Department of Defense
Fiscal Year (FY) 2016 President's Budget Submission

February 2015

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, $6,926,459,000.00 to remain available for obligation until September 30, 2017.

The following Justification Books were prepared at a cost of $1,187,353.84: 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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Department of Defense
FY 2016 President's Budget
Exhibit R-1 FY 2016 President's Budget
Total Obligational Authority
(Dollars in Thousands)

15 Jan 2015

Appropriation	FY 2014 (Base & OCO)	FY 2015 Base Enacted	FY 2015 OCO Enacted	FY 2015 Total Enacted	FY 2016 Base	FY 2016 OCO	FY 2016 Total
Research, Development, Test & Eval, Army	7,124,298	6,673,146	2,000	6,675,146	6,924,959	1,500	6,926,459
Total Research, Development, Test & Evaluation	7,124,298	6,673,146	2,000	6,675,146	6,924,959	1,500	6,926,459

Department of Defense
FY 2016 President's Budget
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(Dollars in Thousands)

15 Jan 2015

Summary Recap of Budget Activities	FY 2014 (Base & OCO)	FY 2015 Base Enacted	FY 2015 OCO Enacted	FY 2015 Total Enacted	FY 2016 Base	FY 2016 OCO	FY 2016 Total
Basic Research	425,321	460,268		460,268	425,079		425,079
Applied Research	930,900	981,421		981,421	879,685		879,685
Advanced Technology Development	1,044,919	1,113,149		1,113,149	895,747		895,747
Advanced Component Development & Prototypes	424,652	302,922	2,000	304,922	498,659	1,500	500,159
System Development & Demonstration	1,955,833	1,622,353		1,622,353	2,068,950		2,068,950
RDT&E Management Support	1,317,280	1,015,139		1,015,139	1,027,542		1,027,542
Operational Systems Development	1,025,393	1,177,894		1,177,894	1,129,297		1,129,297
Total Research, Development, Test & Evaluation	7,124,298	6,673,146	2,000	6,675,146	6,924,959	1,500	6,926,459
Summary Recap of FYDP Programs							
Strategic Forces	58,383						
General Purpose Forces	581,979	716,615		716,615	693,053		693,053
Intelligence and Communications	201,878	165,416		165,416	163,446		163,446
Research and Development	6,222,823	5,710,126	2,000	5,712,126	6,015,482	1,500	6,016,982
Central Supply and Maintenance	54,392	76,187		76,187	48,442		48,442
Administration and Associated Activities	126						
Classified Programs	4,717	4,802		4,802	4,536		4,536
Total Research, Development, Test & Evaluation	7,124,298	6,673,146	2,000	6,675,146	6,924,959	1,500	6,926,459

R-1C1: FY 2016 President's Budget (Published Version of PB Position), as of January 15, 2015 at 09:20:53

Department of the Army
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(Dollars in Thousands)

15 Jan 2015

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Department of the Army
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Exhibit R-1 FY 2016 President's Budget
Total Obligational Authority
(Dollars in Thousands)

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

Line No	Program Element Number	Item	Act	FY 2014 (Base & OCO)	FY 2015 Base Enacted	FY 2015 OCO Enacted	FY 2015 Total Enacted	FY 2016 Base	FY 2016 OCO	FY 2016 Total	Sec
1	0601101A	In-House Laboratory Independent Research	01	21,255	13,427		13,427	13,018		13,018	U
2	0601102A	Defense Research Sciences	01	216,774	248,283		248,283	239,118		239,118	U
3	0601103A	University Research Initiatives	01	76,682	89,776		89,776	72,603		72,603	U
4	0601104A	University and Industry Research Centers	01	110,610	108,782		108,782	100,340		100,340	U
		Basic Research		425,321	460,268		460,268	425,079		425,079	
5	0602105A	Materials Technology	02	45,243	46,000		46,000	28,314		28,314	U
6	0602120A	Sensors and Electronic Survivability	02	42,677	46,258		46,258	38,374		38,374	U
7	0602122A	TRACTOR HIP	02	35,493	16,358		16,358	6,879		6,879	U
8	0602211A	Aviation Technology	02	54,667	63,414		63,414	56,884		56,884	U
9	0602270A	Electronic Warfare Technology	02	17,464	18,500		18,500	19,243		19,243	U
10	0602303A	Missile Technology	02	58,426	62,180		62,180	45,053		45,053	U
11	0602307A	Advanced Weapons Technology	02	25,310	38,513		38,513	29,428		29,428	U
12	0602308A	Advanced Concepts and Simulation	02	23,364	27,423		27,423	27,862		27,862	U
13	0602601A	Combat Vehicle and Automotive Technology	02	63,476	72,861		72,861	68,839		68,839	U
14	0602618A	Ballistics Technology	02	73,906	85,575		85,575	92,801		92,801	U
15	0602622A	Chemical, Smoke and Equipment Defeating Technology	02	4,378	3,970		3,970	3,866		3,866	U
16	0602623A	Joint Service Small Arms Program	02	7,592	6,850		6,850	5,487		5,487	U
17	0602624A	Weapons and Munitions Technology	02	52,013	63,057		63,057	48,340		48,340	U
18	0602705A	Electronics and Electronic Devices	02	68,062	73,422		73,422	55,301		55,301	U

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15 Jan 2015

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19	0602709A	Night Vision Technology	02	42,624	44,935		44,935	33,807		33,807	U
20	0602712A	Countermine Systems	02	30,019	29,428		29,428	25,068		25,068	U
21	0602716A	Human Factors Engineering Technology	02	21,118	23,778		23,778	23,681		23,681	U
22	0602720A	Environmental Quality Technology	02	22,333	15,653		15,653	20,850		20,850	U
23	0602782A	Command, Control, Communications Technology	02	33,580	33,807		33,807	36,160		36,160	U
24	0602783A	Computer and Software Technology	02	10,232	10,761		10,761	12,656		12,656	U
25	0602784A	Military Engineering Technology	02	69,192	67,302		67,302	63,409		63,409	U
26	0602785A	Manpower/Personnel/Training Technology	02	17,395	23,288		23,288	24,735		24,735	U
27	0602786A	Warfighter Technology	02	30,950	32,044		32,044	35,795		35,795	U
28	0602787A	Medical Technology	02	81,386	76,044		76,044	76,853		76,853	U
	Applied Research			930,900	981,421		981,421	879,685		879,685	
29	0603001A	Warfighter Advanced Technology	03	64,337	78,109		78,109	46,973		46,973	U
30	0603002A	Medical Advanced Technology	03	100,646	106,264		106,264	69,584		69,584	U
31	0603003A	Aviation Advanced Technology	03	78,513	102,950		102,950	89,736		89,736	U
32	0603004A	Weapons and Munitions Advanced Technology	03	72,934	72,908		72,908	57,663		57,663	U
33	0603005A	Combat Vehicle and Automotive Advanced Technology	03	146,486	147,485		147,485	113,071		113,071	U
34	0603006A	Space Application Advanced Technology	03	10,706	6,880		6,880	5,554		5,554	U
35	0603007A	Manpower, Personnel and Training Advanced Technology	03	6,145	13,574		13,574	12,636		12,636	U

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36	0603008A	Electronic Warfare Advanced Technology	03	40,345	44,851		44,851				U
37	0603009A	TRACTOR HIKE	03	9,161	7,492		7,492	7,502		7,502	U
38	0603015A	Next Generation Training & Simulation Systems	03	13,168	16,740		16,740	17,425		17,425	U
39	0603020A	TRACTOR ROSE	03	10,662	14,483		14,483	11,912		11,912	U
40	0603125A	Combating Terrorism - Technology Development	03	14,546	24,257		24,257	27,520		27,520	U
41	0603130A	TRACTOR NAIL	03	3,192	3,440		3,440	2,381		2,381	U
42	0603131A	TRACTOR EGGS	03	2,366	2,406		2,406	2,431		2,431	U
43	0603270A	Electronic Warfare Technology	03	24,652	26,046		26,046	26,874		26,874	U
44	0603313A	Missile and Rocket Advanced Technology	03	81,951	79,934		79,934	49,449		49,449	U
45	0603322A	TRACTOR CAGE	03	11,857	11,105		11,105	10,999		10,999	U
46	0603461A	High Performance Computing Modernization Program	03	213,238	221,518		221,518	177,159		177,159	U
47	0603606A	Landmine Warfare and Barrier Advanced Technology	03	22,233	13,070		13,070	13,993		13,993	U
48	0603607A	Joint Service Small Arms Program	03	4,902	7,318		7,318	5,105		5,105	U
49	0603710A	Night Vision Advanced Technology	03	43,459	44,119		44,119	40,929		40,929	U
50	0603728A	Environmental Quality Technology Demonstrations	03	11,540	11,445		11,445	10,727		10,727	U
51	0603734A	Military Engineering Advanced Technology	03	23,838	17,606		17,606	20,145		20,145	U
52	0603772A	Advanced Tactical Computer Science and Sensor Technology	03	34,042	39,149		39,149	38,163		38,163	U

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53	0603794A	C3 Advanced Technology	03					37,816		37,816	U
		Advanced Technology Development		1,044,919	1,113,149		1,113,149	895,747		895,747	
54	0603305A	Army Missle Defense Systems Integration	04	23,117	25,795		25,795	10,347		10,347	U
55	0603308A	Army Space Systems Integration	04	13,448	13,996		13,996	25,061		25,061	U
56	0603619A	Landmine Warfare and Barrier - Adv Dev	04					49,636		49,636	U
57	0603627A	Smoke, Obscurant and Target Defeating Sys-Adv Dev	04					13,426		13,426	U
58	0603639A	Tank and Medium Caliber Ammunition	04	31,580	29,318		29,318	46,749		46,749	U
59	0603653A	Advanced Tank Armament System (ATAS)	04	54,259							U
60	0603747A	Soldier Support and Survivability	04	11,513	6,997	2,000	8,997	6,258	1,500	7,758	U
61	0603766A	Tactical Electronic Surveillance System - Adv Dev	04	10,390	8,953		8,953	13,472		13,472	U
62	0603774A	Night Vision Systems Advanced Development	04	8,760	3,050		3,050	7,292		7,292	U
63	0603779A	Environmental Quality Technology - Dem/Val	04	2,544	7,826		7,826	8,813		8,813	U
64	0603782A	Warfighter Information Network-Tactical - DEM/VAL	04	118,256							U
65	0603790A	NATO Research and Development	04	3,743	2,952		2,952	6,075		6,075	U
66	0603801A	Aviation - Adv Dev	04	4,848							U
67	0603804A	Logistics and Engineer Equipment - Adv Dev	04	11,623	13,380		13,380	21,233		21,233	U
68	0603807A	Medical Systems - Adv Dev	04	17,524	23,647		23,647	31,962		31,962	U

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69	0603827A	Soldier Systems - Advanced Development	04	13,844	6,828		6,828	22,194		22,194	U
70	0603850A	Integrated Broadcast Service	04	79							U
71	0604100A	Analysis Of Alternatives	04		9,910		9,910	9,805		9,805	U
72	0604115A	Technology Maturation Initiatives	04	10,741	44,214		44,214	40,917		40,917	U
73	0604120A	Assured Positioning, Navigation and Timing (PNT)	04	7,500	9,925		9,925	30,058		30,058	U
74	0604319A	Indirect Fire Protection Capability Increment 2-Intercept (IFPC2)	04	76,559	96,131		96,131	155,361		155,361	U
75	0604785A	Integrated Base Defense (Budget Activity 4)	04	4,324							U
		Advanced Component Development & Prototypes		424,652	302,922	2,000	304,922	498,659	1,500	500,159	
76	0604201A	Aircraft Avionics	05	64,396	41,236		41,236	12,939		12,939	U
77	0604220A	Armed, Deployable Helos	05	26,000							U
78	0604270A	Electronic Warfare Development	05	134,260	5,999		5,999	18,843		18,843	U
79	0604280A	Joint Tactical Radio	05	30,752	9,827		9,827	9,861		9,861	U
80	0604290A	Mid-tier Networking Vehicular Radio (MNVR)	05	22,553	9,725		9,725	8,763		8,763	U
81	0604321A	All Source Analysis System	05	4,837	5,532		5,532	4,309		4,309	U
82	0604328A	TRACTOR CAGE	05	28,229	19,929		19,929	15,138		15,138	U
83	0604601A	Infantry Support Weapons	05	82,332	34,575		34,575	74,128		74,128	U
84	0604604A	Medium Tactical Vehicles	05	2,068	210		210				U
85	0604611A	JAVELIN	05	4,471	4,164		4,164	3,945		3,945	U
86	0604622A	Family of Heavy Tactical Vehicles	05	23,944	12,906		12,906				U

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87	0604633A	Air Traffic Control	05	514	16,756		16,756	10,076		10,076	U
88	0604641A	Tactical Unmanned Ground Vehicle (TUGV)	05		2,769		2,769	40,374		40,374	U
89	0604710A	Night Vision Systems - Eng Dev	05	47,811	65,299		65,299	67,582		67,582	U
90	0604713A	Combat Feeding, Clothing, and Equipment	05	1,874	3,034		3,034	1,763		1,763	U
91	0604715A	Non-System Training Devices - Eng Dev	05	22,168	8,943		8,943	27,155		27,155	U
92	0604741A	Air Defense Command, Control and Intelligence - Eng Dev	05	38,412	15,898		15,898	24,569		24,569	U
93	0604742A	Constructive Simulation Systems Development	05	19,596	4,394		4,394	23,364		23,364	U
94	0604746A	Automatic Test Equipment Development	05	6,498	11,079		11,079	8,960		8,960	U
95	0604760A	Distributive Interactive Simulations (DIS) - Eng Dev	05	12,193	10,022		10,022	9,138		9,138	U
96	0604780A	Combined Arms Tactical Trainer (CATT) Core	05	26,720	34,712		34,712	21,622		21,622	U
97	0604798A	Brigade Analysis, Integration and Evaluation	05	91,427	85,246		85,246	99,242		99,242	U
98	0604802A	Weapons and Munitions - Eng Dev	05	16,770	14,998		14,998	21,379		21,379	U
99	0604804A	Logistics and Engineer Equipment - Eng Dev	05	43,497	24,566		24,566	48,339		48,339	U
100	0604805A	Command, Control, Communications Systems - Eng Dev	05	7,131	4,431		4,431	2,726		2,726	U
101	0604807A	Medical Materiel/Medical Biological Defense Equipment - Eng Dev	05	33,890	30,384		30,384	45,412		45,412	U
102	0604808A	Landmine Warfare/Barrier - Eng Dev	05	87,895	57,674		57,674	55,215		55,215	U

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103	0604814A	Artillery Munitions - EMD	05	6,352							U
104	0604818A	Army Tactical Command & Control Hardware & Software	05	22,900	29,675		29,675	163,643		163,643	U
105	0604820A	Radar Development	05	1,796	5,221		5,221	12,309		12,309	U
106	0604822A	General Fund Enterprise Business System (GFEBS)	05	3,218				15,700		15,700	U
107	0604823A	Firefinder	05	17,734	23,480		23,480	6,243		6,243	U
108	0604827A	Soldier Systems - Warrior Dem/Val	05	25,477	6,155		6,155	18,776		18,776	U
109	0604854A	Artillery Systems - EMD	05	117,241	1,911		1,911	1,953		1,953	U
110	0605013A	Information Technology Development	05	59,329	69,728		69,728	67,358		67,358	U
111	0605018A	Integrated Personnel and Pay System-Army (IPPS-A)	05	34,400	68,434		68,434	136,011		136,011	U
112	0605028A	Armored Multi-Purpose Vehicle (AMPV)	05	27,345	92,309		92,309	230,210		230,210	U
113	0605030A	Joint Tactical Network Center (JTNC)	05	65,849	8,436		8,436	13,357		13,357	U
114	0605031A	Joint Tactical Network (JTN)	05		17,989		17,989	18,055		18,055	U
115	0605032A	TRACTOR TIRE	05					5,677		5,677	U
116	0605035A	Common Infrared Countermeasures (CIRCM)	05		145,337		145,337	77,570		77,570	U
117	0605051A	Aircraft Survivability Development	05					18,112		18,112	U
118	0605350A	WIN-T Increment 3 - Full Networking	05		113,155		113,155	39,700		39,700	U
119	0605380A	AMF Joint Tactical Radio System (JTRS)	05	9,874	6,878		6,878	12,987		12,987	U
120	0605450A	Joint Air-to-Ground Missile (JAGM)	05	15,684	83,799		83,799	88,866		88,866	U
121	0605456A	PAC-3/MSE Missile	05	86,223	34,991		34,991	2,272		2,272	U

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122	0605457A	Army Integrated Air and Missile Defense (AIAMD)	05	358,192	152,516		152,516	214,099		214,099	U
123	0605625A	Manned Ground Vehicle	05	96,820	49,134		49,134	49,247		49,247	U
124	0605626A	Aerial Common Sensor	05	10,377	17,748		17,748	2		2	U
125	0605766A	National Capabilities Integration (MIP)	05	21,132	15,212		15,212	10,599		10,599	U
126	0605812A	Joint Light Tactical Vehicle (JLTV) Engineering and Manufacturing Development Ph	05	81,388	45,694		45,694	32,486		32,486	U
127	0605830A	Aviation Ground Support Equipment	05		10,036		10,036	8,880		8,880	U
128	0210609A	Paladin Integrated Management (PIM)	05		80,263		80,263	152,288		152,288	U
129	0303032A	TROJAN - RH12	05	3,463	983		983	5,022		5,022	U
130	0304270A	Electronic Warfare Development	05	10,801	8,961		8,961	12,686		12,686	U
		System Development & Demonstration		1,955,833	1,622,353		1,622,353	2,068,950		2,068,950	
131	0604256A	Threat Simulator Development	06	23,598	22,057		22,057	20,035		20,035	U
132	0604258A	Target Systems Development	06	13,139	10,037		10,037	16,684		16,684	U
133	0604759A	Major T&E Investment	06	38,534	56,285		56,285	62,580		62,580	U
134	0605103A	Rand Arroyo Center	06	18,281	20,601		20,601	20,853		20,853	U
135	0605301A	Army Kwajalein Atoll	06	187,225	175,956		175,956	205,145		205,145	U
136	0605326A	Concepts Experimentation Program	06	21,563	19,430		19,430	19,430		19,430	U
137	0605502A	Small Business Innovative Research	06	182,958							U
138	0605601A	Army Test Ranges and Facilities	06	335,270	274,980		274,980	277,646		277,646	U
139	0605602A	Army Technical Test Instrumentation and Targets	06	63,944	45,573		45,573	51,550		51,550	U

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Department of the Army
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15 Jan 2015

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

Line No	Program Element Number	Item	Act	FY 2014 (Base & OCO)	FY 2015 Base Enacted	FY 2015 OCO Enacted	FY 2015 Total Enacted	FY 2016 Base	FY 2016 OCO	FY 2016 Total	Sec
140	0605604A	Survivability/Lethality Analysis	06	42,865	33,294		33,294	33,246		33,246	U
141	0605606A	Aircraft Certification	06	5,953	4,700		4,700	4,760		4,760	U
142	0605702A	Meteorological Support to RDT&E Activities	06	7,210	6,411		6,411	8,303		8,303	U
143	0605706A	Materiel Systems Analysis	06	19,694	20,744		20,744	20,403		20,403	U
144	0605709A	Exploitation of Foreign Items	06	7,125	7,015		7,015	10,396		10,396	U
145	0605712A	Support of Operational Testing	06	55,062	49,217		49,217	49,337		49,337	U
146	0605716A	Army Evaluation Center	06	64,425	55,031		55,031	52,694		52,694	U
147	0605718A	Army Modeling & Sim X-Cmd Collaboration & Integ	06	1,239	1,124		1,124	938		938	U
148	0605801A	Programwide Activities	06	81,013	64,160		64,160	60,319		60,319	U
149	0605803A	Technical Information Activities	06	33,018	32,303		32,303	28,478		28,478	U
150	0605805A	Munitions Standardization, Effectiveness and Safety	06	56,543	64,027		64,027	32,604		32,604	U
151	0605857A	Environmental Quality Technology Mgmt Support	06	5,019	2,611		2,611	3,186		3,186	U
152	0605898A	Management HQ - R&D	06	53,476	49,583		49,583	48,955		48,955	U
153	0909999A	Financing for Cancelled Account Adjustments	06	126							U
	RDT&E	Management Support		1,317,280	1,015,139		1,015,139	1,027,542		1,027,542	
154	0603778A	MLRS Product Improvement Program	07	93,621	17,103		17,103	18,397		18,397	U
155	0603813A	TRACTOR PULL	07					9,461		9,461	U
156	0607131A	Weapons and Munitions Product Improvement Programs	07					4,945		4,945	U

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Line No	Program Element Number	Item	Act	FY 2014 (Base & OCO)	FY 2015 Base Enacted	FY 2015 OCO Enacted	FY 2015 Total Enacted	FY 2016 Base	FY 2016 OCO	FY 2016 Total	Sec
157	0607133A	TRACTOR SMOKE	07					7,569		7,569	U
158	0607135A	Apache Product Improvement Program	07		86,099		86,099	69,862		69,862	U
159	0607136A	Blackhawk Product Improvement Program	07		48,446		48,446	66,653		66,653	U
160	0607137A	Chinook Product Improvement Program	07		35,424		35,424	37,407		37,407	U
161	0607138A	Fixed Wing Product Improvement Program	07		819		819	1,151		1,151	U
162	0607139A	Improved Turbine Engine Program	07		49,328		49,328	51,164		51,164	U
163	0607140A	Emerging Technologies from NIE	07		4,916		4,916	2,481		2,481	U
164	0607141A	Logistics Automation	07	3,592	3,652		3,652	1,673		1,673	U
165	0607664A	Biometric Enabling Capability (BEC)	07		1,332		1,332				U
166	0607665A	Family of Biometrics	07	7,160				13,237		13,237	U
167	0607865A	Patriot Product Improvement	07	33,935	57,962		57,962	105,816		105,816	U
168	0102419A	Aerostat Joint Project - EMD	07	58,383							U
169	0202429A	Aerostat Joint Project - COCOM Exercise	07	22,252	43,248		43,248	40,565		40,565	U
170	0203726A	Adv Field Artillery Tactical Data System	07	24,120	1,273		1,273				U
171	0203728A	Joint Automated Deep Operation Coordination System (JADOCS)	07		36,658		36,658	35,719		35,719	U
172	0203735A	Combat Vehicle Improvement Programs	07	171,543	297,850		297,850	257,167		257,167	U
173	0203740A	Maneuver Control System	07	35,337	45,065		45,065	15,445		15,445	U
174	0203744A	Aircraft Modifications/Product Improvement Programs	07	227,333							U

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

Line No	Program Element Number	Item	Act	FY 2014 (Base & OCO)	FY 2015 Base Enacted	FY 2015 OCO Enacted	FY 2015 Total Enacted	FY 2016 Base	FY 2016 OCO	FY 2016 Total	Sec
175	0203752A	Aircraft Engine Component Improvement Program	07	309	381		381	364		364	U
176	0203758A	Digitization	07	5,978	5,993		5,993	4,361		4,361	U
177	0203801A	Missile/Air Defense Product Improvement Program	07	1,830	5,112		5,112	3,154		3,154	U
178	0203802A	Other Missile Product Improvement Programs	07	60,005	38,323		38,323	35,951		35,951	U
179	0203808A	TRACTOR CARD	07	18,768	22,691		22,691	34,686		34,686	U
180	0205402A	Integrated Base Defense - Operational System Dev	07		4,362		4,362	10,750		10,750	U
181	0205410A	Materials Handling Equipment	07		834		834	402		402	U
182	0205412A	Environmental Quality Technology - Operational System Dev	07		280		280				U
183	0205456A	Lower Tier Air and Missile Defense (AMD) System	07		78,720		78,720	64,159		64,159	U
184	0205778A	Guided Multiple-Launch Rocket System (GMLRS)	07		45,353		45,353	17,527		17,527	U
185	0208053A	Joint Tactical Ground System	07	14,504	10,209		10,209	20,515		20,515	U
187	0303028A	Security and Intelligence Activities	07	7,596	12,518		12,518	12,368		12,368	U
188	0303140A	Information Systems Security Program	07	9,040	14,167		14,167	31,154		31,154	U
189	0303141A	Global Combat Support System	07	39,834	4,525		4,525	12,274		12,274	U
190	0303142A	SATCOM Ground Environment (SPACE)	07	17,644	11,006		11,006	9,355		9,355	U
191	0303150A	WWMCCS/Global Command and Control System	07	13,852	2,150		2,150	7,053		7,053	U
193	0305179A	Integrated Broadcast Service (IBS)	07					750		750	U

