoxigenic E. coli.) that together are responsible for most diarrhea cases in deployed Warfighter's; and continue epidemiological studies on various deployed populations with regard to disease-causing microorganisms of the digestive system. These epidemiological studies aid the planning and evaluation of strategies to prevent diarrhea in deployed Warfighters. Define indicators of vaccine effectiveness (correlates of protection) in animal models of bacterial diarrhea. The correlates of protection aid in vaccine development; Continue to identify additional therapies and tools for preventing and treating wound infection and improving wound healing; and evaluate novel technologies for treatment and prevention of multi-drug resistant bacteria most commonly encountered in trauma-associated infections. ***FY 2017 Plans:*** Will continue to identify new antigen (substance that causes your immune system to produce antibodies) targets and explore their immunogenicity potential for the development of vaccines against Campylobacter, Shigella, and enterotoxigenic E. coli. (ETEC) which together are responsible for most of the cases of diarrhea in deployed Warfighters. Will continue to perform epidemiological studies in various deployed populations to identify relevant types of pathogens to inform vaccine development and include these in vaccine formulations. Will continue to identify indicators of vaccine effectiveness (correlates of protection) in animal models of bacterial diarrhea in order to predict vaccine effectiveness in humans. Will continue identification and characterization of potential therapeutics and/or diagnostic targets within the host or pathogen associated with multi-drug resistant wound infections and/or biofilm (a group of microorganisms that stick to each other, on a surface) formation.			
Title: Viral Threats Research ***Description:*** This effort is to better understand highly lethal or incapacitating viruses, including those that cause hemorrhagic diseases (viral infection that causes severe internal bleeding) such as dengue hemorrhagic fever (life-threatening form if disease caused by the Dengue virus, transmitted by mosquitoes) and Hantaviral pulmonary syndrome (caused by hantavirus infection resulting in internal bleeding; can be transmitted by exposure to rodents or their droppings). Basic research includes understanding risk to the Warfighter of contracting a viral disease based on its prevalence in the respective area of operations, viral biology (structure, function, life cycle of the virus and its ecological factors), the disease process, and disease interaction (symptomology) with the human body. ***FY 2015 Accomplishments:*** Identified and evaluated the role of human cells and antibodies in developing medical countermeasures to prevent and/or treat hantavirus and dengue virus infections; identified host and viral determinants (risk factors) of dengue disease severity; explored innovative vaccine designs, adjuvant (agent that enhances the immune response, usually used with a vaccine antigen) systems, and delivery methods for dengue virus vaccine; and continued world-wide epidemiological studies to determine the prevalence and incidence of dengue fever and dengue hemorrhagic fever. ***FY 2016 Plans:***	1.588	1.619	1.653

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** S13 / *Sci BS/Med Rsh Inf Dis*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
Continue to assess host and viral determinants of dengue fever disease severity among populations at risk; continue to explore innovative vaccine designs, adjuvant systems and delivery methods for a dengue virus vaccine; and continue studies to identify and evaluate the role of human cells and antibodies in developing medical countermeasures to prevent and/or treat diseases caused by hantaviruses and other lethal viruses (i.e. Crimean Congo Hemorrhagic Fever (CCHF) virus. ***FY 2017 Plans:*** Will continue to identify regions of the virus particles that induce protective immune response against all four serotypes of dengue fever virus; Will study the role of human cells and antibodies recovered from patients vaccinated during dengue vaccine trials in Asia and Latin America and dengue human infection model studies conducted in the United States to identify new methods of vaccine formulations. Will investigate the possible role of nonspecific defense mechanisms that come into play immediately or within hours of a pathogen's appearance in the body to develop protective countermeasures. Will identify viral sequence based determinants (particles that cause infection) obtained from dengue viruses recovered from patient populations enrolled in expanded (FDA) safety/efficacy/dosing study in humans to understand protection mechanisms. Will identify and validate viral particle neutralization assay that will be used to measure neutralizing antibodies against Hantavirus. Will determine an optimal delivery device for the Hantavirus vaccine.			
Title: Vector Identification and Control	1.456	1.518	1.550
Description: This effort conducts research to investigate the biology of biting arthropods (i.e. mosquitoes and sand flies) and other vectors (organisms that transmit disease) and their control. This effort also expands identification of infectious disease pathogens in vectors and disease surveillance capabilities in the field. This research will help to direct new interventions into preventing disease transmission. ***FY 2015 Accomplishments:*** Explored innovative technologies (traps, attractants, and devices) for vector surveillance in military operations; continued development of user friendly, web-based tools for identification of medically relevant arthropods and insects; identified novel pesticide (chemicals used for the control of insects and allied organisms) matrices/application strategies for vector control; and explored passive arthropod repellent systems/strategies (do not require pesticide applications). ***FY 2016 Plans:*** Leverage worldwide capabilities utilizing an information exchange program involving site visits to museums (e.g. United Kingdom (UK)/ Museum Natural History, London; Belgium/Royal Museum of Central Africa, Tervuren) to compare and exchange insect type specimens assisting development of tools to identify wild-caught insects; complete the Identification Guide to the Culex mosquitoes of East, West and Central Africa; leverage studies with the Defense War Fighter Program and Global Emerging Infectious Systems to develop novel pesticide application strategies and passive repellent systems/strategies for vector control. ***FY 2017 Plans:***			

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** S13 / *Sci BS/Med Rsh Inf Dis*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
Will explore the current gaps in the area of vector control. Will explore the latest technology in vector-borne disease risk assessment tools to manage data and support decision making for vector control operations. Will explore integrated vector control strategies, new insecticides or unique formulations, application equipment, and non-chemical control methods. Will identify novel molecular markers or antigens that can be used to produce better detection tools. This will be a crucial component for the successful development of multiplexed detection assays to identify multiple pathogens in a vector population.			
Accomplishments/Planned Programs Subtotals	10.924	11.181	11.318

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army			Date: February 2016
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*	Project (Number/Name) S14 / *Sci BS/Cbt Cas Care Rs*	

COST ($ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
S14: *Sci BS/Cbt Cas Care Rs*	-	10.183	9.758	5.699	-	5.699	5.540	5.636	5.743	5.857	-	-

Note

In Fiscal Year (FY) 2015 and 2016 the funding for Clinical and Rehabilitative Medicine is this Project. The Clinical and Rehabilitative Medicine basic research effort moves to Project ET6 starting in FY17.

A. Mission Description and Budget Item Justification

This project supports basic research to understand the fundamental mechanisms of severe trauma to advance treatment and surgical procedures to save lives and improve medical outcomes for the Warfighter. Experimental models are developed to support in-depth trauma research studies. This project includes studies of predictive indicators and decision aids for life-support systems, studies to heal and repair burned or traumatically injured hard and soft tissues of the eye, face, mouth, and extremities, control of severe bleeding, and traumatic brain injury (TBI). Such efforts will minimize lost duty time and provide military medical capabilities for far-forward medical/surgical care of injuries. Funding for Clinical and Rehabilitative Medicine basic research moved to project ET6 starting in FY17.

Research conducted in this project focuses on the following five areas:
(1) Damage Control Resuscitation
(2) Combat Trauma Therapies
(3) Combat Critical Care Engineering
(4) TBI
(5) Clinical and Rehabilitative Medicine (moves to Project ET6 in FY17)

Work in this project complements and is fully coordinated with program element (PE) 0602787A (Medical Technology).

The cited work is consistent with the Assistant Secretary of Defense for Research and Engineering Science and Technology, priority focus areas and the Army Modernization Strategy.

Work in this project is performed by the Walter Reed Army Institute of Research (WRAIR), Silver Spring, MD; the United States Army Dental Trauma Research Detachment (USADTRD) and the United States Army Institute of Surgical Research (USAISR), Joint Base San Antonio, TX.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
Title: Damage Control Resuscitation	2.606	2.268	1.644
Description: This effort conducts studies to define and identify cellular processes and metabolic (biochemical activity) mechanisms associated with blood clotting to understand the relationships between the human immune processes and bleeding in trauma.			

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** S14 / *Sci BS/Cbt Cas Care Rs*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
FY 2015 Accomplishments: Conducted studies of cell and tissue protective drugs as potential new candidate alternatives to blood products and fluids when these are not available. ***FY 2016 Plans:*** As a follow on to the FY15 work, perform cell-based (in vitro) studies of drugs to assess their ability to protect cells and tissues from harmful effects of severe blood loss. ***FY 2017 Plans:*** As follow on to the FY16 work, will perform cell-based (in vitro) studies of small-volume cytoprotectant (protect cells from freezing effects) drugs as resuscitation adjuncts. Will characterize response of capillary function in tissue from traumatic bleeding and explore applications of stem cell technology for treatment of traumatic bleeding.			
Title: Combat Trauma Therapies ***Description:*** This effort conducts studies of trauma to tissues and organs, including dental (facial and oral) injuries, extremity wounds and fractures, and burns, and ways to mitigate and/or repair this damage. ***FY 2015 Accomplishments:*** Conducted studies to determine the optimal thicknesses of skin grafts for more rapid closure and improved functional outcomes of face wounds. ***FY 2016 Plans:*** Start development of models to identify optimal combinations of skin components for transplantation as a potential means to repair severe facial injuries. As follow on to FY15 work, study molecular, cellular and structural skin components to identify mechanisms to optimize healing, appearance and function following traumatic injury of hard and soft tissues. ***FY 2017 Plans:*** Will perform genetic analyses of bacteria to aid in developing improved products to prevent or treat infected facial, mouth, and extremity wounds. Will identify combinations of antiseptics and antimicrobial peptides (constituent parts of proteins) that interact together to eliminate bacterial infections in wounds of the face, mouth, and extremities.	0.772	0.824	1.889
Title: Combat Critical Care Engineering ***Description:*** This effort conducts basic science studies of vital sign (e.g. heart rate, blood pressure, blood oxygen concentration) responses to trauma as predictors of medical outcomes and as a basis for developing life-saving interventions. This effort also conducts basic science studies to support development of technologies to preserve function of vital organs following traumatic injury.	0.775	0.774	0.857

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** S14 / *Sci BS/Cbt Cas Care Rs*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
FY 2015 Accomplishments: Continued research on decision support algorithms using non-traditional vital signs(for example, individual physical components of arterial pressure waveforms and light-based measurement of muscle oxygen content) to assess patient status and optimize fluid resuscitation; and conducted studies to identify new physiological (characteristic of or appropriate to an organism's healthy or normal functioning) information that distinguish individuals with high and low tolerances to blood loss. ***FY 2016 Plans:*** Validate sensitivity and specificity of blood-loss prediction algorithm under differing clinical and environmental conditions, for example heat, cold, low oxygen, and stress; start basic research examining potential use of stem-cell (primitive cells that give rise to more specialized cells of the body) based therapy for treatment of lung injury; and start basic research to explore means to safely provide oxygen to, and remove carbon dioxide from casualties with severe lung injuries without further damaging the lungs. ***FY 2017 Plans:*** Will develop physiological models to aid in solving current pre-hospital clinical problems as identified by the Committee on Tactical Combat Casualty Care. Will develop models to address airway management and early detection of tension pneumothorax (a trapping of air in the space between the lung and chest wall that if untreated will collapse the lung and push the heart and windpipe against the other side of the chest) and to address pain management in far forward areas and during transport.			
Title: Traumatic Brain Injury	1.447	1.294	1.309
Description: This effort conducts basic research in poly-trauma (multiple injuries)/Traumatic Brain Injury (TBI) model, mechanisms of cell death, and the discovery of novel drugs and medical procedures to mitigate the effects of TBI. ***FY 2015 Accomplishments:*** Continued studies applying Systems Biology (field of study that focuses on complex interactions within biological systems, using a holistic approach) to refine models of mild and severe TBI to aid in discovery of novel proteins in the blood that appear as a result of traumatic injury, which may aid in diagnosis of TBI; continued basic research to study the brain and nervous system during the sub-acute (weeks) and chronic (months) periods after head injury to identify predictors of long-term consequences of TBI; continued research to understand cell death and neuroprotection (protection of the brain) mechanisms and determined critical thresholds for secondary injuries (polytrauma) complicating TBI; and conducted studies to determine the time course of neuroplasticity (capacity of the nervous system for adaptation or regeneration after trauma) markers during the post-injury recovery periods. ***FY 2016 Plans:*** Utilize the application of systems biology methods to aid in discovery of novel proteins that appear in blood as result of TBI; study the multiple stages of TBI recovery to identify predictors of long-term consequences of TBI; and characterize cell death and			

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** S14 / *Sci BS/Cbt Cas Care Rs*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
potential mechanisms (a process, technique, or system for achieving a result) to protect brain cells from subsequent inflammation and secondary injuries. ***FY 2017 Plans:*** Will continue work from FY16 to apply systems biology methods to identify new proteins that appear in blood as result of TBI. Will examine metabolic changes (changes in the way the neuron assimilates nutrients and converts them to energy to support nerve function) as mechanisms or markers of TBI. Will develop models of acute, severe TBI in combination with severe bleeding and lung injury supporting studies to determine if these other injuries and their subsequent treatment may worsen TBI outcome.			
Title: Clinical and Rehabilitative Medicine ***Description:*** This effort conducts basic studies of mechanisms of tissue growth and traumatic injury to gain an understanding that will assist or facilitate the healing or transplantation process. The focus is placed on severe trauma to the limbs, head, face (including eye), genitalia (organs of reproduction), and abdomen. In FY15 and 16 the funding for this research effort is in project S14. The Clinical and Rehabilitative Medicine basic research effort has a separate project starting in FY17 (ET6). ***FY 2015 Accomplishments:*** Explored the cellular mechanisms and functional challenges of eye trauma injuries and advanced promising therapies for eye trauma wounds into the applied research phase; correlated the epidemiology of eye trauma with clinical outcomes. Explored innovative strategies to regenerate and reconstruct tissues to enable promising approaches to advance into the applied research phase through directed experimentation in the lab and in animal models to address injury of the extremities, craniomaxillofacial, genitalia, and abdominal regions. ***FY 2016 Plans:*** Analyze the cellular mechanisms and functional deficits of eye trauma injuries; advance promising therapies for eye trauma wounds into the applied research phase and correlate the epidemiology of eye trauma with clinical outcomes; and explore innovative strategies to regenerate and reconstruct hard (e.g. bone) and soft (e.g. skin and muscle) tissues to enable promising approaches to advance into the applied research phase through directed experimentation in the lab and in animal models to address injury of the extremities, face, genitalia, and abdominal regions. Advance novel immunomodulation (modification of the immune response / immune system functioning) technologies to treatment model development to enable improved outcomes in hand and face transplant procedures.	4.583	4.598	-
Accomplishments/Planned Programs Subtotals	10.183	9.758	5.699

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** S14 / *Sci BS/Cbt Cas Care Rs*

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army			Date: February 2016
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*	Project (Number/Name) S15 / *Sci BS/Army Op Med Rsh*	

COST ($ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
S15: *Sci BS/Army Op Med Rsh*	-	6.721	6.599	6.688	-	6.688	6.801	6.924	7.060	7.201	-	-

A. Mission Description and Budget Item Justification

This project fosters basic research on physiological and psychological factors that limit Warfighter effectiveness and on characterization of health hazards generated by military systems that result as a consequence of military operations; includes research on the neurobehavioral aspects of post-traumatic stress; develops concepts for medical countermeasures to prevent or mitigate the effects of muscle and bone injury to include reducing the effects of sleep loss and other stressors on Warfighter performance. The hazards of exposure to directed energy, repetitive use, fatigue, heat, cold, and altitude are also investigated under this project.

Research conducted in this project focuses on the following four areas:

(1) Injury Prevention and Reduction
(2) Physiological Health
(3) Environmental Health and Protection
(4) Psychological Health and Resilience

Work in this project complements and is fully coordinated with Program Element 0602787A (Medical Technology).

The cited work is consistent with the Assistant Secretary of Defense for Research and Engineering Science and Technology, priority focus areas and the Army Modernization Strategy.

Work in this project is performed by the Walter Reed Army Institute of Research (WRAIR), Silver Spring, MD; United States Army Institute of Surgical Research (USAISR), Joint Base San Antonio, TX; and the United States Army Research Institute of Environmental Medicine (USARIEM), Natick, MA.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
Title: Injury Prevention and Reduction	0.986	1.429	1.304
Description: This effort identifies biological patterns of change in Warfighters during states of physical exertion, identifies physiological (human physical and biochemical functions) mechanisms of physical injury and exertion that will predict musculoskeletal (muscle, bone, tendons, and ligaments) injury. Also includes the characterization of ocular injury pathways resulting from blast exposure in small animal models.			
FY 2015 Accomplishments: Explored inflammatory processes in muscle and surrounding tissues following physical injury and during cellular repair, using cell and animal models. Examined and documented the presence or absence of visible retinal alterations following blast exposure to			

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** S15 / *Sci BS/Army Op Med Rsh*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
rodents and laser exposures to eyes in a non-human primate model by using retinal imaging (photographic procedure that details the optic nerve, retinal blood vessels and the light sensing tissues in the back of the eye). ***FY 2016 Plans:*** Identify the mechanism of nerve remodeling to enhance functional neuromuscular (central nervous system control of muscle functioning) adaptation following muscle injury and determine the effect of inflammatory processes on muscle repair / regeneration, incomplete healing and subsequent risk of re-injury; and identify possible points of intervention to minimize musculoskeletal injuries or re-injury based on modifiable and non-modifiable risks. Collect ocular injury data from blast exposure in multiple animal species for the development of scaling models. ***FY 2017 Plans:*** Will use computational modeling to reveal mechanisms of control of the inflammatory and regenerative response to tissue damage. Will identify musculoskeletal damage markers that provide damage/injury resolution assessment and validation of those markers in mouse models of musculoskeletal injury. Will develop non-invasive tools capable of supporting decisions for treatment, prognosis and return to duty following tissue injury with applicability far forward. Will develop blast injury scaling laws for the eyes across species (including mice, rabbits and humans), which enables the development of a surrogate human ocular injury model.			
Title: Physiological Health ***Description:*** This effort conducts research on the physiological mechanisms of sleep, fatigue, and nutrition on Warfighter performance and well-being. ***FY 2015 Accomplishments:*** Investigated the metabolic mechanisms underlying injury recovery and explored the capability of macronutrients and micronutrients to promote metabolic recovery using cell and animal models; and determined the neurophysiological basis (how the nervous system functions on a molecular and tissue level) of recuperation during sleep and explored the use of pharmaceuticals and non-pharmacological approaches for improving the recuperation processes during sleep. ***FY 2016 Plans:*** Identify nutrients (carbohydrates, proteins, fats, vitamins, etc.) that could regulate the recovery of muscle cells after musculoskeletal injury; identify factors affecting the absorption of nutrients that contribute to bone structure and function; determine the impact on gut health of only eating operational rations; identify the brain neurochemistry (the interaction between small molecules and cells via signaling between and within cells) and functional pathophysiology (molecular and cellular signature of disease) associated with repeated blast exposures; and identify biomarkers (indicator of a process, event, condition or change within the body) of sleep debt and recuperation. ***FY 2017 Plans:***	2.481	2.084	3.466

