Department of Defense
Fiscal Year (FY) 2019 Budget Estimates

February 2018

Army

Justification Book of

Research, Development, Test & Evaluation, Army

RDT&E − Volume I, Budget Activity 1

Table of Contents

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, $10,484,483,000.00 to remain available for obligation until September 30, 2020.

The following Justification Books were prepared at a cost of $226,413: 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.

Department of Defense
FY 2019 President's Budget
Exhibit R-1 FY 2019 President's Budget
Total Obligational Authority
(Dollars in Thousands)

18 Jan 2018

Appropriation	FY 2017 (Base + OCO)	FY 2018 PB Request with CR Adj Base	FY 2018 Total PB Requests* with CR Adj Base	FY 2018 PB Request with CR Adj OCO	FY 2018 Total PB Requests+ with CR Adj OCO
Research, Development, Test & Eval, Army	8,852,507	8,273,447	8,273,447	342,356	342,356
Total Research, Development, Test & Evaluation	8,852,507	8,273,447	8,273,447	342,356	342,356

R-119PB: FY 2019 President's Budget (Published Version), as of January 18, 2018 at 15:06:20

Department of Defense
FY 2019 President's Budget
Exhibit R-1 FY 2019 President's Budget
Total Obligational Authority
(Dollars in Thousands)

18 Jan 2018

Appropriation	FY 2018 Emergency Requests** Emergency	FY 2018 Less Enacted Div B P.L.115-96*** MDDE + Ship Repairs	FY 2018 Remaining Req Emergency	FY 2018 Total PB Requests* with CR Adj Base + OCO + Emergency**	FY 2018 Less Enacted DIV B P.L.115-96*** MDDE + Ship Repairs	FY 2018 Remaining Req with CR Adj Base + OCO + Emergency
Research, Development, Test & Eval, Army	20,700	-20,700		8,636,503	-20,700	8,615,803
Total Research, Development, Test & Evaluation	20,700	-20,700		8,636,503	-20,700	8,615,803

Department of Defense
FY 2019 President's Budget
Exhibit R-1 FY 2019 President's Budget
Total Obligational Authority
(Dollars in Thousands)

18 Jan 2018

Appropriation	FY 2019 Base	FY 2019 OCO	FY 2019 Total
Research, Development, Test & Eval, Army	10,159,379	325,104	10,484,483
Total Research, Development, Test & Evaluation	10,159,379	325,104	10,484,483

Department of Defense
FY 2019 President's Budget
Exhibit R-1 FY 2019 President's Budget
Total Obligational Authority
(Dollars in Thousands)

18 Jan 2018

Summary Recap of Budget Activities	FY 2017 (Base + OCO)	FY 2018 PB Request with CR Adj Base	FY 2018 Total PB Requests* with CR Adj Base	FY 2018 PB Request with CR Adj OCO	FY 2018 Total PB Requests+ with CR Adj OCO
Basic Research	473,216	430,022	430,022		
Applied Research	1,196,132	889,182	889,182		
Advanced Technology Development	1,351,035	1,070,977	1,070,977		
Advanced Component Development & Prototypes	619,976	890,889	890,889	18,000	18,000
System Development & Demonstration	2,502,560	3,012,840	3,012,840	57,840	57,840
RDT&E Management Support	1,413,481	1,253,845	1,253,845		
Operational Systems Development	1,296,107	1,877,685	1,877,685	43,528	43,528
Undistributed		-1,151,993	-1,151,993	222,988	222,988
Total Research, Development, Test & Evaluation	8,852,507	8,273,447	8,273,447	342,356	342,356
Summary Recap of FYDP Programs					
General Purpose Forces	611,072	710,401	710,401	15,000	15,000
Intelligence and Communications	342,648	370,519	370,519	29,728	29,728
Research and Development	7,826,372	8,215,942	8,215,942	74,640	74,640
Central Supply and Maintenance	59,891	60,877	60,877		
Administration and Associated Activities	7,899	-1,151,993	-1,151,993	222,988	222,988
Space		60,547	60,547		
Classified Programs	4,625	7,154	7,154		
Total Research, Development, Test & Evaluation	8,852,507	8,273,447	8,273,447	342,356	342,356