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(Dollars in Thousands)

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

Line No	Program Element Number	Item	Act	FY 2014 (Base & OCO)	FY 2015 Base Enacted	FY 2015 OCO Enacted	FY 2015 Total Enacted	FY 2016 Base	FY 2016 OCO	FY 2016 Total	Sec
194	0305204A	Tactical Unmanned Aerial Vehicles	07	33,515	22,870		22,870	13,225		13,225	U
195	0305206A	Airborne Reconnaissance Systems	07					22,870		22,870	U
196	0305208A	Distributed Common Ground/Surface Systems	07	27,607	20,155		20,155	25,592		25,592	U
197	0305219A	MQ-1C Gray Eagle UAS	07	13,074	46,472		46,472				U
198	0305232A	RQ-11 UAV	07	5,984							U
199	0305233A	RQ-7 UAV	07	12,025	16,389		16,389	7,297		7,297	U
200	0307665A	Biometrics Enabled Intelligence	07	7,443	1,973		1,973				U
201	0310349A	Win-T Increment 2 - Initial Networking	07		3,247		3,247	3,800		3,800	U
202	0708045A	End Item Industrial Preparedness Activities	07	54,392	76,187		76,187	48,442		48,442	U
9999	9999999999	Classified Programs		4,717	4,802		4,802	4,536		4,536	U
		Operational Systems Development		1,025,393	1,177,894		1,177,894	1,129,297		1,129,297	
Total Research, Development, Test & Eval, Army				7,124,298	6,673,146	2,000	6,675,146	6,924,959	1,500	6,926,459	

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Program Element Table of Contents (by Budget Activity then Line Item Number)

Budget Activity 01: Basic Research
Appropriation 2040: Research, Development, Test & Evaluation, Army

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Program Element Title	Program Element Number	Line Item	Budget Activity	Page
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In-House Laboratory Independent Research	0601101A	1	01	1
University Research Initiatives	0601103A	3	01	115
University and Industry Research Centers	0601104A	4	01	123

Exhibit R-2, RDT&E Budget Item Justification: PB 2016 Army											Date: February 2015	
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 2014**	**FY 2015**	**FY 2016 Base**	**FY 2016 OCO**	**FY 2016 Total**	**FY 2017**	**FY 2018**	**FY 2019**	**FY 2020**	**Cost To Complete**	**Total Cost**
Total Program Element	-	21.255	13.427	13.018	-	13.018	12.381	11.971	11.540	11.723	-	-
91A: *ILIR-AMC*	-	16.606	12.579	12.107	-	12.107	11.457	11.031	10.583	10.747	-	-
91C: *ILIR-Med R&D Cmd*	-	3.031	-	-	-	-	-	-	-	-	-	-
91D: *ILIR-Corps Of Engr*	-	0.811	-	-	-	-	-	-	-	-	-	-
F16: *ILIR-SMDC*	-	0.807	0.848	0.911	-	0.911	0.924	0.940	0.957	0.976	-	-

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 the AMC, MRMC, and ERDC (multiple sites); and the SMDC Technical Center (Huntsville,AL).

Exhibit R-2, RDT&E Budget Item Justification: PB 2016 Army					Date: February 2015
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 2014**	**FY 2015**	**FY 2016 Base**	**FY 2016 OCO**	**FY 2016 Total**
Previous President's Budget	21.792	13.464	13.762	-	13.762
Current President's Budget	21.255	13.427	13.018	-	13.018
Total Adjustments	-0.537	-0.037	-0.744	-	-0.744
• Congressional General Reductions	-	-0.037			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-0.537	-			
• Adjustments to Budget Years	-	-	-0.744	-	-0.744

Exhibit R-2A, RDT&E Project Justification: PB 2016 Army			Date: February 2015
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 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total	FY 2017	FY 2018	FY 2019	FY 2020	Cost To Complete	Total Cost
91A: *ILIR-AMC*	-	16.606	12.579	12.107	-	12.107	11.457	11.031	10.583	10.747	-	-

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 2014	FY 2015	FY 2016
Title: Edgewood Chemical Biological Center	0.921	0.997	1.018
Description: Funds basic research in chemistry, biology, biotechnology, and aerosol for counter improvised explosive devices (IEDs), obscurants, and/or target defeat. Work in this project provides theoretical underpinnings for PE 0602622A (Chemical, Smoke, and Equipment Defeating Technologies).			
FY 2014 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; synthesis of new materials for protection, decontamination, and detection; and the mathematics involved in data processing and interpretation.			
FY 2015 Plans:			

Exhibit R-2A, RDT&E Project Justification: PB 2016 Army		Date: February 2015
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 2014	FY 2015	FY 2016
Conduct 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:*** Will 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 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 2014 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 (IM) properties, counter terrorism technologies, power and energy systems, smaller more lethal warheads and composite materials. ***FY 2015 Plans:*** Continue 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 IM properties, counter terrorism technologies, power and energy systems, smaller more lethal warheads and composite materials. ***FY 2016 Plans:*** Will further basic research in areas such as advanced materials and nanotechnologies, more powerful energetics including those with IM properties, counter terrorism technologies, power and energy systems, smaller more lethal warheads and composite materials.	1.619	1.695	1.655
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 2014 Accomplishments:***	1.157	1.496	1.452

Exhibit R-2A, RDT&E Project Justification: PB 2016 Army		Date: February 2015
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 2014	FY 2015	FY 2016
Researched novel nanofluid coolants and lubricants; investigated statistical theories and algorithms for multi-disciplinary design optimization; researched the combustion properties of new fuels; explored novel on-chip microwave nonreciprocal devices; researched manned/unmanned teaming and cooperative mobility behaviors; and studied electromagnetic wave reflection from nano-structured non-reciprocal metamaterials for non-reflective, cloak-type coatings. ***FY 2015 Plans:*** Investigate shock wave localization and propagation in layered media; research the combustion properties of new fuels; investigate discrete element modeling for granular terrain – vehicle interaction; study on-wafer microwave nonreciprocal devices (isolators and circulators) based on artificial magnetic metamaterials and naturally anisotropic ferrite materials; research manned/unmanned teaming and cooperative mobility behaviors; research incremental learning for autonomous systems; and research optical limiter techniques and materials for laser protection. ***FY 2016 Plans:*** Will 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 will address several Army-identified major research efforts for the future including materials science and multiscale modeling, intelligent/autonomous systems, and human sciences.			
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 2014 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 2015 Plans:*** Explore the unique physics of photonic nanomaterials for revolutionizing the performance and size of systems such as IR detectors, power generation and remote imaging; continue 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:***	1.272	1.396	1.350

Exhibit R-2A, RDT&E Project Justification: PB 2016 Army		Date: February 2015
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 2014	FY 2015	FY 2016
Will create a new 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.			
Title: Aviation and Missile Research, Development and Engineering Center: Missile Efforts ***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 2014 Accomplishments:*** Investigated paucity of attractors phenomenon in dynamical systems; developed theory of harmonic generation and Raman scattering from surfaces in nano-cavity environments; studied optical propagation phenomena in the plasmonic regime in semiconductor and metal-based nanostructures and metamaterials; explored remote sensing of trace gases in the atmosphere using infrared/terahertz double resonance active interrogation; assessed enhancement of infrared emissivity/absorptivity of polar materials near optical phonon resonances by surface phonon coupling and metamaterial effects. ***FY 2015 Plans:*** Perform a pioneering demonstration of surface-enhanced analyte sensing and damage using plasmonic metal nanostructures; perform experimental test of analytic density matrix models in pump-probe spectroscopy; demonstrate chaotic dynamics in hybrid and non-smooth systems; pioneer innovative terahertz (THz) imaging techniques by combining state-of-the-art coherent imaging hardware and computational imaging methodologies; identify novel propagation phenomena that can dramatically modify/ enhance linear and nonlinear interactions with artificial, metal-based plasmonic materials and semiconductors; and perform an experimental study of plasmonic nanostructures in the enhanced transmission regime for applications to beam steering. ***FY 2016 Plans:*** Will 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; develop novel high performance signal processing techniques for chaotic waveforms in radar and communications.	2.156	2.808	2.608
Title: Aviation and Missile Research, Development and Engineering Center: Aviation Efforts ***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 2014 Accomplishments:***	1.562	1.595	1.553

Exhibit R-2A, RDT&E Project Justification: PB 2016 Army		Date: February 2015
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 2014	FY 2015	FY 2016
Continued basic aerodynamic science research in the areas of vorticity dynamics, compressible dynamic stall, bluff body flow separation and flow physics; and investigated advanced boundary layer flow control phenomenon including fluidic oscillators and plasma devices. ***FY 2015 Plans:*** Continue basic fluid dynamic research in the areas of vorticity dynamics, unsteady flow separation, and flow control to identify fundamental governing principles; complete analysis of wing/vortex interaction; conduct detailed measurements of boundary layer response to flow control; and continue work to increase control authority of plasma devices. ***FY 2016 Plans:*** Will 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.			
Title: Communications-Electronics Research, Development, and Engineering Center	2.379	2.592	2.471
Description: Funds basic research for communication and network enabling technologies in the areas of antenna design, network management, power generation and storage, and also sensors. Work in this project provides theoretical underpinnings for PE 0602705A (Electronics and Electronic Devices). ***FY 2014 Accomplishments:*** Conducted research into signals exploitation techniques by investigating algorithms for intelligently and rapidly searching wide bands of radio frequency (RF) spectrum for short duration signals by mathematically representing the shape of a specific RF signals; researched new algorithms based on mathematical models and new routing schemes for scalable and secure mobile ad hoc network (MANET)-based Real-Time Peer-to-Peer (P2P) Voice-over-IP (VoIP)/Multimedia Network; synthesized and evaluated high energy cathode materials for application to electrochemical capacitors for increased energy density and longer cycle life; investigated the feasibility of real-time, in-vacuo band edge thermometry for heteroepitaxy of II-VI thin films on semiconductor substrates for advanced IR detectors; and researched the synthesis of dense Bismuth Selenide thin films, maximizing the material properties of conduction on the surface and insulating properties in the bulk, for use in RF front end electronics. ***FY 2015 Plans:*** Conduct research on a novel class of quasi-orthogonal waveforms that will allow radar systems to perform their primary target detection mission while simultaneously allowing data sharing with other systems; investigate a new compressive sensing approach to adaptive target detection, which can potentially ease antenna integration requirements for future multi-band/multi-aperture systems and improve the spatial resolution for target detection; investigate the fundamental distributed reformation			

Exhibit R-2A, RDT&E Project Justification: PB 2016 Army		Date: February 2015
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 2014	FY 2015	FY 2016
reactions which affects species production, soot (coke) formation with more favorable reformed product gases; investigate the fundamental electrochemical properties of applied composite solid electrolyte interface for lithium electrochemical cells; investigate how Compressive Sensing (CS) affects image quality and develop metrics and model for CS; investigate how carrier transport phenomenology in epitaxial multilayer structures contribute to the performance of infrared focal plane arrays (FPAs); and investigate graph anomaly detection to identify network intrusions using traffic flow graph analysis and anomaly detection. ***FY 2016 Plans:*** Will 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 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.			
Title: Peer Reviewed Proposal Efforts ***Description:*** Funds peer reviewed proposals in basic research to provide increased quality and responsiveness in exploring new technological concepts that are highly relevant to Army needs. This funding also enhances recruitment, development, and retention of outstanding scientists and engineers engaged in high quality basic research for the Army, which provides a constant flow of new knowledge to Army laboratories. Beginning in FY15, ILIR funds in this category are redistributed to the RDECs within this project to align with DoD Instruction 3201.04 (In-House Laboratory Independent Research Program) requirements. ***FY 2014 Accomplishments:*** Solicited new basic research efforts aimed at developing and maintaining a cadre of active research scientists who can distill and extend results from worldwide research in areas of interest to the Army.	5.540	-	-
Accomplishments/Planned Programs Subtotals	16.606	12.579	12.107

C. Other Program Funding Summary ($ in Millions)

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2016 Army		Date: February 2015
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601101A / *In-House Laboratory Independent Research*	**Project (Number/Name)** 91A / *ILIR-AMC*

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 2016 Army			Date: February 2015
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601101A / *In-House Laboratory Independent Research*	Project (Number/Name) 91C / *ILIR-Med R&D Cmd*	

COST ($ in Millions)	Prior Years	FY 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total	FY 2017	FY 2018	FY 2019	FY 2020	Cost To Complete	Total Cost
91C: *ILIR-Med R&D Cmd*	-	3.031	-	-	-	-	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This project fosters investigator-driven medical and force-health protection basic research initiatives performed at the six U.S. Army Medical Research and Materiel Command laboratories. Research areas address countermeasures against infectious diseases, defense against environmental extremes and operational hazards to health, mechanisms of combat trauma and innovative treatment and surgical procedures, and medical chemical/biological warfare threats.

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

Work in this project is performed by the Walter Reed Army Institute of Research, Silver Spring, MD; U.S. Army Medical Research Institute of Chemical Defense, Aberdeen Proving Ground, MD; US Army Medical Research Institute of Infectious Diseases, Fort Detrick, MD; U.S. Army Institute of Environmental Medicine, Natick, MA; U.S. Army Institute of Surgical Research, Fort Sam Houston, TX; U.S. Aeromedical Research Laboratory, Fort Rucker, AL; and the Telemedicine and Advanced Technology Research Center, Fort Detrick, MD.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Title: Independent Research Efforts	3.031	-	-
Description: Funds basic research in medical and force health protection. ***FY 2014 Accomplishments:*** The program funded innovative in-house basic research proposals that focused on research to explore treatments and countermeasures against militarily relevant infectious diseases; defense against environmental extremes and operational hazards to health; mechanisms of combat trauma and innovative treatment and surgical procedures; and medical chemical/biological warfare threats.			
Accomplishments/Planned Programs Subtotals	3.031	-	-

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2016 Army		Date: February 2015
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601101A / *In-House Laboratory Independent Research*	**Project (Number/Name)** 91C / *ILIR-Med R&D Cmd*

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2016 Army			Date: February 2015
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601101A / *In-House Laboratory Independent Research*	Project (Number/Name) 91D / *ILIR-Corps Of Engr*	

COST ($ in Millions)	Prior Years	FY 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total	FY 2017	FY 2018	FY 2019	FY 2020	Cost To Complete	Total Cost
91D: *ILIR-Corps Of Engr*	-	0.811	-	-	-	-	-	-	-	-	-	-

Note

Not applicable for this item

A. Mission Description and Budget Item Justification

This project funds In-house Laboratory Independent Research (ILIR) in the areas of geospatial research and engineering, military engineering, and environmental quality/installations at the seven laboratories within the Corps of Engineer's U.S. Army Engineer Research and Development Center (ERDC).

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 U.S. Army ERDC, Vicksburg, MS.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Title: Geospatial Research and Engineering/Military Engineering/Environmental Quality and Installations	0.811	-	-
Description: Funds basic research in the areas of geospatial research and military engineering as well as environmental quality and installations. ***FY 2014 Accomplishments:*** Quantified the fundamental coupling effects and transfer functions of fiber optic cable sensors inside of protective conduit within realistic and variable geologic media; determined parameters and built physics-based seismic propagation models for fiber, conduit, and geomaterial interaction.			
Accomplishments/Planned Programs Subtotals	0.811	-	-

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2016 Army		Date: February 2015
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601101A / *In-House Laboratory Independent Research*	**Project (Number/Name)** 91D / *ILIR-Corps Of Engr*

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2016 Army			Date: February 2015
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 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total	FY 2017	FY 2018	FY 2019	FY 2020	Cost To Complete	Total Cost
F16: *ILIR-SMDC*	-	0.807	0.848	0.911	-	0.911	0.924	0.940	0.957	0.976	-	-

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 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 2014	FY 2015	FY 2016
Title: SMDC In-house Laboratory Independent Research (ILIR)	0.807	0.848	0.911
Description: Funds basic research to investigate laser propagation phenomenology for application in modeling and simulation and future directed energy weapons design. Activities in this program transition to High Energy Laser Technology in PE 0602307A (Advanced Weapons Technology).			
FY 2014 Accomplishments: Completed laser beam propagation experiments and provided data for model anchoring. Continued spectroscopic research, improved modeling and simulation capabilities, and began design for flowing rare earth laser.			
FY 2015 Plans: Demonstrate a diode pumped rare earth gas laser and begin assessing scalability and potential for very high efficiency operation; complete spectroscope research on Xenon as a potential rare earth gas laser for transition to advanced beam control efforts; complete 1.06 micron laser atmospheric propagation research for transition to solid state laser effects; and complete initial assessment of all-weather tracker phenomenology for transition to advanced beam control efforts.			
FY 2016 Plans:			

Exhibit R-2A, RDT&E Project Justification: PB 2016 Army		Date: February 2015
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 2014	FY 2015	FY 2016
Will complete inductive RF line widths, absorption, plasma control, and lifetimes investigations for an efficient Xenon laser; begin development of a Xenon high power laser scaling model; and complete comparison of different RF pumping mechanisms.			
Accomplishments/Planned Programs Subtotals	0.807	0.848	0.911

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 2016 Army											Date: February 2015	
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 2014**	**FY 2015**	**FY 2016 Base**	**FY 2016 OCO**	**FY 2016 Total**	**FY 2017**	**FY 2018**	**FY 2019**	**FY 2020**	**Cost To Complete**	**Total Cost**
Total Program Element	-	216.774	248.283	239.118	-	239.118	242.896	245.014	252.255	257.828	-	-
305: *ATR Research*	-	2.242	2.003	2.029	-	2.029	2.057	2.093	2.130	2.172	-	-
31B: *Infrared Optics Rsch*	-	2.844	3.307	2.843	-	2.843	2.884	2.932	2.985	3.043	-	-
52C: *Mapping & Remote Sens*	-	2.220	2.004	2.030	-	2.030	2.057	2.092	2.130	2.172	-	-
53A: *Battlefield Env & Sig*	-	3.559	2.610	3.754	-	3.754	3.808	3.873	3.944	4.020	-	-
74A: *Human Engineering*	-	8.287	14.609	13.176	-	13.176	13.342	13.523	13.682	13.997	-	-
74F: *Pers Perf & Training*	-	5.540	5.318	5.459	-	5.459	5.540	5.635	5.737	5.852	-	-
F20: *Adv Propulsion Rsch*	-	4.201	4.107	4.161	-	4.161	4.220	4.290	4.368	4.452	-	-
F22: *Rsch In Veh Mobility*	-	0.601	0.701	0.707	-	0.707	0.718	0.732	0.745	0.760	-	-
H42: *Materials & Mechanics*	-	8.695	9.305	8.603	-	8.603	8.731	8.879	9.040	9.218	-	-
H43: *Research In Ballistics*	-	9.183	8.807	8.410	-	8.410	8.531	8.676	8.834	9.007	-	-
H44: *Adv Sensors Research*	-	10.115	9.807	8.659	-	8.659	9.111	9.440	9.939	10.592	-	-
H45: *Air Mobility*	-	2.493	2.302	2.328	-	2.328	2.364	2.403	2.448	2.495	-	-
H47: *Applied Physics Rsch*	-	5.158	5.304	5.722	-	5.722	5.939	5.898	6.004	5.534	-	-
H48: *Battlespace Info & Comm Rsc*	-	21.049	25.310	25.463	-	25.463	25.856	26.248	26.685	27.204	-	-
H52: *Equip For The Soldier*	-	1.141	1.051	1.119	-	1.119	1.133	1.153	1.173	1.197	-	-
H57: *Single Investigator Basic Research*	-	78.071	81.213	87.001	-	87.001	88.319	87.776	91.389	93.887	-	-
H66: *Adv Structures Rsch*	-	2.011	2.006	2.033	-	2.033	2.061	2.095	2.133	2.174	-	-
H67: *Environmental Research*	-	1.024	0.903	0.913	-	0.913	0.928	0.943	0.961	0.979	-	-
S13: *Sci BS/Med Rsh Inf Dis*	-	10.642	11.004	11.181	-	11.181	11.318	11.503	11.722	11.952	-	-
S14: *Sci BS/Cbt Cas Care Rs*	-	8.940	10.548	9.758	-	9.758	9.900	10.071	10.253	10.457	-	-
S15: *Sci BS/Army Op Med Rsh*	-	7.269	6.814	6.599	-	6.599	6.688	6.801	6.924	7.060	-	-
T14: *BASIC RESEARCH INITIATIVES - AMC (CA)*	-	-	10.250	-	-	-	-	-	-	-	-	-

Exhibit R-2, RDT&E Budget Item Justification: PB 2016 Army											Date: February 2015		
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*								
T22: *Soil & Rock Mech*	-	4.470	5.702	4.456	-	4.456	4.520	4.597	4.681	4.773	-	-
T23: *Basic Res Mil Const*	-	1.734	2.101	1.722	-	1.722	1.747	1.777	1.809	1.844	-	-
T24: *Signature Physics And Terrain State Basic Research*	-	1.593	2.005	1.627	-	1.627	1.649	1.675	1.706	1.740	-	-
T25: *Environmental Science Basic Research*	-	6.966	7.300	6.980	-	6.980	7.081	7.202	7.336	7.480	-	-
T63: *Robotics Autonomy, Manipulation, & Portability Rsh*	-	1.924	6.996	7.233	-	7.233	7.164	7.388	8.080	8.242	-	-
T64: *Sci BS/System Biology And Network Science*	-	2.860	2.397	2.930	-	2.930	2.974	3.025	3.080	3.141	-	-
VR9: *Surface Science Research*	-	1.942	2.499	2.222	-	2.222	2.256	2.294	2.337	2.384	-	-

A. Mission Description and Budget Item Justification

This program element (PE) builds fundamental scientific knowledge contributing to the sustainment of 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.

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.