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** S15 / *Sci BS/Army Op Med Rsh*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
Will continue to assess nutritional approaches that can enhance resistance to stress and augment tissue repair, wound healing and recovery from brain function. Will determine the feasibility of a prophylactic (preventative treatment) nutrient or dietary nutrient cocktail for preventing the deleterious effects of impact, acceleration, and/or blast –induced head injury in a rodent model. Will identify differences in baseline sleep pattern and duration, in the home environment, between mild traumatic brain injury (mTBI) patients, non-mTBI (controls) Warfighters and Warfighters who've recovered from mTBI.			
Title: Environmental Health and Protection ***Description:*** This effort conducts research on the physiological (human physical and biochemical functions) mechanisms of exposure to extreme heat, cold, altitude, and other environmental stressors. This effort establishes scientific evidence for specific and sensitive diagnostics of exertional heat illness to optimize Warfighter performance in austere environments. ***FY 2015 Accomplishments:*** Used animal models to identify sensitive biomarkers (indicator of a process, event, condition or change within the body) of organ damage and delineated the molecular pathways of heat injury. This data can be used to identify targets for therapeutic interventions to accelerate recovery from heat injury. ***FY 2016 Plans:*** Use animal models and cellular-based tests to identify biomarkers of organ damage; and evaluate specific molecular pathways of heat injury and establish the time course, type and extent of organ damage following heat injury. ***FY 2017 Plans:*** Will use animal models to characterize improved (sex-specific and sensitive) circulating biomarkers of organ damage for diagnostics and assessment of severity of heat injury. Will establish scientifically based clinical criteria for return-to-duty status following heat illness.	0.789	0.809	0.821
Title: Psychological Health and Resilience ***Description:*** This effort conducts research into the basic mechanisms of the ability to overcome traumatic events including determination of underlying neurobiological mechanisms (nervous system control of cellular and molecular processes) related to Post-Traumatic Stress Disorder (PTSD) and depression. ***FY 2015 Accomplishments:*** Utilized an animal model to explore traumatic exposure, traumatic stress symptoms (i.e., anxiety, avoidance, hyper vigilance), and trauma recovery to preliminarily screen of pharmaceuticals that may impact mental health status. The results of these studies aided in creating a methodology for systematic testing of novel pharmaceuticals leading ultimately to clinical trials for the treatment	2.465	2.277	1.097

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** S15 / *Sci BS/Army Op Med Rsh*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
of PTSD. Identified the association of exposure to blast and/or blunt impact on the likelihood of a brain concussion in a rodent model. ***FY 2016 Plans:*** Identify if Omega-3 fatty acids are capable of affecting vulnerability to and recovery time following a concussion; and establish a core set of procedures and outcome measures defining a validated animal model of PTSD appropriate for identifying candidate compounds and methods of PTSD treatment. ***FY 2017 Plans:*** Will utilize an animal model to screen compounds for the treatment of PTSD, their ability to inhibit adverse memory formation and related disorders. Will identify vulnerable factors and diagnostic indicators of PTSD and co-existing mental health problems that overlap or complicate PTSD. Will explore and identify candidate compounds that can be administered in a prophylactic manner or post-trauma to mitigate the adverse biological and behavioral effects of trauma in an animal model. Will develop analytic techniques to evaluate neuroendocrine assays (clinical tests that evaluate relevant hormonal and neurotransmitter levels within the body) for stress effects.			
Accomplishments/Planned Programs Subtotals	6.721	6.599	6.688

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army			Date: February 2016
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*	Project (Number/Name) T14 / *BASIC RESEARCH INITIATIVES - AMC (CA)*	

COST ($ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
T14: *BASIC RESEARCH INITIATIVES - AMC (CA)*	-	18.250	40.000	0.000	-	0.000	0.000	0.000	0.000	0.000	-	-

A. Mission Description and Budget Item Justification

Congressional Interest Item funding provided for Defense Research Sciences.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
Title: Reprogramming - Congressional Add for Single Investigator	8.000	-	-
Description: Congressional Add for Single Investigator ***FY 2015 Accomplishments:*** Reprogramming of funding from PE 0601103, Project D58 for Single Investigator for proper execution.			
Accomplishments/Planned Programs Subtotals	8.000	-	-

	FY 2015	FY 2016
Congressional Add: Program Increase ***FY 2015 Accomplishments:*** Program increase for Defense Research Sciences ***FY 2016 Plans:*** Program increase for Defense Research Sciences	8.000	40.000
Congressional Add: Science, Technology, Engineering, and Math (STEM) Pilot Program ***FY 2015 Accomplishments:*** Congressional increase for STEM pilot program focused on underserved populations.	2.250	-
Congressional Adds Subtotals	10.250	40.000

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** T14 / *BASIC RESEARCH INITIATIVES - AMC (CA)*

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army										Date: February 2016		
Appropriation/Budget Activity 2040 / 1					R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*				Project (Number/Name) T22 / *Soil & Rock Mech*			
COST ($ in Millions)	**Prior Years**	**FY 2015**	**FY 2016**	**FY 2017 Base**	**FY 2017 OCO**	**FY 2017 Total**	**FY 2018**	**FY 2019**	**FY 2020**	**FY 2021**	**Cost To Complete**	**Total Cost**
T22: *Soil & Rock Mech*	-	5.537	4.456	4.520	-	4.520	4.597	4.681	4.773	4.868	-	-

A. Mission Description and Budget Item Justification

This project fosters basic research to correlate the effects of the nano- and micro-scale behavior on the macroscale performance of geological and structural materials to provide a foundation for the creation of future revolutionary materials and to revolutionize the understanding of sensor data within heterogeneous geological systems. This research encompasses geologic and structural material behavior, structural systems, and the interaction with dynamic and static loadings. Research includes underlying physics and chemistry that control the mechanics and electromagnetic behavior of geological and structural materials, new techniques that provide measurements at the fundamental scale, and fundamental theories for relating nano- and micro-scale phenomena to macro-scale performance.

Work in this project provides the basis for applied research in Program Element 0602784A (Military Engineering Technology), Project T40 (Mobility/Weapons Effects Technology).

The cited work is consistent with the Assistant Secretary of Defense, Research and Engineering science and technology focus areas and the Army Modernization Strategy.

Work in this project is performed by the Army Engineer Research and Development Center (ERDC), Vicksburg, MS.

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2015**	**FY 2016**	**FY 2017**
Title: Military Engineering Basic Research	2.331	2.137	2.169
Description: Funding is provided for the following efforts.			
FY 2015 Accomplishments: Devised an improved understanding of interaction between gel chemistry and concrete to reduce explosive spalling under ultra-high temperatures; investigated multi-temporal radar physics to identify frequency dependencies of roughness scale and grain size of dielectrically similar soils and snow; directed tunable bacteriophage morphology to assemble high-ordered nanoscale structures.			
FY 2016 Plans: Determine the physical and chemical mechanisms that allow geopolymers to bond strongly to glass, ceramics, and metallic alloys with specific surface compositions; characterize the chemical structures that are involved in gels and thermal effects on gels; and provide fundamental theory for moisture effects on wave propagation in heterogeneous unsaturated soils.			
FY 2017 Plans:			

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** T22 / *Soil & Rock Mech*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
Will investigate soil moisture and density effects on signal to noise ratios in fiber optic sensors, signal diversity, and signal fading; quantify the transitions in soil stiffness with increasing saturation; and investigate the effect of soil organic matter and iron oxide content on quartz infrared response in natural soils.			
Title: Materials Modeling for Force Protection ***Description:*** The long-term goal of this task is to develop a structural ceramic composite that could replace steel and aluminum for most applications at one third the weight. To accomplish this goal, a technical ceramic such as silicon carbide will have to be improved five-fold in tensile strength and fracture toughness. ***FY 2015 Accomplishments:*** Identified and introduced energy dissipation mechanisms in novel multi-layered, heterogeneous structural systems to achieve significant weight reduction; and investigated fundamental nanoscale parameters of biological protective materials on the macroscale damage variables of a multi-layered protective material, where the macroscale variables were incorporated into simulations of multi-layered nano-composite materials. ***FY 2016 Plans:*** Investigate how the material interface prevents delamination for composites during impact and penetration loading; investigate the fundamental mechanisms of concrete composition that inhibit damage initiation and spread; determine calcium carbonate bonding strength in homogeneous mortar; and provide fundamental understanding of deformation and damage mechanisms provided by in-situ nano-mechanical testing and pre- and post-test characterization for metallic materials that exhibit strain rate insensitive stress-activated phase transformations and twinning. ***FY 2017 Plans:*** Will improve the understanding of damage in ultra-high performance concrete and will devise new methods to provide quantitative information about damage evolution; assess chemical and biological agent degradation potential by studying the photocatalytic activity of a biosynthetic polymer composite; and investigate the degradation mechanisms of sample composite systems.	3.206	2.319	2.351
Accomplishments/Planned Programs Subtotals	5.537	4.456	4.520

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** T22 / *Soil & Rock Mech*

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army			Date: February 2016
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*	Project (Number/Name) T23 / *Basic Res Mil Const*	

COST ($ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
T23: *Basic Res Mil Const*	-	2.045	1.722	1.747	-	1.747	1.777	1.809	1.844	1.881	-	-

A. Mission Description and Budget Item Justification

Work in the project fosters basic research and supports facilities research initiatives. The objective of Army installations basic research is to investigate, identify, and quantify the fundamental scientific principles that can be used to predict or influence the development of high performance facilities and sustainable installations, both fixed and contingency. Such basic research provides the requisite long term cost effective training and sustainment platforms for Army mission accomplishment. These efforts provide basic research leading to improved design in a range of facilities to optimize facility mission performance, enhance facility security, reduce design and construction errors and omissions, reduce resource requirements, and reduce the environmental burdens over the facility's life. This project provides leap-ahead technologies to solve military-unique problems in the planning, programming, design, construction, and sustainment of deployed facilities, and energy and utility infrastructure.

Work in this project provides the basic research basis for applied research in Program Element 0602784A (Military Engineering Technology) / Projects T41 (Military Facilities Engineering Technology) and T45 (Energy Technology Applied to Military Facilities).

The cited work is consistent with the Assistant Secretary of Defense for Research and Engineering science and technology priority focus areas and the Army Modernization Strategy.

Work in this project is performed by the Army Engineer Research and Development Center (ERDC), Vicksburg, MS.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
Title: Facilities Research	2.045	1.722	1.747
Description: Funding is provided for the following efforts.			
FY 2015 Accomplishments: Determined fundamental processes in microbial interactions with surfaces that lead to bio-fouling and corrosion; re-created plant photosynthesis processes in an artificial cell matrix.			
FY 2016 Plans: Identify microbial and chemical distribution in a biofilm correlated to points of corrosion; assess transport kinetics of self-assembling vesicles for photocatalytic hydrogen evolution in aqueous solutions; and interpret the vortical structure thermal field with shape memory alloy materials used for inducing vortices to enhance solid-fluid and thermal interactions.			
FY 2017 Plans:			

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
Will replicate key nanostructural and chemical composition features present in natural cicada wings to study parameters leading to self-cleaning, anti-fouling surfaces; and tune bacteriophage-based nanofibers to understand fundamental properties leading to piezoelectric energy generation.			
Accomplishments/Planned Programs Subtotals	2.045	1.722	1.747

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army			Date: February 2016
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*	Project (Number/Name) T24 / *Signature Physics And Terrain State Basic Research*	

COST ($ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
T24: *Signature Physics And Terrain State Basic Research*	-	1.981	1.627	1.649	-	1.649	1.675	1.706	1.740	1.775	-	-

A. Mission Description and Budget Item Justification

This project supports basic research to increase knowledge in the areas of terrain state and signature physics. It investigates the knowledge base for understanding and assessing environmental impacts critical to battlespace awareness. Projects include fundamental material characterization, investigation of physical and chemical processes, and examination of energy and mass transfer applicable to predicting state of the terrain, which control the effects of the environment on targets and target background signatures and mobility, in support of the materiel development community. The terrain state area of terrestrial sciences investigates weather-driven terrain material changes and the sensing and inferring of subsurface properties. The signature physics area of terrestrial sciences focuses on understanding the dynamic changes to electromagnetic, acoustic, and seismic signatures, and energy propagation in response to changing terrain state and near surface atmosphere.

Work in this project provides a foundation for applied research in Program Element 0602784A (Military Engineering Technology)/ Project 855 (Topographical, Image Intel and Space) and T42 (Terrestrial Science Applied Research).

The cited work is consistent with the Assistant Secretary of Defense, Research and Engineering science and technology focus areas and the Army Modernization Strategy.

Work in this project is performed by the Army Engineer Research and Development Center (ERDC), Vicksburg, MS.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
Title: Analysis for Signal and Signature Phenomenology (Previously titled - Terrain State and Signature Physics)	1.981	1.627	1.649
Description: Funding is provided for the following effort.			
FY 2015 Accomplishments: Investigated radio frequency propagation signal loss in mountainous terrain shadow zones to determine causes of attenuation variance to model predictions and determine the utility of a low frequency simulation with reduced computational demand to emulate actual high frequency behavior; enabled realistic modeling of high bandwidth impulsive waveforms to improve space/time localization of high resolution acoustic and electromagnetic receivers by extending wave propagation theory in random media to include decorrelations of signals over separations in space and time resulting from dynamic variability of the atmosphere.			
FY 2016 Plans: Determine controls on the broadband complex relative permitivities (a measure of resistance) of mixtures containing high salt content, such as ammonium nitrate, to determine the characteristic maximum frequency-domain that will establish the			

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** T24 / *Signature Physics And Terrain State Basic Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
scientific basis for subsurface geophysical technique for detection; establish proof of subsurface target detection through new electromagnetic methodology by understanding the causes of asymmetric dispersive resonance within full diffraction signatures from buried targets; and investigate high-frequency wave propagation methods to determine in-situ near-surface micro-pore geometry parameters in surface materials (forest litter, soil, and snow) to improve Army sensor systems through adjusting to changes in environmental conditions. ***FY 2017 Plans:*** Will formulate theory and numerical modeling approaches for sound propagation along long range and slanted paths through forests, with realistic representation of the vegetation and layered structure, to enable future capability for predicting long range acoustic and other wave propagation through dense forests and multi-tiered canopies; research broadband radio frequency (RF) spread spectrum scattering in mountainous terrain to understand effects of terrain geometry and vegetation on band structure that may lead to prediction of viable frequencies for improved communications in mountainous regions; and investigate the statistical evolution of signatures (target source) and their probability of detection, given imperfect knowledge of the battlefield environment, to improve physics-based estimates of sensor and communication system performance.			
Accomplishments/Planned Programs Subtotals	1.981	1.627	1.649

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army			Date: February 2016
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*	Project (Number/Name) T25 / *Environmental Science Basic Research*	

COST ($ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
T25: *Environmental Science Basic Research*	-	7.061	6.980	7.081	-	7.081	7.202	7.336	7.480	7.630	-	-

A. Mission Description and Budget Item Justification

This project supports basic research to investigate fundamental scientific principles and phenomena necessary to ensure efficient development of the technologies needed to address Army sustainment issues in the restoration, compliance, conservation, and non-industrial pollution prevention areas. These efforts include: investigating and monitoring contaminated sites, including chemical contamination and unexploded ordnance (UXO) detection and discrimination; better characterization of contaminants through improved risk-based assessment; destruction, containment, or neutralization of organics in water, soil, and sediments resulting from military activities; adhering to applicable federal, state, and local environmental laws and regulations; monitoring and controlling noise generation and transport; protecting and enhancing natural and cultural resources; reducing pollution associated with military activities; and the study of ecosystem genomics and proteomics in support of the Army's Network Science initiative.

Work in this project provides a fundamental basis for applied research in Program Element 0602720A (Environmental Quality Technology)/Project 048 (Industrial Operations Pollution Control Technology), Project 835 (Military Medical Environmental Criteria) and Project 896 (Base Facilities Environmental Quality).

The cited work is consistent with the Assistant Secretary of Defense for Research and Engineering science and technology priority focus areas and the Army Modernization Strategy.

Work in this project is performed by the Army Engineer Research and Development Center (ERDC), Vicksburg, MS.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
Title: Environmental and Ecological Fate of Explosives, Energetics, and Other Contaminants	2.797	3.719	3.781
Description: Funding is provided for the following efforts. ***FY 2015 Accomplishments:*** Determined the fundamental biological mechanisms that predict interactions of new insensitive munitions with environmental constituents; increased understanding of chemical-environmental interactions and ecosystem functions for advanced sensing; and provided underlying mechanisms of biological networks to utilize in man-made systems. ***FY 2016 Plans:*** Experimentally determine the fundamental environmental cues required to develop a workable multi-modular agent-based model decision network; determine the rate controlling physiological mechanisms in order to formulate a systems biology model which			

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** T25 / *Environmental Science Basic Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
will improve ability to rapidly assess and predict the effects of individual chemicals and mixtures of chemicals; and describe the fundamental relationship of perturbed biological pathways by toxicity of military materials and other chemicals across species. ***FY 2017 Plans:*** Will devise theoretical relationships between geomorphic specific nutrient and available water thresholds controlling the environmental persistence of munition constituents in soils as a foundation for site-specific predictions of munition constituents fate; will quantify chemical kinetic parameters for insensitive munition retention on soil mineral surfaces that can be used for predicting the long-term fate of inorganic and organic military relevant contaminants in the environment; and will determine mechanisms of zone migration and zone dispersion in a microfluidic separation (i.e. traveling-wave electrophoresis) that will lead to improved performance for separation and enrichment of toxicants, biomolecules, and military-specific compounds.			
Title: Fundamental Understanding of Explosives, Energetics and UXO in the Environment ***Description:*** Previously titled:Remediation of Explosives, Energetics, and UXO ***FY 2015 Accomplishments:*** Determined the potential for use of aquatic biological systems as a basis for trace chemical sensors in water; determined how understanding of chemical impact on biological systems can be translated across different species through similarities in molecular systems; and identified the mode of toxic interactions of multiple chemical mixtures in IMX. ***FY 2016 Plans:*** Assess the basics of physiological response to and toxicity of the IMX-101 mixture constituents and provide intensive characterization of the molecular and metabolic mechanisms for previously observed non-additive toxicity. ***FY 2017 Plans:*** Will increase understanding of insensitive munition photo-degradation pathways and kinetics through computational chemistry methods, lab experiments, and field sample analysis; and increase understanding of mechanistic sorption properties of insensitive munitions compounds on the surface of polysaccharide polymers, so the sorption properties can be tuned for selective binding of munitions compounds.	2.296	1.039	1.054
Title: Training Land Natural Resources ***Description:*** Funding is provided for the following efforts. ***FY 2015 Accomplishments:*** Investigated how invasive species impact the affected ecosystem at the molecular level; and determined the potential of novel mechanisms to assess ecosystem components utilizing specialized monitoring of unique sounds. ***FY 2016 Plans:***	1.097	1.306	1.327