R-119PB: FY 2019 President's Budget (Published Version), as of January 18, 2018 at 15:06:20

Department of Defense
FY 2019 President's Budget
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(Dollars in Thousands)

18 Jan 2018

Summary Recap of Budget Activities	FY 2018 Emergency Requests** Emergency	FY 2018 Less Enacted Div B P.L.115-96*** MDDE + Ship Repairs	FY 2018 Remaining Req Emergency	FY 2018 Total PB Requests* with CR Adj Base + OCO + Emergency**	FY 2018 Less Enacted DIV B P.L.115-96*** MDDE + Ship Repairs	FY 2018 Remaining Req with CR Adj Base + OCO + Emergency
Basic Research				430,022		430,022
Applied Research				889,182		889,182
Advanced Technology Development	12,000	-12,000		1,082,977	-12,000	1,070,977
Advanced Component Development & Prototypes	8,700	-8,700		917,589	-8,700	908,889
System Development & Demonstration				3,070,680		3,070,680
RDT&E Management Support				1,253,845		1,253,845
Operational Systems Development				1,921,213		1,921,213
Undistributed				-929,005		-929,005
Total Research, Development, Test & Evaluation	20,700	-20,700		8,636,503	-20,700	8,615,803
Summary Recap of FYDP Programs						
General Purpose Forces				725,401		725,401
Intelligence and Communications				400,247		400,247
Research and Development	20,700	-20,700		8,311,282	-20,700	8,290,582
Central Supply and Maintenance				60,877		60,877
Administration and Associated Activities				-929,005		-929,005
Space				60,547		60,547
Classified Programs				7,154		7,154
Total Research, Development, Test & Evaluation	20,700	-20,700		8,636,503	-20,700	8,615,803

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Department of Defense
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(Dollars in Thousands)

18 Jan 2018

Summary Recap of Budget Activities	FY 2019 Base	FY 2019 OCO	FY 2019 Total
Basic Research	445,895		445,895
Applied Research	919,609		919,609
Advanced Technology Development	1,026,698		1,026,698
Advanced Component Development & Prototypes	1,329,393	28,500	1,357,893
System Development & Demonstration	3,192,689	236,863	3,429,552
RDT&E Management Support	1,322,481		1,322,481
Operational Systems Development	1,922,614	59,741	1,982,355
Undistributed			
Total Research, Development, Test & Evaluation	10,159,379	325,104	10,484,483

Summary Recap of FYDP Programs			
General Purpose Forces	783,464	10,000	793,464
Intelligence and Communications	313,112	40,613	353,725
Research and Development	8,775,582	274,491	9,050,073
Central Supply and Maintenance	53,958		53,958
Administration and Associated Activities			
Space	227,308		227,308
Classified Programs	5,955		5,955
Total Research, Development, Test & Evaluation	10,159,379	325,104	10,484,483

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Department of the Army
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18 Jan 2018

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Basic Research	473,216	430,022	430,022		
Applied Research	1,196,132	889,182	889,182		
Advanced Technology Development	1,351,035	1,070,977	1,070,977		
Advanced Component Development & Prototypes	619,976	890,889	890,889	18,000	18,000
System Development & Demonstration	2,502,560	3,012,840	3,012,840	57,840	57,840
RDT&E Management Support	1,413,481	1,253,845	1,253,845		
Operational Systems Development	1,296,107	1,877,685	1,877,685	43,528	43,528
Undistributed		-1,151,993	-1,151,993	222,988	222,988
Total Research, Development, Test & Evaluation	8,852,507	8,273,447	8,273,447	342,356	342,356