Exhibit R-2, RDT&E Budget Item Justification: PB 2016 Army	Date: February 2015
Appropriation/Budget Activity 2040: *Research, Development, Test & Evaluation, Army* / BA 1: *Basic Research*	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*

B. Program Change Summary ($ in Millions)	FY 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total
Previous President's Budget	221.783	238.167	239.560	-	239.560
Current President's Budget	216.774	248.283	239.118	-	239.118
Total Adjustments	-5.009	10.116	-0.442	-	-0.442
• Congressional General Reductions	-	-0.134			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	10.250			
• Congressional Directed Transfers	-	-			
• Reprogrammings	2.635	-			
• SBIR/STTR Transfer	-7.644	-			
• Adjustments to Budget Years	-	-	-0.442	-	-0.442

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2014	FY 2015
Project: T14: *BASIC RESEARCH INITIATIVES - AMC (CA)*		
Congressional Add: *Program Increase*	-	8.000
Congressional Add: *STEM Pilot Program*	-	2.250
Congressional Add Subtotals for Project: T14	-	10.250
Congressional Add Totals for all Projects	-	10.250

Exhibit R-2A, RDT&E Project Justification: PB 2016 Army											Date: February 2015	
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 2014**	**FY 2015**	**FY 2016 Base**	**FY 2016 OCO**	**FY 2016 Total**	**FY 2017**	**FY 2018**	**FY 2019**	**FY 2020**	**Cost To Complete**	**Total Cost**
305: *ATR Research*	-	2.242	2.003	2.029	-	2.029	2.057	2.093	2.130	2.172	-	-

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 several Program Elements (PEs) to include 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 2014	FY 2015	FY 2016
Title: ATR Algorithms	1.316	2.003	2.029
Description: Investigate new algorithms to improve aided/unaided target detection and identification.			
FY 2014 Accomplishments: Investigated methods for human detection, cross-modality face recognition, and robust spectral signature analysis to enhance Data-to-Decision capabilities; and developed ATR algorithms insensitive to signature variations and environmental changes.			
FY 2015 Plans:			

Exhibit R-2A, RDT&E Project Justification: PB 2016 Army		Date: February 2015
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 2014	FY 2015	FY 2016
Investigate methods for automatic human and vehicle activity detection and classification, and multimodal biometrics for improved situational understanding and reduced Soldier workload; research methods to select relevant data for enhanced decision making; and develop machine learning algorithms for scene understanding. ***FY 2016 Plans:*** Will 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.			
Title: Tagging, Tracking and Locating (TTL) ***Description:*** Conduct basic research to support advances in state-of-the-art clandestine (Transistor-transistor logic) TTL for non-traditional hostile force and non-cooperative targets. Specific technical objectives, products, and deliverables are in accordance with the Hostile Forces TTL Capabilities Development Document and the TTL Science and Technology Roadmap. This effort directly supports the U.S. ARL's efforts in applied research and the U.S. Army CERDEC's advanced research in clandestine TTL. ***FY 2014 Accomplishments:*** Developed multimodal methods to monitor, extract and disseminate information related to targets' changing characteristics and the means to influence target behavior to create measurable signatures of interest; and developed (from the hyperspectral data assessment made in FY13) more effective methods for autonomous, non-motion based, motor-vehicle tracking by fusing proven detection/classification techniques for different applications (e.g., hyperspectral target detection, and speech recognition) to provide enhanced TTL standoff capabilities.	0.926	-	-
Accomplishments/Planned Programs Subtotals	2.242	2.003	2.029

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 2016 Army										Date: February 2015		
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 2014**	**FY 2015**	**FY 2016 Base**	**FY 2016 OCO**	**FY 2016 Total**	**FY 2017**	**FY 2018**	**FY 2019**	**FY 2020**	**Cost To Complete**	**Total Cost**
31B: *Infrared Optics Rsch*	-	2.844	3.307	2.843	-	2.843	2.884	2.932	2.985	3.043	-	-

Note

Not applicable for this item.

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 and mid-wavelength IR 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 and IR FPAs. 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 and study 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. 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 interband cascade lasers. This work is coordinated with the U.S. Army Communications Electronics Research, Development, and Engineering Center (CERDEC).

Work in this project supports key Army needs and provides the technical underpinning to several Program Elements (PEs)to include 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 U.S. Army Research Laboratory (ARL), Adelphi, MD.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Title: Electro-Optic Materials Research, RF Photonics for Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance (C4ISR), and Photonics Research for Electronic Warfare	2.844	3.307	2.843

Exhibit R-2A, RDT&E Project Justification: PB 2016 Army		Date: February 2015
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 2014	FY 2015	FY 2016
Description: Conduct research into infrared focal plane arrays (IR FPAs), radio-frequency (RF) photonics, and IR countermeasures to increase situational awareness in open and complex terrain; improve target detection, identification, and discrimination; and enhance missile threat IR countermeasure (IRCM) protection. ***FY 2014 Accomplishments:*** Researched advanced (RF)-photonic/optical techniques to study noise generation and mitigation in RF-over fiber links to achieve ultra high resolution, wideband signal transmission; investigated long-wave infrared (LWIR) two-color IR detectors using combinations of bulk materials and artificially layered structures, taking advantage of low cost materials and novel insights in materials properties; established a 3D, finite element electromagnetic model to calculate quantum efficiency (QE) for any IR detector structures; designed novel semiconductor metastructure photonic devices to provide the basic building blocks for future chip scale processing; investigated frontier optical effects to design high QE detectors; and improved power output of quantum cascade lasers. ***FY 2015 Plans:*** Grow and characterize new long-wave IR (LWIR) bulk semiconductor materials used in new detector designs with potential for low-cost, high performance applications; investigate 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; investigate 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 study electro-optical (EO) modulator based on nano-crystal silicon for next generation high speed chip scale communication. ***FY 2016 Plans:*** Will 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 will 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 perrformance; 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.			
Accomplishments/Planned Programs Subtotals	2.844	3.307	2.843

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

Exhibit R-2A, RDT&E Project Justification: PB 2016 Army		Date: February 2015
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** 31B / *Infrared Optics Rsch*

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2016 Army										Date: February 2015		
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 2014**	**FY 2015**	**FY 2016 Base**	**FY 2016 OCO**	**FY 2016 Total**	**FY 2017**	**FY 2018**	**FY 2019**	**FY 2020**	**Cost To Complete**	**Total Cost**
52C: *Mapping & Remote Sens*	-	2.220	2.004	2.030	-	2.030	2.057	2.092	2.130	2.172	-	-

Note

Not applicable to this item

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 PE 0602784A (Military Engineering Technology), Project 855 (Mapping and Remote Sensing).

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 U.S. Army Engineer Research and Development Center (ERDC), Vicksburg, MS.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Title: Sensor Phenomenology and Spatial-Temporal Pattern Discovery	2.220	2.004	2.030
Description: Funding provided for the following research.			
FY 2014 Accomplishments: Investigated and defined the concepts of neighborhood and scale for human terrain parameters, and examined clustering and topology in human terrain neighborhoods to understand how human terrain events propagate through Euclidean and social network space; investigated methodologies for transforming multi-dimensional spatial-temporal trajectory data into linear representation for discovering patterns and hierarchical structure; investigated approaches to estimating terrain physical properties from proprioceptive sensor data.			
FY 2015 Plans: Investigate aerosol effects on the integrity of Light Detection and Ranging (LiDAR) signals to improve signal and data collection capabilities; explore methods of describing objects in massive unstructured datasets through novel machine learning techniques			

Exhibit R-2A, RDT&E Project Justification: PB 2016 Army		Date: February 2015
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 2014	FY 2015	FY 2016
to advance Big Data capabilities; investigate multi-source signal decomposition and characterization from single acoustic sensors to increase monitoring capabilities; and theorize metrics for the quantification of adaptive capacity of human populations resulting from environmental change to monitor instability. ***FY 2016 Plans:*** Will 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 sensing signatures; and explore uncertainty in seismic signatures due to both the source and propagation mediums (i.e., soil and rock).			
Accomplishments/Planned Programs Subtotals	2.220	2.004	2.030

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 2016 Army			Date: February 2015
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 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total	FY 2017	FY 2018	FY 2019	FY 2020	Cost To Complete	Total Cost
53A: *Battlefield Env & Sig*	-	3.559	2.610	3.754	-	3.754	3.808	3.873	3.944	4.020	-	-

Note

Not applicable for this item

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 U.S. Army Research Laboratory (ARL), Adelphi, MD and White Sands Missile Range, NM.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Title: Research in optical and acoustical propagation in the atmosphere	2.105	-	-
Description: Research in optical and acoustical propagation in the atmosphere for enhanced Intelligence, Surveillance, and Reconnaissance capabilities for the future force to support situational understanding and rapid targeting.			

Exhibit R-2A, RDT&E Project Justification: PB 2016 Army		Date: February 2015
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 2014	FY 2015	FY 2016
FY 2014 Accomplishments: Investigated and modeled atmospheric water vapor impacts on THz band communications propagation statistics for digital link quality for U.S. Army Aviation and Missile Research, Development and Engineering Command (AMRDEC) covert local wireless communications technology applications. Measured and modeled optical turbulence to improve the prediction of strong turbulence effects on high energy laser propagation in complex terrain.			
Title: Predictive Modeling of the Boundary Layer ***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 2014 Accomplishments:*** Formulated and evaluated numerical methods to improve the microscale (local) weather prediction model Atmospheric Boundary Layer Environment (ABLE) performance for Army decision aid applications; investigated biologically-inspired fast patterned responses to control surface wind flow changes to more effectively predict and mitigate boundary layer wind gust effects on micro air vehicle hover and stability; and investigated and developed an experimental hybrid data assimilation approach to improve fine-scale weather forecast performance. ***FY 2015 Plans:*** Finalize and implement an experimental hybrid data assimilation approach into microscale and mesoscale numerical weather prediction models to improve fine-scale weather forecast performance; research 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; explore 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 determine feasibility of atmospheric energy harvesting for small scale applications. ***FY 2016 Plans:*** Will 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-	1.454	2.610	3.754

Exhibit R-2A, RDT&E Project Justification: PB 2016 Army		Date: February 2015
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 2014	FY 2015	FY 2016
N and 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.			
Accomplishments/Planned Programs Subtotals	3.559	2.610	3.754

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 2016 Army										Date: February 2015		
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 2014**	**FY 2015**	**FY 2016 Base**	**FY 2016 OCO**	**FY 2016 Total**	**FY 2017**	**FY 2018**	**FY 2019**	**FY 2020**	**Cost To Complete**	**Total Cost**
74A: *Human Engineering*	-	8.287	14.609	13.176	-	13.176	13.342	13.523	13.682	13.997	-	-

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).

Exhibit R-2A, RDT&E Project Justification: PB 2016 Army		Date: February 2015
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 2014	FY 2015	FY 2016
Title: Research to Characterize and Enhance Soldier Performance	2.025	2.349	1.628
Description: Characterize and enhance human auditory performance of the dismounted warrior in complex environments while protecting the hearing of the Soldier. ***FY 2014 Accomplishments:*** Quantified the effects of compression type on relative distance perception when wearing tactical communication and protection systems (TCAPS). ***FY 2015 Plans:*** Conduct Soldier-oriented research to understand the auditory conditions that lead to misinterpretation of auditory events in a complex sensory environment; quantify and describe spatial range across which detection of auditory location changes are unlikely to be detected; and characterize the environmental elements and contexts that may be vulnerable to misinterpretation. ***FY 2016 Plans:*** Will 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	2.586	2.850	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 2014 Accomplishments:*** Enhanced recognition of places and objects for the Symbolic and Sub-symbolic Robotics Intelligence Control System project by integrating multiple independent cues for perpetual processing to include contextual processing, depth processing, and color processing; performed engineering evaluation tests of key autonomous robotic functions for navigation, object recognition, short- and long-term memory, and understanding and acting on verbal operator commands through natural language processing; expanded the project on temporal network dynamics for the social-cognitive network science initiative by identifying specific			

Exhibit R-2A, RDT&E Project Justification: PB 2016 Army		Date: February 2015
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 2014	FY 2015	FY 2016
behaviors of complex dynamical systems (i.e., networks) and implemented techniques for capturing those behaviors using an enhanced version of the computer model Command, Control and Communications Technologies for Reliable Assessment of Concept Execution (C3TRACE), which allows development of a "network sandbox"; and conducted research investigating the effects of operationally relevant stressors on Soldier performance during tactical operations (for the cognitive readiness initiative). ***FY 2015 Plans:*** Further develop 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; establish a theoretical foundation for human networking behavior yielding testable predictions for laboratory experiments (modeling effort); continue the development of object recognition of places and objects (cognitively-inspired intelligent robotic technology); leverage the results of industry efforts in shape recognition features; conduct experiments in realistic contexts with human interaction; conduct experiments to fill data voids and develop models describing and able to predict the key simulation parameters affecting perception, cognition, and physical performance independently (simulation and training); and outline experimentation required to determine simulation parameters affecting the interactions across perception, cognition, and physical performance. Includes preliminary Training and Soldier performance research to identify and evalute performance models, metrics and enviroments for determining Soldier behavior. This work will be continued under a new R2 bullet beginning in FY16. ***FY 2016 Plans:*** Will 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 2014 Accomplishments:*** Enhanced neuroimaging technologies for increased resolution, greater wearability by Soldiers, and enhanced interpretability of neural signatures in realistic environments; and investigated the relationships between neuromodulators, brain electrical activity, and behavior for improved understanding of Soldier neurocognitive function. ***FY 2015 Plans:***	2.422	4.398	3.579

Exhibit R-2A, RDT&E Project Justification: PB 2016 Army		Date: February 2015
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 2014	FY 2015	FY 2016
Develop and refine 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; examine effects of environmental context on cognitive brain state assessments; explore analytical approaches for interpreting brain activity in unstructured tasks; and investigate 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:*** Will 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.			
Title: Cognition and Neuroergonomics ***Description:*** Devise and show fundamental translational principles for neuroscience-based research and theory to complex operations settings in three focus areas: Soldier-system information transfer, commander-level decision making, and individualized analysis and assessment of cognitive performance in operational environments. Beginning in FY15, this work will be incorporated into Translational Neuroscience. ***FY 2014 Accomplishments:*** Investigated sensitivity of identified individual difference measures to variability in performance across individuals, tasks, and cognitive states; and evaluated predictive capability of structural networks and/or functional processing for individualized performance assessment.	1.254	-	-
Title: Human System Integration – Cybernetics ***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 Plans:*** Determine areas of convergence for cognitive, social, information and computational sciences to develop and apply the cybernetic approach to human centered design of complex systems; invoke 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; examine 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; conduct research using novel paradigms, such as wearable computing and augmented reality technologies	-	5.012	5.119

Exhibit R-2A, RDT&E Project Justification: PB 2016 Army		Date: February 2015
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 2014	FY 2015	FY 2016
to identify key temporal and context parameters in multi-sensory integration; and lay foundation for scaling up to societal-level cybernetics. ***FY 2016 Plans:*** Will 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.			
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 2016 Plans:*** Will 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).	-	-	1.221
Accomplishments/Planned Programs Subtotals	8.287	14.609	13.176

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2016 Army		Date: February 2015
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** 74A / *Human Engineering*

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2016 Army			Date: February 2015
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 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total	FY 2017	FY 2018	FY 2019	FY 2020	Cost To Complete	Total Cost
74F: *Pers Perf & Training*	-	5.540	5.318	5.459	-	5.459	5.540	5.635	5.737	5.852	-	-

Note

Not applicable for this item.

A. Mission Description and Budget Item Justification

This program element 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 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 U.S. Army Research Institute for the Behavioral and Social Sciences (ARI), Ft. Belvoir, VA.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Title: Personnel Measures (previously Human Behavior)	3.730	1.800	1.834
Description: Funding is provided for basic research to develop innovative theories, models, and methods to improve personnel assessment, training, and leader development.			
FY 2014 Accomplishments: Investigated factors that influence on-the-job learning; identified predictors of leader development and retention; and identified contextual facets that influence decision making.			
FY 2015 Plans: Initiate the development of measurement theory and performance-based measurement methods to improve selection, classification, and assignment.			
FY 2016 Plans:			

Exhibit R-2A, RDT&E Project Justification: PB 2016 Army		Date: February 2015
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 2014	FY 2015	FY 2016
Will investigate the integration of psychological and neurometric approaches for improving individual difference assessment and personnel testing methods.			
Title: Climate, Readiness, and Resilience (previously Human in Complex Organizations) ***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 2014 Accomplishments:*** Conducted research to understand social and organizational network variables that affect contextual control; developed real-time assessment and feedback mechanisms to shape group relationships. ***FY 2015 Plans:*** Initiate research to develop group and organizational measures of organizational cohesion, resilience, and effectiveness. ***FY 2016 Plans:*** Will investigate integrated approaches to understanding and assessing systematic contextual moderators of behavior in organizations with primary emphasis on improving prediction of mistreatment and inclusion.	1.810	3.518	3.625
Accomplishments/Planned Programs Subtotals	5.540	5.318	5.459

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 2016 Army			Date: February 2015
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 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total	FY 2017	FY 2018	FY 2019	FY 2020	Cost To Complete	Total Cost
F20: *Adv Propulsion Rsch*	-	4.201	4.107	4.161	-	4.161	4.220	4.290	4.368	4.452	-	-

Note

Not applicable for this item

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 today's 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 U.S. Army Research Laboratory (ARL) at Aberdeen Proving Ground, MD.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Title: Thermal Materials	2.489	2.407	2.431
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 2014 Accomplishments: Investigated surface engineering techniques to reduce engine and transmission friction losses for improved vehicle fuel economy, reduced maintenance cost, and reduced logistic burden; and established the capabilities to assess high temperature materials and components for next-generation Army wheeled tactical and combat vehicle power train concepts.			
FY 2015 Plans:			

Exhibit R-2A, RDT&E Project Justification: PB 2016 Army		Date: February 2015
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 2014	FY 2015	FY 2016
Conduct 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; develop advanced computational damage models; and conduct 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:*** Will 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 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 2014 Accomplishments:*** Experimentally evaluated advanced heavy fuel injection spray characteristics under simulated engine conditions to optimize combustion performance; used modeling and simulation coupled with experimentation to assess unmanned vehicle engines fueled with JP-8 and other heavy fuels; and evaluated the performance of Army unmanned vehicle engines and small heavy fuel injectors to enable heavy fuel operability and to optimize performance and efficiency. ***FY 2015 Plans:*** Evaluate transient spray and combustion characteristics of heavy fuel injectors under simulated engine conditions to optimize engine combustion, performance, and efficiency; and develop more accurate and reliable modeling and simulation tools to predict spray and combustion characteristics under complex fluid dynamics conditions that will enable effective design of small engines for a range of Army applications. ***FY 2016 Plans:*** Will 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.	1.712	1.700	1.730
Accomplishments/Planned Programs Subtotals	4.201	4.107	4.161

Exhibit R-2A, RDT&E Project Justification: PB 2016 Army		Date: February 2015
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** F20 / *Adv Propulsion Rsch*

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 2016 Army										Date: February 2015		
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 2014**	**FY 2015**	**FY 2016 Base**	**FY 2016 OCO**	**FY 2016 Total**	**FY 2017**	**FY 2018**	**FY 2019**	**FY 2020**	**Cost To Complete**	**Total Cost**
F22: *Rsch In Veh Mobility*	-	0.601	0.701	0.707	-	0.707	0.718	0.732	0.745	0.760	-	-

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 2014**	**FY 2015**	**FY 2016**
Title: Advanced Mathematical Algorithms for Improved Vehicle Efficiency	0.601	0.701	0.707
Description: Funding is provided for the following effort: ***FY 2014 Accomplishments:*** Researched ignition under high-pressure injection conditions, and analyzed heat release data for new fuels; researched new analytical tools for characterizing vehicle duty cycles and physics-based vehicle and powertrain dynamics; explored power available for mobility; and researched mobility for small platforms (i.e., the interaction of wheeled or tracked vehicles on various surfaces). ***FY 2015 Plans:*** Research new physics based analytical tools for more accurately and rapidly predicting vehicle terrain interaction effects; and explore new methodologies/relationships for improving intelligent mobility including latency. ***FY 2016 Plans:*** Will research development of NATO Reference Mobility Model (NRMM) 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.			
Accomplishments/Planned Programs Subtotals	0.601	0.701	0.707

Exhibit R-2A, RDT&E Project Justification: PB 2016 Army		Date: February 2015
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** F22 / *Rsch In Veh Mobility*

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 2016 Army										Date: February 2015		
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 2014**	**FY 2015**	**FY 2016 Base**	**FY 2016 OCO**	**FY 2016 Total**	**FY 2017**	**FY 2018**	**FY 2019**	**FY 2020**	**Cost To Complete**	**Total Cost**
H42: *Materials & Mechanics*	-	8.695	9.305	8.603	-	8.603	8.731	8.879	9.040	9.218	-	-

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 U.S. Army Research Laboratory (ARL), Aberdeen Proving Ground, MD.

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2014**	**FY 2015**	**FY 2016**
Title: Microscopic/Nanostructural Materials	2.553	2.599	2.341
Description: Devise new materials and design capabilities based upon fundamental concepts derived at the microscopic and nanostructural levels for the future force.			
FY 2014 Accomplishments: Developed mathematical descriptions of full non-linear and transient coupling in armor grade piezoelectric ceramics for novel protection; reported on the full-field penetration response of ultra high molecular weight polyethylene (UHMWPE) fabric and fabric systems for application to soldier protection; established patterned thin film techniques to fabricate a metamaterial lens for corrosion detection under dielectric and paint coatings with high sensitivity; and improved adhesion bio-inspired polymer adhesives for composite armors.			
FY 2015 Plans: Create numerical models and experimental techniques to design energy-absorbing, adaptive, damage-tolerant nanocomposites; develop new paradigms for thermodynamically stable nanostructured materials systems that overcome traditional property			

Exhibit R-2A, RDT&E Project Justification: PB 2016 Army		Date: February 2015
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 2014	FY 2015	FY 2016
trade-offs; and pursue revolutionary new polymeric building block materials for structural, membrane, sensor, and power/energy applications. ***FY 2016 Plans:*** Will develop computational capabilities and methods to explore grain boundary structure-property relationships for predicting the strength and failure response of metals and ceramics; and will continue thermodynamic stability research of micro/nanomaterials including synthesis of new nanocrystalline iron-based alloys that employ novel particulate oxide strengthening mechanisms.			
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 2014 Accomplishments:*** Investigated modeling and simulation of clean and doped grain boundaries in boron-based armor ceramics; design novel, thermodynamically stable nanocrystalline alloys for shaped charge liners; determined the importance of composition and microstructure on rate dependent properties of epoxy resins; and completed an initial 3D microstructural model of lightweight magnesium or aluminum alloys. ***FY 2015 Plans:*** Develop 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; create novel experimental research tools to enable the study of these high deformation rate phenomena with greater resolution; incorporate microstructural and high deformation response into robust multiscale computational codes; and begin to create new materials specifically designed to enhance performance at high deformation rates in applications ranging from armor to new armaments. ***FY 2016 Plans:*** Will 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.	3.039	3.407	3.107
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 2014 Accomplishments:***	3.103	3.299	3.155

Exhibit R-2A, RDT&E Project Justification: PB 2016 Army		Date: February 2015
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 2014	FY 2015	FY 2016
Validated new multi-axial mechanical characterization methods and apply to conventional and novel ballistic fibers to elucidate the effect of nanostructure; developed in-situ capabilities for electron microscopy to elucidate the mechanical response of soft tissue and polymer gels; and characterized the water transport properties of polymer electrolyte materials. ***FY 2015 Plans:*** Develop 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; utilize thermodynamic and kinetic studies of self-assembly processes to design, create, and characterize nanostructured surfaces and interfaces; and create and utilize small scale materials characterization techniques to further the fundamental understanding of small scale materials and processes. ***FY 2016 Plans:*** Will 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.			
Accomplishments/Planned Programs Subtotals	8.695	9.305	8.603

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 2016 Army										Date: February 2015		
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 2014**	**FY 2015**	**FY 2016 Base**	**FY 2016 OCO**	**FY 2016 Total**	**FY 2017**	**FY 2018**	**FY 2019**	**FY 2020**	**Cost To Complete**	**Total Cost**
H43: *Research In Ballistics*	-	9.183	8.807	8.410	-	8.410	8.531	8.676	8.834	9.007	-	-

Note

Not applicable for this item

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 to several Program Elements (PEs) to include 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 U.S. Army Research Laboratory (ARL), Aberdeen Proving Ground, Adelphi, MD, and Research Triangle Park, NC.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Title: Advanced Energetics Initiative	2.947	3.599	3.155
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 2014 Accomplishments: Synthesized and fabricated gram quantities of disruptive energetic materials that have two-fold energy content compared to conventional explosives; developed reactive variants of the dissipative particle dynamics method with multi-step chemical reactions and performed simulations of multi-scale coarse grain models to determine pressure dependent stress-strain behavior for input into plasticity model; and refined and validated existing model via comparison with nano-indentation experiments.			
FY 2015 Plans: Exploit material micro/nanostructure, high pressure synthesis, and managed energy release mechanisms to develop energetic materials with 2-10 times the energy content of conventional explosives; further advance theory required to develop accurate			

Exhibit R-2A, RDT&E Project Justification: PB 2016 Army		Date: February 2015
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 2014	FY 2015	FY 2016
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 develop synthetic capabilities to produce high-nitrogen containing materials. ***FY 2016 Plans:*** Will 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 develop predictive models and associated experimental methods to enable precise control of energy release in shear-mediated acceleration of solid-solid chemical reactions.			
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 2014 Accomplishments:*** Continued to develop first principles state-of-the-art computational aerodynamics techniques using coupled computational fluid dynamics (CFD), rigid body dynamics (RBD) and flight control systems (FCS) to exploit novel flow physics and increase maneuverability for next generation, low cost, hyper-accurate munitions; added structural dynamics model to simulate guided maneuvers and unsteady effects; and computed a coupled calculation of a canard-controlled finned projectile (using a skid-to-turn maneuver), computed and validated a roll maneuver (with dynamic wind tunnel data), and simulated uncontrolled and controlled trajectories (of a long flexible finned body). ***FY 2015 Plans:*** Further develop 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:*** Will 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.	1.730	1.699	1.730
Title: Extramural Research in Non-Lethal (NL) Control Methods ***Description:*** Extramural research in NL control methods to exploit potentially innovative approaches that offer unique battlefield and homeland defense capabilities. ***FY 2014 Accomplishments:***	1.248	-	-

Exhibit R-2A, RDT&E Project Justification: PB 2016 Army		Date: February 2015
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 2014	FY 2015	FY 2016
Developed statistical methods to analyze spatially and temporally evolving patterns designed to provide decision makers with the capability to distill concise meaning from large quantities of experimental observations.			
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 2014 Accomplishments:*** Developed a model for thermo-physical properties of plasmas and explored advanced electro-magnetic effects using hydrocodes and experimentation to better understand conductivity and fields in order to optimize electromagnetic armors; advanced computational models by exploring dynamic effects in 3D; and studied the physics of using electromagnetic fields to enhance the detonation of energetic materials which included designing a new diagnostic tool to study the detonation zone. ***FY 2015 Plans:*** Establish capabilities to extract electron temperature data from time resolved imaging spectroscopy measurements of shaped charge jet induced plasma for comparison to numerical simulation predictions; develop hierarchical multiscale methodology for transfer of relevant information from mesoscale computation to macroscale constitutive and failure models; and develop 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:*** Will 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.	3.258	3.509	3.525
Accomplishments/Planned Programs Subtotals	9.183	8.807	8.410

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 2016 Army										Date: February 2015		
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 2014**	**FY 2015**	**FY 2016 Base**	**FY 2016 OCO**	**FY 2016 Total**	**FY 2017**	**FY 2018**	**FY 2019**	**FY 2020**	**Cost To Complete**	**Total Cost**
H44: *Adv Sensors Research*	-	10.115	9.807	8.659	-	8.659	9.111	9.440	9.939	10.592	-	-

Note

Not applicable for this item

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 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, digital and image processing modules and algorithms, beam propagation and material modeling of nonlinear optical effects, hazardous material detection, remote sensing and intelligent system distributive interactive simulations, unique sensor development, sensor data feature and information fusion in the concept of Data-to-Decisions (D2D), and battlefield acoustic signal processing algorithms. Research performed under this project also supports survivable sensor systems, organic thin film transistor technology and organic light emitting diode technology for affordable rugged flexible displays. 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, low cost compact flexible displays for the Soldier and for the Army, 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 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 capabilities in hazardous material and event sensing.