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** T25 / *Environmental Science Basic Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
Investigate molecular mechanisms behind foreign species invasion and interpret findings to preventative and proactive strategies towards the management and containment of these species on military lands. ***FY 2017 Plans:*** Will decode the molecular basis of frog olfaction for amphibian conservation to provide an understanding of chemical cues that frogs can sense; will join a tunable genetic memory capability to a novel odor-based reporter to create a bio-alarm usable in austere environments; and will examine the relationship of climate and habitation to biodiversity to enable better predictions of climate change.			
Title: Network Science ***Description:*** Funding is provided for the following efforts. ***FY 2015 Accomplishments:*** Investigated how molecular design impacts biological function and how this can be translated to man-made systems like robotics; and investigated biological cell assembly mechanisms for man-made systems and programming. ***FY 2016 Plans:*** Evaluate the basic effects of noise (e.g., extraneous molecules, temperature) and resources on performance of synthetic networks through direct observation and modeling with statistical comparison of the performance of different synthetic circuits. ***FY 2017 Plans:*** Will investigate how biological signals propagate through a highly interconnected network of alternative paths and barriers, such as noise, signal degradation, competing responses, or physical obstructions.	0.871	0.916	0.919
Accomplishments/Planned Programs Subtotals	7.061	6.980	7.081

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army										Date: February 2016		
Appropriation/Budget Activity 2040 / 1					R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*				Project (Number/Name) T63 / *Robotics Autonomy, Manipulation, & Portability Rsh*			
COST ($ in Millions)	**Prior Years**	**FY 2015**	**FY 2016**	**FY 2017 Base**	**FY 2017 OCO**	**FY 2017 Total**	**FY 2018**	**FY 2019**	**FY 2020**	**FY 2021**	**Cost To Complete**	**Total Cost**
T63: *Robotics Autonomy, Manipulation, & Portability Rsh*	-	6.730	7.233	8.764	-	8.764	8.988	9.680	11.242	11.407	-	-

A. Mission Description and Budget Item Justification

This project supports basic research in areas that expands the autonomous capabilities, utility, and portability of small robotic systems for military applications, with a focus on enhanced intelligence, biomimetic functionality, and robust mobility, to permit these systems to serve as productive tools for dismounted Soldiers. It enables future systems to support and unburden Soldiers by integrating technologies with an understanding of cognitive and physical needs, and the missions of the humans and (non-human) agents operating on the battlefield. The ability of the Warfighter to command a suite of small unmanned systems (e.g., air, ground, and hybrid vehicles) reduces exposure of the Soldier to harm and improves the efficiency by which a dismounted unit achieves tactical objectives such as securing a targeted zone. Example missions requiring enhanced autonomy, manipulation, and man-portability include rapid room clearing and interior structure mapping; detection of human presence, chemical/biological/nuclear/radiological/explosive (CBNRE), and booby-traps; surveillance; and subterranean passage detection and exploration. Because of their relatively small size, light weight, and service in dismounted environments, small unmanned systems have unique challenges in perception, autonomous processing, mobility mechanics, propulsive power, and multi-functional packaging that transcend similar challenges associated with large unmanned systems. The Army Research Laboratory (ARL) conducts research in related disciplines, including machine perception, intelligent control, biomimetic robotics, manipulator mechanics, and propulsive power and drives to foster the development of technologies for lightweight, small-volume, robotics applications for harsh environments. Machine perception research includes the exploration of lightweight ultra-compact sensor phenomenology and the maturation of basic machine vision algorithms that enable small unmanned systems to more fully understand their local environment. Intelligent control research includes the maturation of autonomous processing capabilities and the advancement of artificial intelligence techniques that lead to reliable autonomous behavior in a large-displacement, highly-dynamic environment and permit unmonitored task performance. Research in biomimetic robotics and manipulator mechanics includes the advancement of mechatronic and biomimetic appendages to enable agile high-speed locomotion, dexterous task-performance, and environmental-manipulation; and the maturing of nonlinear control algorithms to support robust, stable mobility. Propulsion power research includes investigations of engine cycles and alternative hybrid energy conversion techniques to provide compact, lightweight, quiet, low-emission, high-density power sources that support highly-portable unmanned systems capable of performing long-endurance missions.

Work in this project supports key Army needs and provides the technical underpinnings to several Program Elements (PEs) to include PE 0601104A (University and Industry Research Center)/Project H54 (Micro-Autonomous Systems Technology Collaborative Technology Alliance) and PE 0602622A (Chemical, Smoke and Equipment Defeating Technology)/Project 552 (Smoke/Novel Effect Munition).

The cited work is consistent with the Assistant Secretary of Defense for Research and Engineering Science and Technology priority focus areas and the Army Modernization Strategy.

Work in this project is performed by ARL at the Aberdeen Proving Ground, MD.

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** T63 / *Robotics Autonomy, Manipulation, & Portability Rsh*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
Title: Robotics Autonomy and Human Robotic Interface Research	1.996	1.983	2.012
Description: In-house research with a focus on enabling robust autonomous mobility for small robotic systems, including autonomous operations in Global Positioning System (GPS) denied areas, planning, behaviors, intelligent control, and the interface of perception technologies to accomplish Army missions in the area of unmanned systems. These efforts include research activities in micromechanics conducted in association with the Micro Autonomous Systems and Technology Collaborative Technology Alliance (PE 0601104A/Project H54). ***FY 2015 Accomplishments:*** Conducted experimental studies related to fundamental flow behavior of very small scale air vehicles; explored algorithms for semantic labeling and relationship determination between objects in the environment to permit robots to interact with soldiers using more intuitive and natural means and to enable the robot to infer the purpose of objects and human activity; and examined novel locomotion concepts to enable greater efficiency and application in complex and confined environments. ***FY 2016 Plans:*** Explore the use of neuromorphic (software systems that implement models of neural systems) control employing analog elements to enable robust low-level control of microsystems; examine hybrid mobility concepts to enable robust maneuver in three dimensional environments, including biomimetic utilization of appendages, to achieve both functionality and efficiency; and explore control strategies to enable rapid, dynamic manipulation of objects. ***FY 2017 Plans:*** Will explore novel methods for learning and abstract reasoning to enhance understanding of the local environment by an intelligent unmanned vehicle; and explore novel methods for embedded control to facilitate intelligent manipulation of objects in the environment and modes of mobility.			
Title: Intelligent Systems	4.734	5.250	5.152
Description: Pursue in-house research that supports and unburdens Soldiers in a flexible, robust, survivable and comprehensive manner. This work will address the cognitive requirements of humans and (non-human) agents, both hardware and software based, operating individually or in collaboration, on the battlefield. Emphasis will be placed on perception, reasoning, and collaboration techniques that can apply to and transfer between a broad range of systems (such as: adaptive communication and data collection networks; cyber defense, crowd-sourcing and information retrieval software agents; and predictive and explanatory decision support systems). ***FY 2015 Accomplishments:*** Explored and characterized architectures and algorithms for intelligent explanation, facilitating human interpretation of machine outputs; investigated techniques for limited supervised learning to enhance machine recognition of threats and objectives and			

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** T63 / *Robotics Autonomy, Manipulation, & Portability Rsh*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
assessed their impact on baseline planning algorithms; and addressed socially-inspired concepts for collective intelligence in the context of dynamic situation assessment, re-organization and collaboration. ***FY 2016 Plans:*** Research the use of language as a construct for a robot architecture in the development of a common model for the physical (e.g., weather, terrain/structure, and other elements that affect mobility and speed) and operational (e.g., mission description, commanders intent, friendly and enemy forces disposition, and non-combatant participants) environment; explore the use of semantic understanding and learning to enhance robotic behavior and perceptual capabilities; and explore the use of abstractions (i.e., using common model with smaller number of descriptors to convey complex picture or concept) to enable effective communication between teammates, both human and machine, with reduced bandwidth requirements. ***FY 2017 Plans:*** Will assess the scalability of semantic labeling of objects and behaviors to permit a more detailed description of the environment; expand research on collaborative problem solving across a set of human, robotic and software agents; explore concepts for exploiting most relevant imagery and video for enhanced system autonomy; develop control algorithms to better enable real-time decision-making; and explore intelligent control strategies that couple sensing, control algorithms, and actuation for unique mobility modes applicable to small unmanned vehicles (e.g., legged mobility, hybrid ground/air).			
Title: Unmanned Air Vehicle Research ***Description:*** Conduct basic research focused on topics that contribute to the body of knowledge required to create future intelligent unmanned air systems that can effectively team with manned aircraft. Emphasis will be placed upon topics of control and aeromechanics that will expand the flight envelope for unmanned systems, manipulation of objects, and specialized topics relating to perception, reasoning, and creation of a common model of the surrounding environment and planning for behaviors in adversarial environments at high tempo. ***FY 2017 Plans:*** Will explore algorithms and concepts for perception, planning, and reasoning that will enable manned-unmanned teaming for unmanned air vehicles; and examine control techniques for the manipulation of objects by unmanned air platforms.	-	-	1.600
Accomplishments/Planned Programs Subtotals	6.730	7.233	8.764

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** T63 / *Robotics Autonomy, Manipulation, & Portability Rsh*

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army			Date: February 2016
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*	Project (Number/Name) T64 / *Sci BS/System Biology And Network Science*	

COST ($ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
T64: *Sci BS/System Biology And Network Science*	-	2.306	2.930	2.974	-	2.974	3.025	3.080	3.141	3.204	-	-

A. Mission Description and Budget Item Justification

This project fosters research investigations through a systematic approach using iterative computer simulation with mathematical modeling and biological information to analyze and refine biological studies. Information gained from these studies has the potential to provide a better understanding of the overall biological system and its molecular network of interactions, leading to improved early strategic decision-making in the development of preventive and treatment solutions to diseases. This approach establishes a model for application of computational biology processes and knowledge of biological networks to discover medical products that prevent and/or treat diseases or medical conditions.

The cited work provides theoretical underpinnings for Program Element 0602787A (Medical Technology).

Work in this project is performed by the Medical Research Materiel Command (MRMC), Fort Detrick, MD / Biotechnology High Performance Computing Software Applications Institute (BHSAI), Frederick, MD.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
Title: Network Sciences Initiative	2.306	2.930	2.974
Description: This effort involves the use of mathematical models and data search algorithms to extract medical information from large-scale genomics (generated from the study of cellular genetic makeup, protein structures and function, and whole organism responses) to improve understanding, prevention, diagnostics, and treatments of traumatic brain injury (TBI), post-traumatic stress disorder (PTSD), uncontrolled bleeding, infections, and exposure to environmental stressors and hazards.			
FY 2015 Accomplishments: Used algorithms to investigate the discrimination between biomarkers of mild, moderate, and severe TBI; tested and extended computational biology algorithms to identify drug targets and therapies for conditions such as infectious diseases; developed mathematical models of upper respiratory airflow patterns for the non-invasive diagnosis of pulmonary (lung) diseases; computationally predicted potential drug targets that could induce re-sensitization to current antibiotics in biofilm (a group of microorganisms that stick to each other, on a surface) forming bacteria (tend to be more antibiotic-resistant than individual bacteria); and mathematically modeled standard vital-sign data to enable the non-invasive prediction of heat stress injury and allow for timely counteractive measures.			
FY 2016 Plans:			

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** T64 / *Sci BS/System Biology And Network Science*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
Develop new models of (a) underlying mechanisms of blast-induced TBI and (b) susceptibility to stress-related bone fracture in male and female Warfighters related to the high level of repeated physical activity experienced during basic combat training (BCT); and improve and refine algorithms and models for (a) identification of drug targets and drugs for conditions such as infectious disease, trauma-inducted coagulopathy, and biofilm-producing bacteria, (b) upper respiratory airflow patterns for the non-invasive diagnosis of lung diseases, and (c) standard vital-sign data to enable the non-invasive prediction of heat-stress injury to allow for timely counteractive measures. ***FY 2017 Plans:*** Will improve and refine algorithms to identify the susceptibility to stress-related bone fracture in male and female Warfighters related to the high level of repeated physical activity experienced during BCT; will develop computational algorithms to investigate the association of genetic factors with neurological disorders, e.g., PTSD; will refine models to (a) predict drug targets for enhancing antibiotic sensitivity in wound pathogens that tend to be more antibiotic-resistant because they form biofilms, (b) identify key determinants that guide the evolution of viruses, and (c) identify molecular biomarkers of viral, e.g., Ebola virus, infection; will improve models to (a) identify cellular mechanisms of the inflammatory response, (b) predict blood coagulopathy genetic risk factors, and (c) investigate the underlying mechanisms of trauma-induced coagulopathy coupled with blood flow.			
Accomplishments/Planned Programs Subtotals	2.306	2.930	2.974

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army										Date: February 2016		
Appropriation/Budget Activity 2040 / 1					R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*				Project (Number/Name) VR9 / *Surface Science Research*			
COST ($ in Millions)	**Prior Years**	**FY 2015**	**FY 2016**	**FY 2017 Base**	**FY 2017 OCO**	**FY 2017 Total**	**FY 2018**	**FY 2019**	**FY 2020**	**FY 2021**	**Cost To Complete**	**Total Cost**
VR9: *Surface Science Research*	-	2.403	2.222	2.256	-	2.256	2.294	2.337	2.384	2.432	-	-

A. Mission Description and Budget Item Justification

This project fosters basic research to establish and maintain a core capability to enable a molecular level understanding of properties and behaviors of materials relevant to the Army; by developing understanding and ability to manipulate nanostructured materials as a means to tune properties which meet desired performance requirements; by advancing the scientific understanding of surface properties and interfacial dynamics of complex materials; and by providing scalable processes grounded in a molecular understanding of materials. This project funds basic research in the characterization of chemical and biochemical phenomena occurring at or near solid surfaces and interfaces; the interactions between chemical reactions and transport processes on surfaces; theory and modeling of processes at complex surfaces; and the synthesis and characterization of catalysts that function at the nanoscale. Investment in basic research centered on the surface science disciplines will enable growth of a knowledge base that will result in improved understanding of the interactions of complex materials in real world environments.

The cited work provides the theoretical underpinnings for Program Element 0602622A (Chemical, Smoke and Equipment Defeating Technology).

Work in this project is performed by the Army Edgewood Chemical and Biological Center (ECBC), Research, Development and Engineering Command, in Aberdeen, MD.

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2015**	**FY 2016**	**FY 2017**
Title: Surface Science Research	2.403	2.222	2.256
Description: The activities in this program are related to performing basic research in chemistry, biology, and physics on fundamental problems related to surfaces, interfacial dynamics, thin film materials, chemical-biological catalysis and opto-electronic/sensory technologies.			
FY 2015 Accomplishments: Investigated chemical and biochemical phenomena occurring at or near solid surfaces and material interfaces, to include the effects of binding energy, reactions, transport and deposition; the interactions between chemical reactions and transport processes on surfaces; theory and modeling of processes at complex surfaces; and experimental work focused on the systematic understanding of surface structure, morphology (the study of form and structure), and surface group properties.			
FY 2016 Plans: Conduct fundamental research related to the creation and synthesis of novel materials that allows for the precise control of chemical and biochemical phenomena occurring at surfaces and interfaces to include the effects of transport; research catalytic chemical reactions and transport processes on surfaces; further develop theory and multiscale modeling of processes at complex surfaces; and make physical measurements of surface structure, morphology, and properties.			
FY 2017 Plans:			

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** VR9 / *Surface Science Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
Will conduct fundamental research on the processes required to control transport of species across liquid-solid boundaries; research mechanisms associated with liquid-phase extraction of absorbed molecular species from polymers; and investigate techniques to enhance the charge transfer efficiency from a given absorbing molecule or material into semiconductor nanoparticles using theory and modeling of processes at complex nanostructured surfaces.			
Accomplishments/Planned Programs Subtotals	2.403	2.222	2.256

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2, RDT&E Budget Item Justification: PB 2017 Army											Date: February 2016	
Appropriation/Budget Activity 2040: *Research, Development, Test & Evaluation, Army I* BA 1: *Basic Research*					R-1 Program Element (Number/Name) PE 0601103A *I University Research Initiatives*							
COST ($ in Millions)	**Prior Years**	**FY 2015**	**FY 2016**	**FY 2017 Base**	**FY 2017 OCO**	**FY 2017 Total**	**FY 2018**	**FY 2019**	**FY 2020**	**FY 2021**	**Cost To Complete**	**Total Cost**
Total Program Element	-	79.122	72.603	69.166	-	69.166	69.339	70.730	71.205	72.701	-	-
D55: *University Research Initiative*	-	64.700	69.573	66.090	-	66.090	66.209	67.543	67.955	69.386	-	-
D58: *URI ACTIVITIES (CA)*	-	12.000	0.000	0.000	-	0.000	0.000	0.000	0.000	0.000	-	-
V72: *Minerva*	-	2.422	3.030	3.076	-	3.076	3.130	3.187	3.250	3.315	-	-

A. Mission Description and Budget Item Justification

This Program Element (PE) supports the Multidisciplinary University Research Initiative (MURI), the Defense University Research Instrumentation Program (DURIP), the Presidential Early Career Awards for Scientists and Engineers (PECASE)
program, and the Army's efforts in the Minerva Research Initiative (MRI). The MURI program funds university based basic research in a wide range of scientific and engineering disciplines pertinent to maintaining land combat technology superiority. Army MURI efforts involve teams of researchers investigating high-priority, transformational topics that intersect more than one traditional technical discipline (e.g., Intelligent Luminescence for Communication, Display, and Identification). For many complex problems, this multidisciplinary approach serves to accelerate research progress and expedite transition of results to application. The DURIP provides funds to acquire major research equipment to augment current, or devise new, research capabilities in support of Army transformational research. The PECASE program funds single-investigator research efforts performed by outstanding academic scientists and engineers early in their independent research careers. The MRI is a university-based social science research program.

Work in this PE provides a foundation for applied research initiatives at the Army laboratories and research, development and engineering centers.

The cited work is consistent with the Assistant Secretary of Defense for Research and Engineering Science and Technology priority focus areas and the Army Modernization Strategy.

Work on this PE is performed by the Army Research Laboratory (ARL) located in Research Triangle Park, NC.

Exhibit R-2, RDT&E Budget Item Justification: PB 2017 Army	Date: February 2016
Appropriation/Budget Activity 2040: *Research, Development, Test & Evaluation, Army* / BA 1: *Basic Research*	**R-1 Program Element (Number/Name)** PE 0601103A / *University Research Initiatives*

B. Program Change Summary ($ in Millions)	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total
Previous President's Budget	89.776	72.603	72.741	-	72.741
Current President's Budget	79.122	72.603	69.166	-	69.166
Total Adjustments	-10.654	0.000	-3.575	-	-3.575
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-8.000	-			
• SBIR/STTR Transfer	-2.654	-			
• Adjustments to Budget Years	-	-	-3.575	-	-3.575

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2015	FY 2016
Project: D58: *URI ACTIVITIES (CA)*		
Congressional Add: *Program Increase*	12.000	-
Congressional Add Subtotals for Project: D58	12.000	-
Congressional Add Totals for all Projects	12.000	-

Change Summary Explanation

FY 2015: Congressional increase for University Research Initiatives - totaled $20M. Army reprogrammed $8M of the congressional increase to PE 0601102, Project T14 for proper execution of congressional intent - (i.e., for Single Investigator).