Summary Recap of FYDP Programs					
General Purpose Forces	611,072	710,401	710,401	15,000	15,000
Intelligence and Communications	342,648	370,519	370,519	29,728	29,728
Research and Development	7,826,372	8,215,942	8,215,942	74,640	74,640
Central Supply and Maintenance	59,891	60,877	60,877		
Administration and Associated Activities	7,899	-1,151,993	-1,151,993	222,988	222,988
Space		60,547	60,547		
Classified Programs	4,625	7,154	7,154		
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RDT&E Management Support				1,253,845		1,253,845
Operational Systems Development				1,921,213		1,921,213
Undistributed				-929,005		-929,005
Total Research, Development, Test & Evaluation	20,700	-20,700		8,636,503	-20,700	8,615,803
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General Purpose Forces				725,401		725,401
Intelligence and Communications				400,247		400,247
Research and Development	20,700	-20,700		8,311,282	-20,700	8,290,582
Central Supply and Maintenance				60,877		60,877
Administration and Associated Activities				-929,005		-929,005
Space				60,547		60,547
Classified Programs				7,154		7,154
Total Research, Development, Test & Evaluation	20,700	-20,700		8,636,503	-20,700	8,615,803

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Administration and Associated Activities			
Space	227,308		227,308
Classified Programs	5,955		5,955
Total Research, Development, Test & Evaluation	10,159,379	325,104	10,484,483

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Department of the Army
FY 2019 President's Budget
Exhibit R-1 FY 2019 President's Budget
Total Obligational Authority
(Dollars in Thousands)

18 Jan 2018

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

Line No	Program Element Number	Item	Act	FY 2017 (Base + OCO)	FY 2018 PB Request with CR Adj Base	FY 2018 Total PB Requests* with CR Adj Base	FY 2018 PB Request with CR Adj OCO	FY 2018 Total PB Requests+ with CR Adj OCO	Sec
1	0601101A	In-House Laboratory Independent Research	01	11,936	12,010	12,010			U
2	0601102A	Defense Research Sciences	01	286,086	263,590	263,590			U
3	0601103A	University Research Initiatives	01	66,506	67,027	67,027			U
4	0601104A	University and Industry Research Centers	01	108,688	87,395	87,395			U
	Basic Research			473,216	430,022	430,022			
5	0602105A	Materials Technology	02	81,950	29,640	29,640			U
6	0602120A	Sensors and Electronic Survivability	02	50,574	35,730	35,730			U
7	0602122A	TRACTOR HIP	02	6,995	8,627	8,627			U
8	0602126A	TRACTOR JACK	02						U
9	0602211A	Aviation Technology	02	67,593	66,086	66,086			U
10	0602270A	Electronic Warfare Technology	02	34,528	27,144	27,144			U
11	0602303A	Missile Technology	02	66,173	43,742	43,742			U
12	0602307A	Advanced Weapons Technology	02	52,766	22,785	22,785			U
13	0602308A	Advanced Concepts and Simulation	02	29,767	28,650	28,650			U
14	0602601A	Combat Vehicle and Automotive Technology	02	89,852	67,232	67,232			U
15	0602618A	Ballistics Technology	02	103,484	85,309	85,309			U
16	0602622A	Chemical, Smoke and Equipment Defeating Technology	02	3,772	4,004	4,004			U
17	0602623A	Joint Service Small Arms Program	02	5,331	5,615	5,615			U

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Department of the Army
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Total Obligational Authority
(Dollars in Thousands)

18 Jan 2018

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

Line No	Program Element Number	Item	Act	FY 2018 Emergency Requests** Emergency	FY 2018 Less Enacted Div B P.L.115-96*** MDDE + Ship Repairs	FY 2018 Remaining Req Emergency	FY 2018 Total PB Requests* with CR Adj Base + OCO + Emergency**	FY 2018 Less Enacted DIV B P.L.115-96*** MDDE + Ship Repairs	FY 2018 Remaining Req with CR Adj Base + OCO + Emergency	Sec
1	0601101A	In-House Laboratory Independent Research	01				12,010		12,010	U
2	0601102A	Defense Research Sciences	01				263,590		263,590	U
3	0601103A	University Research Initiatives	01				67,027		67,027	U
4	0601104A	University and Industry Research Centers	01				87,395		87,395	U
		Basic Research					430,022		430,022	
5	0602105A	Materials Technology	02				29,640		29,640	U
6	0602120A	Sensors and Electronic Survivability	02				35,730		35,730	U
7	0602122A	TRACTOR HIP	02				8,627		8,627	U
8	0602126A	TRACTOR JACK	02							U
9	0602211A	Aviation Technology	02				66,086		66,086	U
10	0602270A	Electronic Warfare Technology	02				27,144		27,144	U
11	0602303A	Missile Technology	02				43,742		43,742	U
12	0602307A	Advanced Weapons Technology	02				22,785		22,785	U
13	0602308A	Advanced Concepts and Simulation	02				28,650		28,650	U
14	0602601A	Combat Vehicle and Automotive Technology	02				67,232		67,232	U
15	0602618A	Ballistics Technology	02				85,309		85,309	U
16	0602622A	Chemical, Smoke and Equipment Defeating Technology	02				4,004		4,004	U
17	0602623A	Joint Service Small Arms Program	02				5,615		5,615	U