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

Work in this project complements and is fully coordinated with research at the U.S. Army Armaments Research, Development, and Engineering Center (ARDEC); the U.S. Army Communications Electronics Research, Development, and Engineering Center (CERDEC), the U.S. Army Natick Soldier RDEC (NSRDEC) and the U.S. 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 U.S. Army Research Laboratory (ARL), Adelphi, MD.

Exhibit R-2A, RDT&E Project Justification: PB 2016 Army		Date: February 2015
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 2014	FY 2015	FY 2016
Title: Adaptive, Active, and Intelligent Optical Systems	1.818	1.800	-
Description: Adaptive, active, and intelligent optical systems for high-data-rate military communications and directed energy applications. ***FY 2014 Accomplishments:*** Developed application of advanced Army battle-space tactical, short-haul, and long-range atmospheric laser ultraviolet/light-emitting diode/radio frequency (UV/LED/RF) communication and imaging technologies to achieve high bandwidth communication, high fidelity visualization, and allow utilization of advanced command and control techniques (including improving comprehensive link modeling and prediction of ultraviolet communication (UVC) and visible light communication (VLC), including atmospheric propagation, source and detection technology, and modulation and coding strategies); and investigated and developed novel quantum physics and coupled processing techniques to provide tactically superior quantum imaging and battlefield communications particularly in obscured, obstructed, or adverse tactical environments. ***FY 2015 Plans:*** Complete the optimization of the pointing, acquisition, and tracking sub-systems of the Free-Space Optical (FSO) networked multi-gigabit communication system; conduct a performance evaluation of the FSO and its related control software; and develop a visible light multispectral quantum imager capable of imaging through turbulence and demonstrate its capability in turbulence and low light field experiments to beyond 1 km.			
Title: Improving Sensor and Photonics Research (Nano)	2.754	2.999	2.850
Description: Create more survivable and secure sensors and displays; improve hazardous material monitoring; and investigate new magnetic sensor technologies for personnel and improvised explosive device (IED) detection. ***FY 2014 Accomplishments:*** Developed time-domain acoustic models that incorporate ground impedance and atmospheric effects to create synthetic sensor waveform data in various environments for training and evaluating acoustic classification algorithms. Investigated utilization of spin-torque-oscillators for reading non-erasable magnetic memory; developed algorithms and software for modeling non-linear signature response of RF devices in complex urban environments; performed theoretical and experimental analysis on metamaterials with randomly oriented unit cells and investigated the viability of their use in RF lens structures (e.g., a Rotman lens); and researched organic devices and materials and diodes for large-area radiation and particle sensors utilizing charge-transfer electro-chemical designs. ***FY 2015 Plans:*** Research methods to improve acoustic classification robustness in diverse environments; study a physics-based tracker algorithm for extremely long-range infrasound (low-frequency sound) detections; research methods to improve sensitivity and miniaturize interface of magnetic tunnel junction sensor sensitivity and interface for reading non-erasable magnetic memory permeability			

Exhibit R-2A, RDT&E Project Justification: PB 2016 Army		Date: February 2015
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 2014	FY 2015	FY 2016
bits of stored information; and investigate signal processing algorithms for exploiting flexible and adaptable low frequency ultra-wideband (UWB) waveforms that support stepped frequency radar technology. ***FY 2016 Plans:*** Will 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.			
Title: Engineered Biotechnology ***Description:*** Use a multi-scale modeling approach to investigate biological systems to develop biologically-inspired sensors as well as bio-inspired power generation and storage techniques. ***FY 2014 Accomplishments:*** Used synthetic biology, building off of previous genetic sensing constructs, to engineer sense and respond module for neutralizing biological contamination; developed second generation peptide recognition elements using an iterative process involving computational modeling coupled with experimental characterization for materials that perform in extreme environments; used synthetic microbiology to engineer second generation strains for production commodity chemicals based upon predictions made in FY13; and used biological characterization data generated in FY13 to refine advanced modeling techniques of multi-scale modeling for prediction of improved biological interactions.	3.043	-	-
Title: Multi-Scale Modeling for Novel Materials ***Description:*** Explore and develop multiscale modeling techniques to support fundamental studies of electronic and structural materials properties from the atomistic to the continuum. Resulting models are needed to design/ 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 061104A/Project VS2 (Multi-Scale Materials Modeling Centers). ***FY 2014 Accomplishments:*** Used FY13 results to design and expand fundamental studies to identify and model 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; established fundamental underpinnings of physics between	2.500	2.999	2.795

Exhibit R-2A, RDT&E Project Justification: PB 2016 Army		Date: February 2015
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 2014	FY 2015	FY 2016
nano- and meso-scales up to the continuum; continued to develop new multi-scale experimental techniques and characterization methods to probe materials microstructure, including defects and interfaces, and responses under extreme conditions; developed 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; created and disseminated web-based security schemes for external and internal project users to foster multi-disciplinary collaboration; conducted research in multi-scale computational sciences and couple different modeling paradigms at the algorithm level; and advanced methods to support high performance computing users and software developers. ***FY 2015 Plans:*** Continue 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; validate multi-scale experimental techniques and characterization methods; continue to develop advanced computational models for multiscale modeling of electrochemical systems; investigate 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 conduct research in multi-scale computational sciences and couple different modeling paradigms at the algorithm level. ***FY 2016 Plans:*** Will 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.			
Title: Bio-inspired Materials and Devices Research ***Description:*** Create synthetic biological materials for electronic devices and force protection. ***FY 2015 Plans:*** Investigate 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; study novel synthetic recognition reagents in response to new and emerging threats that possess superior performance, stability and adaptability; and research hybrid biological/electronic/photonic materials capabilities based on bio-engineered cellular machinery or specific properties of bio-interfacial chemistry. ***FY 2016 Plans:*** Will 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; study	-	2.009	3.014

Exhibit R-2A, RDT&E Project Justification: PB 2016 Army		Date: February 2015
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 2014	FY 2015	FY 2016
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.			
Accomplishments/Planned Programs Subtotals	10.115	9.807	8.659

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 2016 Army				Date: February 2015
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 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total	FY 2017	FY 2018	FY 2019	FY 2020	Cost To Complete	Total Cost
H45: *Air Mobility*	-	2.493	2.302	2.328	-	2.328	2.364	2.403	2.448	2.495	-	-

Note

Not applicable for this item

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 U.S. Army Aviation & Missile Research, Development and Engineering Center, Aero-Flight Dynamics Directorate at NASA Ames Research Center, CA and Langley Research Center, VA.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Title: Rotary Wing Aerodynamics	2.493	2.302	2.328
Description: Funding is provided for the following effort			
FY 2014 Accomplishments: Continued computational aero-science investigations using numerical methods including work on validation and development testing the physical assumptions forming the building blocks of the underlying theory. Continued fundamental experiments aimed at the underlying physics of rotor downwash flow fields and rotorcraft testing techniques such as pressure sensitive paint.			
FY 2015 Plans: Continue computational aero-science investigations aimed at developing novel numerical methods for rotorcraft unique flow phenomena and continue fundamental aeromechanics experiments; conduct an experimental investigation of rotor wake physics			

Exhibit R-2A, RDT&E Project Justification: PB 2016 Army		Date: February 2015
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 2014	FY 2015	FY 2016
including worm-like flow instabilities; investigate flow phenomena in unsteady flow separation; and develop and improve testing techniques for aerodynamics/fluid flow such as pressure sensitive paint and particle image velocimetry. ***FY 2016 Plans:*** Will 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.			
Accomplishments/Planned Programs Subtotals	2.493	2.302	2.328

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 2016 Army			Date: February 2015
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 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total	FY 2017	FY 2018	FY 2019	FY 2020	Cost To Complete	Total Cost
H47: *Applied Physics Rsch*	-	5.158	5.304	5.722	-	5.722	5.939	5.898	6.004	5.534	-	-

Note

Not applicable for this item

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 application to very sensitive sensors and ultra-stable atomic clocks. These investigations will 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. Applications of cold atom chips include gyroscopes and accelerometers for inertial navigation units in global positioning system (GPS) denied environments, gravitational sensors for detecting underground facilities, very-low-phase noise precision oscillators for low-velocity Doppler radar, and atomic clocks for GPS denied environments as well as for future space-based timing applications. 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 several Program Elements (PEs) to include PE 0602705A (Electronics and Electronic Devices)/Project H94 (Electronics & Electronic Devices). Work in this project complements and is fully coordinated with research at 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 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 U.S. Army Research Laboratory (ARL), Adelphi, MD.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Title: Nanoelectronic Devices and Sensors	3.166	3.005	3.326
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-band gap 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 microrobotic applications.			

Exhibit R-2A, RDT&E Project Justification: PB 2016 Army		Date: February 2015
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 2014	FY 2015	FY 2016
FY 2014 Accomplishments: Studied decoherence mechanisms and optical Raman techniques to coherently control cold atoms and atomic spin to improve the sensitivity of a chip-scale atom interferometer for inertial navigation in GPS denied environments; investigated and evaluated actuator designs using piezoelectric actuators using 3D growth and patterning techniques; investigated modes of propagation for on-chip energetic materials and determining factors that influence reaction rate; developed novel 2D material growth, characterization, transfer and processing technology and conducted experiments to achieve electronic device quality materials for nanoelectronics and supercapacitors; investigated solid electrolyte interphase (SEI) formation on silicon (Si) anodes for lithium (Li) ion batteries; investigated GaN for high power conditions by improving breakdown voltage and crystalline via reduced contaminants with improved electrical efficiency and associated thermal management; and investigated materials structures for catalyst activities for energy conversion. ***FY 2015 Plans:*** Investigate 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; investigate integration of 3-D piezoelectric materials and processes with flexible substrate and circuit technologies for radio frequency (RF) MEMS and millimeter scale robotics; study and characterize the growth and electrical properties of stacked 2D electronic materials for application to RF and/or logic devices; and refine the early development of on-chip energetic materials and processing for supplying slow, high temperature thermal sources. Investigate composition and effect of additives on SEI formation on Si anodes for Li ion batteries. ***FY 2016 Plans:*** Will 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; research 1D/2D novel phenomena for alternative device architectures for operation in extreme environments.			
Title: Advanced Energy Science Research	1.992	2.299	2.396

Exhibit R-2A, RDT&E Project Justification: PB 2016 Army		Date: February 2015
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 2014	FY 2015	FY 2016
Description: Conduct materials research and multi-scale modeling that will lead to advances in energy storage, harvesting, and conversion for a wide range of Army applications such as Soldiers, platforms, and microgrids. ***FY 2014 Accomplishments:*** Investigated wide-band gap semiconductor materials for direct photoelectrochemical production of hydrogen gas for use as fuel; and researched novel device architectures for solar energy conversion. ***FY 2015 Plans:*** Study the physical limits of wide-band gap materials for direct photoelectrochemical production of hydrogen for use as fuel; investigate the effect of plasmonic arrays on the catalysis of oxygen reduction and ethanol oxidation as alternative methods for fuel production; and develop advanced superconducting materials by metal organic chemical vapor deposition (MOCVD) processes to aid in energy conversion. ***FY 2016 Plans:*** Will investigate plasmonic arrays and effect of array structure on catalysis of O2 reduction, CO2 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; investigate the use of metamaterials to enhance EM effects on catalysis for higher conversions to useful fuels.			
Accomplishments/Planned Programs Subtotals	5.158	5.304	5.722

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 2016 Army			Date: February 2015
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 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total	FY 2017	FY 2018	FY 2019	FY 2020	Cost To Complete	Total Cost
H48: *Battlespace Info & Comm Rsc*	-	21.049	25.310	25.463	-	25.463	25.856	26.248	26.685	27.204	-	-

Note

Not applicable to this item

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 several Program Elements (PEs) to include 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 U.S. Army Research Laboratory (ARL), Adelphi, MD.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Title: Communication for Tactical Networks	1.777	1.898	1.934
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 2014 Accomplishments:			

Exhibit R-2A, RDT&E Project Justification: PB 2016 Army		Date: February 2015
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 2014	FY 2015	FY 2016
Developed a framework for modeling quality of information, which enhances communications by delivering more relevant information (enhancing decision making); researched use of non-traditional communication technologies (optical & ultra-violet (UV)) to support connectivity in radio frequency (RF) challenged environments; and identified and developed limits, techniques and algorithms for unicast and multicast communications over hybrid networks (wired and wireless networks). ***FY 2015 Plans:*** Conduct analysis, simulation, 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); develop quality of information (QoI) theories based upon human-in-the-loop analysis; and develop mathematical representations for the QoI of static and dynamic data and its effectiveness for situational awareness. ***FY 2016 Plans:*** Will 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.			
Title: Data to Knowledge to Support Decision Making ***Description:*** Design and implement a laboratory-scale common information-processing infrastructure, inclusive of cloud computing for networking processes that aids in the transformation of data into actionable intelligence to support decision-making under uncertainty. ***FY 2014 Accomplishments:*** Investigated algorithms and techniques (in-house, academia, and industry) for exploiting context and value of information from unstructured full motion imagery and text including the leveraging of industry investment in graphic processing units (GPU) and cluster-based computing architectures; and investigated techniques for adaptive data collection on collaborating mobile platforms to improve current decision making capabilities. ***FY 2015 Plans:*** Research 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 validate the value of information construct within a tactical military decision support system;	2.591	2.499	2.545

Exhibit R-2A, RDT&E Project Justification: PB 2016 Army		Date: February 2015
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 2014	FY 2015	FY 2016
and investigate algorithms for intelligent exploration and focused data collection in relevant environments using collaborative mobile platforms. ***FY 2016 Plans:*** Will 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.			
Title: Information Protection for Mobile Ad-Hoc Networks (MANETs) ***Description:*** Perform research in 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 FY15, includes work previously conducted under Network Science for MANETs and Tactical Communications. ***FY 2014 Accomplishments:*** Enhanced security techniques and algorithms decreasing detection time and ensuring information protection while maintaining suitability for operation in both tactical mobile and hybrid networking environments. These methods improve the capability of Soldiers to detect and defeat malicious activities of adversaries on mobile tactical networks. ***FY 2015 Plans:*** Develop 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; develop techniques to minimize energy required to support security functions; develop security protocols and processes for using tactical cloudlets as a shared resource among Warfighters and coalition forces; and develop and characterize 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:*** Will investigate techniques for novel, stealthy communications that are less likely to be detected and intercepted by the adversary than conventional RF 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.	4.880	6.098	5.902
Title: Multi-Lingual Computing Research	1.141	1.100	1.120

Exhibit R-2A, RDT&E Project Justification: PB 2016 Army		Date: February 2015
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 2014	FY 2015	FY 2016
Description: Establishes formal methods for bridging language barriers in tactical environments, incorporating state of the art techniques in machine translation and natural language processing. ***FY 2014 Accomplishments:*** Investigated use of information extracted from machine translated text in constructing task-based metrics and predictive models of machine translation quality, for low-resource languages and domains. This enables situation awareness when information sources are multi-lingual in nature. ***FY 2015 Plans:*** Identify and extract 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 examine the extension of linguistics analysis techniques to image processing. ***FY 2016 Plans:*** Will 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.			
Title: Network Science for MANETs and Tactical Communications ***Description:*** Study the behavior of mobile ad-hoc networks (MANETs) as part of the Army's Network Science initiative. Emphasis is on mobile communications networks research with the Army's University Affiliated Research Center, the Institute for Collaborative Biotechnologies at the University of California, Santa Barbara (PE 0601104A/Project H05). In FY15 this effort is moved to Information Protection for MANETs. ***FY 2014 Accomplishments:*** Developed methodologies, techniques and algorithms for the analysis of realistic finite networks, that provide insights for the design and provisioning of tactical, mobile, ad-hoc networks to improve network performance; and developed mathematical models of dynamic networks that enable the representation of group interactions, the analysis of the behaviors of such networks, and the characterization of the fundamental limits on information flow within such networks.	1.003	-	-
Title: Advanced Computing ***Description:*** Investigate computing and networking architectures, algorithms, and visualization techniques to support advanced battle command applications for Command, Control, Communications, Computer, and Intelligence (C4I) systems.	3.668	3.499	3.562

Exhibit R-2A, RDT&E Project Justification: PB 2016 Army		Date: February 2015
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 2014	FY 2015	FY 2016
FY 2014 Accomplishments: Explored use of mathematical approaches that allow the prediction of certain outcomes using incomplete information and developed scenarios for verification and validation; and verified and validated scalable programming models and software developed for tactical computing concept. ***FY 2015 Plans:*** Explore 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 extend 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:*** Will 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.			
Title: Network Science Technology Experimental Center	5.989	5.198	5.123
Description: Supports in-house Network Science studies in conjunction with the Network Sciences Collaborative Technology Alliance (PE 0601104A/Project H50). ***FY 2014 Accomplishments:*** Examined the interaction of social, informational and communication processes as they adapt to changes in mission, adversarial attacks and changes in tactics, and structure; began designing and developing composite trust management techniques and metrics that consider the interactions between social, information and communication networks; and began developing techniques to model a hybrid network (wired and wireless). ***FY 2015 Plans:*** Expand the wireless emulation capabilities to include the interactions among communication, social, and information networks; continue to develop techniques for modeling the performance of hybrid networks; and develop, analyze and validate composite trust management techniques and metrics that consider the interactions between social, information and communication networks. These efforts provide improved understanding of tactical network behaviors, improved network designs, secure information flows and enhanced decision-making. ***FY 2016 Plans:*** Will 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 RF			

Exhibit R-2A, RDT&E Project Justification: PB 2016 Army		Date: February 2015
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 2014	FY 2015	FY 2016
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.			
Title: Quantum Information Sciences ***Description:*** Perform research to enable new techniques for ultra-precise navigation, timing, communications and imaging using atomitronics and spintronics (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 forth new insights regarding the use of quantum science to enhance Warfighter effectiveness. ***FY 2015 Plans:*** Study 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; study 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 obtain 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:*** Will 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.	-	5.018	5.277
Accomplishments/Planned Programs Subtotals	21.049	25.310	25.463

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2016 Army		Date: February 2015
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** H48 / *Battlespace Info & Comm Rsc*

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2016 Army											Date: February 2015	
Appropriation/Budget Activity 2040 / 1					R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*				Project (Number/Name) H52 / *Equip For The Soldier*			
COST ($ in Millions)	**Prior Years**	**FY 2014**	**FY 2015**	**FY 2016 Base**	**FY 2016 OCO**	**FY 2016 Total**	**FY 2017**	**FY 2018**	**FY 2019**	**FY 2020**	**Cost To Complete**	**Total Cost**
H52: *Equip For The Soldier*	-	1.141	1.051	1.119	-	1.119	1.133	1.153	1.173	1.197	-	-

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 which focus on core technology areas that include mathematical modeling, physical and cognitive performance, polymer science/textile technology, nanotechnology, biotechnology, and combat ration research. The research effort is targeted on 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 U.S. Army Natick Soldier Research, Development, and Engineering Center (NSRDEC), Natick, MA.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Title: Equipment for the Soldier	1.141	1.051	1.119
Description: This project supports basic research to achieve technologies for the Soldier of the future which include mathematical modeling, physical and cognitive performance, polymer science/textile technology, nanotechnology, biotechnology, and combat ration research.			
FY 2014 Accomplishments: Explored the permeation phenomena of multilayer films leading to improved barrier properties for the myriad needs for effective polymer films; investigated the cognitive foundations of spatial navigation for route planning through complex environments; continued to explore the aerodynamics and structural behavior of permeable structures under dynamic loads for improving parachute performance.			
FY 2015 Plans:			

Exhibit R-2A, RDT&E Project Justification: PB 2016 Army		Date: February 2015
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** H52 / *Equip For The Soldier*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Examine thermal degradation mechanisms in selected natural materials as basis for potential flame/fire protection approaches; create nonwoven electrospun composites of unique composition and examine their properties and material behavior to provide foundation for robust, Soldier-based sensing of pathogens in food and ambient environment. ***FY 2016 Plans:*** Will 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; and examine a novel in-vitro gut fermentation model to gain fundamental understanding of dietary component influence on gut health as it relates to improving Soldier performance through nutrition.			
Accomplishments/Planned Programs Subtotals	1.141	1.051	1.119

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 2016 Army										Date: February 2015		
Appropriation/Budget Activity 2040 / 1					R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*				Project (Number/Name) H57 / *Single Investigator Basic Research*			
COST ($ in Millions)	**Prior Years**	**FY 2014**	**FY 2015**	**FY 2016 Base**	**FY 2016 OCO**	**FY 2016 Total**	**FY 2017**	**FY 2018**	**FY 2019**	**FY 2020**	**Cost To Complete**	**Total Cost**
H57: *Single Investigator Basic Research*	-	78.071	81.213	87.001	-	87.001	88.319	87.776	91.389	93.887	-	-

Note

Not applicable

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 several Program Elements (PEs) to include 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 the U.S. Army Research Laboratory (ARL), Adelphi, MD.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Title: Basic Research in Life Sciences	7.954	7.806	9.782
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,			

Exhibit R-2A, RDT&E Project Justification: PB 2016 Army		Date: February 2015
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016

and other influences to human actions, and vi) auditory and signal processing research to map the cognitive implications of multisensory information integration.