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army			Date: February 2016
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601103A / *University Research Initiatives*	Project (Number/Name) D55 / *University Research Initiative*	

COST ($ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
D55: *University Research Initiative*	-	64.700	69.573	66.090	-	66.090	66.209	67.543	67.955	69.386	-	-

A. Mission Description and Budget Item Justification

This project supports the Multidisciplinary University Research Initiative (MURI), the Defense University Research Instrumentation Program (DURIP) and the Presidential Early Career Awards for Scientists and Engineers (PECASE) program. The MURI program funds university based basic research in a wide range of scientific and engineering disciplines pertinent to maintaining land combat technology superiority. Army MURI efforts involve teams of researchers investigating high-priority, transformational topics that intersect more than one traditional technical discipline (e.g. Intelligent Luminescence for Communication, Display, and Identification). For many complex problems, this multidisciplinary approach serves to accelerate research progress and expedite transition of results to application. The DURIP provides funds to acquire major research equipment to augment current, or devise new, research capabilities in support of Army transformational research. The PECASE program funds single-investigator research efforts performed by outstanding academic scientists and engineers early in their independent research careers.

Work in this project provides a foundation for applied research initiatives at the Army laboratories and research, development and engineering centers.

The cited work is consistent with the Assistant Secretary of Defense for Research and Engineering Science and Technology priority focus areas and the Army Modernization Strategy.

Work on this project is performed by the Army Research Laboratory (ARL) located in Research Triangle Park, NC.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
Title: Multidisciplinary University Research Initiative (MURI)	48.660	53.136	53.134
Description: MURI programs are typically 5 years in length at a cost of $1.25 million per year.			
FY 2015 Accomplishments: Provided support for MURI awards made in prior years and started eight new Fiscal Year (FY) 2015 (FY15) MURI awards critical to supporting the future force. Effective transition mechanisms included collaboration among principal investigators, participation by 6.2/6.3 program managers in MURI program reviews, and communication of the MURI research results to the ARL, Research Development and Engineering Centers (RDECs), Engineer Research and Development Center (ERDC), Medical Research and Materiel Command (MRMC), Army Research Institute for the Behavioral and Social Sciences (ARI) and industry.			
FY 2016 Plans: Provide support for MURI awards made in prior years and start six to eight new FY16 MURI awards critical to supporting the future force. Effective transition mechanisms include collaboration among principal investigators, participation by 6.2/6.3 program			

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601103A / *University Research Initiatives*	**Project (Number/Name)** D55 / *University Research Initiative*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
managers in MURI program reviews, and communication of the MURI research results to the ARL, RDECs, ERDC, MRMC, ARI and industry. ***FY 2017 Plans:*** Will provide support for MURI awards made in prior years, and will start six to eight new FY17 MURI awards critical to supporting the future force. Effective transition mechanisms will include collaboration among principal investigators, participation by applied research and advanced technology development program managers in MURI program reviews, and communication of the MURI research results to the ARL, RDECs, ERDC, MRMC, ARI and industry.			
Title: Presidential Early Career Awards for Scientists and Engineers (PECASE) ***Description:*** Supports PECASE investigators started in prior years. ***FY 2015 Accomplishments:*** Continued support for prior year awardees and selection of four new awards. ***FY 2016 Plans:*** Continue support for prior year awardees and select four new awards. ***FY 2017 Plans:*** Will continue support for prior year awardees and select four new awards.	4.329	4.478	4.546
Title: Defense University Research Instrumentation Program (DURIP) ***Description:*** Supports basic research through competitive grants for research instrumentation. ***FY 2015 Accomplishments:*** Awarded competitive grants for research instrumentation to enhance universities' capabilities to conduct world class research critical to Army transformation. ***FY 2016 Plans:*** Award competitive grants for research instrumentation to enhance universities' capabilities to conduct world class research critical to Army transformation. ***FY 2017 Plans:*** Will award competitive grants for research instrumentation to enhance universities' capabilities to conduct world class research critical to Army transformation.	11.711	11.959	8.410
Accomplishments/Planned Programs Subtotals	64.700	69.573	66.090

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601103A / *University Research Initiatives*	**Project (Number/Name)** D55 / *University Research Initiative*

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army			Date: February 2016
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601103A / *University Research Initiatives*	Project (Number/Name) D58 / *URI ACTIVITIES (CA)*	

COST ($ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
D58: *URI ACTIVITIES (CA)*	-	12.000	0.000	0.000	-	0.000	0.000	0.000	0.000	0.000	-	-

Note

Not applicable for this item.

A. Mission Description and Budget Item Justification

Congressional Interest Item funding provided for University Research Initiatives.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016
Congressional Add: Program Increase	12.000	-
FY 2015 Accomplishments: Congressional increase for University Research Initiatives - totaled $20M. Army reprogrammed $8M of the congressional increase to PE 0601102, Project T14 for proper execution of congressional intent (i.e., for Single Investigator).		
Congressional Adds Subtotals	12.000	-

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army			Date: February 2016
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601103A / *University Research Initiatives*	Project (Number/Name) V72 / *Minerva*	

COST ($ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
V72: *Minerva*	-	2.422	3.030	3.076	-	3.076	3.130	3.187	3.250	3.315	-	-

A. Mission Description and Budget Item Justification

This project supports the Minerva Research Initiative (MRI), a university-based social science research program initiated by the Secretary of Defense in Fiscal Year (FY) 2009. It focuses on areas in the social sciences that are of strategic importance to national security policy which have not been substantially pursued in the past. The Minerva research effort will be performed to understand the internal military-political dynamics of repressive regimes, the vulnerabilities of regimes and institutions to various kinds of disruption and instability, the nature of crowd dynamics, group violence, community belief structures, the potential to influence public opinion and attitudes in diverse cultures, cultural effects on network security and military operations, the influence of technology on military capabilities of potential adversaries and allies, and other intersections of social-cultural issues with military activities and national security. Predictive models and other analysis tools will be developed. Leveraging the expertise in the social sciences within the academic community is needed to provide understanding of the roots of terrorist organizations and the challenges and opportunities for military operations in a culturally diverse environment. Better understanding at a fundamental level and new computational tools will provide a beneficial impact on war fighting capabilities at the national policy, military strategy, operational, and tactical levels, and will enhance the capabilities of intelligence activities at all levels. All research results are open source.

The cited work is consistent with the Assistant Secretary of Defense for Research and Engineering science and technology priority focus areas and the Army Modernization Strategy.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
Title: The Minerva Research Initiative (MRI)	2.422	3.030	3.076
Description: The MRI is a university-based social science research program initiated by the Secretary of Defense. It focuses on areas in the social sciences of strategic importance to national security policy. It seeks to increase the Department's intellectual capital in the social sciences and improve its ability to address future challenges and build bridges between the Department and the social science community. Minerva will bring together universities, research institutions, and individual scholars and support multidisciplinary and cross-institutional projects addressing specific topic areas determined by the Department.			
FY 2015 Accomplishments: Tested theories on the direct and indirect effects of characteristics of natural resources on violence and state stability, which have provided predictive models of the relationship between natural resources and conflict, and provided options for anticipating and mitigating the acceleration of violence around the globe; and performed social scientific surveys with neuroscientific brain imaging revealing the role of moral values in social mobilization which in the long term provides effective strategies and policies in reducing organized violence and preventing its contagion.			
FY 2016 Plans:			

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601103A / *University Research Initiatives*	**Project (Number/Name)** V72 / *Minerva*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
Design and validate new quantitative models to identify the antecedents of civil unrest and violence, to generate new predictive models of the relationship between social systems, natural systems, and sociopolitical instability worldwide, enabling enhanced Army capacity to detect emerging political instabilities; and develop integrated geo-coded databases and time series data sets from existing archives to serve as experimental test beds for developing and validating predictive theories to identify potential hotspots for violence and instability that will aid in Army development of strategies for early intervention and reduction of sociopolitical violence. ***FY 2017 Plans:*** Will develop and validate new computational models that represent how failures in telecommunications, energy, transportation, and economic, systems propagate into civil and governmental systems, thus putting nations and regions at risk of conflict and sociopolitical instability, Will build and validate new models for interdependence between natural resources and state power structures. This work will provide insight regarding national and regional risk of conflict, sociopolitical instability, and threat of violence resulting from studied failures allowing for the development of appropriate mitigation and intervention strategies.			
Accomplishments/Planned Programs Subtotals	2.422	3.030	3.076

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2, RDT&E Budget Item Justification: PB 2017 Army											Date: February 2016	
Appropriation/Budget Activity 2040: *Research, Development, Test & Evaluation, Army* / BA 1: *Basic Research*					R-1 Program Element (Number/Name) PE 0601104A / *University and Industry Research Centers*							
COST ($ in Millions)	**Prior Years**	**FY 2015**	**FY 2016**	**FY 2017 Base**	**FY 2017 OCO**	**FY 2017 Total**	**FY 2018**	**FY 2019**	**FY 2020**	**FY 2021**	**Cost To Complete**	**Total Cost**
Total Program Element	-	105.766	104.340	94.280	-	94.280	94.903	98.297	98.660	100.589	-	-
EA6: *Cyber Collaborative Research Alliance*	-	4.039	3.234	3.281	-	3.281	3.338	4.887	4.984	5.084	-	-
F17: *Neuroergonomics Collaborative Technology Alliance*	-	3.838	5.254	5.332	-	5.332	4.924	4.721	4.832	4.945	-	-
H04: *HBCU/MI Programs*	-	3.024	1.887	1.486	-	1.486	1.536	1.591	1.630	1.671	-	-
H05: *Institute For Collaborative Biotechnologies*	-	7.692	6.485	6.595	-	6.595	6.727	6.870	7.008	7.148	-	-
H09: *Robotics CTA*	-	5.619	5.557	4.040	-	4.040	4.136	4.241	2.958	3.077	-	-
H50: *Network Sciences Cta*	-	11.057	11.065	9.166	-	9.166	9.037	8.824	8.708	8.686	-	-
H53: *Army High Performance Computing Research Center*	-	5.184	5.658	4.404	-	4.404	4.469	4.544	4.621	4.742	-	-
H54: *Micro-Autonomous Systems Technology (MAST) CTA*	-	7.021	7.679	6.792	-	6.792	6.678	6.572	6.733	6.898	-	-
H59: *International Tech Centers*	-	5.745	6.978	6.563	-	6.563	6.676	6.798	6.933	7.072	-	-
H73: *Automotive Research Center (ARC)*	-	3.040	3.133	3.180	-	3.180	3.234	3.294	3.359	3.426	-	-
J08: *Institute For Creative Technologies (ICT)*	-	7.210	6.080	6.186	-	6.186	6.309	6.442	6.572	6.703	-	-
J12: *Institute For Soldier Nanotechnology (ISN)*	-	6.454	6.080	6.185	-	6.185	6.308	6.445	6.574	6.705	-	-
J13: *UNIVERSITY AND INDUSTRY INITIATIVES (CA)*	-	6.100	4.000	0.000	-	0.000	0.000	0.000	0.000	0.000	-	-
J14: *Army Educational Outreach Program*	-	9.182	9.670	9.864	-	9.864	10.048	10.274	10.470	10.679	-	-
J15: *Network Sciences ITA*	-	3.712	4.070	4.078	-	4.078	4.083	4.112	4.152	4.235	-	-

Exhibit R-2, RDT&E Budget Item Justification: PB 2017 Army												Date: February 2016
Appropriation/Budget Activity 2040: *Research, Development, Test & Evaluation, Army* / BA 1: *Basic Research*					R-1 Program Element (Number/Name) PE 0601104A / *University and Industry Research Centers*							
J17: *Vertical Lift Research Center Of Excellence*	-	2.774	3.031	3.076	-	3.076	3.130	3.187	3.250	3.315	-	-
VS2: *Multi-Scale Materials Modeling Centers*	-	9.268	9.296	8.851	-	8.851	9.048	9.256	9.493	9.692	-	-
VS3: *Center For Quantum Science Research*	-	4.807	5.183	5.201	-	5.201	5.222	6.239	6.383	6.511	-	-

A. Mission Description and Budget Item Justification

This Program Element (PE) fosters university and industry based research to provide a scientific foundation for enabling technologies for future force capabilities. Broadly, the work in this PE falls into three categories: Collaborative Technology Alliances / Collaborative Research Alliances (CTAs/CRAs), University Centers of Excellence (COE), and University Affiliated Research Centers (UARCs). The Army formed CTAs to leverage large investments by the commercial sector in basic research areas that are of great interest to the Army. CTAs are industry-led partnerships between industry, academia, and the Army Research Laboratory (ARL) to incorporate the practicality of industry, the expansion of the boundaries of knowledge from universities, and Army scientists to shape, mature, and transition technology relevant to the Army mission. CTAs have been competitively established in the areas of Micro Autonomous Systems Technology (MAST), Network Sciences, Robotics, and Cognition and Neuroergonomics. CRAs are academia-led partnerships, which leverage the cutting-edge innovation found in the academic environment. CRAs have been established in the areas of Multi-Scale Materials Modeling (electronic materials and materials in extreme environments) and in cyber security. The COEs focus on expanding the frontiers of knowledge in research areas where the Army has enduring needs, and couples state-of-the-art research programs at academic institutions with broad-based graduate education programs to increase the supply of scientists and engineers in automotive and rotary wing technology. Also included are Army Educational Outreach Program (AEOP) and activities to stimulate interest in science, math, and technology among middle and high school students. This PE includes support for basic research at three Army UARCs, which have been created to exploit opportunities to advance new capabilities through a sustained long-term multidisciplinary effort. The Institute for Soldier Nanotechnologies focuses on Soldier protection by emphasizing revolutionary materials research for advanced Soldier protection and survivability. The Institute for Collaborative Biotechnologies focuses on enabling network centric-technologies, and broadening the Army's use of biotechnology for the development of bio-inspired materials, sensors, and information processing. The Institute for Creative Technologies is a partnership with academia and the entertainment and gaming industries to leverage innovative research and concepts for training and simulation. Examples of specific research of mutual interest to the entertainment industry and the Army are technologies for realistic immersion in synthetic environments, networked simulation, standards for interoperability, and tools for creating simulated environments. This PE also includes the Historically Black Colleges and Universities and Minority Institution (HBCU/MI) Centers of Excellence that address critical research areas for Army Transformation.

The cited work is consistent with the Assistant Secretary of Defense, Research and Engineering science and technology focus areas and the Army Modernization Strategy.

Work in this PE is performed by the ARL in Adelphi, MD; the Army Tank Automotive Research, Development, and Engineering Center (TARDEC) in Warren, MI; the Army Aviation and Missile Research, Development and Engineering Center (AMRDEC), in Huntsville, AL, and the Army Research, Development and Engineering Command (RDECOM), in Aberdeen, MD.

Exhibit R-2, RDT&E Budget Item Justification: PB 2017 Army					Date: February 2016
Appropriation/Budget Activity 2040: *Research, Development, Test & Evaluation, Army I* BA 1: *Basic Research*			R-1 Program Element (Number/Name) PE 0601104A *I University and Industry Research Centers*		
B. Program Change Summary ($ in Millions)	**FY 2015**	**FY 2016**	**FY 2017 Base**	**FY 2017 OCO**	**FY 2017 Total**
Previous President's Budget	108.782	100.340	101.725	-	101.725
Current President's Budget	105.766	104.340	94.280	-	94.280
Total Adjustments	-3.016	4.000	-7.445	-	-7.445
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	4.000			
• Congressional Directed Transfers	-	-			
• Reprogrammings	0.850	-			
• SBIR/STTR Transfer	-3.866	-			
• Adjustments to Budget Years	-	-	-7.445	-	-7.445

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2015	FY 2016
Project: J13: *UNIVERSITY AND INDUSTRY INITIATIVES (CA)*		
Congressional Add: *Program Increase*	6.100	4.000
Congressional Add Subtotals for Project: J13	6.100	4.000
Congressional Add Totals for all Projects	6.100	4.000

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army			Date: February 2016
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601104A / *University and Industry Research Centers*	Project (Number/Name) EA6 / *Cyber Collaborative Research Alliance*	

COST ($ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
EA6: *Cyber Collaborative Research Alliance*	-	4.039	3.234	3.281	-	3.281	3.338	4.887	4.984	5.084	-	-

A. Mission Description and Budget Item Justification

This project fosters research performed through the Cyber Security Collaborative Research Alliance (CSEC CRA), a competitively selected consortium, formed to advance the theoretical foundations of cyber science in the context of Army networks. This CRA consists of academia, industry and government researchers working jointly with the objective of developing a fundamental understanding of cyber phenomena so that fundamental laws, theories, and theoretically grounded and empirically validated models can be applied to a broad range of Army domains, applications, and environments. This research focuses on three interrelated aspects of cyber security and is conducted using a trans-disciplinary approach that takes into account the human element of the network. The three aspects of cyber that are addressed are: 1) vulnerabilities and risks of cyber networks to malicious activities, 2) anticipating, detecting, and analyzing malicious activities, and 3) agile cyber maneuver to thwart and defeat malicious activities. Overarching goals of cyber security are to significantly decrease the adversary's return on investment when considering cyber attack on Army networks, and minimizing the impact on (Army) network performance related to implementing cyber security. The CRA research creates a framework that effectively integrates the knowledge of cyber assets and potential adversary capabilities and approaches, and provides defense mechanisms that dynamically adjust to changes related to mission, assets, vulnerability state, and defense mechanisms.

Work in this project supports key Army needs and provides the technical underpinnings to Program Element (PE) 0602782A (Command, Control, Communications Technology)/Project H92 (Communications Technology).

The cited work is consistent with the Assistant Secretary of Defense for Research and Engineering science and technology priority focus areas and the Army Modernization Strategy.