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Department of the Army
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18 Jan 2018

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

Line No	Program Element Number	Item	Act	FY 2019 Base	FY 2019 OCO	FY 2019 Total	Sec
1	0601101A	In-House Laboratory Independent Research	01	11,585		11,585	U
2	0601102A	Defense Research Sciences	01	276,912		276,912	U
3	0601103A	University Research Initiatives	01	65,283		65,283	U
4	0601104A	University and Industry Research Centers	01	92,115		92,115	U
	Basic Research			445,895		445,895	
5	0602105A	Materials Technology	02	28,600		28,600	U
6	0602120A	Sensors and Electronic Survivability	02	32,366		32,366	U
7	0602122A	TRACTOR HIP	02	8,674		8,674	U
8	0602126A	TRACTOR JACK	02	400		400	U
9	0602211A	Aviation Technology	02	64,847		64,847	U
10	0602270A	Electronic Warfare Technology	02	25,571		25,571	U
11	0602303A	Missile Technology	02	50,183		50,183	U
12	0602307A	Advanced Weapons Technology	02	29,502		29,502	U
13	0602308A	Advanced Concepts and Simulation	02	28,500		28,500	U
14	0602601A	Combat Vehicle and Automotive Technology	02	70,450		70,450	U
15	0602618A	Ballistics Technology	02	75,541		75,541	U
16	0602622A	Chemical, Smoke and Equipment Defeating Technology	02	5,032		5,032	U
17	0602623A	Joint Service Small Arms Program	02	12,394		12,394	U

Department of the Army
FY 2019 President's Budget
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18 Jan 2018

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Line No	Program Element Number	Item	Act	FY 2017 (Base + OCO)	FY 2018 PB Request with CR Adj Base	FY 2018 Total PB Requests* with CR Adj Base	FY 2018 PB Request with CR Adj OCO	FY 2018 Total PB Requests+ with CR Adj OCO	Sec
18	0602624A	Weapons and Munitions Technology	02	118,068	41,455	41,455			U
19	0602705A	Electronics and Electronic Devices	02	72,979	58,352	58,352			U
20	0602709A	Night Vision Technology	02	34,762	34,723	34,723			U
21	0602712A	Countermine Systems	02	29,495	26,190	26,190			U
22	0602716A	Human Factors Engineering Technology	02	23,359	24,127	24,127			U
23	0602720A	Environmental Quality Technology	02	21,553	21,678	21,678			U
24	0602782A	Command, Control, Communications Technology	02	36,396	33,123	33,123			U
25	0602783A	Computer and Software Technology	02	13,452	14,041	14,041			U
26	0602784A	Military Engineering Technology	02	92,140	67,720	67,720			U
27	0602785A	Manpower/Personnel/Training Technology	02	23,475	20,216	20,216			U
28	0602786A	Warfighter Technology	02	59,327	39,559	39,559			U
29	0602787A	Medical Technology	02	78,341	83,434	83,434			U
		Applied Research		1,196,132	889,182	889,182			
30	0603001A	Warfighter Advanced Technology	03	50,004	44,863	44,863			U
31	0603002A	Medical Advanced Technology	03	106,040	67,780	67,780			U
32	0603003A	Aviation Advanced Technology	03	111,654	160,746	160,746			U
33	0603004A	Weapons and Munitions Advanced Technology	03	198,245	84,079	84,079			U
34	0603005A	Combat Vehicle and Automotive Advanced Technology	03	163,501	125,537	125,537			U