FY 2014 Accomplishments:

Investigated the genetic plasticity of bacterial genomes during long-term stationary phase growth and developed an empirical understanding of the general mechanisms by which genomic (gene-based), transcriptomic (RNA-based), and proteomic (protein-based) prokaryotic features responded to alterations in the population-genetic environment, to ultimately enable accurate identification of the origin of biological threats; investigated and characterized sensory auditory processing to determine how Soldiers can separate several streams of sounds into meaningful sequences in order to develop algorithms to augment both natural and automated hearing in noisy and confused environments; assembled and characterized a synthetic biological receptor and signaling program within a bacterial strain capable of encapsulating itself within a natural cellulose filter, which may ultimately enable new chemical/biological detection applications; characterized the resolution of holographic microscopy for visualizing microbes based on recent discoveries in lens-less holographic imaging, which in the long term may replace optical microscopes, enabling low-cost, rugged microscopes for field use; and designed and validated robust optimal social system interventions based on a more formal understanding of feedback mechanisms with the objective of avoiding failed negotiations, socio-economic crises and societal collapse.

FY 2015 Plans:

Identify 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; expand 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; characterize 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 devise 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:

Will 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

Exhibit R-2A, RDT&E Project Justification: PB 2016 Army		Date: February 2015
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
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).			
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 2014 Accomplishments:*** Pursued atmospheric examinations in the convective boundary layer using vertically pointing clear-air doppler radars and sodars to measure mean vertical velocities; and improved estimates of soil moisture through a data assimilation approach that utilizes remotely sensed soil moisture information at coarse spatial resolution and combines it with a physics-based land surface process model to produce soil moisture estimates at the fine spatial scales of Army operational interest. ***FY 2015 Plans:*** Exploit recent theoretical and experimental advances in soft-matter physics to isolate and examine the granular dynamics of fluid-driven sediment transport, focusing on bed load transport in rivers. ***FY 2016 Plans:*** Will 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. This research will generate high resolution information about terrain, vegetation, drainage, and erosion and have implications for change detection.	3.665	1.499	1.527
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 2014 Accomplishments:***	9.148	9.396	9.567

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Explored and characterized the reaction pathways for nitroaromatics and nitramines (classes of compounds that include explosives) to determine mechanisms by which these molecules undergo dissociation to initial product species; investigated nanoscale patterning of protein-based fibers on non-biological surfaces to understand how these surface properties can be manipulated to control the structure and function of biological molecules, and tested novel single-molecule probes to investigate proteins in near-surface environments at the molecular level, for potential long-term applications in chemical and biological defense; and investigated electrochemical systems utilizing new materials with controllable structures and chemical properties that may ultimately enable lighter, more efficient batteries or fuel sources. ***FY 2015 Plans:*** Investigate and characterize the ionic states of energetic compounds which will enable the design of safer (e.g. during transport and storage), more powerful explosives and propellants; identify 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, which will ultimately lead to new capabilities for protection from, and inactivation of, chemical and biological warfare agents and toxic industrial chemicals; synthesize 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, which may ultimately 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, which 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:*** Will 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).			
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.	11.968	13.630	16.262

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
FY 2014 Accomplishments: Investigated dynamics of thermally-isolated systems in atomic systems which facilitate the future engineering of new materials with dynamic properties for the future warfighter; designed and demonstrated laser-plasma beams using ultra-short pulsed lasers and investigated the unique light-propagation characteristics in the atmosphere not possible with conventional lasers, which may enable standoff detection of explosive residue; explored high-intensity lasers as a method for creating gamma ray beams that may obviate the need for conventional large, expensive, immobile, reactors or extremely hazardous reactive materials; designed and explored quantum systems, such as nitrogen in synthetic diamond, for low-power high-precision sensing and imaging exceeding the capabilities of current classical systems; designed and synthesized topological insulators (e.g., a novel type of material that changes electrical properties based on its three-dimensional structure); and discovered and characterized the properties of these new topological insulators under varying magnetic and electrical conditions, which may enable new ultra-sensitive detectors and ultra-low power electronics. ***FY 2015 Plans:*** Explore the infrared and optical responses of electrostatically-induced effects in correlated oxides, such as metal-to-insulator transitions, which may lead to advanced electronic technologies for sensing and computational hardware; investigate new synthetic physics in cold quantum gases, which will contribute to the development of cold-atom interferometers for ultra-accurate navigation and quantum computing applications for secure communication; detect single molecular ion spectra using laser-cooled atomic ions by exploiting previous research on trapped ions for quantum information science, which may ultimately 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 DoD, airline, financial, and telecommunications industries; demonstrate 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), which may enable future applications in standoff explosives detection and sensing through obscurants. ***FY 2016 Plans:*** Will 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).			
Title: Basic Research in Electronics and Photonics	10.592	10.895	11.094

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
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 2014 Accomplishments:*** Improved optical quality and coherency of mid infrared lasers to facilitate free space optical communications, ladar and infrared countermeasures; showed feasibility of semiconductor-less infrared detection that utilizes electron tunneling; explored time-frequency and non-laplacian phenomena to understand and extend the fundamental performance limits of radio, radar, and electronic warfare systems; and developed terahertz frequency photomixing arrays with 10x improvement in output powers to enable the remote detection of chemical, biological and explosive threats. ***FY 2015 Plans:*** Show independent tuning of the temperature coefficient of resistance and noise in bolometers to improve signal to noise ratio of room temperature infrared detectors; show 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; demonstrate 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 create and investigate a novel sensor based on optical dark modes in nanorods for use in biomolecule, chemical sensing, and near-field imaging. ***FY 2016 Plans:*** Will 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 GaN-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.			
Title: Basic Research in Materials Sciences ***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 2014 Accomplishments:*** Established the use of resonant optical effects to achieve size sorting of microspheres in solution with unprecedented precision; demonstrated a new class of materials for low power sensing based on variable temperature conduction; provided a robust computational methodology to predict the relationships between a material's electronic structure, its local elastic properties, and	6.864	7.098	7.227

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
its composition for the vast majority of transition metal critical points; and fabricated novel fully transparent materials with record hardness and toughness for advanced protection. ***FY 2015 Plans:*** Elucidate the molecular mechanisms by which living cells regulate intracellular biochemical activity with mechanical force and design novel materials with force-activated control; provide novel functional materials with unprecedented physical properties through strongly linked multi-scale models developed specific to the materials systems; and complete a vigorous investigation of two-dimensional non-graphitic atomic layers and heterostructures and identify advanced material properties and capabilities. ***FY 2016 Plans:*** Will enable 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 and extraordinary energy production and storage; create stable free-standing single monomer thick novel 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.			
Title: Basic Research in Computing Sciences ***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 2014 Accomplishments:*** Explored robust computational methodologies for large dataset processing and analysis with optimized data representations, and obtained optimal realization of Real-Time Multi-core Systems to support complex, resource-demanding, real-time Intelligence, Surveillance, and Reconnaissance (ISR) applications; created new image data feature analysis and pattern classification methods for object detection, recognition, and long-term tracking under challenging dynamic conditions; and developed quantification and metrics for effective analysis of social-interaction phenomena for better prediction of unusual social events in asymmetric defense. ***FY 2015 Plans:*** Establish 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; investigate new concepts	7.502	7.797	7.938

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
such as value of information, and invest in new research opportunity areas such as social informatics; and pursue efforts on information assurance with a special focus on hardware based resilient techniques. ***FY 2016 Plans:*** Will 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.			
Title: Basic Research In Network Sciences ***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 manmade 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 2014 Accomplishments:*** Explored the notion of a tipping point (e.g., when a society changes its views) from a Statistical Mechanics perspective and from a Behavioral Game Theory perspective, with attendant efforts to reconcile the two views; continued mathematical modeling of neuronal structures informed by experiments to grow neurons and extend to capture cognitive intelligence that arises from networks of neurons; studied games derived from observation with respect to equilibrium and robustness properties and validated on problems related to reasoning about adversarial networks; and studied the effect of human networks on communication networks with the goal of finding effective bandwidth/spectrum/resource utilization. ***FY 2015 Plans:*** Study interconnected networks and how failure in a network spreads to other networks; investigate rigorous mathematical theories that bring together statistical mechanics, operations research, game theory and reliability theory that could predict how failures propagate and when/how failures could be controlled; explore new game theory inspired models for how economic and social factors lead to large societal changes, such as Arab spring style revolutions; and study 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:*** Will 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	8.023	8.396	8.549

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
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.			
Title: Basic Research in Mechanical Sciences	6.260	6.798	6.913
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 2014 Accomplishments:*** Conducted counter-flow burner studies for investigating high molecular weight hydrocarbon fuel and jet fuel chemistry at elevated pressures up to 2.5MPa; investigated novel transparent fully cross-linked Molecular Interpenetrating Polymer Composites (MIPCs) under high strain rate loading conditions; developed a new representation of the Navier-Stokes equations providing rapid convergence when compared to existing solvers for equivalent flow field models, grid types and grid sizes; and elucidated the fundamental physical interactions responsible for energy dissipation and quality factor magnification within prototypical nano-electromechanical systems. ***FY 2015 Plans:*** Gain understanding of oxidizer behavior in energetic materials via determination of how the morphology and phase behavior is evolving during the heating and reaction process; demonstrate new capabilities to actively control entropy production and free energy exchange in arrays of molecular motors; develop a reduced-order methodology suitable for the study of the large parameter design space associated with "dynamic stall"; and develop 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:*** Will 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			

Exhibit R-2A, RDT&E Project Justification: PB 2016 Army		Date: February 2015
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
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.			
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 2014 Accomplishments:*** Conducted innovative basic research in statistical analysis, commutative and quantum stochastics and control, multiscale computational methods, computational cell and molecular biology and fundamental laws of biology in order to revolutionize methodologies for information assurance, counter-terrorism, next generation communication networks, weapon design, testing, and evaluation, and coordination and collective decision-making. ***FY 2015 Plans:*** Conduct 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 3D terrain and new metrics for small-group social and sociolinguistic phenomena. This mathematical sciences research is leading to improved conventional and quantum information networks and information processing, soldier health and performance, decision making, training, simulation and mission planning. ***FY 2016 Plans:*** Will 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. Development of these new mathematical areas is expected to bring new modeling capabilities in secure communication, in prediction of collective behavior, enable designer materials, and in other related areas.	6.095	5.999	6.106
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	-	1.899	2.036

Exhibit R-2A, RDT&E Project Justification: PB 2016 Army		Date: February 2015
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
simulation and training. This research will also include extensive studies to discover and map the neural circuitry that enables cognitive adaptation. The dynamic mechanisms of neural network modification need to be established. ***FY 2015 Plans:*** Conduct basic research efforts related to the design of mathematical models and experimental methods to map the cognitive implications of multisensory information integration. This includes neurobiology studies to elucidate the mechanisms of synaptic signaling that underlies perception, network science to characterize the functional connectivity and information processing, and computer scientists to design models to accurately represent these systems. ***FY 2016 Plans:*** Will further the research in the design of mathematical models and experimental methods that map the 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.			
Accomplishments/Planned Programs Subtotals	78.071	81.213	87.001

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 2016 Army										Date: February 2015		
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 2014**	**FY 2015**	**FY 2016 Base**	**FY 2016 OCO**	**FY 2016 Total**	**FY 2017**	**FY 2018**	**FY 2019**	**FY 2020**	**Cost To Complete**	**Total Cost**
H66: *Adv Structures Rsch*	-	2.011	2.006	2.033	-	2.033	2.061	2.095	2.133	2.174	-	-

Note

Not applicable for this item

A. Mission Description and Budget Item Justification

This project funds basic research for improved tools and methods to enable the structural health monitoring capabilities and condition-based maintenance for 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/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 U.S.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 2014	FY 2015	FY 2016
Title: Structural Analysis and Vibration Methods	2.011	2.006	2.033

Exhibit R-2A, RDT&E Project Justification: PB 2016 Army		Date: February 2015
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 2014	FY 2015	FY 2016
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 2014 Accomplishments:*** Investigated adaptive seat damper materials and strategies for improved vibration reduction over a variety of terrains and for different gross vehicle weight configurations; developed and demonstrated a virtual testing capability for lightweight composite structures by integrating probabilistic methods, which are reliant on current and historical data, into existing physics-based models; developed signal processing algorithm for tracking damage transients; and investigated three-dimensional printing of novel multifunctional materials for micro air and ground vehicle applications. ***FY 2015 Plans:*** Investigate strategies for improving the durability of vehicle platforms through the introduction of novel composite materials; develop and demonstrate a probabilistic tool for the development of novel composite materials to address specific structural performance requirements; develop the capability to capture and quantify precursors to damage in structural components that will enhance the operation and sustainability of future vehicle systems; and demonstrate 3D printing of multifunctional structural components for air and ground vehicle applications. ***FY 2016 Plans:*** Will 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.			
Accomplishments/Planned Programs Subtotals	2.011	2.006	2.033

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 2016 Army			Date: February 2015
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 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total	FY 2017	FY 2018	FY 2019	FY 2020	Cost To Complete	Total Cost
H67: *Environmental Research*	-	1.024	0.903	0.913	-	0.913	0.928	0.943	0.961	0.979	-	-

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 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. The CW remediation efforts concentrate on the application of biotechnology in the characterization and physical clean up of agent contaminated soils and groundwater and reduced corrosive and more environmentally benign decontamination of biological warfare (BW) agents on field equipment and weapon systems, with the goal of reducing the cost of remediating a site by at least 50% versus the use of conventional methods. CW thrusts 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. The program element 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 U.S. Army Armament, Research, Development and Engineering Center, Picatinny, NJ.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Title: Industrial Pollution Prevention	1.024	0.903	0.913
Description: This effort conducts research on innovative environmentally-friendly technologies that support the warfighter (focusing on pollution prevention technologies).			
FY 2014 Accomplishments: Researched gasification/biofuels technology, green technologies for energetic/propellants to eliminate hazardous materials, next generation of bio-based materials from sustainable resources and microbial resistance to disinfectants.			
FY 2015 Plans:			

Exhibit R-2A, RDT&E Project Justification: PB 2016 Army		Date: February 2015
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 2014	FY 2015	FY 2016
Research green technologies for new energetics/propellants, airborne lead reduction in Army weapon systems, and environmentally friendly technologies to support Army soldier systems; select projects to support the Army Environmental Requirements and Technology Assessments (AERTA). ***FY 2016 Plans:*** Will 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.			
Accomplishments/Planned Programs Subtotals	1.024	0.903	0.913

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 2016 Army			Date: February 2015
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 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total	FY 2017	FY 2018	FY 2019	FY 2020	Cost To Complete	Total Cost
S13: *Sci BS/Med Rsh Inf Dis*	-	10.642	11.004	11.181	-	11.181	11.318	11.503	11.722	11.952	-	-

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 soldiers are stationed across all COCOMS, are the highest priorities for basic research.

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

(1) Prevention/Treatment of Parasitic (organism living in or on another organism) Diseases
(2) Vaccines for the Prevention of Malaria
(3) Bacterial Disease Threats
(4) Viral Disease Threats
(5) Diagnostics and Disease Transmission Control

Work is managed by USAMRMC 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 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 2014	FY 2015	FY 2016
Title: Prevention/Treatment of Parasitic (organism living in or on another organism) Diseases	3.791	3.899	3.997
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			

Exhibit R-2A, RDT&E Project Justification: PB 2016 Army		Date: February 2015
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 2014	FY 2015	FY 2016
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. ***FY 2014 Accomplishments:*** Optimized candidate anti-parasitic drugs by chemically modifying them to improve their safety, efficacy, and bio-availability. These modified compounds were evaluated in animal models for down-selection of best compounds of interest. ***FY 2015 Plans:*** Continue to identify new lead candidate drugs and combinations to stay ahead of emerging drug resistance in malaria parasite; and identify new technologies to deliver drugs into the human body by using novel formulations. ***FY 2016 Plans:*** Will 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 from the 8-aminoquinoline class of compounds.			
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. ***FY 2014 Accomplishments:*** Assessed immunogenicity (causes an immune response) and protective effectiveness of new vaccine candidates in small-animal models to determine suitability in formulations of multiple antigen (a substance, usually a protein, that stimulates an immune response generating antibodies that recognize the antigen) vaccines. ***FY 2015 Plans:*** Identify and characterize mechanism of protective immunity; continue to assess immunogenicity of new vaccine candidates in small-animal models to determine suitability in formulations of multiple antigen vaccines and identify and characterize new technologies to deliver candidate vaccine into the human body by using novel formulations. ***FY 2016 Plans:*** Will continue to identify and characterize mechanisms of protective immunity elicited by new candidate malaria protein-based antigens; will define a strategy to develop a candidate vaccine against falciparum malaria that contains several different kinds	2.295	2.500	2.530

Exhibit R-2A, RDT&E Project Justification: PB 2016 Army		Date: February 2015
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 2014	FY 2015	FY 2016
of antigens, to improve vaccine effectiveness; and will identify new recombinant (artificially produced via genetic engineering) protein-based vaccine candidate(s) against vivax malaria.			
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 2014 Accomplishments:*** Studied the mechanism bacterial diarrheal pathogens stick to the wall of the intestine to develop countermeasures against these pathogens; studied novel methods of formulating vaccine candidates to more effectively deliver them inside the human body; and studied mechanisms of bacterial wound infection pathogenesis to develop effective treatments. ***FY 2015 Plans:*** Explore common adjuvants and routes of delivery for a combination vaccine against the major diarrheal causing bacterial impacting soldiers: 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). Identify epidemiologic (study of the causes, distribution, and control of disease) importance of enteric (gastrointestinal) pathogens to develop strategies for preventing diarrhea in deployed US forces. Identify correlates of protection (indicator of effectiveness) in animal models; identify new techniques and tools for improved infection control and wound healing; and identify and evaluate novel methods for prevention of trauma-associated infection by highly antibiotic-resistant bacteria. ***FY 2016 Plans:*** Will 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 will aid the planning and evaluation of strategies to prevent diarrhea in deployed US forces. Define indicators of vaccine effectiveness (correlates of protection) in animal models of bacterial diarrhea. The correlates of protection will aid in vaccine development; Will continue to identify additional therapies and tools for preventing and treating wound infection and improving wound healing; and will evaluate novel technologies for treatment and prevention of multi-drug resistant bacteria most commonly encountered in trauma-associated infections.	1.529	1.538	1.517
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	1.563	1.600	1.619

Exhibit R-2A, RDT&E Project Justification: PB 2016 Army		Date: February 2015
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 2014	FY 2015	FY 2016
disease caused by the Dengue virus, transmitted by mosquitoes) and Hanatviral 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 2014 Accomplishments:*** Studied the role of human cells and antibodies to develop medical countermeasures to prevent and/or treat diseases caused by hantaviruses and dengue viruses; conducted epidemiological studies to determine the prevalence and incidence of dengue fever and dengue hemorrhagic fever in diverse populations; and used the epidemiological information to develop and/or maintain the infrastructure of vaccine test site(s) aiding in evaluation the safety and effectiveness of promising dengue vaccine candidates. ***FY 2015 Plans:*** Identify and evaluate the role of human cells and antibodies in developing medical countermeasures to prevent and/or treat hantavirus and dengue virus infections ; identify host and viral determinants (risk factors) of dengue disease severity; explore 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 continue world-wide epidemiological studies to determine the prevalence and incidence of dengue fever and dengue hemorrhagic fever. ***FY 2016 Plans:*** Will continue to assess host and viral determinants of dengue fever disease severity among populations at risk; will continue to explore innovative vaccine designs, adjuvant systems and delivery methods for a dengue virus vaccine; and will 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.			
Title: Diagnostics and Disease Transmission Control ***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 medical diagnostic and disease surveillance capabilities in the field. This research will help to direct new interventions into preventing disease transmission. ***FY 2014 Accomplishments:*** Developed identification keys for medically important arthropods (e.g., ticks, mosquitoes, and sandflies) vectors in geographic areas not previously studied but potentially deployable locations. Evaluated new technologies selected as part of the next generation diagnostic systems for use in the deployed setting for detection of pathogens in humans. ***FY 2015 Plans:***	1.464	1.467	1.518

Exhibit R-2A, RDT&E Project Justification: PB 2016 Army		Date: February 2015
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 2014	FY 2015	FY 2016
Explore innovative technologies (traps, attractants, and devices) for vector surveillance in military operations; continue development of user friendly, web-based tools for identification of medically relevant arthropods and insects; identify novel pesticide (chemicals used for the control of insects and allied organisms) matrices/application strategies for vector control; and explore passive arthropod repellent systems/strategies (do not require pesticide applications). ***FY 2016 Plans:*** : Will leverage worldwide capabilities utilizing an information exchange program involving site visits to museums (e.g. 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; will 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.			
Accomplishments/Planned Programs Subtotals	10.642	11.004	11.181

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 2016 Army										Date: February 2015		
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 2014**	**FY 2015**	**FY 2016 Base**	**FY 2016 OCO**	**FY 2016 Total**	**FY 2017**	**FY 2018**	**FY 2019**	**FY 2020**	**Cost To Complete**	**Total Cost**
S14: *Sci BS/Cbt Cas Care Rs*	-	8.940	10.548	9.758	-	9.758	9.900	10.071	10.253	10.457	-	-

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 Soldier. 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 tissue, control of severe bleeding, traumatic brain injury (TBI), ocular (eye) and face trauma, and transplant technology. Such efforts will minimize lost duty time and provide military medical capabilities for far-forward medical/surgical care of injuries, as well as post-evacuation restorative and rehabilitative care.

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

Work in this project complements and is fully coordinated with 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 WRAIR, Silver Spring, MD; the U.S. Army Dental Trauma Research Detachment (USADTRD) and the U.S. Army Institute of Surgical Research (USAISR), Fort Sam Houston, TX; and the Armed Forces Institute of Regenerative Medicine (AFIRM), Fort Detrick, MD.