Work in this project is performed by the Army Research Laboratory (ARL) in Adelphi and Aberdeen Proving Grounds, MD.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
Title: Cyber Security Collaborative Research Alliance	4.039	3.234	3.281
Description: The Cyber Security Collaborative Research Alliance (CSEC CRA) supports basic research to enable capabilities for rapid development and adaptation of cyber tools for dynamically assessing cyber risks, detecting hostile activities on friendly networks, and supporting agile maneuver in cyber space in spite of the continuous evolution and emergence of novel threats.			
FY 2015 Accomplishments: Developed theories and models relating fundamental properties and features of dynamic risk assessment algorithms to the fundamental properties of dynamic cyber threats, Army's networks, and defensive mechanisms taking into account the context of the mission; developed theories and models relating properties and capabilities of cyber threat detection and recognition			

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University and Industry Research Centers*	**Project (Number/Name)** EA6 / *Cyber Collaborative Research Alliance*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
processes/mechanisms to properties of malicious activity and of Army networks; developed theories and models to support planning and control of cyber maneuver (i.e., "maneuver" in the space of network characteristics and topologies) that would describe how control and the end-state of the maneuver are influenced by fundamental properties of threats - such as might be rapidly inferred from limited observations of a new, recently observed threat; and developed a theoretical understanding of the socio-cognitive factors that impact the decision making of the user/Soldier, defender/analyst, and adversary. ***FY 2016 Plans:*** Develop theories and models relating fundamental properties of dynamic cyber threats to dynamic risk assessments and defensive maneuver algorithms; develop a mathematical formalism for representing cyber tasks or missions that will provide a common framework for reasoning about risk, maneuver, detection and the underlying socio-cognitive factors; develop approaches to assessment of aggregate risk in such a dynamic hostile environment; develop diagnosis-enabling detection algorithms that can go from symptoms to root causes; develop and validate computational cognitive models that represent human processes of threat detection; and develop multi-party game-theory etic models and computational algorithms leading to pragmatic defense strategies. ***FY 2017 Plans:*** Will extend fundamental theories and models of dynamic cyber threats and defense developed in Fiscal Year (FY) 2015 and 2016, leading to practical defense strategies via analytical models of collaborative and composite risk, and appropriate communication of risk metrics; user/defender/attacker feedback models to capture interactions; optimized evidence collection and introspective detection; model-based generation and verification of cyber maneuvers; multi-party stealth games; and extensive validation on realistic data-sets and test-beds.			
Accomplishments/Planned Programs Subtotals	4.039	3.234	3.281

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army			Date: February 2016
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601104A / *University and Industry Research Centers*	Project (Number/Name) F17 / *Neuroergonomics Collaborative Technology Alliance*	

COST ($ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
F17: *Neuroergonomics Collaborative Technology Alliance*	-	3.838	5.254	5.332	-	5.332	4.924	4.721	4.832	4.945	-	-

A. Mission Description and Budget Item Justification

This project fosters research through the Cognition and Neuroergonomics Collaborative Technology Alliance (CTA), a competitively selected industry and university consortium, to leverage world-class research in support of future force and Army transformation needs. Escalating levels of complexity and uncertainty on the current and future battlefield present conditions which have never existed before now. Solution strategies and approaches must be developed or tailored. The emerging field of neuroergonomics, which seeks to understand the brain at work and to leverage that understanding to optimize system design, offers tremendous potential for providing the solutions needed to meet the needs of Army forces in the future. This CTA addresses the solution strategies and approaches needed to design systems to fully exploit investments in revolutionary technological advances in areas such as robotics, microelectronics, and computer and network information systems. These technologies present significant opportunities to enhance Army mission capabilities, but impose significant burdens on the human brain, which will ultimately limit Soldier-system effectiveness, sustainability, and survivability. The technical barriers associated with this project include: immature knowledge base to guide the neuroergonomic approach to human-system integration; inadequate capabilities to sense and extract information about brain activity in dynamic, operational environments; lack of valid measures to robustly and uniquely characterize operationally-relevant cognitive performance; lack of techniques for integrating advanced understandings of brain activity into systems designs, including real-time use of measures of cognitive behavior as system inputs and the capability to account for individual differences in maximizing Soldier-system performance. This CTA conducts an intensive and accelerated program to formulate, validate, and transition basic research findings through multi-dimensional approaches focused in three areas: understanding fundamental principles underlying Soldier neurocognitive performance in operational environments, advancing computational approaches for the analysis and interpretation of neural functioning, and fundamental advancement in neurotechnologies that enhance Soldier-system interactions and performance.

The cited work is consistent with the Assistant Secretary of Defense for Research and Engineering science and technology priority focus areas and the Army Modernization Strategy.

Work in this project is performed by the Army Research Laboratory (ARL) in Adelphi, MD.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
Title: Neurocognitive performance in operational environments	1.463	1.941	1.970
Description: This effort is intended to understand fundamental principles underlying Soldier neurocognitive performance in operational environments.			
FY 2015 Accomplishments:			

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University and Industry Research Centers*	**Project (Number/Name)** F17 / *Neuroergonomics Collaborative Technology Alliance*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
Evaluated neurocognitive performance using novel scenarios of increasing military relevance to determine feasibility of military applications; and identified methods of mathematical processing and evaluate utility for interpreting brain activity recordings under conditions that demand complex neural functioning of operationally relevant tasks. ***FY 2016 Plans:*** Develop novel set of algorithmic principles and approaches for integrating multiple, concurrently record data streams to enable interpretation and use of brain-based recordings in complex conditions; and enhance estimates of confidence in environmental and human states for improved reliability of sensor information. ***FY 2017 Plans:*** Will develop models of neural activity to characterize performance in Army-relevant tasks; and investigate relationships between brain activity recorded on the scalp and brain activity recorded within the skull to improve understanding of how the skull and scalp affect recorded brain signals.			
Title: Computational neural analysis ***Description:*** This effort advances computational approaches for the analysis and interpretation of neural functioning. ***FY 2015 Accomplishments:*** Used information obtained from data mining explorations of large-scale simulation for development of improved algorithms for brain computer interaction technologies that better account for variability among individuals. ***FY 2016 Plans:*** Develop algorithms that use adaptive approaches to account for the gradual changes in the mean and variance of the underlying neural signatures that occur when participants perform the same task for an extended period of time. Adapting to these time-on-task effects will increase the performance of brain computer interaction technology. ***FY 2017 Plans:*** Will develop algorithms for reliable comparisons between simple experimental tasks and operationally-relevant tasks; and develop analytical methods for automated characterization of within-subject, cognitive state fluctuations during long-term task performance.	1.148	1.599	1.622
Title: Neurotechnologies ***Description:*** This effort provides a fundamental advancement in neurotechnologies that enhance Soldier-system interactions and performance. ***FY 2015 Accomplishments:***	1.227	1.714	1.740

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University and Industry Research Centers*	**Project (Number/Name)** F17 / *Neuroergonomics Collaborative Technology Alliance*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
Pursued adaptation of neuroimaging technologies to enhance functionality in complex environments; and developed technical capabilities for identification of brain activity in realistic environments, including hardware and software algorithms robust to environmental and user-induced signal noise. ***FY 2016 Plans:*** Develop experimental mobile applications to monitor and track real-world fluctuations in sleep patterns and perceived levels of stress and fatigue in order to examine how these behavioral variations effect neural data; and develop novel big data mining methods to unite data on this effort that are collected at different research centers. ***FY 2017 Plans:*** Will investigate performance of dry electrode systems in high noise conditions inherent to real-world tasks for applications in mobile environments; and develop a combined hardware-software solution for mitigation of noise in the signal for enhanced interpretation of brain data.			
Accomplishments/Planned Programs Subtotals	3.838	5.254	5.332

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army			Date: February 2016
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601104A / *University and Industry Research Centers*	Project (Number/Name) H04 / *HBCU/MI Programs*	

COST ($ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
H04: *HBCU/MI Programs*	-	3.024	1.887	1.486	-	1.486	1.536	1.591	1.630	1.671	-	-

Note

Fiscal Year (FY) 2014 Office of the Secretary of Defense (OSD) funding for Historically Black Colleges and Universities and Minority Institutions (HBCU/MI)was realigned from the Research, Development, Test, and Evaluation (RDTE), Army appropriation to RDTE, Defense-wide appropriation. Army specific efforts continue to be funded in this project.

A. Mission Description and Budget Item Justification

This project supports basic research through the Partnership in Research Transition (PIRT) program, the Army's research initiative focused on partnerships with HBCU/MI, and provides support to Department of Defense (DoD) HBCU/MI program providing support for research and collaboration with DoD facilities and personnel for research and collaboration with DoD facilities and personnel. The focus of this effort is to enhance programs and capabilities of high-interest scientific and engineering disciplines through innovative research performed: 1) at Centers of Excellence (CoE) established at HBCU/MIs, and 2) through Collaborative Technology Alliances and Collaborative Research Alliances (CTA/CRAs). The COEs and CTA/CRAs work with Army, industry, and other academic partners to transition research to technology demonstration. In addition, the CoEs and CTA/CRA partnerships provide opportunities to recruit, educate, and train outstanding students and post-doctoral researchers in science and technology areas relevant to the Army.

Work in this project if fully coordinated with the OSDprogram manager for HBCU/MI programs.

Work performed in this project supports key Army needs and is coordinated with one or more of the following Projects: 0601104A (University and Industry Research Center)/Project EA6 (Cyber CRA), /Project F17 (Neuroergonomics CTA), /Project H09 (Robotics CTA), /Project H50 (Network Sciences CTA), Micro Autonomous Systems Technology CTA), and /Project VS2 (Multiscale Modeling of Materials).

The cited work is consistent with the Assistant Secretary of Defense for Research and Engineering science and technology priority focus areas and the Army Modernization Strategy.

Work on this project is performed by the Army Research Laboratory (ARL) in Adelphi, MD.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
Title: Centers of Excellence for Battlefield Capability Enhancements (BCE)	3.024	1.887	1.486
Description: Five new Partnership in Research Transition (PIRT) Centers of Excellence were established in 2011 at: Hampton Univ. (Lower Atmospheric Research Using Light Detection and Ranging (Lidar) Remote Sensing); NCA&T State Univ. (Nano to Continuum Multi-Scale Modeling Techniques and Analysis for Cementitious Materials Under Dynamic Loading); Delaware State Univ. (Center for Advanced Algorithms); Howard Univ.(2) (Bayesian Imaging and Advanced Signal Processing for Landmine			

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University and Industry Research Centers*	**Project (Number/Name)** H04 / *HBCU/MI Programs*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
and Improvised Explosive Device (IED) Detection Using Ground Penetrating Radar (GPR), and Extracting Social Meaning From Linguistic Structures in African Languages). These Centers were selected to: enhance programs and capabilities through Army-relevant, topic-focused, near-transition-ready innovative research; strengthen the capacity of the HBCUs to provide excellence in education; and to conduct research critical to the national security functions of the DoD. ***FY 2015 Accomplishments:*** Continued to support research at PIRT Centers of Excellence and collaboration with Army Labs and other institutions of higher learning to transition science and innovation to enhance warfighting capabilities of U.S. Soldiers. ***FY 2016 Plans:*** Conclude support of research at the five PIRT Centers of Excellence; and continue research investigations with HBCU/MIs universities, either through follow-on activity with PIRT Centers to enable research/technology transition or fund new high interest research with HBCU/MIs through single-investigator efforts, new centers of excellence, or other grant or cooperative research mechanisms. ***FY 2017 Plans:*** Will conduct new research efforts with HBCU/MIs through ARL's CTA/CRAs. Projects will be within the scope of CTA/CRAs and will represent opportunities to pursue new, high quality research in areas of strategic importance to the Army. Areas of research will include: network science, cognition and neuroergonomics, multiscale modeling of materials, robotics, and/or cyber security.			
Accomplishments/Planned Programs Subtotals	3.024	1.887	1.486

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army			Date: February 2016
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601104A / *University and Industry Research Centers*	Project (Number/Name) H05 / *Institute For Collaborative Biotechnologies*	

COST ($ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
H05: *Institute For Collaborative Biotechnologies*	-	7.692	6.485	6.595	-	6.595	6.727	6.870	7.008	7.148	-	-

A. Mission Description and Budget Item Justification

This project supports research at the Army's Institute for Collaborative Biotechnologies (ICB), led by the University of California-Santa Barbara, and two major supporting partners, the California Institute of Technology and the Massachusetts Institute of Technology. The ICB was established as a University Affiliated Research Center (UARC) to support leveraging biotechnology for: advanced sensors; new electronic, magnetic, and optical materials; and information processing and bioinspired network analysis. The objective is to perform sustained multidisciplinary basic research supporting technology to provide the Army with biomolecular sensor platforms with unprecedented sensitivity, reliability, and durability; higher-order arrays of functional electronic and optoelectronic components capable of self-assembly and with multi-functions; and new biological means to process, integrate, and network information. These sensor platforms will incorporate proteomics (large scale study of proteins) technology, DNA sequence identification and detection tools, and the capability for recognition of viral pathogens. A second ICB objective is to educate and train outstanding students and post-doctoral researchers in revolutionary areas of science to support Army Transformation. The ICB has many industrial partners, such as International Business Machine (IBM) and Science Applications International Corporation (SAIC), and has strong collaborations with Argonne, Lawrence Berkley, Lawrence Livermore, Los Alamos, Oak Ridge, and Sandia National Laboratories, the Army's Institute for Soldier Nanotechnologies, the Institute for Creative Technologies, and Army Medical Research and Materiel Command (MRMC) laboratories.

The cited work is consistent with the Assistant Secretary of Defense for Research and Engineering science and technology priority focus areas and the Army Modernization Strategy.

Work in this project is performed extramurally by the Army Research Laboratory (ARL) in Adelphi, MD.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
Title: Institute for Collaborative Biotechnologies	6.926	5.773	5.872
Description: Perform sustained multidisciplinary basic research supporting technology to provide the Army with bio-inspired materials and biomolecular sensor platforms.			
FY 2015 Accomplishments: Showed independent tuning of the temperature coefficient of resistance and noise to improve signal to noise ratio of room temperature infrared detectors; showed electrically injected, high-speed 1.55 μm nanoscale lasers on a silicon (Si) platform for potential gains in energy efficiency of computational and sensor systems; showing that plasmonic antennas can mitigate			

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University and Industry Research Centers*	**Project (Number/Name)** H05 / *Institute For Collaborative Biotechnologies*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
efficiency degradation for efficient data communications and energy harvesting; and created and investigated a novel sensor based on optical dark modes in nanorods for use in biomolecule, chemical sensing, and near-field imaging. ***FY 2016 Plans:*** Assess bacterial viability using ultra-high precision mass sensing for enhancement in Soldier protection against bacterial pathogens; experimentally engineer controlled biofeedback capability within cells to regulate cellular metabolic pathways and provide a basis for biosensing and environmental remediation; experimentally engineer scalable biological circuits in yeast cells that can provide sense-and-respond capabilities against harmful chemical and biological agents; experimentally design and synthesize soft, hydrogel microparticles and characterize their properties as cell mimics in vascular networks as a potential vehicle for drug delivery; show how the hierarchical and anisotropic structure of trabecular bone leads to its mechanical properties and translate such understanding to the fabrication of artificial bone; elucidate and translate mechanisms of biological, hierarchical self-assembly to synthetic, stimuli-responsive, optoelectronic materials that can provide responsive antireflective capabilities for the Soldier; experimentally test the ability of modified bacterial genes to enhance electron transfer within bacteria toward a novel means of energy generation; and using bio-inspired models, understand how shape, optical anisotropy and quasi-ordering at the nano-scale allow for control of the broad-band optical response of material interfaces toward improvements in infrared detection. ***FY 2017 Plans:*** Will conduct basic research efforts in systems and synthetic biology, photonic and electronic materials, cellular structural materials, and biotechnology tools; and increase research efforts in understanding and engineering microbial consortia for potential biological processing and manufacturing. Understanding microbial consortia and engineering them for biological processing/manufacture could provide the Army with the ability to produce complex chemical intermediates/feed stocks for material synthesis, bioremediation of toxic materials in the environment, probiotics for enhanced Solider health/performance, waste mitigation, and novel routes to energy generation for reduced logistics loads.			
Title: Neuroscience ***Description:*** Perform multidisciplinary basic research in the area of neuroscience. ***FY 2015 Accomplishments:*** Utilized psychophysics, mathematical modeling and cutting-edge neuroscientific measurements to explore the neural components underlying perceptual decision making, indecisiveness, learning capabilities and attentional states while performing complex visual tasks, which may ultimately lead to new methods, tools, and models to enhance warfighter performance; and explored the organizational principles governing the structure and topology of brain networks and analyzed brain imaging data that, in the long term, may enable the design of improved training protocols to reduce unwanted maladaptive behaviors. ***FY 2016 Plans:***	0.766	0.712	0.723

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University and Industry Research Centers*	**Project (Number/Name)** H05 / *Institute For Collaborative Biotechnologies*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
Investigate the potential of multi-brain computing and EEG to better understand group decision making, to predict the outcome of future human group decisions in complex tasks, and to track collective cognitive and emotional responses when presented with a common visual stimulus; investigate whether neural markers can be used to indicate biases that may affect optimal decision making; assess the variable influences of physical fatigue on cognition and on decisions that require complex motor behavior; and develop an understanding of the effects of stress on cognition and adaptive decision-making on the neural level toward a characterization of the interaction between decision-making and attentional mechanisms. ***FY 2017 Plans:*** Will continue supporting basic cognitive neuroscience research efforts to better understand decision-making, the effect of fatigue on cognition, and identification of neural indicators/biomarkers for optimal decision making; understand how the brain achieves accurate classification under high stress; and develop neuro-engineering techniques to make inferences about human's cognitive and attentional states that are particularly relevant to challenges faced by the Soldier.			
Accomplishments/Planned Programs Subtotals	7.692	6.485	6.595

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army			Date: February 2016
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601104A / *University and Industry Research Centers*	Project (Number/Name) H09 / *Robotics CTA*	

COST ($ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
H09: *Robotics CTA*	-	5.619	5.557	4.040	-	4.040	4.136	4.241	2.958	3.077	-	-

A. Mission Description and Budget Item Justification

This project supports a collaborative effort between the competitively selected industry and university consortium, the Robotics Collaborative Technology Alliance (CTA), and the Army Research Laboratory (ARL) for the purpose of leveraging world-class research in support of the future force and Army transformation needs. This project conducts basic research in areas that will expand the capabilities of intelligent mobile robotic systems for military applications with a focus on enhanced, innate intelligence, ultimately approaching that of a dog or other intelligent animal, to permit unmanned systems to function as productive members of a military team. Research is conducted in machine perception, including the exploration of sensor phenomenology, and the investigation of basic machine vision algorithms enabling future unmanned systems to better understand their local environment for enhanced mobility and tactical performance; intelligent control, including the advancement of artificial intelligence techniques for robot behaviors permitting future systems to autonomously adapt, and alter their behavior to dynamic tactical situations; understanding the interaction of humans with machines focusing upon intuitive control by Soldiers to minimize cognitive burden; dexterous manipulation of the environment by unmanned systems; and unique modes of mobility to enable unmanned systems to seamlessly navigate complex or highly constrained three dimensional environments. The program will conduct both analytic and validation studies.

Work in this projects builds fundamental knowledge for and complements the companion applied technology program, Program Element (PE) 0602120A, project TS2 (Robotics).

The cited work is consistent with the Assistant Secretary of Defense for Research and Engineering science and technology priority focus areas and the Army Modernization Strategy.

Work in this project is performed by the Army Research Laboratory (ARL) at the Aberdeen Proving Ground, MD.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
Title: Autonomous Systems	5.619	5.557	4.040
Description: Explore opportunities enabling revolutionary, autonomous, and highly mobile systems for the future force. Research focuses on unmanned systems operating as a team with human supervisors and displaying a high degree of adaptability to dynamic environmental and tactical situations.			
FY 2015 Accomplishments: Expanded upon utilization of learning to conduct semantic labeling of objects and behaviors; expanded upon the concept of a hybrid cognitive-metric architecture, including perceptual and reasoning skills, to enable teaming of humans and unmanned			

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University and Industry Research Centers*	**Project (Number/Name)** H09 / *Robotics CTA*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
systems; and explored novel modes of mobility, including legs and snake-like motion, to enable efficient, effective mobility in complex three-dimensional (3D) environments. ***FY 2016 Plans:*** Explore concepts and create algorithms to enable "peer-to-peer" teaming between humans and robots focusing upon a flexible multi-agent teaming architecture, problem solving at a cognitive level, and dialog to engender trust; examine mechanisms for creating social and tactical "understanding" and fast, adaptive, on-line, and on-the-fly learning and interaction with complex 3D environments. ***FY 2017 Plans:*** Will develop "peer-to-peer" teaming between humans and robots through expanded fine grained semantic perception especially through the inclusion of contextual information, exploration of deep-learning techniques and techniques for learning based upon sparse data, modeling of basic human behaviors, and exploration of techniques for energy efficient mobility in complex environments.			
Accomplishments/Planned Programs Subtotals	5.619	5.557	4.040

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army			Date: February 2016
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601104A / *University and Industry Research Centers*	Project (Number/Name) H50 / *Network Sciences Cta*	

COST ($ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
H50: *Network Sciences Cta*	-	11.057	11.065	9.166	-	9.166	9.037	8.824	8.708	8.686	-	-

A. Mission Description and Budget Item Justification

This project supports a competitively selected university and industry consortium, the Network Sciences Collaborative Technology Alliance (NS CTA), formed to leverage commercial research investments to provide solutions to Army's requirements for robust, survivable, and highly mobile wireless communications networks, while meeting the Army's needs for a state-of-the-art wireless mobile communications networks for command-on-the-move. The NS CTA performs foundational, cross-cutting network science research leading to: a fundamental understanding of the interplay and common underlying science among social/cognitive, information, and communications networks; determination of how processes and parameters in one network affect and are affected by those in other networks; and prediction and control of the individual and composite behavior of these complex interacting networks. This research will lead to optimized human performance in network-enabled warfare and greatly enhanced speed and precision for complex military operations. The CTA facilitates the exchange of people among the collaborating organizations to provide cross-organizational perspectives on basic research challenges, as well as the use of state-of-the-art facilities and equipment at the participating organizations.