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Line No	Program Element Number	Item	Act	FY 2018 Emergency Requests** Emergency	FY 2018 Less Enacted Div B P.L.115-96*** MDDE + Ship Repairs	FY 2018 Remaining Req Emergency	FY 2018 Total PB Requests* with CR Adj Base + OCO + Emergency**	FY 2018 Less Enacted DIV B P.L.115-96*** MDDE + Ship Repairs	FY 2018 Remaining Req with CR Adj Base + OCO + Emergency	Sec
18	0602624A	Weapons and Munitions Technology	02				41,455		41,455	U
19	0602705A	Electronics and Electronic Devices	02				58,352		58,352	U
20	0602709A	Night Vision Technology	02				34,723		34,723	U
21	0602712A	Countermine Systems	02				26,190		26,190	U
22	0602716A	Human Factors Engineering Technology	02				24,127		24,127	U
23	0602720A	Environmental Quality Technology	02				21,678		21,678	U
24	0602782A	Command, Control, Communications Technology	02				33,123		33,123	U
25	0602783A	Computer and Software Technology	02				14,041		14,041	U
26	0602784A	Military Engineering Technology	02				67,720		67,720	U
27	0602785A	Manpower/Personnel/Training Technology	02				20,216		20,216	U
28	0602786A	Warfighter Technology	02				39,559		39,559	U
29	0602787A	Medical Technology	02				83,434		83,434	U
		Applied Research					889,182		889,182	
30	0603001A	Warfighter Advanced Technology	03				44,863		44,863	U
31	0603002A	Medical Advanced Technology	03				67,780		67,780	U
32	0603003A	Aviation Advanced Technology	03				160,746		160,746	U
33	0603004A	Weapons and Munitions Advanced Technology	03				84,079		84,079	U
34	0603005A	Combat Vehicle and Automotive Advanced Technology	03				125,537		125,537	U

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Line No	Program Element Number	Item	Act	FY 2019 Base	FY 2019 OCO	FY 2019 Total	Sec
18	0602624A	Weapons and Munitions Technology	02	40,444		40,444	U
19	0602705A	Electronics and Electronic Devices	02	58,283		58,283	U
20	0602709A	Night Vision Technology	02	29,582		29,582	U
21	0602712A	Countermine Systems	02	21,244		21,244	U
22	0602716A	Human Factors Engineering Technology	02	24,131		24,131	U
23	0602720A	Environmental Quality Technology	02	13,242		13,242	U
24	0602782A	Command, Control, Communications Technology	02	55,003		55,003	U
25	0602783A	Computer and Software Technology	02	14,958		14,958	U
26	0602784A	Military Engineering Technology	02	78,159		78,159	U
27	0602785A	Manpower/Personnel/Training Technology	02	21,862		21,862	U
28	0602786A	Warfighter Technology	02	40,566		40,566	U
29	0602787A	Medical Technology	02	90,075		90,075	U
		Applied Research		919,609		919,609	
30	0603001A	Warfighter Advanced Technology	03	39,338		39,338	U
31	0603002A	Medical Advanced Technology	03	62,496		62,496	U
32	0603003A	Aviation Advanced Technology	03	124,958		124,958	U
33	0603004A	Weapons and Munitions Advanced Technology	03	102,686		102,686	U
34	0603005A	Combat Vehicle and Automotive Advanced Technology	03	119,739		119,739	U