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2014**	**FY 2015**	**FY 2016**
Title: Damage Control Resuscitation	1.577	2.699	2.268
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.			
FY 2014 Accomplishments:			

Exhibit R-2A, RDT&E Project Justification: PB 2016 Army		Date: February 2015
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 2014	FY 2015	FY 2016
Conducted studies of re-engineered blood products to control traumatic bleeding and treat shock. Performed studies to better understand the cellular processes and metabolic genetic basis of survival from hemorrhage. ***FY 2015 Plans:*** Conducting 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, will perform cell-based (in vitro) studies of drugs to assess their ability to protect cells and tissues from harmful effects of severe blood loss.			
Title: Combat Trauma Therapies ***Description:*** This effort conducts studies of trauma to tissues and organs and ways to mitigate and/or repair this damage. Research addresses cellular repair/growth mechanisms to treat TBI, dental (facial and oral) injuries, extremity wounds and fractures, and burns. ***FY 2014 Accomplishments:*** Studied mechanisms to manipulate the molecules, cells, and structure of the skin to optimize healing, appearance and function. ***FY 2015 Plans:*** Begin studies to determine the optimal thicknesses of skin grafts for more rapid closure and improved functional outcomes of face wounds. ***FY 2016 Plans:*** Will 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, will study molecular, cellular and structural skin components to identify mechanisms to optimize healing, appearance and function following traumatic injury of hard and soft tissues.	0.764	0.800	0.824
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. ***FY 2014 Accomplishments:***	0.836	0.803	0.774

Exhibit R-2A, RDT&E Project Justification: PB 2016 Army		Date: February 2015
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 2014	FY 2015	FY 2016
Performed research on decision support algorithms that use non-traditional vital signs to assess patient physiologic status and continued studies of algorithms for early identification of individuals with high- and low-tolerance to blood loss to optimize resuscitation. ***FY 2015 Plans:*** Continue research on decision support algorithms using non-traditional vital signs to assess patient status and optimize fluid resuscitation; and conduct 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:*** Will 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.			
Title: Traumatic Brain Injury ***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 2014 Accomplishments:*** Applied Systems Biology (field of study that focuses on complex interactions within biological systems, using a holistic approach) metrics to 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; performed basic research to study the brain and nervous system during the first 2 months following head injury to identify predictors of long-term consequences of TBI; and continued research to understand cell death and neuroprotection (protection of the brain) mechanisms and determined critical thresholds for secondary injuries (polytrauma) complicating TBI. ***FY 2015 Plans:*** Continue studies applying Systems Biology metrics to 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; continue 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; continue research to understand cell death and neuroprotection (protection of the brain) mechanisms and determine critical thresholds for secondary injuries (polytrauma) complicating TBI; and conduct 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:***	0.965	1.499	1.294

Exhibit R-2A, RDT&E Project Justification: PB 2016 Army		Date: February 2015
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Will utilize the application of systems biology methods to aid in discovery of novel proteins that appear in blood as result of traumatic brain injury (TBI); study the multiple stages of TBI recovery to identify predictors of long-term consequences of TBI; and characterize cell death and potential mechanisms (a process, technique, or system for achieving a result) to protect brain cells from subsequent inflammation and secondary injuries.			
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 blast trauma to the limbs, head, face (including eye), and genitalia (organs of reproduction), abdomen and burns. ***FY 2014 Accomplishments:*** Evaluated the cellular mechanisms of eye trauma injuries to identify promising therapies for eye trauma wounds, explored the epidemiology (studying incidence or prevalence of injury, including severity) of eye trauma injuries; and explored innovative strategies to regenerate tissues and advance promising approaches to the applied research phase to repair extremities (arms and legs), craniomaxillofacial (head, neck, face, and jaw), genitalia, and abdominal regions. ***FY 2015 Plans:*** Explore the cellular mechanisms and functional challenges of eye trauma injuries and advance promising therapies for eye trauma wounds into the applied research phase; correlate the epidemiology of eye trauma with clinical outcomes. Explore 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:*** Will continue to 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 will continue to 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, craniomaxillofacia, genitalia, and abdominal regions. Novel immunomodulation (modification of the immune response / immune system functioning) technologies will advance to treatment model development to enable improved outcomes in hand and face transplant procedures.	4.798	4.747	4.598
Accomplishments/Planned Programs Subtotals	8.940	10.548	9.758

C. Other Program Funding Summary ($ in Millions)

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2016 Army		Date: February 2015
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*

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 2016 Army			Date: February 2015
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 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total	FY 2017	FY 2018	FY 2019	FY 2020	Cost To Complete	Total Cost
S15: *Sci BS/Army Op Med Rsh*	-	7.269	6.814	6.599	-	6.599	6.688	6.801	6.924	7.060	-	-

A. Mission Description and Budget Item Justification

This project fosters basic research on physiological and psychological factors that limit Soldier 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 /suicide; 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; US Army Institute of Surgical Research (USAISR), San Antonio TX; and the U.S. Army Research Institute of Environmental Medicine (USARIEM), Natick, MA.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Title: Injury Prevention and Reduction	1.169	1.000	1.429
Description: This effort identifies biological patterns of change in Soldiers 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..			
FY 2014 Accomplishments: Explored musculoskeletal injury and repair mechanisms to identify possible therapeutic targets that regulate skeletal muscle and bone function; assessed damage to the retina (a light-sensitive membrane in the back of the eye that receives an image from the lens and sends it to the brain, through the optic nerve,) following changes to long-duration laser exposures using advanced			

Exhibit R-2A, RDT&E Project Justification: PB 2016 Army		Date: February 2015
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 2014	FY 2015	FY 2016
ophthalmic (eye) imaging systems and retinal scanning devices; and established ocular (eye) injury metrics for blast exposures that will be transitioned to applied research protocols to inform the development of ocular protection strategies. ***FY 2015 Plans:*** Explore inflammatory processes in muscle and surrounding tissues following physical injury and during cellular repair, using cell and animal models. Examine and document the presence or absence of visible retinal alterations following blast exposure to 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:*** Will 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 will identify possible points of intervention to minimize musculoskeletal injuries or re-injury based on modifiable and non-modifiable risks.			
Title: Physiological Health ***Description:*** This effort conducts research on the physiological mechanisms of sleep, fatigue, and nutrition on Soldier performance and well-being. ***FY 2014 Accomplishments:*** Determined whether electrical brain stimulation can be used to induce sleep; explored promoting sleep during intervals between missions when sleep is not physiologically required; established nutritional requirements for optimizing muscle formation and repair; determined the effects of various nutritional interventions on cell function; explored various nutritional interventions that might enhance resistance to cellular injury; and explored nutritional interventions that might promote physiological improvements to training and enhance recovery from physical injury. ***FY 2015 Plans:*** Investigate the metabolic mechanisms underlying injury recovery and explore the capability of macronutrients and micronutrients to promote metabolic recovery using cell and animal models; and determine the neurophysiological basis of recuperation during sleep and explore the use of pharmaceuticals and non-pharmacological approaches for improving the recuperation processes during sleep. ***FY 2016 Plans:*** Will identify nutrients (carbohydrates, proteins, fats, vitamins, etc.) that could regulate the recovery of muscle cells after musculoskeletal injury; will identify factors affecting the absorption of nutrients that contribute to bone structure and function; will determine the impact on gut health of only eating operational rations; will identify the brain neurochemistry (the interaction between small molecules and cells via signaling between and within cells) and functional pathophysiology (molecular and cellular	3.001	2.515	2.084

Exhibit R-2A, RDT&E Project Justification: PB 2016 Army		Date: February 2015
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 2014	FY 2015	FY 2016
signature of disease) associated with repeated blast exposures; and will identify biomarkers (indicators within the human body that signal a change) of sleep debt and recuperation.			
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. ***FY 2014 Accomplishments:*** Identified metabolic pathways that are regulated by inflammation, which increases heat stroke susceptibility and/or alters the time course and extent of organ damage following heat injury that results in multi-organ failure, and explored treatments to protect against organ damage resulting from heat injuries. ***FY 2015 Plans:*** Use animal models to identify sensitive biomarkers of organ damage and delineate 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:*** Will use animal models and cellular-based assays to identify biomarkers (indicator of a particular biological condition or process) of organ damage; and will evaluate specific molecular pathways of heat injury and will establish the time course, type and extent of organ damage following heat injury.	0.793	0.800	0.809
Title: Psychological Health and Resilience ***Description:*** This effort conducts research into the basic mechanisms of psychological resilience (mental toughness and the ability to overcome traumatic events) and post-concussion related mental and physical challenges; including determination of underlying neurobiological mechanisms related to post-traumatic stress disorder (PTSD) and depression. ***FY 2014 Accomplishments:*** Determined whether a sleep-related intervention strategy can enhance resilience to concussion/mild TBI effects in a proof-of-concept rodent model potentially providing a preventative strategy to decrease negative consequences of concussions; and established cellular mechanisms for regulation of PTSD symptoms associated with increased stress sensitivity and increased anxiety in a rodent model of PTSD. ***FY 2015 Plans:*** Utilize an animal model to explore traumatic exposure, traumatic stress symptoms (i.e., anxiety, avoidance, hypervigilance),, and trauma recovery to preliminarily screen of pharmaceuticals that may impact mental health status. The results of these studies will	2.306	2.499	2.277

Exhibit R-2A, RDT&E Project Justification: PB 2016 Army		Date: February 2015
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 2014	FY 2015	FY 2016
aid in creating a methodology for systematic testing of novel pharmaceuticals leading ultimately to clinical trials for the treatment of PTSD. Identify the association of exposure to blast and/or blunt impact on the likelihood of a brain concussion in a rodent model. ***FY 2016 Plans:*** Will identify if Omega-3 fatty acids are capable of affecting vulnerability to and recovery time following a concussion; and will 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.			
Accomplishments/Planned Programs Subtotals	7.269	6.814	6.599

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 2016 Army			Date: February 2015
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 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total	FY 2017	FY 2018	FY 2019	FY 2020	Cost To Complete	Total Cost
T14: *BASIC RESEARCH INITIATIVES - AMC (CA)*	-	-	10.250	-	-	-	-	-	-	-	-	-

Note

Not applicable for this item

A. Mission Description and Budget Item Justification

Congressional Interest Item funding provided for Defense Research Sciences.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015
Congressional Add: Program Increase ***FY 2015 Plans:*** Program increase for Defense Research Sciences	-	8.000
Congressional Add: STEM Pilot Program ***FY 2015 Plans:*** Congressional increase for STEM pilot program focused on underserved populations.	-	2.250
Congressional Adds Subtotals	-	10.250

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 2016 Army										Date: February 2015		
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 2014**	**FY 2015**	**FY 2016 Base**	**FY 2016 OCO**	**FY 2016 Total**	**FY 2017**	**FY 2018**	**FY 2019**	**FY 2020**	**Cost To Complete**	**Total Cost**
T22: *Soil & Rock Mech*	-	4.470	5.702	4.456	-	4.456	4.520	4.597	4.681	4.773	-	-

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 macro-scale 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 a 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 controls 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 U.S. Army Engineer Research and Development Center (ERDC), Vicksburg, MS.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Title: Military Engineering Basic Research	2.265	2.400	2.137
Description: Funding is provided for this activity			
FY 2014 Accomplishments: Quantified the amplitude, frequency content, and time series of seismic loads caused by the impact of tools on granular media; determined the effect of snow grain shape on near-infrared reflectance; estimated soil texture and moisture from polarimetric imaging.			
FY 2015 Plans: Develop improved understanding of interaction between gel chemistry and concrete to reduce explosive spalling under ultra-high temperatures; investigate multi-temporal radar physics to identify frequency dependencies of roughness scale and grain size of dielectrically similar soils and snow; direct tunable bacteriophage morphology to assemble high-ordered nano-scale structures.			
FY 2016 Plans:			

Exhibit R-2A, RDT&E Project Justification: PB 2016 Army		Date: February 2015
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 2014	FY 2015	FY 2016
Will determine the physical and chemical mechanisms that allow geopolymers to bond strongly to glass, ceramics, and metallic allys 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.			
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 2014 Accomplishments:*** Modeled deformation and change in particles using a novel Mixed Least Squares method for Finite Elements that permits discontinuities in the displacement field of the particles; determined if polycrystalline ceramics can theoretically be improved by multiple-fold current values of fracture toughness and tensile strength; determined energy dissipation mechanisms in nano-coiled vertically aligned carbon nanotubes with a stiffness gradient under dynamic loading conditions. ***FY 2015 Plans:*** Identify and introduce energy dissipation mechanisms in novel multi-layered, heterogeneous structural systems to achieve significant weight reduction; and investigate fundamental nano-scale parameters of biological protective materials on the macro-scale damage variables of a multi-layered protective material, where the macro-scale variables will be incorporated into simulations of multi-layered nano-composite materials. ***FY 2016 Plans:*** Will 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 homongeneous 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.	2.205	3.302	2.319
Accomplishments/Planned Programs Subtotals	4.470	5.702	4.456

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2016 Army		Date: February 2015
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 2016 Army			Date: February 2015
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 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total	FY 2017	FY 2018	FY 2019	FY 2020	Cost To Complete	Total Cost
T23: *Basic Res Mil Const*	-	1.734	2.101	1.722	-	1.722	1.747	1.777	1.809	1.844	-	-

Note

Not applicable for this item

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 in terms of 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 US Army Engineer Research and Development Center (ERDC), Vicksburg, MS.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Title: Facilities Research	1.734	2.101	1.722
Description: Funding is provided for the following effort.			
FY 2014 Accomplishments: Determined the relationship between amino acid sequence and nanostructure self-assembly properties in a unique protein motif; redirected electron flux from highly reduced organic fermentation products towards hydrogenase production.			
FY 2015 Plans: Determine fundamental processes in microbial interactions with surfaces that lead to bio-fouling and corrosion; re-create plant photosynthesis processes in an artificial cell matrix.			
FY 2016 Plans:			

Exhibit R-2A, RDT&E Project Justification: PB 2016 Army		Date: February 2015
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** T23 / *Basic Res Mil Const*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Will 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.			
Accomplishments/Planned Programs Subtotals	1.734	2.101	1.722

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 2016 Army			Date: February 2015
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 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total	FY 2017	FY 2018	FY 2019	FY 2020	Cost To Complete	Total Cost
T24: *Signature Physics And Terrain State Basic Research*	-	1.593	2.005	1.627	-	1.627	1.649	1.675	1.706	1.740	-	-

Note

Not applicable for this item

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/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 sensing/inferring 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 U.S. Army Engineer Research and Development Center (ERDC), Vicksburg, MS.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Title: Analysis for Signal and Signature Phenomenology (Previously titled - Terrain State and Signature Physics)	1.593	2.005	1.627
Description: Funding is provided for the following effort.			
FY 2014 Accomplishments: Investigated and quantified full waveform Light Detection and Ranging (LiDAR) backscatter characteristics and known system response to enhance sensor calibration models for increased target identification in variable terrain environments; researched and defined annually repeating spatial snow patterns as a function of topography, vegetation, and weather, and determined the			

Exhibit R-2A, RDT&E Project Justification: PB 2016 Army		Date: February 2015
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 2014	FY 2015	FY 2016
efficacy and utility of this new knowledge to improve satellite derived snow mapping estimates of depth and density for enhancing water storage estimates and mobility products. ***FY 2015 Plans:*** Investigate 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; enable 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:*** Will 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 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.			
Accomplishments/Planned Programs Subtotals	1.593	2.005	1.627

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 2016 Army			Date: February 2015
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 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total	FY 2017	FY 2018	FY 2019	FY 2020	Cost To Complete	Total Cost
T25: *Environmental Science Basic Research*	-	6.966	7.300	6.980	-	6.980	7.081	7.202	7.336	7.480	-	-

Note

Not applicable for this item

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/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 U.S. Army Engineer Research and Development Center (ERDC), Vicksburg, MS.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Title: Environmental and Ecological Fate of Explosives, Energetics, and Other Contaminants	2.704	2.897	3.719
Description: Funding is provided for the following effort.			
FY 2014 Accomplishments: Determined the fundamental physics that control transport of both ionic and neutral species through nanochannels; characterized the structural changes in integral membrane proteins upon ligand binding; determined soil mobility and bioavailability of IMX-101			

Exhibit R-2A, RDT&E Project Justification: PB 2016 Army		Date: February 2015
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 2014	FY 2015	FY 2016
in terrestrial systems; and expanded the metabolic capacity of aerobic RDX- degrading bacteria to enable degradation of 4-nitro-2,4-diazabutanal. ***FY 2015 Plans:*** Determine the fundamental biological mechanisms that predict interactions of new insensitive munitions with environmental constituents; increase understanding of chemical-environmental interactions and ecosystem functions for advanced sensing; and provide underlying mechanisms of biological networks to utilize in man-made systems. ***FY 2016 Plans:*** Will 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 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.			
Title: Fundamental Understanding of Explosives, Energetics and UXO in the Environment ***Description:*** Previously titled:Remediation of Explosives, Energetics, and UXO ***FY 2014 Accomplishments:*** Determined the potential for bioaccumulation and food-chain transfer of 2,4 Dinitroanisole; isolated and chemically identify predominant phytosiderophores and/or organic acids exuded by two grass plants that may serve to complex lead; and identified and characterized novel biocatalysts involved in the direct incorporation of molecular oxygen into amines resulting in a green biosynthesis route to energetic. ***FY 2015 Plans:*** Determine the potential for use of aquatic biological systems as a basis for trace chemical sensors in water; determine how understanding of chemical impact on biological systems can be translated across different species through similarities in molecular systems; and identify the mode of toxic interactions of multiple chemical mixtures in the IMX. ***FY 2016 Plans:*** Will 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.	2.241	2.396	1.039
Title: Training Land Natural Resources ***Description:*** Funding is provided for the following effort. ***FY 2014 Accomplishments:***	0.982	1.107	1.306

Exhibit R-2A, RDT&E Project Justification: PB 2016 Army		Date: February 2015
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 2014	FY 2015	FY 2016
Devised a mathematical description of multiple scattering of impulsive signals that includes variability due to spatial and size distributions of scattering objects; determined how climate induced change affects the adsorption and biotransformation characteristics of peatland ecosystems; and characterized and compared munitions compounds and insensitive munitions impacts on critically sensitive larval stages of amphibian development. ***FY 2015 Plans:*** Investigate how invasive species impact the affected ecosystem at the molecular level; and determine the potential of novel mechanisms to assess ecosystem components utilizing specialized monitoring of unique sounds. ***FY 2016 Plans:*** Will 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.			
Title: Network Science ***Description:*** Funding is provided for the following effort. ***FY 2014 Accomplishments:*** Investigated genetic and genomic basis for differences in chemical sensitivity between different asexually or sexually reproducing populations; characterized sensitivity to traditional (lead) and insensitive (dinitroanisole) munitions over time under ideal and stressful conditions; and quantified the long-term contribution of environmental stress to sensitivity drifting in age stratified, reproducing populations. ***FY 2015 Plans:*** Investigate how molecular design impacts biological function and how this can be translated to man-made systems like robotics; and investigate biological cell assembly mechanisms for man-made systems and programming. ***FY 2016 Plans:*** Will 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.	1.039	0.900	0.916
Accomplishments/Planned Programs Subtotals	6.966	7.300	6.980

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

Exhibit R-2A, RDT&E Project Justification: PB 2016 Army		Date: February 2015
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** T25 / *Environmental Science Basic Research*

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2016 Army			Date: February 2015
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 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total	FY 2017	FY 2018	FY 2019	FY 2020	Cost To Complete	Total Cost
T63: *Robotics Autonomy, Manipulation, & Portability Rsh*	-	1.924	6.996	7.233	-	7.233	7.164	7.388	8.080	8.242	-	-

Note

Not applicable for this item.

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 U.S. Army Research Lab 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, environmentally-harsh robotics applications. 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.

Exhibit R-2A, RDT&E Project Justification: PB 2016 Army		Date: February 2015
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*

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Title: Robotics Autonomy and Human Robotic Interface Research	1.924	1.996	1.983
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 61104/Project H54). ***FY 2014 Accomplishments:*** Conducted experimental studies to investigate the fundamental flow behavior of small scale flyers as it impacts range and endurance; investigated cognitive approaches for machine perception; explored concepts from game theory and machine learning to determine adversarial intent from sensor observations; examined mechanics and control related to whole body manipulation; and examined novel locomotion mechanisms focusing upon energy efficiency and mobility. ***FY 2015 Plans:*** Conduct experimental studies related to fundamental flow behavior of very small scale air vehicles; explore 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 examine novel locomotion concepts to enable greater efficiency and application in complex and confined environments. ***FY 2016 Plans:*** Will 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 biomimentic utilization of appendages, to achieve both functionality and efficiency; explore control strategies to enable rapid, dynamic manipulation of objects.			
Title: Intelligent Systems	-	5.000	5.250
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 Plans:***			

Exhibit R-2A, RDT&E Project Justification: PB 2016 Army		Date: February 2015
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 2014	FY 2015	FY 2016
Explore and characterize architectures and algorithms for intelligent explanation, facilitating human interpretation of machine outputs; investigate techniques for limited supervised learning to enhance machine recognition of threats and objectives and assess their impact on baseline planning algorithms; and address socially-inspired concepts for collective intelligence in the context of dynamic situation assessment, re-organization and collaboration. ***FY 2016 Plans:*** Will 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.			
Accomplishments/Planned Programs Subtotals	1.924	6.996	7.233

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 2016 Army											Date: February 2015	
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 2014**	**FY 2015**	**FY 2016 Base**	**FY 2016 OCO**	**FY 2016 Total**	**FY 2017**	**FY 2018**	**FY 2019**	**FY 2020**	**Cost To Complete**	**Total Cost**
T64: *Sci BS/System Biology And Network Science*	-	2.860	2.397	2.930	-	2.930	2.974	3.025	3.080	3.141	-	-

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 USAMRMC, Fort Detrick, MD / Biotechnology High Performance Computing Software Applications Institute (BHSAI), Frederick, MD.

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2014**	**FY 2015**	**FY 2016**
Title: Network Sciences Initiative	2.860	2.397	2.930
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 2014 Accomplishments: Validated and extended algorithms for discovery of biomarkers (indicator of a particular biological condition or process) for severe TBI to include moderate and mild TBI; developed systems biology algorithms to establish new strategies to identify drug targets and therapeutics for malaria- and trauma-induced coagulopathy (abnormal blood clotting); exploited novel in-silico (performed on computer via simulation) models to identify biomarkers and determine the time course of wound healing; and developed mathematical models to characterize how viruses escape immune response to support the development of anti-viral drugs.			
FY 2015 Plans: Use algorithms to investigate the discrimination between biomarkers of mild, moderate, and severe TBI; test and extend computational biology algorithms to identify drug targets and therapies for conditions such as infectious diseases ; develop mathematical models of upper respiratory airflow patterns for the non-invasive diagnosis of pulmonary (lung) diseases; computationally predict potential drug targets that could induce re-sensitization to current antibiotics in biofilm (an aggregate			

Exhibit R-2A, RDT&E Project Justification: PB 2016 Army		Date: February 2015
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 2014	FY 2015	FY 2016
of microorganisms in which cells adhere to each other on a surface)forming bacteria (tend to be more antibiotic-resistant than individual bacteria); and mathematically model standard vital-sign data to enable the non-invasive prediction of heat stress injury and allow for timely counteractive measures. ***FY 2016 Plans:*** Will develop new models of (a) underlying mechanisms of blast-induced traumatic brain injury (TBI) and (b) susceptibility to stress-related bone fracture in male and female soldiers related to the high level of repeated physical activity experienced during basic combat training (BCT); and will 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.			
Accomplishments/Planned Programs Subtotals	2.860	2.397	2.930

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 2016 Army											Date: February 2015	
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 2014**	**FY 2015**	**FY 2016 Base**	**FY 2016 OCO**	**FY 2016 Total**	**FY 2017**	**FY 2018**	**FY 2019**	**FY 2020**	**Cost To Complete**	**Total Cost**
VR9: *Surface Science Research*	-	1.942	2.499	2.222	-	2.222	2.256	2.294	2.337	2.384	-	-

Note

Not applicable for this item.

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 U.S. Army Edgewood Chemical and Biological Center (ECBC), Research, Development and Engineering Command, in Aberdeen, MD.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Title: Surface Science Research	1.942	2.499	2.222
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 2014 Accomplishments: Performed structural determination and computational modeling of trans-membrane proteins; building on FY13 efforts, continued to develop a set of surface science tools that further our understanding of surface properties and interfacial dynamics of complex materials; continued to investigate rational design approaches to metal-metal oxide nano-architectures; continued to systematically model engineered functional systems; and investigated the mechanisms governing specific binding or adherence of biological molecules to abiotic surfaces.			
FY 2015 Plans:			

Exhibit R-2A, RDT&E Project Justification: PB 2016 Army		Date: February 2015
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 2014	FY 2015	FY 2016
Investigate 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:*** Will 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; catalytic chemical reactions and transport processes on surfaces; theory and multiscale modeling of processes at complex surfaces; and physical determination of surface structure, morphology and properties.			
Accomplishments/Planned Programs Subtotals	1.942	2.499	2.222

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 2016 Army											Date: February 2015	
Appropriation/Budget Activity 2040: *Research, Development, Test & Evaluation, Army* / BA 1: *Basic Research*					R-1 Program Element (Number/Name) PE 0601103A / *University Research Initiatives*							
COST ($ in Millions)	**Prior Years**	**FY 2014**	**FY 2015**	**FY 2016 Base**	**FY 2016 OCO**	**FY 2016 Total**	**FY 2017**	**FY 2018**	**FY 2019**	**FY 2020**	**Cost To Complete**	**Total Cost**
Total Program Element	-	76.682	89.776	72.603	-	72.603	72.741	72.914	74.305	74.780	-	-
D55: *University Research Initiative*	-	73.457	67.258	69.573	-	69.573	69.665	69.784	71.118	71.530	-	-
D58: *URI ACTIVITIES (CA)*	-	-	20.000	-	-	-	-	-	-	-	-	-
V72: *Minerva*	-	3.225	2.518	3.030	-	3.030	3.076	3.130	3.187	3.250	-	-

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 U.S. 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 U.S. Army Research Laboratory (ARL) located in Research Triangle Park, NC.