Work in this project builds fundamental knowledge for and accelerates the transition of communications and networks technology to Program Element (PE) 0602783A (Computer and Software Technology).

The cited work is consistent with the Assistant Secretary of Defense for Research and Engineering science and technology priority focus areas and the Army Modernization Strategy.

Work in this project is performed by the Army Research Laboratory (ARL) in Adelphi, MD.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
Title: Network Sciences Collaborative Technology Alliance (NS CTA)	10.057	10.128	8.133
Description: The Network Sciences CTA focuses on four major research areas: Information Networks, Communication Networks, Social/Cognitive Networks, and Interdisciplinary Research to develop a fundamental understanding of the ways that information, social/cognitive, and communications networks can be designed, composed, and controlled to dramatically increase mission effectiveness and ultimately enable humans to effectively exploit information for timely decision-making. Information Networks research develops the fundamental understanding of autonomous network activities and its linkage to the physical and human domains as related to human decision making within the networked command and control (C2) structure. Social/Cognitive Networks research is developing the fundamental understanding of the interplay of the various aspects of the social and cognitive networks with information and communications. Communications Networks research is developing the foundational techniques to model, analyze, predict, and control the behavior of secure tactical communication networks as an enabler for information and C2			

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University and Industry Research Centers*	**Project (Number/Name)** H50 / *Network Sciences Cta*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
networks. Integration is focused on achieving an integrated Information Networks, Social/Cognitive Networks, Communications Networks research program that significantly enhances the fundamental understanding of the underlying science of networks. ***FY 2015 Accomplishments:*** Developed an understanding and associated metrics representative of the relationship between security and network performance in the context of tactical and coalition networks by developing models of socio-cognitive trust and quantification of trust relationships and risk management; developed theories of quality of information, employing human-in-the-loop analysis, to model the tradeoffs between quality of information and efficiency of analysis on affecting the accuracy of analysis and data interpretation; and developed mathematical representations for the quality of information of static and dynamic data and its effectiveness for situational awareness. These efforts resulted in the identification of data for more accurate situational awareness. ***FY 2016 Plans:*** Develop an analytical framework for modeling the dynamics and evolution of interacting multi-genre networks , such as interacting communications, information, and socio-cognitive network components of a tactical network (this will lead to new models for group-to-group interactions and algorithms and performance metrics for discovering unusual patterns); develop approaches for controlling networks with time-varying structures; develop a foundational science to model, characterize and control information delivered through multi-genre networks (based on the semantics and context of information requests and requisite composite quality-of-information measures); develop fundamental understanding of how to transform data and observations from multi-genre networks into relevant situational understanding for the users in a highly constrained environment; and develop mathematical and computational models of human networks, leading to models for influencing individuals and communities within and between cultures. ***FY 2017 Plans:*** Will model dynamics and co-evolution of inter-genre networks and discovery, inference, and prediction in inter-genre networks; generate models for optimal design and decentralized control of time-varying, non-linear, composite networks; derive algorithms for context-aware knowledge synthesis and analytics over multi-genre (communications, information and socio-cognitive) networks that model uncertainty in distributed processing and user interactions for better situational understanding; create a unifying semantic framework, in the context of multi-genre needs, to address information capacity across multi-genre networks, and to characterize and control the trade-offs in semantic information delivery; and generate predictive models of social-cognitive aspects of multi-genre networks, and mechanisms for influencing networks across cultures, and augmentation of human performance in networked operations.			
Title: Mobile Network Modeling Institute	1.000	0.937	1.033
Description: This research focuses on novel computational models, data structures, computational architectures and techniques that enable predictions of performance and stability of large, complex communications networks. It takes into account the impact			

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University and Industry Research Centers*	**Project (Number/Name)** H50 / *Network Sciences Cta*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
of Soldiers' information needs and modalities of access and use of communication networks in complex adversarial environments, high mobility, and adversarial effects such as jamming or cyber attacks. Also considered are computational modeling approaches that capture dynamics of information that flows through the network and/or is stored within the network, and undergoes continual changes as new information arrives and other information ages or is refuted/superseded by newly arrived information; and the impact of clouds and local tactical cloudlets on network behaviors. ***FY 2015 Accomplishments:*** Investigated approaches to computational modeling of large-scale networks that incorporate alternative routing techniques, such as trust-based or quality-based routing schemes; used computational experiments to inform study of pathological phenomena that might be induced in large-scale network behaviors by such novel schemes with unknown ramifications; explored impact of such models on existing computational architectures and their performance; and identified constraints on potential uses of alternative routing schemes on applicability of available computational modeling techniques. ***FY 2016 Plans:*** Develop high-fidelity scalable live-virtual simulation/emulation methods for large-scale networks on emerging large-scale high performance computing architectures; investigate uncertainty quantification methods to evaluate and improve highly dynamic live-virtual network modeling; and develop new validation mathematical methods and investigate how these methods can assist in training communication systems for Soldiers. ***FY 2017 Plans:*** Will validate high-fidelity scalable simulation methods for large-scale networks on emerging large-scale high performance computing architectures; use large-scale network experiments to observe and identify atypical behaviors with unknown ramifications; document methods for quantifying uncertainty (for large-scale networking modeling); and derive new mathematical algorithms on emerging heterogeneous computing that can assist in training communication systems for Soldiers.			
Accomplishments/Planned Programs Subtotals	11.057	11.065	9.166

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army			Date: February 2016
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601104A / *University and Industry Research Centers*	Project (Number/Name) H53 / *Army High Performance Computing Research Center*	

COST ($ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
H53: *Army High Performance Computing Research Center*	-	5.184	5.658	4.404	-	4.404	4.469	4.544	4.621	4.742	-	-

A. Mission Description and Budget Item Justification

This project supports critical research at the Army High Performance Computing Research Center (AHPCRC). Research at the AHPCRC is focused on the Lightweight Combat Systems Survivability, computational nano- and bio-sciences, computational battlefield network and information sciences including evaluating materials suitable for armor/anti-armor and sensor applications, defense from chemical and biological agents, and associated enabling technologies requiring computationally intensive algorithms in the areas of combat systems survivability, battlefield network sciences, chemical and biological defense, nanoscience and nanomechanics, and computational information sciences, scientific visualization enabling technologies that support the future force transition path.

The cited work is consistent with the Assistant Secretary of Defense for Research and Engineering science and technology priority focus areas and the Army Modernization Strategy.

Work in this project is performed by the Army Research Laboratory (ARL) in Adelphi, MD.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
Title: Army High Performance Computing Research Center (AHPCRC)	5.184	5.658	4.404

Description: The AHPCRC research mission is to advance computational science and its application to critical Army technologies through an Army-university-industry collaborative research program in such areas as combat systems survivability, and chemical and biological defense.

FY 2015 Accomplishments:

The goal of the reduced order modeling (ROM) for underbody blast project is to develop predictive capability for practical underbody blast applications. Earlier work demonstrated feasibility by adopting Department of Defense (DoD) engineering software Conventional Weapons Effects. Developed highly non-linear mathematical formulations and implemented fully coupled, high-fidelity blast-structure interaction problem-solving. Developed and implemented new energy conserving algorithms in the context of ROM; validated, verified and transitioned research software working with Army partners; continued exascale algorithms development under LISZTFE (domain specific finite element code) environment; investigated a new class of direct solvers, called fast direct solvers (FDS), which use low-rank-matrix approximations to reduce the computational complexity; transitioned software developed for blood transfusion; and continued new scalable algorithmic development research for simulating inhalation of toxic agents for realistic patient-specific geometric features.

FY 2016 Plans:

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University and Industry Research Centers*	**Project (Number/Name)** H53 / *Army High Performance Computing Research Center*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
Validate the innovative Model Order Reduction (MOR) method for underbody blast application with experimental data and show two orders of magnitude increased efficiency of MOR method; develop new programming models for emerging heterogeneous memory hierarchies for tactical High Performance Computing (HPC); and develop domain specific languages for mesh based and graph problems and explore these algorithmic approaches for exascale computers. ***FY 2017 Plans:*** Will investigate new scalable methods for data intensive sciences, specifically exploring next generation computing architectures (scalable algorithms development for data intensive sciences); research next generation computing and programming models and battle command software for emerging heterogeneous memory and storage hierarchies; and develop algorithmic approaches for exascale computers for physics based modeling.			
Accomplishments/Planned Programs Subtotals	5.184	5.658	4.404

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army			Date: February 2016
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601104A / *University and Industry Research Centers*	Project (Number/Name) H54 / *Micro-Autonomous Systems Technology (MAST) CTA*	

COST ($ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
H54: *Micro-Autonomous Systems Technology (MAST) CTA*	-	7.021	7.679	6.792	-	6.792	6.678	6.572	6.733	6.898	-	-

A. Mission Description and Budget Item Justification

This project fosters basic research through the Micro Autonomous Systems and Technology (MAST) Collaborative Technology Alliance (CTA), a competitively selected industry-university consortium which leverages world-class research necessary to address future force and Army Transformation needs. The CTA links a broad range of government technology agencies, as well as industrial and academic partners with the Army Research Laboratory (ARL). The MAST CTA focuses on innovative research in four main technical areas related to the coherent and collaborative operation of multiple micro autonomous platforms: microsystem mechanics, processing for autonomous operation, microelectronics, and platform integration. Payoff to the warfighter will be advanced technologies to support future force requirements in situational awareness. The CTA facilitates the exchange of people among the collaborating organizations to provide cross-organizational perspectives on basic research challenges, and to make available to the Alliance state-of-the-art facilities and equipment at the participating organizations.

Work in this project complements and is fully coordinated with the U.S. Army Tank and Automotive Research, Development, and Engineering Center (TARDEC); the U.S. Army Natick Soldier Research, Development, and Engineering Center (NSRDEC); and the U.S. Special Operations Command (SOCOM).

The cited work is consistent with the Assistant Secretary of Defense for Research and Engineering science and technology priority focus areas and the Army Modernization Strategy.

Work in this project is performed by the ARL in Adelphi, MD.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
Title: Micro-Autonomous Systems Technology (MAST) CTA	7.021	7.679	6.792
Description: Enhance tactical situational awareness in urban and complex terrain by enabling the autonomous operation of a collaborative ensemble of multifunctional mobile microsystems.			
FY 2015 Accomplishments: Investigated bio-inspired air and ground robotic platform mobility and control methods (for Micro-Autonomous Systems (MAS) in real world environments), sensors (for on-board state estimation and perception for size, weight, power, and processing constrained MAS), and architectures and algorithms (for heterogeneous teaming, communications, and navigation); studied trades between increased risk, uncertainty and increased operational tempo; and conducted joint experiments on emerging MAS			

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University and Industry Research Centers*	**Project (Number/Name)** H54 / *Micro-Autonomous Systems Technology (MAST) CTA*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
technology to assess the ability to support rapid and mobile Intelligence, Surveillance, and Reconnaissance for the Soldier in complex three-dimensional (3D) environments. ***FY 2016 Plans:*** Investigate 1) bio-inspired optic flow, sensors, and control algorithms for micro aerial platforms with goal of increasing platform stability and agility, 2) principles of transitions between surfaces for MAST-scale ambulatory robots to operate in complex 3D terrains, and 3) an advanced 5 gram sub-millimeter radar for use in obstacle detection and platform navigation. Determine methods to enable 1) cooperative control for teams of micro autonomous platforms, 2) rapid deployment of heterogeneous robot teams for exploration of unknown environments, 3) robust estimation and path planning for navigation in 3D environments, and 4) bio-inspired landing, perching and grasping for micro aerial vehicles. ***FY 2017 Plans:*** Will analyze, integrate and experimentally validate bio-inspired optic flow and gust detection sensors and control algorithms for MAST-scaled aerial platforms; analyze, integrate, and experimentally validate increased platform stability and bio-inspired agility concepts for MAST-scale ambulatory robots in complex 3D terrains; characterize and experimentally validate an advanced 5 gram submillimeter radar concept for obstacle detection and platform navigation; develop and experimentally validate advanced optical methods to enable cooperative control for teams of MAST-scaled platforms; characterize methods and experimentally validate rapid deployment of heterogeneous robot teams for exploration of unknown environments and bio-inspired landing, perching, and grasping for micro-aerial vehicles; and develop and experimentally validate concepts for robust communications in complex RF environments.			
Accomplishments/Planned Programs Subtotals	7.021	7.679	6.792

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army			Date: February 2016
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601104A / *University and Industry Research Centers*	Project (Number/Name) H59 / *International Tech Centers*	

COST ($ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
H59: *International Tech Centers*	-	5.745	6.978	6.563	-	6.563	6.676	6.798	6.933	7.072	-	-

A. Mission Description and Budget Item Justification

This project funds the International Technology Centers (ITCs), the Foreign Technology (and Science) Assessment Support (FTAS) program, and the Basic Research Center for Network Science located at the United States Military Academy (USMA).

The nine ITCs located in Australia, the United Kingdom, Canada, France, Germany, Japan, Chile, Argentina, and Singapore support the Army's goals of providing the best technology in the world to our Warfighters by leveraging the Science and Technology (S&T) investments of our international partners. The ITCs perform identification and evaluation of international technology programs to assess their potential impact on the Army's S&T investment strategy. ITC 'technology finds' are submitted as technology information papers (TIPs) to various Army S&T organizations for evaluation and consideration for further research and development. The FTAS program builds upon the TIPs submitted by the ITCs. In some cases the TIP is truly unique and may well meet an Army requirement or potentially support ongoing Army S&T investments. In such cases, the FTAS program can provide initial resources (seed money) to fund basic research in these technology areas identified by the TIPs as having potential relevance to the Army. The research will provide information useful in making early assessments of the technology's potential contributions to the Army's S&T strategy.

Work in this project related to the USMA Basic Research Center for Network Science is fully coordinated with and complementary to PE 0601104A (University and Industry Research Centers)/Project H50 (Network Science CTA).

The cited work is consistent with the Assistant Secretary of Defense for Research and Engineering science and technology priority focus areas and the Army Modernization Strategy.

Work in this project is performed by Headquarters, Army Research, Development and Engineering Command (RDECOM), the Army Research Laboratory (ARL) in Adelphi, MD, and the United States Military Academy, NY.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
Title: International Technology Centers (ITC)	5.351	6.469	6.563
Description: Funding is provided for the following effort.			
FY 2015 Accomplishments:			

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Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University and Industry Research Centers*	**Project (Number/Name)** H59 / *International Tech Centers*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
Solicited projects and built on the success of the FTAS Program; continued to enhance and refine technology search capabilities using customer feedback (U.S. Army Research, Development and Engineering Centers (RDECs), Program Managers (PMs) and labs) to focus on near and long term capabilities. ***FY 2016 Plans:*** Continue to solicit projects and build on the success of the FTAS Program; continue to enhance and refine technology search capabilities using customer feedback (RDECs, PMs and labs) to focus on near and long term capabilities. ***FY 2017 Plans:*** Will continue to solicit projects and build on the success of the FTAS Program; continue to enhance and refine technology search capabilities using customer feedback (RDECs, PMs and labs) to focus on near and long term capabilities.			
Title: Basic Research Center in Network Science at the United States Military Academy (USMA) ***Description:*** Network science research at USMA in coordination with the Network Science CTA (0601104A/Project H50). ***FY 2015 Accomplishments:*** Continued to refine algorithms based on the convergence of "vertex probabilities" to improve the ability to "influence" networks; and continued to refine advances in cooperation networks to include how these theoretical frameworks can improve systems and organizations. ***FY 2016 Plans:*** Building academic impact networks and military information networks (unit teams) and refining process algorithms that produce and enhance advances in performance, collaboration and cooperation; validating systems using operational data to design and optimize network frameworks and processes to improve military systems and unit organizations. Theoretical work is connected with intelligence, surveillance, and reconnaissance and command and control systems (mission command) and results are used in Army Training and Doctrine Command (TRADOC)-supported exercises; research subgroup measures, topological models and information security algorithms to support the use of network science in cyber and intelligence processing systems; and refining economic development models and cultural and logical networks in Africa to assist military decision makers and diplomatic policy makers.	0.394	0.509	-
Accomplishments/Planned Programs Subtotals	5.745	6.978	6.563

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University and Industry Research Centers*	**Project (Number/Name)** H59 / *International Tech Centers*

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army			Date: February 2016
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601104A / *University and Industry Research Centers*	Project (Number/Name) H73 / *Automotive Research Center (ARC)*	

COST ($ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
H73: *Automotive Research Center (ARC)*	-	3.040	3.133	3.180	-	3.180	3.234	3.294	3.359	3.426	-	-

A. Mission Description and Budget Item Justification

This project fosters basic research in novel, high payoff technologies that can be integrated into Army ground platforms. The Center of Excellence for Automotive Research is part of the basic research component of the National Automotive Center (NAC), a business group within the Army Tank-Automotive Research, Development, and Engineering Center (TARDEC). The Center of Excellence for Automotive Research is an innovative university/industry/government consortium leveraging commercial technology for potential application in Army vehicle systems through ongoing and new programs in automotive research, resulting in significant cost savings and performance enhancing technological opportunities. The research performed in this project contributes to formulating and establishing the basic scientific and engineering principles for these technologies.

Work in this project complements and is fully coordinated with work under Program Element (PE) 0602601A (Combat Vehicle and Automotive Technology). Selected university partners include: University of Michigan, Virginia Tech, Wayne State University, University of Iowa, Oakland University, and Clemson University. Key industry partners include all major US automotive manufacturers and suppliers. The Automotive Research Center (ARC) formulates and evaluates advanced automotive technologies and advances state-of-the-art modeling and simulation for the Army's future ground vehicle platforms.

The cited work is consistent with the Assistant Secretary of Defense for Research and Engineering science and technology priority focus areas and the Army Modernization Strategy.