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35	0603006A	Space Application Advanced Technology	03	3,787	12,231	12,231			U
36	0603007A	Manpower, Personnel and Training Advanced Technology	03	12,110	6,466	6,466			U
37	0603009A	TRACTOR HIKE	03	21,374	28,552	28,552			U
38	0603015A	Next Generation Training & Simulation Systems	03	18,238	16,434	16,434			U
39	0603020A	TRACTOR ROSE	03	11,910					U
40	0603125A	Combating Terrorism - Technology Development	03	33,553	26,903	26,903			U
41	0603130A	TRACTOR NAIL	03	2,340	4,880	4,880			U
42	0603131A	TRACTOR EGGS	03	2,470	4,326	4,326			U
43	0603270A	Electronic Warfare Technology	03	40,819	31,296	31,296			U
44	0603313A	Missile and Rocket Advanced Technology	03	113,683	62,850	62,850			U
45	0603322A	TRACTOR CAGE	03	11,107	12,323	12,323			U
46	0603461A	High Performance Computing Modernization Program	03	215,462	182,331	182,331			U
47	0603606A	Landmine Warfare and Barrier Advanced Technology	03	16,798	17,948	17,948			U
48	0603607A	Joint Service Small Arms Program	03	5,615	5,796	5,796			U
49	0603710A	Night Vision Advanced Technology	03	42,798	47,135	47,135			U
50	0603728A	Environmental Quality Technology Demonstrations	03	21,415	10,421	10,421			U

R-119PB: FY 2019 President's Budget (Published Version), as of January 18, 2018 at 15:06:20

Department of the Army
FY 2019 President's Budget
Exhibit R-1 FY 2019 President's Budget
Total Obligational Authority
(Dollars in Thousands)

18 Jan 2018

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

Line No	Program Element Number	Item	Act	FY 2018 Emergency Requests** Emergency	FY 2018 Less Enacted Div B P.L.115-96*** MDDE + Ship Repairs	FY 2018 Remaining Req Emergency	FY 2018 Total PB Requests* with CR Adj Base + OCO + Emergency**	FY 2018 Less Enacted DIV B P.L.115-96*** MDDE + Ship Repairs	FY 2018 Remaining Req with CR Adj Base + OCO + Emergency	Sec
35	0603006A	Space Application Advanced Technology	03				12,231		12,231	U
36	0603007A	Manpower, Personnel and Training Advanced Technology	03				6,466		6,466	U
37	0603009A	TRACTOR HIKE	03	12,000	-12,000		40,552	-12,000	28,552	U
38	0603015A	Next Generation Training & Simulation Systems	03				16,434		16,434	U
39	0603020A	TRACTOR ROSE	03							U
40	0603125A	Combating Terrorism - Technology Development	03				26,903		26,903	U
41	0603130A	TRACTOR NAIL	03				4,880		4,880	U
42	0603131A	TRACTOR EGGS	03				4,326		4,326	U
43	0603270A	Electronic Warfare Technology	03				31,296		31,296	U
44	0603313A	Missile and Rocket Advanced Technology	03				62,850		62,850	U
45	0603322A	TRACTOR CAGE	03				12,323		12,323	U
46	0603461A	High Performance Computing Modernization Program	03				182,331		182,331	U
47	0603606A	Landmine Warfare and Barrier Advanced Technology	03				17,948		17,948	U
48	0603607A	Joint Service Small Arms Program	03				5,796		5,796	U
49	0603710A	Night Vision Advanced Technology	03				47,135		47,135	U
50	0603728A	Environmental Quality Technology Demonstrations	03				10,421		10,421	U

R-119PB: FY 2019 President's Budget (Published Version), as of January 18, 2018 at 15:06:20

Department of the Army
FY 2019 President's Budget
Exhibit R-1 FY 2019 President's Budget
Total Obligational Authority
(Dollars in Thousands)

18 Jan 2018

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

Line No	Program Element Number	Item	Act	FY 2019 Base	FY 2019 OCO	FY 2019 Total	Sec
35	0603006A	Space Application Advanced Technology	03	13,000		13,000	U
36	0603007A	Manpower, Personnel and Training Advanced Technology	03	8,044		8,044	U
37	0603009A	TRACTOR HIKE	03	22,631		22,631	U
38	0603015A	Next Generation Training & Simulation Systems	03	25,682		25,682	U
39	0603020A	TRACTOR ROSE	03				U
40	0603125A	Combating Terrorism - Technology Development	03	3,762		3,762	U
41	0603130A	TRACTOR NAIL	03	4,896		4,896	U
42	0603131A	TRACTOR EGGS	03	6,041		6,041	U
43	0603270A	Electronic Warfare Technology	03	31,491		31,491	U
44	0603313A	Missile and Rocket Advanced Technology	03	61,132		61,132	U
45	0603322A	TRACTOR CAGE	03	16,845		16,845	U
46	0603461A	High Performance Computing Modernization Program	03	183,322		183,322	U
47	0603606A	Landmine Warfare and Barrier Advanced Technology	03	11,104		11,104	U
48	0603607A	Joint Service Small Arms Program	03	5,885		5,885	U
49	0603710A	Night Vision Advanced Technology	03	61,376		61,376	U
50	0603728A	Environmental Quality Technology Demonstrations	03	9,136		9,136	U