Exhibit R-2, RDT&E Budget Item Justification: PB 2016 Army					Date: February 2015
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 2014**	**FY 2015**	**FY 2016 Base**	**FY 2016 OCO**	**FY 2016 Total**
Previous President's Budget	79.317	69.808	73.136	-	73.136
Current President's Budget	76.682	89.776	72.603	-	72.603
Total Adjustments	-2.635	19.968	-0.533	-	-0.533
• Congressional General Reductions	-	-0.032			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	20.000			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-2.635	-			
• Adjustments to Budget Years	-	-	-0.533	-	-0.533

Congressional Add Details ($ in Millions, and Includes General Reductions)	**FY 2014**	**FY 2015**
Project: D58: *URI ACTIVITIES (CA)*		
Congressional Add: *Program Increase*	-	20.000
Congressional Add Subtotals for Project: D58	-	20.000
Congressional Add Totals for all Projects	-	20.000

Exhibit R-2A, RDT&E Project Justification: PB 2016 Army			Date: February 2015
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 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total	FY 2017	FY 2018	FY 2019	FY 2020	Cost To Complete	Total Cost
D55: *University Research Initiative*	-	73.457	67.258	69.573	-	69.573	69.665	69.784	71.118	71.530	-	-

Note

Not applicable for this item.

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 US 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 U.S. Army Research Laboratory (ARL) located in Research Triangle Park, NC.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Title: Multidisciplinary University Research Initiative (MURI)	54.829	50.584	53.136
Description: MURI programs are typically 5 years in length at a cost of $1.25M/yr.			
FY 2014 Accomplishments: Supported MURI awards made in prior years and initiated eight FY14-start 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 U.S. ARL, the U.S. Army Research Development and Engineering Centers (RDECs), the U.S. Army Engineer Research and Development Center (ERDC), the U.S.			

Exhibit R-2A, RDT&E Project Justification: PB 2016 Army		Date: February 2015
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 2014	FY 2015	FY 2016
Army (Medical Research and Materiel Command (MRMC), the U.S. Army Research Institute for Behavioral and Social Sciences (ARI) and industry. ***FY 2015 Plans:*** Provide support for MURI awards made in prior years and start six to eight new FY15 MURI awards critical to supporting the future force. Effective transition mechanisms include 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, RDECs, ERDC, MRMC, ARI and industry. ***FY 2016 Plans:*** Will provide support for MURI awards made in prior years and will 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 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 2014 Accomplishments:*** Selected four new awardees and supported prior year's awardees. ***FY 2015 Plans:*** Continue support for prior year awardees and selection of four new awards. ***FY 2016 Plans:*** Will continue support for prior year awardees and select four new awards.	5.231	4.500	4.478
Title: Defense University Research Instrumentation Program (DURIP) ***Description:*** Supports basic research through competitive grants for research instrumentation. ***FY 2014 Accomplishments:*** Awarded competitive grants for research instrumentation to enhance universities' capabilities to conduct world class research critical to Army transformation. ***FY 2015 Plans:***	13.397	12.174	11.959

Exhibit R-2A, RDT&E Project Justification: PB 2016 Army		Date: February 2015
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 2014	FY 2015	FY 2016
Award competitive grants for research instrumentation to enhance universities' capabilities to conduct world class research critical to Army transformation. ***FY 2016 Plans:*** Will award competitive grants for research instrumentation to enhance universities' capabilities to conduct world class research critical to Army transformation.			
Accomplishments/Planned Programs Subtotals	73.457	67.258	69.573

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 2016 Army			Date: February 2015
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 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total	FY 2017	FY 2018	FY 2019	FY 2020	Cost To Complete	Total Cost
D58: *URI ACTIVITIES (CA)*	-	-	20.000	-	-	-	-	-	-	-	-	-

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 2014	FY 2015
Congressional Add: Program Increase	-	20.000
FY 2015 Plans: Congressional increase for University Research Initiatives		
Congressional Adds Subtotals	-	20.000

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 2016 Army			Date: February 2015
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 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total	FY 2017	FY 2018	FY 2019	FY 2020	Cost To Complete	Total Cost
V72: *Minerva*	-	3.225	2.518	3.030	-	3.030	3.076	3.130	3.187	3.250	-	-

Note

Not applicable for this item.

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 FY09. It focuses on areas in the social sciences that are of strategic importance to U.S. 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 2014	FY 2015	FY 2016
Title: The Minerva Research Initiative (MRI)	3.225	2.518	3.030
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 U.S. 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 2014 Accomplishments: Completed the university consortium projects started in FY09; supported new and ongoing Minerva social science research of strategic importance to the Army and U.S. national security policy; focused research efforts on understanding group belief			

Exhibit R-2A, RDT&E Project Justification: PB 2016 Army		Date: February 2015
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 2014	FY 2015	FY 2016
formation, factors causing or influencing social change and violence, societal resilience, theories of deterrence, and new approaches to conflict and cooperation. ***FY 2015 Plans:*** Test theories on the direct and indirect effects of characteristics of natural resources on violence and state stability, which may ultimately provide predictive models of the relationship between natural resources and conflict, and providing options for anticipating and mitigating the acceleration of violence around the globe; and perform social scientific surveys with neuroscientific brain imaging to reveal the role of moral values in social mobilization which in the long term may provide effective strategies and policies in reducing organized violence and preventing its contagion. ***FY 2016 Plans:*** Will design and validate new quantitative models to identify the antecedents of civil unrest and violence, which will 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; 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.			
Accomplishments/Planned Programs Subtotals	3.225	2.518	3.030

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 2016 Army											Date: February 2015	
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 2014**	**FY 2015**	**FY 2016 Base**	**FY 2016 OCO**	**FY 2016 Total**	**FY 2017**	**FY 2018**	**FY 2019**	**FY 2020**	**Cost To Complete**	**Total Cost**
Total Program Element	-	110.610	108.782	100.340	-	100.340	101.725	103.356	107.560	109.584	-	-
EA6: *Cyber Collaborative Research Alliance*	-	2.908	4.198	3.234	-	3.234	3.281	3.338	4.887	4.984	-	-
F17: *Neuroergonomics Collaborative Technology Alliance*	-	5.199	3.989	5.254	-	5.254	5.332	5.424	5.521	5.632	-	-
H04: *HBCU/MI Programs*	-	3.611	2.104	1.887	-	1.887	1.930	1.980	2.035	2.074	-	-
H05: *Institute For Collaborative Biotechnologies*	-	12.037	7.996	6.485	-	6.485	6.595	6.727	6.870	7.008	-	-
H09: *Robotics CTA*	-	6.425	5.841	5.557	-	5.557	5.640	5.736	5.841	5.958	-	-
H50: *Network Sciences Cta*	-	13.724	11.494	11.065	-	11.065	11.130	11.251	11.288	11.422	-	-
H53: *Army High Performance Computing Research Center*	-	4.736	5.389	5.658	-	5.658	5.742	5.841	5.950	6.068	-	-
H54: *Micro-Autonomous Systems Technology (MAST) CTA*	-	7.823	7.299	7.679	-	7.679	7.792	7.928	8.072	8.233	-	-
H59: *International Tech Centers*	-	7.380	6.094	6.978	-	6.978	7.080	7.201	7.333	7.479	-	-
H73: *Automotive Research Center (ARC)*	-	4.058	3.155	3.133	-	3.133	3.180	3.234	3.294	3.359	-	-
J08: *Institute For Creative Technologies (ICT)*	-	7.830	7.496	6.080	-	6.080	6.186	6.309	6.442	6.572	-	-
J12: *Institute For Soldier Nanotechnology (ISN)*	-	10.927	6.709	6.080	-	6.080	6.185	6.308	6.445	6.574	-	-
J13: *UNIVERSITY AND INDUSTRY INITIATIVES (CA)*	-	-	6.100	-	-	-	-	-	-	-	-	-
J14: *Army Educational Outreach Program*	-	8.685	9.545	9.670	-	9.670	9.864	10.048	10.274	10.470	-	-
J15: *Network Sciences ITA*	-	3.985	3.859	4.070	-	4.070	4.078	4.083	4.112	4.152	-	-

Exhibit R-2, RDT&E Budget Item Justification: PB 2016 Army												Date: February 2015
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*	-	2.959	2.883	3.031	-	3.031	3.076	3.130	3.187	3.250	-	-
VS2: *Multi-Scale Materials Modeling Centers*	-	8.323	9.634	9.296	-	9.296	9.433	9.596	9.770	9.966	-	-
VS3: *Center For Quantum Science Research*	-	-	4.997	5.183	-	5.183	5.201	5.222	6.239	6.383	-	-

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 project 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, Cognition and Neuroergonomics, and Multi-Scale Materials Modeling. 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 U. S. Army Research Lab (ARL) in Adelphi, MD; the U.S. Army Tank Automotive Research, Development, and Engineering Center (TARDEC) in Warren, MI; U.S. Army Aviation and Missile Research, Development and Engineering Center (AMRDEC), in Huntsville, AL, and U.S. Army Research, Development and Engineering Command (RDECOM), in Aberdeen, MD.

Exhibit R-2, RDT&E Budget Item Justification: PB 2016 Army					Date: February 2015
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*		
B. Program Change Summary ($ in Millions)	**FY 2014**	**FY 2015**	**FY 2016 Base**	**FY 2016 OCO**	**FY 2016 Total**
Previous President's Budget	113.601	102.737	101.024	-	101.024
Current President's Budget	110.610	108.782	100.340	-	100.340
Total Adjustments	-2.991	6.045	-0.684	-	-0.684
• Congressional General Reductions	-	-0.055			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	6.100			
• Congressional Directed Transfers	-	-			
• Reprogrammings	0.750	-			
• SBIR/STTR Transfer	-3.741	-			
• Adjustments to Budget Years	-	-	-0.684	-	-0.684

Congressional Add Details ($ in Millions, and Includes General Reductions)	**FY 2014**	**FY 2015**
Project: J13: *UNIVERSITY AND INDUSTRY INITIATIVES (CA)*		
Congressional Add: *Program Increase*	-	6.100
Congressional Add Subtotals for Project: J13	-	6.100
Congressional Add Totals for all Projects	-	6.100

Exhibit R-2A, RDT&E Project Justification: PB 2016 Army			Date: February 2015
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 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total	FY 2017	FY 2018	FY 2019	FY 2020	Cost To Complete	Total Cost
EA6: *Cyber Collaborative Research Alliance*	-	2.908	4.198	3.234	-	3.234	3.281	3.338	4.887	4.984	-	-

A. Mission Description and Budget Item Justification

This project fosters research performed through the Cyber Security Collaborative Research Alliance (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.

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 U.S. Army Research Laboratory (ARL) in Adelphi and Aberdeen Proving Grounds, MD.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Title: Cyber Security Collaborative Research Alliance	2.908	4.198	3.234
Description: The Cyber Security Collaborative Research Alliance (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 2014 Accomplishments: Competitively selected a consortium consisting of academia, industry and government researchers to advance the theoretical foundations of cyber science in the context of Army networks; investigated new holistic conceptualizations and definitions of risk, resiliency and robustness under an adversarial setting; studied and created theory and techniques for effective non-signature based detection of advanced persistent threats; developed mathematical theories and models leading to algorithms to affect			

Exhibit R-2A, RDT&E Project Justification: PB 2016 Army		Date: February 2015
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 2014	FY 2015	FY 2016
a desired maneuver end-state in dynamic environments and deliberate obfuscation attempts by the adversary; and explored theoretical models of the cyber defender leading to improved defender effectiveness. ***FY 2015 Plans:*** Develop 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; develop theories and models relating properties and capabilities of cyber threat detection and recognition processes/ mechanisms to properties of malicious activity and of Army networks; develop 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 develop a theoretical understanding of the socio-cognitive factors that impact the decision making of the user/Soldier, defender/analyst, and adversary. ***FY 2016 Plans:*** Will 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.			
Accomplishments/Planned Programs Subtotals	2.908	4.198	3.234

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 2016 Army											Date: February 2015	
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 2014**	**FY 2015**	**FY 2016 Base**	**FY 2016 OCO**	**FY 2016 Total**	**FY 2017**	**FY 2018**	**FY 2019**	**FY 2020**	**Cost To Complete**	**Total Cost**
F17: *Neuroergonomics Collaborative Technology Alliance*	-	5.199	3.989	5.254	-	5.254	5.332	5.424	5.521	5.632	-	-

Note

Not applicable for this item.

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 U.S. Army Research Laboratory (ARL) in Adelphi, MD.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Title: Neurocognitive performance in operational environments	1.868	1.515	1.941

Exhibit R-2A, RDT&E Project Justification: PB 2016 Army		Date: February 2015
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 2014	FY 2015	FY 2016
Description: This effort is intended to understand fundamental principles underlying Soldier neurocognitive performance in operational environments. ***FY 2014 Accomplishments:*** Developed and transitioned lessons learned on individual differences in neurocognitive performance from large scale simulation evaluations to second phase of evaluation with increased military relevance/realism; and developed simulation evaluations with increased military relevance/realism to evaluate formal models of neurocognitive performance issues of individuals in neurocognitive performance ***FY 2015 Plans:*** Evaluate neurocognitive performance using novel scenarios of increasing military relevance to determine feasibility of military applications; and identify 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:*** Will develop novel set of algorithmic principles and approaches for integrating multiple, concurrently recorded 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.			
Title: Computational neural analysis ***Description:*** This effort advances computational approaches for the analysis and interpretation of neural functioning. ***FY 2014 Accomplishments:*** Conducted data mining explorations of large-scale simulation evaluations using novel computational methods for identification and clustering of predictive features of inter- and intra-subject variability; and implemented extensible database designs for enabling data exploration and modeling of individual differences in neurocognitive function. ***FY 2015 Plans:*** Use 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:*** Will 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.	1.606	1.197	1.599
Title: Neurotechnologies	1.725	1.277	1.714

Exhibit R-2A, RDT&E Project Justification: PB 2016 Army		Date: February 2015
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 2014	FY 2015	FY 2016
Description: This effort provides a fundamental advancement in neurotechnologies that enhance Soldier-system interactions and performance. ***FY 2014 Accomplishments:*** Refined methods, sensor performance, and system designs for on-line monitoring and assessment of Soldier fatigue and neurocognitive state; validated performance of algorithms for a neuro-computer vision for automated environment appraisal; and evaluated and validated methods for Soldier monitoring and assessment in human-computer interaction technologies for Soldier intentional and target detection performance and adaptive automation systems ***FY 2015 Plans:*** Pursue adaptation of neuroimaging technologies to enhance functionality in complex environments; and develop technical capabilities for identification of brain activity in realistic environments, including hardware and software algorithms robust to environmental and user-induced artifacts. ***FY 2016 Plans:*** Will 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.			
Accomplishments/Planned Programs Subtotals	5.199	3.989	5.254

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 2016 Army			Date: February 2015
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 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total	FY 2017	FY 2018	FY 2019	FY 2020	Cost To Complete	Total Cost
H04: *HBCU/MI Programs*	-	3.611	2.104	1.887	-	1.887	1.930	1.980	2.035	2.074	-	-

Note

FY 14 OSD funding for Historically Black Colleges and Universities and Minority Institutions was realigned from the RDT&E, Army appropriation to RDT&E, 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 Historically Black Colleges and Universities and Minority Institutions (HBCU/MI), and provides support to Department of Defense (DoD) Historically Black Colleges and Universities and Minority Institutions (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 a select number of high-interest scientific and engineering disciplines through innovative research at Centers of Excellence (CoE) established at Historically Black Colleges and Universities. These COEs work with Army, industrial, and other academic partners to accelerate the transition from the research phase to technology demonstration. In addition, these CoEs 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 Office of Secretary of Defense program manager for HBCU/MI programs.

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 U.S. Army Research Laboratory (ARL) in Adelphi, MD.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Title: Centers of Excellence for Battlefield Capability Enhancements (BCE)	3.611	2.104	1.887
Description: Five new Partnership in Research Transition (PIRT) Centers of Excellence were established in 2011 at: Hampton Univ. (Lower Atmospheric Research Using 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 and IED Detection Using 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 Historically Black Colleges and Universities (HBCUs) to provide excellence in education; and to conduct research critical to the national security functions of the DoD.			

Exhibit R-2A, RDT&E Project Justification: PB 2016 Army		Date: February 2015
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 2014	FY 2015	FY 2016
FY 2014 Accomplishments: Continued research efforts at PIRT Centers of Excellence that began in FY11 and continued in FY12 and FY13, for centers showing sufficient progress toward research goals and transition. ***FY 2015 Plans:*** Continue 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:*** Will conclude support of research at the five PIRT Centers of Excellence; and continue research investigations with HBCU/MI 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.			
Accomplishments/Planned Programs Subtotals	3.611	2.104	1.887

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 2016 Army			Date: February 2015
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 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total	FY 2017	FY 2018	FY 2019	FY 2020	Cost To Complete	Total Cost
H05: *Institute For Collaborative Biotechnologies*	-	12.037	7.996	6.485	-	6.485	6.595	6.727	6.870	7.008	-	-

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 IBM and 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 U.S. 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 U.S. Army Research Laboratory (ARL) in Adelphi, MD.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Title: Institute for Collaborative Biotechnologies	10.642	7.196	5.773
Description: Perform sustained multidisciplinary basic research supporting technology to provide the Army with bio-inspired materials and biomolecular sensor platforms.			
FY 2014 Accomplishments: Investigated methods for designing and characterizing bio-inspired materials such as exploring new architectures for mechanical strength which can form the basis for new protective materials for the Soldier; expanded computational tools that allow for improved selection of engineered enzymes as candidates for potential use in biofuel production; designed biomolecular circuitry and control systems within cells to enable rapid detection and response to environmental effects; and examined the effects of			

Exhibit R-2A, RDT&E Project Justification: PB 2016 Army		Date: February 2015
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 2014	FY 2015	FY 2016
oligoelectrolyte insertion within the membranes of a variety of bacterial species to better determine the effects of membrane modification on the potential for generating power from wastewater remediation. ***FY 2015 Plans:*** Show independent tuning of the temperature coefficient of resistance and noise to improve signal to noise ratio of room temperature infrared detectors; showing 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 efficiency degradation for efficient data communications and energy harvesting; and creating and investigating a novel sensor based on optical dark modes in nanorods for use in biomolecule, chemical sensing, and near-field imaging. ***FY 2016 Plans:*** Will 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.			
Title: Neuroscience ***Description:*** Perform multidisciplinary basic research in the area of neuroscience. ***FY 2014 Accomplishments:*** Assessed the relationship between brain structural and functional connections with behavior to gain a better understanding of the relationship between a Soldier's hardwired brain structure and cognitive ability; assessed whether neural measurements (e.g., functional magnetic resonance imaging or electroencephalography (EEG)) can predict the performance of an individual to correctly perceive and detect targets placed at unusual locations within natural environments; and identified neural and physiological biomarkers associated with adaptive cognitive capacity under stress and fatigue ***FY 2015 Plans:*** Utilize 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	1.395	0.800	0.712

Exhibit R-2A, RDT&E Project Justification: PB 2016 Army		Date: February 2015
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 2014	FY 2015	FY 2016
visual tasks, which may ultimately lead to new methods, tools, and models to enhance warfighter performance; and explore the organizational principles governing the structure and topology of brain networks and analyze brain imaging data that, in the long term, may enable the design of improved training protocols to reduce unwanted maladaptive behaviors. ***FY 2016 Plans:*** Will 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.			
Accomplishments/Planned Programs Subtotals	12.037	7.996	6.485

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 2016 Army			Date: February 2015
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 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total	FY 2017	FY 2018	FY 2019	FY 2020	Cost To Complete	Total Cost
H09: *Robotics CTA*	-	6.425	5.841	5.557	-	5.557	5.640	5.736	5.841	5.958	-	-

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 U.S. 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, 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 U.S. Army Research Laboratory (ARL) at the Aberdeen Proving Ground, MD.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Title: Autonomous Systems	6.425	5.841	5.557
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 2014 Accomplishments: Expanded investigation of learning and recognition of relationships to include more complex dynamic environments and adversarial intent; continue investigation of cognitive approaches to machine perception and the creation of a shared mental model to reduce reliance upon communication between humans and robots; continued exploration of whole body (dynamic)			

Exhibit R-2A, RDT&E Project Justification: PB 2016 Army		Date: February 2015
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 2014	FY 2015	FY 2016
manipulation of objects in the environment; and continued exploration of novel ground locomotion techniques to enable rapid mobility in 3D and confined environments. ***FY 2015 Plans:*** Expand upon utilization of learning to conduct semantic labeling of objects and behaviors; expand upon the concept of a hybrid cognitive-metric architecture, including perceptual and reasoning skills, to enable teaming of humans and unmanned systems; and explore novel modes of mobility, including legs and snake-like motion, to enable efficient, effective mobility in complex 3D environments. ***FY 2016 Plans:*** Will 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.			
Accomplishments/Planned Programs Subtotals	6.425	5.841	5.557

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 2016 Army			Date: February 2015
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 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total	FY 2017	FY 2018	FY 2019	FY 2020	Cost To Complete	Total Cost
H50: *Network Sciences Cta*	-	13.724	11.494	11.065	-	11.065	11.130	11.251	11.288	11.422	-	-

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. Beginning in FY12, all funds from PE 61104/project J22 were realigned to this project.

Work in this project builds fundamental knowledge for and accelerates the transition of communications and networks technology to 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 U.S. Army Research Laboratory (ARL) in Adelphi, MD.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Title: Network Sciences Collaborative Technology Alliance (NS CTA)	13.724	10.500	10.128
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 2016 Army		Date: February 2015
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 2014	FY 2015	FY 2016
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 2014 Accomplishments:*** Explored mathematical representations of dynamic communications, information, and social networks that enable the analysis of their joint behavior; developed techniques for discovering node roles and hierarchical structures in noisy, uncertain social networks, and techniques to maximize information (not bits) delivered based on quality of information needs and the context of decisions (semantics); and developed techniques for social and information-aware caching to improve performance and robustness of composite networks. These efforts will result in analytical techniques for the design of better Army tactical networks that are more resilient in disruptive environments. ***FY 2015 Plans:*** Develop 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; develop 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 develop mathematical representations for the quality of information of static and dynamic data and its effectiveness for situational awareness. These efforts will result in the identification of data for more accurate situational awareness. ***FY 2016 Plans:*** Will 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.			
Title: Mobile Network Modeling Institute ***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 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	-	0.994	0.937

Exhibit R-2A, RDT&E Project Justification: PB 2016 Army		Date: February 2015
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 2014	FY 2015	FY 2016
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 Plans:*** Investigate approaches to computational modeling of large-scale networks that incorporate alternative routing techniques, such as trust-based or quality-based routing schemes; use computational experiments to inform study of pathological phenomena that might be induced in large-scale network behaviors by such novel schemes with unknown ramifications; explore impact of such models on existing computational architectures and their performance; and identify constraints on potential uses of alternative routing schemes on applicability of available computational modeling techniques. ***FY 2016 Plans:*** Will 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.			
Accomplishments/Planned Programs Subtotals	13.724	11.494	11.065

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 2016 Army			Date: February 2015
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 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total	FY 2017	FY 2018	FY 2019	FY 2020	Cost To Complete	Total Cost
H53: *Army High Performance Computing Research Center*	-	4.736	5.389	5.658	-	5.658	5.742	5.841	5.950	6.068	-	-

Note

Not applicable for this item.

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. This project also supports the Robotics Collaborative Technology Alliance (0601104/project H09) which explores new opportunities to enable revolutionary autonomous mobility of unmanned systems for the future force. This research is an integral part of the larger Army Robotics Program and feeds technology into Robotics Technology (0602120A/project TS2). The project also addresses research focusing on unmanned systems operating as a team with human supervisors and displaying a high degree of adaptability to dynamic environmental and tactical situations.