Work in this project is performed by TARDEC, Warren, MI.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
Title: Automotive Research Center (ARC)	3.040	3.133	3.180
Description: Funding is provided for the following effort.			
FY 2015 Accomplishments: Developed valid predictive simulations tools that integrate design strategies that include reliability, product life management and human/machine interactions; improved characterization and representation of human attributes, capabilities, responses, tolerance, and behaviors and employ this knowledge; and pursued occupant centric vehicle structures that provide safety from explosive threats.			
FY 2016 Plans:			

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University and Industry Research Centers*	**Project (Number/Name)** H73 / *Automotive Research Center (ARC)*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
Research and develop modeling and simulation methodologies for enabling autonomy in ground vehicle systems and increased force protection/survivability; research tire and track modeling necessary for terramechanics advancements. Research thrust areas focus on dynamics and control of vehicles with emphasis on autonomy-enabled systems, human-centered modeling and simulation, high performance structures and materials, advanced and hybrid power trains, and vehicle system integration, optimization and robustness.			
FY 2017 Plans: Will expand research and further develop modeling and simulation methodologies for enabling autonomy in ground vehicle systems and increased force protection/survivability focused on real-time obstacle avoidance, latency compensation and shared human-machine control; research tire and track modeling and other off-road mobility related topics necessary for terramechanics advancements. Research thrust areas will focus on dynamics and control of vehicles with emphasis on autonomous and autonomy-enabled systems, human-centered modeling and simulation, high performance structures and materials as it pertains to lightweighting/advanced battery systems/lubricants/fuels, next-generation propulsion systems, advanced and hybrid power trains, and vehicle system integration, multi-objective and multi-disciplinary design optimization and robustness focused on modular systems that are expeditionary in nature.			
Accomplishments/Planned Programs Subtotals	3.040	3.133	3.180

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army			Date: February 2016
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601104A / *University and Industry Research Centers*	Project (Number/Name) J08 / *Institute For Creative Technologies (ICT)*	

COST ($ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
J08: *Institute For Creative Technologies (ICT)*	-	7.210	6.080	6.186	-	6.186	6.309	6.442	6.572	6.703	-	-

A. Mission Description and Budget Item Justification

This project supports simulation and training technology research at the Army's Institute for Creative Technologies (ICT) at the University of Southern California. The ICT was established as a University Affiliated Research Center (UARC) to support Army training and readiness through research into simulation, mixed and virtual reality, artificial intelligence, computer graphics, and learning sciences. ICT applies the results of this research and proves its value in Army relevant applications such as training, mission rehearsal, leadership development, cultural awareness, negotiation, health and medical, and distance learning. The ICT actively performs research and engages industry and academic institutions internationally to incorporate the latest research results and hardware and software into its research program and application development and exploit dual-use technology. The ICT serves as a means for the military to learn about, benefit from, and facilitate the transfer of applicable technologies into military systems. In addition the ICT works with creative talent from the entertainment industry to advance and leverage techniques and capabilities and adapt concepts of story and character to increase the degree of participant immersion in synthetic environments in order to improve the realism and usefulness of these experiences. In developing a true synthesis of the creativity, research, technology, and capability of industry and the research and development community, the ICT is revolutionizing capabilities for the Army by making it more effective in terms of cost, time, range of experiences and the quality of the result and by producing research and applications that will benefit the Army of the 21st century. Resulting research, techniques, and technologies are transitioned for maturation to Program element (PE) 0602308A/project D02 (Modeling and Simulation for Training and Design).

The cited work is consistent with the Assistant Secretary of Defense for Research and Engineering science and technology priority focus areas and the Army Modernization Strategy.

Work in this project is performed by the Army Research Laboratory (ARL) in Adelphi, MD.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
Title: Immersive Environments	2.770	2.307	2.347
Description: Conduct basic research in immersive environments, to include virtual humans, three-dimensional (3D) sound and visual media, to achieve more efficient and affordable training, modeling, simulation and application solutions and tools. Research includes investigation of techniques and methods to address the rapid development of synthetic environments and the study of perception and cognition to help direct the development of new technologies and techniques that evoke more realistic responses from users. Perform research into auditory aspects of immersion to provide the sound stimulus for increasing the realism for military training and simulation devices.			
FY 2015 Accomplishments:			

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University and Industry Research Centers*	**Project (Number/Name)** J08 / *Institute For Creative Technologies (ICT)*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
Investigated techniques for creating immersive environments and interactions with virtual humans on computing platforms with limited computational resources such as tablet computers and mobile devices; and assessed effectiveness of techniques across a variety of contexts (e.g., training, mission rehearsal). ***FY 2016 Plans:*** Continue investigation of techniques for creating immersive environments using mobile computing platforms such as tablet computers, smart phones, and other mobile devices for the purpose of training and mission rehearsal; and explore the creation of novel virtual reality training platforms using mixed reality techniques and coordinated quadrotor robots to expand virtual training operating space. ***FY 2017 Plans:*** Will conduct studies with immersive virtual reality environments to identify ways to induce users to react in realistic and naturalistic ways to support more effective training and learning experiences in virtual spaces; investigate research technologies to automatically recognize nonverbal behaviors and interpersonal dynamics in groups for improved human-computer and human-robot interactions; and investigate the use of machine learning techniques to acquire automatically through interaction with users a variety of linguistic features that support more natural and fluid language interaction.			
Title: Graphics and Animations ***Description:*** Conduct basic research to identify new computational techniques in graphics for achieving real-time photo-realistic rendering of physical and synthetic environments for training and simulations. Research innovative methods for automatically generating animations and gestures for virtual humans based on what is being communicated. Research new technologies for scanning real people and rapidly generating virtual humans which look like these people significantly reducing the time, expense and effort required to develop virtual humans and virtual environments. ***FY 2015 Accomplishments:*** Researched and developed new methods and algorithms in multi-view optical flow triangulation to align laser-scanned geometry with photographs to reconstruct missed data from previous data capture pipelines. ***FY 2016 Plans:*** Develop finite element models to improve facial capture performance and animation of eyes and lips for virtual humans allowing for enhanced non-verbal communications in social interactive training environments; and develop techniques to display life-sized, 3D virtual humans resulting in a high-fidelity, simulated social interactions for training and leader development. ***FY 2017 Plans:*** Will research new technologies for developing life-like, high definition novel performances that include the rapid synthesis of a wide range of facial animations by digital characters allowing for the creation of new performances even when the original	1.668	1.409	1.434

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University and Industry Research Centers*	**Project (Number/Name)** J08 / *Institute For Creative Technologies (ICT)*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
(real) subject is no longer available; investigate methods and techniques for the autostereoscopic rendering and display of virtual humans in 3D shared spaces such that they can be viewed by multiple simultaneous viewers without the need for special glasses or headwear; research computational camera system techniques for the purpose of rapidly capturing photorealistic digital characters and authoring performance-driven animations; conduct experiments to determine effectiveness of the human-virtual human interaction at varying levels of fidelity; and extend virtual character capture methods to extract and model hair and cloth to improve the photorealism of dynamic virtual characters.			
Title: Techniques and Human-Virtual Human Interaction ***Description:*** Will conduct basic research to investigate methods and techniques for creating virtual humans — computer-generated characters that look, communicate and behave like real people meaning virtual humans will be autonomous, use verbal and non-verbal communication, exhibit emotions, model their own beliefs, desires and intentions as well as those of others, and reason using advanced artificial intelligence. Investigate methods and techniques for improving the perception, communication, understanding, and responsiveness of virtual humans when interacting with live humans and explore how people relate to virtual humans. ***FY 2015 Accomplishments:*** Conducted evaluations and developed theoretical design frameworks to identify the most cost-effective balance between virtual human fidelity and training effectiveness and investigate an individual's response to the human-like behaviors (e.g., persuasion, cultural biases, etc.) of virtual role-players; extended virtual human cognitive architecture research to recognize various human behaviors and learn from the agent's past experiences; and investigated the use of linguistics and machine learning for automated knowledge acquisition allowing for the creation of more intelligent and communicative artificial agents. ***FY 2016 Plans:*** Develop and validate theoretical framework to increase the effectiveness of human interactions with virtual humans and robots; develop algorithms and models for virtual humans to engage in multiple activities extending their conversational ability to beyond one specific scenario; and continue development of human cognitive architecture supporting virtual human learning. ***FY 2017 Plans:*** Will explore strategic use of emotion and how emotional displays can be used to manipulate negotiation outcomes and develop a dynamic computer model representation; extend research to explore in depth differences between how people respond to virtual humans, real humans and robots; create meta-dialogue strategies for controlling interactions between people and virtual humans and use online learning to enhance speech synthesis so that virtual humans engage in human-like interaction with people and other virtual human agents; and refine conceptual virtual humans architecture to validate advanced and more natural emotional behaviors, reasoning, and interactions via natural language and speech.	2.772	2.364	2.405
Accomplishments/Planned Programs Subtotals	7.210	6.080	6.186

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University and Industry Research Centers*	**Project (Number/Name)** J08 / *Institute For Creative Technologies (ICT)*

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army			Date: February 2016
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601104A / *University and Industry Research Centers*	Project (Number/Name) J12 / *Institute For Soldier Nanotechnology (ISN)*	

COST ($ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
J12: *Institute For Soldier Nanotechnology (ISN)*	-	6.454	6.080	6.185	-	6.185	6.308	6.445	6.574	6.705	-	-

A. Mission Description and Budget Item Justification

This project supports sustained multidisciplinary research at the Army's Institute for Soldier Nanotechnologies (ISN) at the Massachusetts Institute of Technology. The ISN was established as a University Affiliated Research Center (UARC) to support research to devise nanotechnology-based solutions for the Soldier. The ISN emphasizes revolutionary materials research for advanced Soldier protection and survivability. The ISN works in close collaboration with the U.S. Army Research Laboratory (ARL), the Army Natick Soldier Research, Development and Engineering Center (NSRDEC), and other U.S. Army Research Development and Engineering Command (RDECOM) elements, as well as several major industrial partners, including Raytheon and DuPont, in pursuit of its goals. This project emphasizes revolutionary materials research toward an advanced uniform concept. The future uniform will integrate a wide range of functionality, including ballistic protection, responsive passive cooling and insulating, screening of chemical and biological agents, biomedical monitoring, performance enhancement, and extremities protection. The objective is to lighten the Soldier's load through system integration and multifunctional devices while increasing survivability. The new technologies will be compatible with other Soldier requirements, including Soldier performance, limited power generation, integrated sensors, communication and display technologies, weapons systems, and expected extremes of temperature, humidity, storage lifetimes, damage, and spoilage.

The cited work is consistent with the Assistant Secretary of Defense for Research and Engineering science and technology priority focus areas and the Army Modernization Strategy.

Work in this project is performed by the ARL in Adelphi, MD.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
Title: Nanomaterials	1.620	1.487	1.540
Description: Nanomaterials research efforts focus on light-weight, multifunctional nanostructured fibers and materials. ***FY 2015 Accomplishments:*** Modeled, synthesized, and studied nanoscale objects with tailored composition, size, and geometry that may lead to future applications in obscurant and optical broadband communications; designed releasable layer-by-layer, assemblies of stabilized lipid nanocapsules on microneedles that may ultimately enable dynamic monitoring of disease states and enhanced vaccine delivery; modeled and synthesized nanotube-adsorbed polymer complexes that may provide completely synthetic analogues of antibodies and aptamers capable of detecting and recognizing neurotransmitters and other biologically relevant molecules; and modeled, synthesized, and characterized scalable and flexible nanoscale patterned metamaterial objects and photonic topological			

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University and Industry Research Centers*	**Project (Number/Name)** J12 / *Institute For Soldier Nanotechnology (ISN)*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
insulators that are able to dynamically respond to electromagnetic fields ranging from optical to microwave wavelengths, potentially providing future materials for integrated sensing or communication elements. ***FY 2016 Plans:*** Design and chemically synthesize colloidal nanoparticles to efficiently convert ultra violet (UV) to Short Wavelength Infrared (SWIR) light to enable night vision and secure communications with one, inexpensive device and to add capability to current SWIR commercial, off-the-shelf devices; devise novel chemistry for synthesis and functionalization of thin core-shell nanoparticle constructs to enable economical, highly efficient SWIR emission devices; develop piezo-electric fibers and fiber arrays for acoustic sensing and potential use in sniper detection; create crystalline semi-conductors from high melting materials using novel lower temperature fiber drawing technology to enable novel, in-uniform fiber devices for communications and sensing; design and produce by fiber thermal drawing methods all-in-fiber electrical capacitors of prescribed architectures for use in electric power and electronics applications in the uniform and in devices of unusual shape and size; and develop and apply new computational modeling and simulation tools to enable tractable design of high efficiency optical obscurant particles to enable better obscurant capabilities in smoke grenades. ***FY 2017 Plans:*** Will continue to fund basic nanomaterials research efforts, including functional nanocrystals for spectral applications, graphene integration for infrared (IR) detection, and nanoparticles with specified optical resonances for obscurant applications.			
Title: Blast Effects on Soldier	3.224	3.063	3.100
Description: Blast Effects on Soldier research involves the areas of Battle Suit Medicine and Blast and Ballistic Protection. ***FY 2015 Accomplishments:*** Evaluated and validated advanced large-scale modeling capabilities that may enable high-fidelity, full-scale simulations of the effect of blast and ballistic impact loading on soldier protection systems; computationally probe the physical mechanisms leading to the failure of bone tissue under dynamic compressive loading (may provide predictive models of blast injuries and improve the development of protective foot gear); and objectively defined and modeled the neural correlates of mild traumatic brain injury (mTBI) produced by blast waves (may provide new methods to detect cognitive disorders resulting from mTBI). ***FY 2016 Plans:*** Design, fabricate and test experimental graphene polymer composites to provide lighter weight and higher strength protective materials for the Soldier; perform experiments, mathematical modeling and simulation studies (to enable the design and production of light weight, high strength nanocrystalline and superelastic metal alloys for blast and ballistic protection and damping of mechanical energy); develop improved fundamental understanding of the physics, biology and physiology of blast-induced trauma and of the strengths and limitations of various materials to protect against blast related injuries; and develop computational			

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University and Industry Research Centers*	**Project (Number/Name)** J12 / *Institute For Soldier Nanotechnology (ISN)*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
tools for high-fidelity three-dimensional (3D) simulations of blast and ballistic impacts on human protective materials including crack formation and propagation, and materials failure. ***FY 2017 Plans:*** Will continue basic research to improve understanding of the physics, biology and physiology of blast-induced trauma and the strengths and limitations of various materials to protect against blast related injuries. Support efforts to develop computational tools for high-fidelity 3D simulations of blast and ballistic impacts on human protective materials, including crack formation and propagation, and materials failure.			
Title: Soldier Protection ***Description:*** Soldier Protection research efforts focused on Soldier Survivability and Protection and Nanosystems Integration. ***FY 2015 Accomplishments:*** Modeled and synthesized nanocomposite, metamaterial architectures and examine if and how these materials can guide and dissipate energy, potentially providing a method to dissipate blast energy for soldier protection; modeled, synthesized, and characterized nanostructured protein hydrogels under physiologically relevant conditions which may ultimately lead to a rapid field treatment option for hemorrhagic shock or other trauma; and explored and modeled the rate-dependent response of biological and synthetic gels to intense loadings over a broad range of length and time scales, which will guide the future design of compliant, protective materials. ***FY 2016 Plans:*** Design, construct and assess compact devices to allow storage and rapid administration of pain relief and agents to treat battlefield injuries; devise compact, high sensitivity hollow-core photonic band gap fiber devices to extend the detection limits and range of improvised explosive devices that can be detected with compact hand held and robot-borne devices; exploit the novel electronic properties of chemically and biologically functionalized nanocarbon structures to design compact, low power devices to sense food pathogens and to sense chemical-biological agents or other hazardous materials; create nanostructured capabilities to treat battlefield wounds including engineered hydrogels to rapidly stop bleeding, engineered bacteriophages and nanoparticles to combat antibiotic resistant wound pathogens, and nanoparticles to deliver anti-inflammatory agents into cells; perform theoretical, computational and experimental studies of how photonic crystals interact with light waves that may enable the development of all optical integrated circuits for more robust devices; design, build, and assess advanced thermo-photo-voltaic power generation devices that exploit nanostructured photonic crystals to achieve much higher fuel-to-electricity conversion efficiencies and thus enable efficient portable power; employ analytical theory, high-fidelity computation, and experiments to enable practical applications of a recently discovered photonic crystal phenomenon, that may ultimately enable novel sensing applications. ***FY 2017 Plans:***	1.610	1.530	1.545

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University and Industry Research Centers*	**Project (Number/Name)** J12 / *Institute For Soldier Nanotechnology (ISN)*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
Will continue funding basic research efforts that could lead to development of novel therapeutic multifunctional materials and drug delivery vehicles. Support efforts in synthesis of nanoscale superelastic alloys and other novel nanomaterial systems for potential flexible protection application.			
Accomplishments/Planned Programs Subtotals	6.454	6.080	6.185

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army			Date: February 2016
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601104A / *University and Industry Research Centers*	Project (Number/Name) J13 / *UNIVERSITY AND INDUSTRY INITIATIVES (CA)*	

COST ($ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
J13: *UNIVERSITY AND INDUSTRY INITIATIVES (CA)*	-	6.100	4.000	0.000	-	0.000	0.000	0.000	0.000	0.000	-	-

Note

Not applicable for this item.

A. Mission Description and Budget Item Justification

Congressional Interest Item funding provided for University and Industry Initiatives.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016
Congressional Add: Program Increase	6.100	4.000
FY 2015 Accomplishments: Congressional increase for basic research efforts.		
FY 2016 Plans: Congressional increase for basic research efforts.		
Congressional Adds Subtotals	6.100	4.000

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army			Date: February 2016
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601104A / *University and Industry Research Centers*	Project (Number/Name) J14 / *Army Educational Outreach Program*	

COST ($ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
J14: *Army Educational Outreach Program*	-	9.182	9.670	9.864	-	9.864	10.048	10.274	10.470	10.679	-	-

A. Mission Description and Budget Item Justification

This project supports science activities that encourage elementary/middle/high school and undergraduate youths to develop an interest in and pursue education and employment in the Science, Technology, Engineering, and Math (STEM) fields. These activities are consolidated within the Army Educational Outreach Program (AEOP) that links and networks appropriate components to derive the best synergies to present the Army to a larger pool of technical talent and to provide students with Army-unique practical experiences at Army laboratories, centers, and institutes to fill future Army Science and Technology workforce needs. AEOP increases interest and involvement of students and teachers across the nation in STEM at all proficiency levels and backgrounds to include under-represented and economically disadvantaged groups through exposure to Army sponsored research, education, competitions, internships, and practical experiences. This project utilizes Army STEM assets to contribute to a STEM literate citizenry as well as enhances the national pool of science and engineering personnel that in turn supports defense industry and Army laboratory and research, development, and engineering center needs.

The cited work is consistent with the Assistant Secretary of Defense for Research and Engineering science and technology priority focus area, the Army Modernization Strategy, the Federal STEM Strategic Plan, and the President's "Educate to Innovate" campaign for STEM education.

Work in this project is performed by the Army Research, Development, and Engineering Command (RDECOM), the Army Research Institute (ARI) for the Behavioral and Social Sciences, the Army Corps of Engineers' Engineer Research and Development Center (ERDC), the Army Medical Research and Materiel Command (MRMC), the Army Space and Missile Defense Command (SMDC), and the United States Military Academy (USMA).