Department of the Army
FY 2019 President's Budget
Exhibit R-1 FY 2019 President's Budget
Total Obligational Authority
(Dollars in Thousands)

18 Jan 2018

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

Line No	Program Element Number	Item	Act	FY 2017 (Base + OCO)	FY 2018 PB Request with CR Adj Base	FY 2018 Total PB Requests* with CR Adj Base	FY 2018 PB Request with CR Adj OCO	FY 2018 Total PB Requests+ with CR Adj OCO	Sec
51	0603734A	Military Engineering Advanced Technology	03	59,101	32,448	32,448			U
52	0603772A	Advanced Tactical Computer Science and Sensor Technology	03	52,572	52,206	52,206			U
53	0603794A	C3 Advanced Technology	03	36,439	33,426	33,426			U
		Advanced Technology Development		1,351,035	1,070,977	1,070,977			
54	0603305A	Army Missle Defense Systems Integration	04	39,395	9,634	9,634			U
55	0603308A	Army Space Systems Integration	04	32,278					U
56	0603327A	Air and Missile Defense Systems Engineering	04	6,100	33,949	33,949	15,000	15,000	U
57	0603619A	Landmine Warfare and Barrier - Adv Dev	04	65,062	72,909	72,909			U
58	0603627A	Smoke, Obscurant and Target Defeating Sys-Adv Dev	04	43,177	7,135	7,135			U
59	0603639A	Tank and Medium Caliber Ammunition	04	47,745	41,452	41,452			U
60	0603645A	Armored System Modernization - Adv Dev	04		32,739	32,739			U
61	0603747A	Soldier Support and Survivability	04	13,607	10,157	10,157	3,000	3,000	U
62	0603766A	Tactical Electronic Surveillance System - Adv Dev	04	15,730	27,733	27,733			U
63	0603774A	Night Vision Systems Advanced Development	04	9,930	12,347	12,347			U
64	0603779A	Environmental Quality Technology - Dem/Val	04	7,480	10,456	10,456			U

R-119PB: FY 2019 President's Budget (Published Version), as of January 18, 2018 at 15:06:20

Department of the Army
FY 2019 President's Budget
Exhibit R-1 FY 2019 President's Budget
Total Obligational Authority
(Dollars in Thousands)

18 Jan 2018

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

Line No	Program Element Number	Item	Act	FY 2018 Emergency Requests** Emergency	FY 2018 Less Enacted Div B P.L.115-96*** MDDE + Ship Repairs	FY 2018 Remaining Req Emergency	FY 2018 Total PB Requests* with CR Adj Base + OCO + Emergency**	FY 2018 Less Enacted DIV B P.L.115-96*** MDDE + Ship Repairs	FY 2018 Remaining Req with CR Adj Base + OCO + Emergency	Sec
51	0603734A	Military Engineering Advanced Technology	03				32,448		32,448	U
52	0603772A	Advanced Tactical Computer Science and Sensor Technology	03				52,206		52,206	U
53	0603794A	C3 Advanced Technology	03				33,426		33,426	U
		Advanced Technology Development		12,000	-12,000		1,082,977	-12,000	1,070,977	
54	0603305A	Army Missle Defense Systems Integration	04				9,634		9,634	U
55	0603308A	Army Space Systems Integration	04							U
56	0603327A	Air and Missile Defense Systems Engineering	04	8,700	-8,700		57,649	-8,700	48,949	U
57	0603619A	Landmine Warfare and Barrier - Adv Dev	04				72,909		72,909	U
58	0603627A	Smoke, Obscurant and Target Defeating Sys-Adv Dev	04				7,135		7,135	U
59	0603639A	Tank and Medium Caliber Ammunition	04				41,452		41,452	U
60	0603645A	Armored System Modernization - Adv Dev	04				32,739		32,739	U
61	0603747A	Soldier Support and Survivability	04				13,157		13,157	U
62	0603766A	Tactical Electronic Surveillance System - Adv Dev	04				27,733		27,733	U
63	0603774A	Night Vision Systems Advanced Development	04				12,347		12,347	U
64	0603779A	Environmental Quality Technology - Dem/Val	04				10,456		10,456	U