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 U.S. Army Research Laboratory (ARL) in Adelphi, MD.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Title: Army High Performance Computing Research Center (AHPCRC)	4.736	5.389	5.658
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 2014 Accomplishments: Implemented reduced order modeling (ROM) approach for underbody blast application including occupant, improvised explosive device (IED) blast, and vehicle structural response; supported verification and validation of ROM approach (with U.S. Army Research Development and Engineering Centers); implemented nano-fluidic based multi-scale/multi-physics approaches on scalable computers and support validation of this work for blood flow and drug delivery (with U.S. Army Medical Reseach and			

Exhibit R-2A, RDT&E Project Justification: PB 2016 Army		Date: February 2015
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 2014	FY 2015	FY 2016
Materiel Command (MRMC)); developed domain specific language (DSL) for finite element-based approaches; investigated emerging hybrid and memory hierarchy computer systems; and supported education and outreach activities formerly funded in PE 0605803A/Project 731 (Army High Performance Computing Centers). ***FY 2015 Plans:*** The goal of the ROM for underbody blast project is to develop predictive capability for practical underbody blast applications. Earlier work demonstrated feasibility by adopting DoD engineering software Conventional Weapons Effects. This phase develops highly non-linear mathematical formulations and implements fully coupled, high-fidelity blast-structure interaction problem-solving. Develop and implement new energy conserving algorithms in the context of ROM; validate and verify and transition research software working with Army partners; continue exascale algorithms development under LISZTFE (domain specific finite element code) environment; investigate a new class of direct solvers, called fast direct solvers (FDS), which use low-rank-matrix approximations to reduce the computational complexity; and transition software developed for blood transfusion and continue new scalable algorithmic development research for simulating inhalation of toxic agents for realistic patient-specific geometric features. ***FY 2016 Plans:*** Will 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 HPC; and develop domain specific languages for mesh based and graph problems and explore these algorithmic approaches for exascale computers.			
Accomplishments/Planned Programs Subtotals	4.736	5.389	5.658

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 2016 Army											Date: February 2015	
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 2014**	**FY 2015**	**FY 2016 Base**	**FY 2016 OCO**	**FY 2016 Total**	**FY 2017**	**FY 2018**	**FY 2019**	**FY 2020**	**Cost To Complete**	**Total Cost**
H54: *Micro-Autonomous Systems Technology (MAST) CTA*	-	7.823	7.299	7.679	-	7.679	7.792	7.928	8.072	8.233	-	-

Note

Not applicable for this item.

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 U.S. 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 U.S. Army Research Laboratory (ARL) in Adelphi, MD.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Title: Micro Autonomous Systems Technology CTA	7.823	7.299	7.679
Description: Enhance tactical situational awareness in urban and complex terrain by enabling the autonomous operation of a collaborative ensemble of multifunctional mobile microsystems.			
FY 2014 Accomplishments: Studied and developed bio-inspired robotic platform mobility and control methods for Micro Autonomous Systems (MAS) in real world environments, sensors for on-board state estimation and perception, architectures and algorithms for heterogenous teaming; studied trades between increased risk and uncertainty and increased operational tempo; and conduct joint experiments			

Exhibit R-2A, RDT&E Project Justification: PB 2016 Army		Date: February 2015
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 2014	FY 2015	FY 2016
on emerging technology to assess the ability of small air and ground platforms to work collaboratively to enter and explore urban and complex 3D environments. ***FY 2015 Plans:*** Investigate bio-inspired air and ground robotic platform mobility and control methods (for 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 heterogenous teaming, communications, and navigation); study trades between increased risk, uncertainty and increased operational tempo; and conduct joint experiments on emerging MAS technology to assess the ability to support rapid and mobile Intelligence, Surveillance, and Reconnaissance for the Soldier in complex 3D environments. ***FY 2016 Plans:*** Will 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. Will advance 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.			
Accomplishments/Planned Programs Subtotals	7.823	7.299	7.679

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 2016 Army			Date: February 2015
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 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total	FY 2017	FY 2018	FY 2019	FY 2020	Cost To Complete	Total Cost
H59: *International Tech Centers*	-	7.380	6.094	6.978	-	6.978	7.080	7.201	7.333	7.479	-	-

Note

Not applicable for this item.

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, U.S. Army Research, Development and Engineering Command (RDECOM), the U.S. Army Research Laboratory (ARL) in Adelphi, MD, and the United States Military Academy, NY.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Title: International Technology Centers (ITC)	6.404	5.700	6.469
Description: Funding is provided for the following effort.			
FY 2014 Accomplishments:			

Exhibit R-2A, RDT&E Project Justification: PB 2016 Army		Date: February 2015
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 2014	FY 2015	FY 2016
Continued to solicit projects and build on the success of the FTAS Program; continued to enhance and refine technology search capabilities using customer feedback (RDECs, PMs and labs) to focus on near and long term capabilities. ***FY 2015 Plans:*** 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 2016 Plans:*** Will continue to solicit projects and build on the success of the FTAS Program; will 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 2014 Accomplishments:*** Developed an algorithm based on the convergence of "vertex probabilities" that will improve the ability to "influence" a social network; refined initial findings concerning cooperation networks and how these theoretical frameworks can improve systems and organizations; studied network topologies and features linked to network vulnerabilities and efficient network-level power management; and studied development of a new network classification model that assists policy makers with economic development strategy. ***FY 2015 Plans:*** Continue to refine algorithms based on the convergence of "vertex probabilities" to improve the ability to "influence" networks; and continue to refine advances in cooperation networks to include how these theoretical frameworks can improve systems and organizations. ***FY 2016 Plans:*** Will build academic impact networks and military information networks (unit teams) and refine process algorithms that produce and enhance advances in performance, collaboration and cooperation; validate systems using operational data to design and optimize network frameworks and processes to improve military systems and unit organizations. Theoretical work will be connected with ISR and command and control systems (mission command) and results will be used in 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 refine economic development models and cultural and logical networks in Africa to assist military decision makers and diplomatic policy makers.	0.976	0.394	0.509
Accomplishments/Planned Programs Subtotals	7.380	6.094	6.978

Exhibit R-2A, RDT&E Project Justification: PB 2016 Army		Date: February 2015
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*

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 2016 Army			Date: February 2015
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 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total	FY 2017	FY 2018	FY 2019	FY 2020	Cost To Complete	Total Cost
H73: *Automotive Research Center (ARC)*	-	4.058	3.155	3.133	-	3.133	3.180	3.234	3.294	3.359	-	-

Note

Not applicable for this item.

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 US 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 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 U.S. Army TARDEC, Warren, MI.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Title: Automotive Research Center (ARC)	4.058	3.155	3.133
Description: Funding is provided for the following effort.			
FY 2014 Accomplishments: Synthesized and tested new hybrid propulsion concepts with novel energy conversion and storage devices; performed engine experiments with combustion modeling to characterize JP-8 performance; designed lightweight and safe structures to address impact protection and reliability; integrated physical and cognitive human models to represent driving behavior; classified driver distraction, fatigue and stress; characterized Soft Soil Terra-mechanics and effects on mobility, safety and fuel economy; and			

Exhibit R-2A, RDT&E Project Justification: PB 2016 Army		Date: February 2015
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 2014	FY 2015	FY 2016
performed vehicle system integration through verification, validation and certification of vehicle tests, and multi-level vehicle design. ***FY 2015 Plans:*** Develop valid predictive simulations tools that integrate design strategies that include reliability, product life management and human/machine interactions; improve characterization and representation of human attributes, capabilities, responses, tolerance, and behaviors and employ this knowledge; and pursue occupant centric vehicle structures that provide safety from explosive threats. ***FY 2016 Plans:*** Will 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 will 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.			
Accomplishments/Planned Programs Subtotals	4.058	3.155	3.133

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 2016 Army			Date: February 2015
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 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total	FY 2017	FY 2018	FY 2019	FY 2020	Cost To Complete	Total Cost
J08: *Institute For Creative Technologies (ICT)*	-	7.830	7.496	6.080	-	6.080	6.186	6.309	6.442	6.572	-	-

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 and training technology for applications such as mission rehearsal, leadership development, health and medical, and distance learning. The ICT actively performs research and engages industry to exploit dual-use technology and 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 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. Resulting research, techniques, and technologies are transitioned for maturation to 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 U.S. Army Research Laboratory (ARL) in Adelphi, MD.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Title: Immersive Environments	2.976	2.884	2.307
Description: Conduct basic research in immersive environments, to include virtual humans, 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.			
FY 2014 Accomplishments: Investigated integrated augmented reality environments that add virtual elements (people, objects, and events) onto real world visualization for training and learning purposes; and examined techniques for the creation of virtual training content from sources such as mobile devices, mobile sensors, public databases, and sensor networks to make training and distance learning more accessible.			
FY 2015 Plans:			

Exhibit R-2A, RDT&E Project Justification: PB 2016 Army		Date: February 2015
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 2014	FY 2015	FY 2016
Investigate 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 assess effectiveness of techniques across a variety of contexts (e.g., training, mission rehearsal). ***FY 2016 Plans:*** Will 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.			
Title: Graphics and Animations ***Description:*** Research will improve computational techniques in graphics for achieving real-time photo-realistic rendering of physical and synthetic environments for training and simulations. Research into auditory aspects of immersion provides the sound stimulus for increasing the realism for military training and simulation devices. ***FY 2014 Accomplishments:*** Developed facial animation techniques that accurately mimic human facial expressions; and developed a pipeline which combines automated rigging based on high-fidelity facial scans. ***FY 2015 Plans:*** Research and develop 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:*** Will 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.	1.878	1.725	1.409
Title: Techniques and Human-Virtual Human Interaction ***Description:*** Conduct basic research to investigate methods and techniques for improving the perception, communication, understanding, and responsiveness of virtual humans when interacting with live humans. ***FY 2014 Accomplishments:*** Conducted evaluations of the social impact of virtual humans on human users and developed social cues that predict cooperative/ competitive orientation in a bargaining task to expand understanding of effectiveness of virtual characters as role players in	2.976	2.887	2.364

Exhibit R-2A, RDT&E Project Justification: PB 2016 Army		Date: February 2015
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 2014	FY 2015	FY 2016
training exercises; and implemented graphical cognitive architecture into Virtual Humans that will lead to less complex but more human-like systems. ***FY 2015 Plans:*** Conduct evaluations and develop 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; extend virtual human cognitive architecture research to recognize various human behaviors and learn from the agent's past experiences; and investigate 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:*** Will 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.			
Accomplishments/Planned Programs Subtotals	7.830	7.496	6.080

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 2016 Army			Date: February 2015
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 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total	FY 2017	FY 2018	FY 2019	FY 2020	Cost To Complete	Total Cost
J12: *Institute For Soldier Nanotechnology (ISN)*	-	10.927	6.709	6.080	-	6.080	6.185	6.308	6.445	6.574	-	-

Note

Not applicable for this item.

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 U.S. 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 U.S. Army Research Lab (ARL) in Adelphi, MD.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Title: Nanomaterials	2.826	1.675	1.487
Description: Nanomaterials research efforts focus on light-weight, multifunctional nanostructured fibers and materials.			
FY 2014 Accomplishments: Characterized a variety of quantum dot and graphene-based structures as detection elements for night vision applications; performed preliminary characterization of thermal properties at ceramic/polymer interfaces that may provide materials for improved cooling and power generation from waste heat; modeled hybrid structure architectures of semiconductor materials within			

Exhibit R-2A, RDT&E Project Justification: PB 2016 Army		Date: February 2015
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 2014	FY 2015	FY 2016
pre-drawn fibers to optimize the semiconductor performance within a fiber; and investigated methods for imaging light and sound within arrays of fibers designed for optical and acoustic detection. ***FY 2015 Plans:*** Model, synthesize, and study nanoscale objects with tailored composition, size, and geometry that may lead to future applications in obscurant and optical broadband communications; design releasable layer-by-layer, assemblies of stabilized lipid nanocapsules on microneedles that may ultimately enable dynamic monitoring of disease states and enhanced vaccine delivery; model and synthesize 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 model, synthesize, and characterize scalable and flexible nanoscale patterned metamaterial objects and photonic topological 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:*** Will design and chemically synthesize colloidal nanoparticles to efficiently convert UV to short wavelength IR (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.			
Title: Blast Effects on Soldier ***Description:*** Blast Effects on Soldier research involves the areas of Battle Suit Medicine and Blast and Ballistic Protection. ***FY 2014 Accomplishments:*** Synthesized a library of brain-lipid nanoparticles as a potential encapsulating agent for potential use in targeted therapies to treat traumatic brain injury; measured structure and properties of two-layer aluminum-alloy nanostructures for future design of improved lightweight materials with optimized strength, hardness and toughness; synthesized new protein-based hydrogels as tissue stimulants and test the effects of these hydrogels against blast and ballistic impact; and designed and tested atomistic level	5.276	3.356	3.063

Exhibit R-2A, RDT&E Project Justification: PB 2016 Army		Date: February 2015
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 2014	FY 2015	FY 2016
models for ceramic and polymer systems toward an ultimate multi-scalar model that provides more accurate predictive tools for material failure under blast and ballistic loading conditions. ***FY 2015 Plans:*** Evaluate and validate 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 define and model 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:*** Will 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 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 2014 Accomplishments:*** Investigated modification of a graphene surface toward the design, fabrication and testing of a first-generation graphene sensor optimized for the detection of food pathogens; determined various polymeric structures bound to carbon nanotubes and to screen these complexes against a panel of explosive compounds to potentially enable the future design of a highly-sensitive chemical detection platform; and investigated methods for fabrication and testing of artificial protein polymer hydrogels for potential use as a biodegradable hemostat that can stop blood flow from a wound. ***FY 2015 Plans:*** Model and synthesize 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; model, synthesize, and characterize nanostructured protein hydrogels under physiologically relevant conditions which may ultimately lead to a rapid field treatment option for hemorrhagic shock or other trauma; and explore and model the rate-dependent response of biological and	2.825	1.678	1.530

Exhibit R-2A, RDT&E Project Justification: PB 2016 Army		Date: February 2015
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 2014	FY 2015	FY 2016
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:*** Will 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.			
Accomplishments/Planned Programs Subtotals	10.927	6.709	6.080

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 2016 Army			Date: February 2015
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 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total	FY 2017	FY 2018	FY 2019	FY 2020	Cost To Complete	Total Cost
J13: *UNIVERSITY AND INDUSTRY INITIATIVES (CA)*	-	-	6.100	-	-	-	-	-	-	-	-	-

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 2014	FY 2015
Congressional Add: Program Increase	-	6.100
FY 2015 Plans: Congressional increase for basic research efforts.		
Congressional Adds Subtotals	-	6.100

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 2016 Army			Date: February 2015
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 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total	FY 2017	FY 2018	FY 2019	FY 2020	Cost To Complete	Total Cost
J14: *Army Educational Outreach Program*	-	8.685	9.545	9.670	-	9.670	9.864	10.048	10.274	10.470	-	-

Note

Consolidated funds from PE 0605803/project 729 and PE 06061104/project J14 to align educational outreach program elements into a central funding line of accounting.

A. Mission Description and Budget Item Justification

This project supports science activities that encourage elementary/middle/high school and college youths to develop an interest in and pursue higher education and employment in the science, mathematics, and engineering (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 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 Department of Defense STEM Educational Outreach Strategic Plan and the President's "Educate to Innovate" campaign for STEM education.

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Title: eCYBERMISSION	3.761	3.600	3.766
Description: This program supports a nation-wide, web-based, science, technology, engineering and mathematics (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 2014 Accomplishments: Increased participation from existing levels with a concentrated effort in underserved populations; increased geographic diversity; sustained eCYBERMISSION; and implemented program enhancements based on lessons learned from previous years.			
FY 2015 Plans:			

Exhibit R-2A, RDT&E Project Justification: PB 2016 Army		Date: February 2015
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 2014	FY 2015	FY 2016
Continue STEM activities with a concentrated effort in underserved populations; increase geographic diversity; sustain eCYBERMISSION; and implement program enhancements based on lessons learned from previous years. ***FY 2016 Plans:*** 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 2014 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 2015 Plans:*** Continue 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 mentor students to broaden their interest in and their development of STEM education. ***FY 2016 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.	2.400	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. ***FY 2014 Accomplishments:***	2.192	3.245	3.199

Exhibit R-2A, RDT&E Project Justification: PB 2016 Army		Date: February 2015
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 2014	FY 2015	FY 2016
Continued Army lab and research center sponsorship of students and STEM education opportunities; provided competition incentives in STEM competitions that include scholarships, experiences and mentorships as well as expose students to DoD career opportunities; streamlined processes, leveraged funding and built educational partnerships; and performed annual comprehensive review and educational assessments to suppport future decisions and best practices. ***FY 2015 Plans:*** Continue Army lab and research center sponsorship of students and STEM education opportunities; provide competition 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 2016 Plans:*** Will continue to have Army lab and research center sponsorship of students and STEM education opportunities; provide competition 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 2014 Accomplishments:*** Conducted West Point cadet research internship program to enhance cadet training through field experience within Army research labs and centers. ***FY 2015 Plans:*** Conduct West Point cadet research internship program to enhance cadet training through field experience within Army research labs and centers. ***FY 2016 Plans:*** Will conduct West Point cadet research internship program to enhance cadet training through field experience within Army research labs and centers.	0.332	0.300	0.305
Accomplishments/Planned Programs Subtotals	8.685	9.545	9.670

C. Other Program Funding Summary ($ in Millions)

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2016 Army		Date: February 2015
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*

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 2016 Army			Date: February 2015
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 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total	FY 2017	FY 2018	FY 2019	FY 2020	Cost To Complete	Total Cost
J15: *Network Sciences ITA*	-	3.985	3.859	4.070	-	4.070	4.078	4.083	4.112	4.152	-	-

Note

Not applicable for this item.

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 U.S. 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 FY06.

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 U.S. Army Research Laboratory (ARL) at Adelphi, MD.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Title: Network and Information Science Basic Research for U.S./U.K. Coalition Operations Information	3.985	3.859	4.070
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 2014 Accomplishments: Developed controlled natural language that enables information extraction from structured and unstructured data sources to improve interactions between analyst and machine processing; developed techniques to enable dynamic group coalition information exchange in hybrid mobile ad hoc and cellular networks; and developed efficient and secure access to distributed			

Exhibit R-2A, RDT&E Project Justification: PB 2016 Army		Date: February 2015
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 2014	FY 2015	FY 2016
data as a service among coalition partners without disclosure of security policies. These efforts enhance network security and information sharing in coalition operations. ***FY 2015 Plans:*** Develop integrated analysis algorithms of data derived from hybrid networks to aid analysts in performing projective analysis; develop techniques to provide risk averse and security conscious analysis capabilities to distributed mobile devices among coalition partners; and develop secure energy-aware and resource-aware access to distributed computing resources. These efforts will enhance network and security analysis while improving the effective use of coalition resources available to the Warfighter. ***FY 2016 Plans:*** Will 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 processing of information; and develop distributed techniques for dynamically assembling information services in dynamic coalition environments to enable distributed analytics.			
Accomplishments/Planned Programs Subtotals	3.985	3.859	4.070

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 2016 Army			Date: February 2015
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 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total	FY 2017	FY 2018	FY 2019	FY 2020	Cost To Complete	Total Cost
J17: *Vertical Lift Research Center Of Excellence*	-	2.959	2.883	3.031	-	3.031	3.076	3.130	3.187	3.250	-	-

Note

Not applicable for this item.

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 U.S. Army Aviation and Missile Research, Development, and Engineering Center (AMRDEC) (located at the NASA Ames Research Center, Moffett Field, CA).

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Title: Vertical Lift Research Center of Excellence (VLRCOE)	2.959	2.883	3.031
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 2014 Accomplishments: Implemented year three of VLRCOE agreements with Penn State University, University of Maryland, and Georgia Institute of Technology and conducted 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 Plans:			

Exhibit R-2A, RDT&E Project Justification: PB 2016 Army		Date: February 2015
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 2014	FY 2015	FY 2016
Implement 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:*** Will 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 research thrust areas of interest to Army Aviation for a new COE center of excellence program that will support future vertical lift in the long term.			
Accomplishments/Planned Programs Subtotals	2.959	2.883	3.031

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 2016 Army			Date: February 2015
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 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total	FY 2017	FY 2018	FY 2019	FY 2020	Cost To Complete	Total Cost
VS2: *Multi-Scale Materials Modeling Centers*	-	8.323	9.634	9.296	-	9.296	9.433	9.596	9.770	9.966	-	-

Note

Not applicable for this item.

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 PE 0601102A (Defense Research Sciences)/Project H44 (Adv Sensor Research).

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 U.S. Army Research Laboratory (ARL) in Aberdeen Proving Ground, MD.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Title: Collaborative Research Alliances in Materials in Extreme Dynamic Environments and Multiscale Multidisciplinary Modeling of Electronic Materials.	8.323	9.634	9.296
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			

Exhibit R-2A, RDT&E Project Justification: PB 2016 Army		Date: February 2015
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 2014	FY 2015	FY 2016

disciplines to facilitate revolutionary advances in materials for coupled environments (electromagnetic, high rate, high pressure and other extreme environments).

FY 2014 Accomplishments:

Modeled and characterized metallic, polymeric, ceramic and composite material systems response to extreme dynamic environments to enhance the fidelity of simulation codes that optimize hybrid multi-material protection for soldier and vehicle systems; began implementation of physics-based modeling of electronic materials by developing a set of multiscale algorithms/ theories that enable better understanding of material, electronic, optical and opto-electronic properties; and developed multiscale models and algorithms that predict the bulk and interfacial properties of fuel cells and electrochemical energy sources. Resulting models and algorithms enable the advancement of the next generation sensors and power and energy devices on the battlefield.

FY 2015 Plans:

Conduct 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; validate 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; research fabrication technology for optimized polymeric, metallic, ceramic and composite systems; and investigate interface physics (with regards to strain, polarization, piezoelectric, electromagnetic phenomena and solid/liquid boundaries). Results will 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:

Will 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),

Exhibit R-2A, RDT&E Project Justification: PB 2016 Army		Date: February 2015
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 2014	FY 2015	FY 2016
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	8.323	9.634	9.296

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 2016 Army			Date: February 2015
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 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total	FY 2017	FY 2018	FY 2019	FY 2020	Cost To Complete	Total Cost
VS3: *Center For Quantum Science Research*	-	-	4.997	5.183	-	5.183	5.201	5.222	6.239	6.383	-	-

Note

Not applicable to this item.

A. Mission Description and Budget Item Justification

This project supports two extramural research consortiums, each of which will bring together a critical mass of preeminent university researchers to explore and develop critical emerging concepts in Quantum Information Science (QIS). Focus will be on two areas of QIS that are expected to provide disruptive impacts on Army Warfighter capabilities, and to perform collaborative research with Army in-house scientists and engineers to help accelerate the transition of the research. One focus area is the application of quantum simulations to provide previously unattainable capabilities to model and design high-performance materials crucial for the individual soldier and Army equipment. The second focus area is in achieving precision measurement using quantum sensing and imaging to provide leap-ahead imaging capabilities that would have been considered impossible using classical physics and current state of the art engineering. In addition to providing the required focused level of effort, the consortiums will also provide the broad unified multidisciplinary effort the field of QIS needs to accelerate progress, ranging from pure mathematics to 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) in Adelphi, MD.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Title: Center for the Exploitation of Quantum Effects	-	4.997	5.183
Description: This work supports critical quantum science basic research at the U.S. ARL exploiting quantum effects to greatly enhance computing, communication, imaging, sensing and security ensuring Army dominance on the future battlefield.			
FY 2015 Plans: Research 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 conduct 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:			

Exhibit R-2A, RDT&E Project Justification: PB 2016 Army		Date: February 2015
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 2014	FY 2015	FY 2016
Will advance the development of the physical layer and networking theory needed for a robust distributed quantum network, including investigation of network protocols, teleportation between quantum nodes and memories, quantum node-to-node communication along fibers, quantum node-to-node communication through free space, photon encoding protocols, frequency conversion, single photon detection, and entanglement verification protocols.			
Accomplishments/Planned Programs Subtotals	-	4.997	5.183

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A