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
Title: eCYBERMISSION	3.459	3.766	3.822
Description: This program supports a nation-wide, web-based STEM competition for students in grades 6 through 9, designed to stimulate interest and encourage continued education in these areas among middle and high school students nationwide.			
FY 2015 Accomplishments: Continued STEM activities with a concentrated effort in underserved populations; increased geographic diversity; sustained eCYBERMISSION; and implemented program enhancements based on lessons learned from previous years.			
FY 2016 Plans: Continue STEM activities with concentrated effort in reaching out to students from underserved populations; increase geographic diversity; sustain program growth; and implement program enhancements based on prior years' evaluations outcomes.			
FY 2017 Plans:			

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University and Industry Research Centers*	**Project (Number/Name)** J14 / *Army Educational Outreach Program*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
Will continue STEM activities with concentrated effort in reaching out to students from underserved populations; increase geographic diversity; sustain program growth; and will implement program enhancements based on prior years' evaluations outcomes.			
Title: Educational Outreach and Workforce Development ***Description:*** This effort aims to broaden STEM competencies through various outreach and workforce development initiatives at participating Army labs and research centers. ***FY 2015 Accomplishments:*** Continued AEOP support to reach under-represented and economically disadvantaged areas to enhance STEM education through student experiences in Army labs and academic partner institutions; and mentored students to broaden their interest in and their development of STEM education. ***FY 2016 Plans:*** Continue AEOP support and outreach to under-represented and economically disadvantaged areas to enhance STEM education through student experiences in Army labs and academic partner institutions, and mentor students to broaden their interest in and their development of STEM education ***FY 2017 Plans:*** Will continue AEOP support and outreach to under-represented and economically disadvantaged areas to enhance STEM education through student experiences in Army labs and academic partner institutions, and mentor students to broaden their interest in and their development of STEM education.	2.328	2.400	2.400
Title: Army Educational Outreach Program Cooperative Agreement ***Description:*** The Army Educational Outreach Program Cooperative Agreement encompasses a variety of outreach activities under AEOP. This activity supports a strong partnership with government, academia and industry to address the shortfall of clearable STEM skilled talent preparing for the workforce. These activities include Army-sponsored research, education, competitions, internships and practical experiences designed to engage and guide students and teachers in Army sponsored STEM programs. AEOP has targeted efforts to reach and engage underserved and underrepresented communities in STEM initiatives to build the pool of diverse STEM competitive talent. ***FY 2015 Accomplishments:*** Continued Army lab and research center sponsorship of students and STEM education opportunities; provided incentives in STEM competitions that include scholarships, experiences and mentorships as well as expose students to Department of Defense	3.095	3.199	3.332

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University and Industry Research Centers*	**Project (Number/Name)** J14 / *Army Educational Outreach Program*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
(DoD) career opportunities; streamlined processes, leverage funding and build educational partnerships; and performed annual comprehensive review and educational assessments to support future decisions and best practices. ***FY 2016 Plans:*** Continue Army lab and research center sponsorship of students and STEM education opportunities; provide incentives in STEM competitions that include scholarships, experiences and mentorships as well as expose students to DoD career opportunities; streamline processes, leverage funding and build educational partnerships; and perform annual comprehensive review and educational assessments to support future decisions and best practices. ***FY 2017 Plans:*** Will continue Army lab and research center sponsorship of students and STEM education opportunities; provide incentives in STEM competitions that include scholarships, experiences and mentorships as well as expose students to DoD career opportunities; streamline processes, leverage funding and build educational partnerships; and perform annual comprehensive review and educational assessments to support future decisions and best practices.			
Title: West Point Cadet Research ***Description:*** The West Point Cadet Research Program provides West Point Cadets an opportunity to work on Army research projects alongside Army and industry scientists and engineers. ***FY 2015 Accomplishments:*** Conducted West Point cadet research internship program to enhance cadet training through field experience in Army research labs and centers. ***FY 2016 Plans:*** Conduct West Point cadet research internship program to enhance cadet training through field experience in Army research labs and centers. ***FY 2017 Plans:*** Will conduct West Point cadet research internship program to enhance cadet training through field experience in Army research labs and centers.	0.300	0.305	0.310
Accomplishments/Planned Programs Subtotals	9.182	9.670	9.864

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University and Industry Research Centers*	**Project (Number/Name)** J14 / *Army Educational Outreach Program*

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army			Date: February 2016
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601104A / *University and Industry Research Centers*	Project (Number/Name) J15 / *Network Sciences ITA*	

COST ($ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
J15: *Network Sciences ITA*	-	3.712	4.070	4.078	-	4.078	4.083	4.112	4.152	4.235	-	-

A. Mission Description and Budget Item Justification

This project supports research at a competitively selected United States (U.S.)/United Kingdom (U.K.) government, university, and industry consortium established to perform fundamental network and information science investigations in the areas of network theory, system-of-systems security, sensor processing and delivery, and distributed coalition planning and decision making. The focus is on enhancing distributed, secure, and flexible decision-making to improve coalition operations, and developing the scientific foundations for complex and dynamic networked systems-of-systems to support the complex human, social, and technical interactions anticipated in future coalition operations with the emphasis on integration of multiple technical disciplines in an international arena. The Army Research Laboratory (ARL) and the U.K. Ministry of Defense (MOD) established the jointly funded and managed U.S. and U.K. consortium, known as the International Technology Alliance (ITA) on Network and Information Sciences, in Fiscal Year (FY) 2006.

The cited work is consistent with the Assistant Secretary of Defense for Research and Engineering science and technology priority focus areas and the Army Modernization Strategy.

Work in this project is performed by the ARL at Adelphi, MD.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
Title: Network and Information Science Basic Research for U.S./U.K. Coalition Operations Information	3.712	4.070	4.078
Description: This research will address the fundamental science underpinning the complex information network issues that are vital to future U.S./U.K. coalition military operations and to fully exploit the joint development of emerging technologies necessary to enable coalition operations. These efforts provide enhanced ability to perform projective analysis on hybrid networks for the purpose of improving security and information distribution in coalition operations.			
FY 2015 Accomplishments: Developed integrated analysis algorithms of data derived from hybrid networks to aid analysts in performing projective analysis; developed techniques to provide risk averse and security conscious analysis capabilities to distributed mobile devices among coalition partners; and developed secure energy-aware and resource-aware access to distributed computing resources. These efforts enhanced network and security analysis while improving the effective use of coalition resources available to the Warfighter.			
FY 2016 Plans: Develop projective analysis techniques for hybrid networks that consider limitations on controllability; develop secure, content-based networking approaches that allow distributed information discovery, resiliency, and adaptability in heterogeneous coalition networks; develop abstract, physical, spatio-temporal analytical models and representations that support distributed			

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University and Industry Research Centers*	**Project (Number/Name)** J15 / *Network Sciences ITA*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
processing of information; and develop distributed techniques for dynamically assembling information services in dynamic coalition environments to enable distributed analytics. ***FY 2017 Plans:*** Will cultivate a fundamental understanding of using distributed services to support coalition information processing in dynamic environments for building composite information infrastructures; develop information-centric networking that supports secure coalition operations via logically distributed and decentralized architectures across heterogeneous coalition networks; formulate dynamic policy-based autonomous management techniques to jointly control both coalition information and infrastructural services that dynamically adjust to mission changes, network dynamics and policy changes; develop formal theories, frameworks and mechanisms to dynamically match operational tasks to information resources for complex coalition operations; and investigate formal theories and techniques to enable multi-level integrated fusion of disparate information sources in context of decision support objectives for coalitions.			
Accomplishments/Planned Programs Subtotals	3.712	4.070	4.078

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army			Date: February 2016
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601104A / *University and Industry Research Centers*	Project (Number/Name) J17 / *Vertical Lift Research Center Of Excellence*	

COST ($ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
J17: *Vertical Lift Research Center Of Excellence*	-	2.774	3.031	3.076	-	3.076	3.130	3.187	3.250	3.315	-	-

A. Mission Description and Budget Item Justification

This project fosters research to provide vertical lift capability and engineering expertise for the Army. The focus of the Vertical Lift Research Center of Excellence (VLRCOE) is to couple state-of-the-art research programs with broad-based graduate education programs at academic institutions with the goal of increasing the supply of scientists and engineers who can contribute to Army Transformation. Work will provide research into technologies that can improve tactical mobility, reduce the logistics footprint, and increase survivability for rotary wing vehicles.

The cited work is consistent with the Assistant Secretary of Defense for Research and Engineering science and technology priority focus areas and the Army Modernization Strategy.

Work in this project is performed extramurally by the Aeroflightdynamics Directorate of the Army Aviation and Missile Research, Development, and Engineering Center (AMRDEC) (located at the National Aeronautics and Space Administration (NASA) Ames Research Center, Moffett Field, CA).

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
Title: Vertical Lift Research Center of Excellence (VLRCOE)	2.774	3.031	3.076
Description: VLRCOE agreements with Penn State University, University of Maryland, and Georgia Institute of Technology to supplement a robust experimental and analytic basic research program in rotorcraft technologies including: Aeromechanics, Structures, Flight Dynamics and Control, Rotorcraft Design and Concepts, Vibration and Noise Control, Propulsion, Affordability, Safety and Survivability, and Naval Operations.			
FY 2015 Accomplishments: Implemented year four of VLRCOE agreements with Penn State University, University of Maryland, and Georgia Institute of Technology to conduct a robust experimental and analytic basic research program in rotorcraft technologies including: Aeromechanics, Structures, Flight Dynamics and Control, Rotorcraft Design and Concepts, Vibration and Noise Control, Propulsion, Affordability, Safety and Survivability, and Naval Operations.			
FY 2016 Plans: Complete the final year of the VLRCOE technology interchange agreements by executing a robust experimental and analytic basic research program in rotorcraft technologies including: aeromechanics, structures, flight dynamics and control, rotorcraft design and concepts, vibration and noise control, propulsion, affordability, safety and survivability, and Naval operations. Identify			

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University and Industry Research Centers*	**Project (Number/Name)** J17 / *Vertical Lift Research Center Of Excellence*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
research thrust areas of interest to Army Aviation for a new Center of Excellence (COE) program that will support future vertical lift in the long term. ***FY 2017 Plans:*** Will initiate a new, five year COE program that supports the Future Vertical Lift program and focuses on graduate education and a robust experimental/computational/analytical basic research program in rotorcraft technologies including: aeromechanics, structures, flight dynamics and control, rotorcraft design and concepts, vibration and noise control, propulsion, affordability, safety and survivability, and Naval operations. Specific areas of interest and proposals will be selected based on evaluations by a consensus of government subject matter experts.			
Accomplishments/Planned Programs Subtotals	2.774	3.031	3.076

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army			Date: February 2016
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601104A / *University and Industry Research Centers*	Project (Number/Name) VS2 / *Multi-Scale Materials Modeling Centers*	

COST ($ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
VS2: *Multi-Scale Materials Modeling Centers*	-	9.268	9.296	8.851	-	8.851	9.048	9.256	9.493	9.692	-	-

A. Mission Description and Budget Item Justification

This project supports two competitively awarded Collaborative Research Alliances (CRAs) to provide the Army with next generation multi-functional materials for ballistic and electronic applications and to address the extreme challenges associated with understanding and modeling materials subject to Army operational environments. The Materials in Extreme Dynamic Environments consortium, led by Johns Hopkins University partnered with CalTech, Rutgers University, and University of Delaware, focuses on understanding materials under high strain rates. The Multiscale Multidisciplinary Modeling of Electronic Materials consortium, led by University of Utah partnered with Boston University and Rensselaer Polytechnic Institute, focuses on microscale properties to design macroscale behavior for electronics. Research at both CRAs will address the modeling and experimental challenges associated with developing multidisciplinary physics simulations across multiple length scales for materials to include: a limited ability to relate materials chemistry, structure, and defects to materials response and failure under extreme conditions; an inadequate ability to predict the roles of materials structure, processing, and properties on performance in relevant extreme environments and designs; and the lack of experimental capabilities to quantify multiscale response and failure of materials under extreme conditions.

Work in this project supports key Army needs and is coordinated with work performed in Program Element (PE) 0601102A (Defense Research Sciences)/Project H44 (Adv Sensor Research) and H42 (Materials and Mechanics).

The cited work is consistent with the Assistant Secretary of Defense for Research and Engineering science and technology priority focus areas and the Army Modernization Strategy.

Work in this project is performed by the Army Research Laboratory (ARL) in Aberdeen Proving Ground, MD.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
Title: Collaborative Research Alliances in Materials in Extreme Dynamic Environments and Multiscale Multidisciplinary Modeling of Electronic Materials.	9.268	9.296	8.851
Description: Research will focus on the following areas: two-way multiscale modeling for predicting performance and designing materials, investigating analytical and theoretical analyses to effectively define the interface physics across length scales; advancing experimental capabilities for verification and validation of multiscale physics; and modeling and strategies for the synthesis of high loading rate tolerant materials so that all of the latter lead to the development of a comprehensive set of metrics that define high loading rate tolerant material systems. The multiscale modeling capability will be applied across multiple disciplines to facilitate revolutionary advances in materials for coupled environments (electromagnetic, high rate, high pressure and other extreme environments).			

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University and Industry Research Centers*	**Project (Number/Name)** VS2 / *Multi-Scale Materials Modeling Centers*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017

FY 2015 Accomplishments:

Conducted research to achieve a comprehensive "materials-by-design" capability to include designing materials and predicting key properties for materials in extreme dynamic environments through the integration of novel experimental methodologies and multiscale computational approaches; validated material characteristics and properties at length scales that govern high rate deformation, fracture and failure phenomena in metallic, polymeric, ceramic and composite material systems through both computational and experimental techniques; researched fabrication technology for optimized polymeric, metallic, ceramic and composite systems; and investigated interface physics (with regards to strain, polarization, piezoelectric, electromagnetic phenomena and solid/liquid boundaries). Results advance the state-of-the art in multiscale modeling for electronic materials to create a capability for "materials optimization" and "materials by design" supporting increased efficiency, source and detector lifetimes, increased power density (in electrochemical energy storage devices), and advancing the understanding of electronic materials to include interactions of electrons, photons, phonons, defects and impurities.

FY 2016 Plans:

Advance the state of the art in multi-scale modeling for electronic materials by creating a capability to tailor properties and ultimately enable an increase in efficiency, lifetimes of sources and detectors and power density in electrochemical energy storage devices; develop complex multi-scale modeling techniques which are validated and verified across critical scales in time and space for tailored electronic materials and optimized band structure; develop algorithms/theories that further advance the state of the art of electronic materials with regards to interactions of electrons, photons, phonons, defects and impurities; and advance the state of the art in interface physics with regards to strain, polarization, piezoelectric, electromagnetic phenomena and solid/liquid boundaries to predict electronic materials' behavior focused on Army relevant devices. Develop a proof-of-concept "materials-by-design" capability in designing materials and predicting key properties for materials in extreme dynamic environments based on the fundamental properties of the atomic and molecular components; synchronize novel experimental methodologies with multiscale computational approaches to enable unprecedented microstructure control and predictive capabilities; validate the comprehensive set of material characteristics and properties at length scales that govern high rate deformation (ballistic effects), fracture and failure phenomena in metallic, polymeric, ceramic and composite material systems through both computational and experimental techniques using representative materials; and begin development of the fabrication technology for optimized polymeric, metallic, ceramic and composite systems.

FY 2017 Plans:

Will continue to advance the state-of-the-art in multi-scale modeling for electronic materials by further validation of the capability to tailor electronic materials' properties; develop the validation and verification techniques for models that cross or tie-together critical scales in time and space for tailored electronic materials and optimized band structure; develop additional algorithms/theories to advance the state-of-the-art of electronic materials with regards to interactions carriers and impurities; and further advance the state of the art in interface physics with regards to strain, polarization, piezoelectric, electromagnetic phenomena and solid/

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University and Industry Research Centers*	**Project (Number/Name)** VS2 / *Multi-Scale Materials Modeling Centers*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
liquid boundaries to map and to predict electronic materials' behavior within Army relevant devices. Continue to develop and refine a proof-of-concept "materials-by-design" capability to predict key properties for materials in extreme dynamic environments based on the fundamental properties of the atomic and molecular components; assess the learning from the novel high rate experimentation results especially when combined with multiscale computational approaches and key visualization techniques; begin confirmation of the ability to predict and control microstructure; validate that we have defined the comprehensive set of material characteristics and properties at length scales that govern high rate deformation (ballistic effects), fracture and failure phenomena in metallic, polymeric, ceramic and composite material systems through both computational and experimental techniques using representative materials; and begin development of the fabrication technology for optimized polymeric, metallic, ceramic and composite systems.			
Accomplishments/Planned Programs Subtotals	9.268	9.296	8.851

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army			Date: February 2016
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601104A / *University and Industry Research Centers*	Project (Number/Name) VS3 / *Center For Quantum Science Research*	

COST ($ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
VS3: *Center For Quantum Science Research*	-	4.807	5.183	5.201	-	5.201	5.222	6.239	6.383	6.511	-	-

A. Mission Description and Budget Item Justification

This project supports an extramural research consortium, which will bring together a critical mass of preeminent university and industry researchers to explore and develop critical emerging concepts in Quantum Information Science (QIS). The focus will be on establishing a first of its kind, multi-site distributed quantum network based on quantum memories. The Center for Distributed Quantum Information will study and demonstrate both the physical backbone and network layer for a robust quantum information network that will provide secure and tamper-proof communications and exponentially greater information processing capabilities for the future Army. The Center for Distributed Quantum Information will perform collaborative research with Army in-house scientists and engineers to help accelerate the transition of the research. In addition to providing the required expertise and critical mass to the effort, the consortium will also bring together a broad but unified multi-disciplinary research team needed to accelerate progress in the field of quantum information sciences.

The cited work is consistent with the Assistant Secretary of Defense for Research and Engineering Science and Technology focus areas, and the Army Modernization Strategy.

Work in this project is performed by the Army Research Laboratory (ARL) in Adelphi, MD.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
Title: Center for Distributed Quantum Information	4.807	5.183	5.201
Description: This work supports critical quantum science basic research at the U.S. ARL exploiting quantum effects to greatly enhance computing, communications, imaging, sensing, and security ensuring Army dominance on the future battlefield.			
FY 2015 Accomplishments: Researched mapping between model quantum systems and the system whose properties need to be understood and controlled using atoms in optical lattices, ions in radio frequency (RF) traps, atoms in cavities with and without mechanical resonators, and other approaches; and conducted research to elucidate the role and creation of quantum resources such as superposition, entanglement, and entanglement swapping (including long-range and long-time as needed for quantum repeaters), in overcoming the limitations of classical systems.			
FY 2016 Plans: Advance the development of the physical layer and networking theory needed for a robust distributed quantum network, including investigation of novel network protocols, teleportation between quantum nodes and memories, quantum node-to-node			

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University and Industry Research Centers*	**Project (Number/Name)** VS3 / *Center For Quantum Science Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
communication along fibers, quantum node-to-node communication through free space, photon encoding protocols, frequency conversion, single photon detection, and entanglement verification protocols. ***FY 2017 Plans:*** Will research and refine quantum network protocols and algorithms, as well as experimentally and theoretically investigate entanglement between two quantum nodes, entanglement verification protocols, teleportation of quantum state between two nodes, and frequency conversion to connect hybrid platforms.			
Accomplishments/Planned Programs Subtotals	4.807	5.183	5.201

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A