R-119PB: FY 2019 President's Budget (Published Version), as of January 18, 2018 at 15:06:20

Department of the Army
FY 2019 President's Budget
Exhibit R-1 FY 2019 President's Budget
Total Obligational Authority
(Dollars in Thousands)

18 Jan 2018

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

Line No	Program Element Number	Item	Act	FY 2019 Base	FY 2019 OCO	FY 2019 Total	Sec
51	0603734A	Military Engineering Advanced Technology	03	25,864		25,864	U
52	0603772A	Advanced Tactical Computer Science and Sensor Technology	03	34,883		34,883	U
53	0603794A	C3 Advanced Technology	03	52,387		52,387	U
		Advanced Technology Development		1,026,698		1,026,698	
54	0603305A	Army Missle Defense Systems Integration	04	10,777		10,777	U
55	0603308A	Army Space Systems Integration	04				U
56	0603327A	Air and Missile Defense Systems Engineering	04	42,802	1,000	43,802	U
57	0603619A	Landmine Warfare and Barrier - Adv Dev	04	45,254		45,254	U
58	0603627A	Smoke, Obscurant and Target Defeating Sys-Adv Dev	04	22,700	1,500	24,200	U
59	0603639A	Tank and Medium Caliber Ammunition	04	41,974		41,974	U
60	0603645A	Armored System Modernization - Adv Dev	04	119,395		119,395	U
61	0603747A	Soldier Support and Survivability	04	8,746	3,000	11,746	U
62	0603766A	Tactical Electronic Surveillance System - Adv Dev	04	35,667		35,667	U
63	0603774A	Night Vision Systems Advanced Development	04	7,350		7,350	U
64	0603779A	Environmental Quality Technology - Dem/Val	04	14,749		14,749	U

Department of the Army
FY 2019 President's Budget
Exhibit R-1 FY 2019 President's Budget
Total Obligational Authority
(Dollars in Thousands)

18 Jan 2018

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

Line No	Program Element Number	Item	Act	FY 2017 (Base + OCO)	FY 2018 PB Request with CR Adj Base	FY 2018 Total PB Requests* with CR Adj Base	FY 2018 PB Request with CR Adj OCO	FY 2018 Total PB Requests+ with CR Adj OCO	Sec
65	0603790A	NATO Research and Development	04	2,211	2,588	2,588			U
66	0603801A	Aviation - Adv Dev	04	7,702	14,055	14,055			U
67	0603804A	Logistics and Engineer Equipment - Adv Dev	04	17,445	35,333	35,333			U
68	0603807A	Medical Systems - Adv Dev	04	47,336	33,491	33,491			U
69	0603827A	Soldier Systems - Advanced Development	04	54,497	20,239	20,239			U
70	0604017A	Robotics Development	04		39,608	39,608			U
71	0604020A	Cross Functional Team (CFT) Advanced Development & Prototyping	04						U
72	0604100A	Analysis Of Alternatives	04	6,354	9,921	9,921			U
73	0604113A	Future Tactical Unmanned Aircraft System (FTUAS)	04						U
74	0604114A	Lower Tier Air Missile Defense (LTAMD) Sensor	04	33,780	76,728	76,728			U
75	0604115A	Technology Maturation Initiatives	04	57,737	115,221	115,221			U
76	0604117A	Maneuver - Short Range Air Defense (M-SHORAD)	04		20,000	20,000			U
77	0604118A	TRACTOR BEAM	04		10,400	10,400			U
78	0604120A	Assured Positioning, Navigation and Timing (PNT)	04	83,074	164,967	164,967			U
79	0604121A	Synthetic Training Environment Refinement & Prototyping	04		1,600	1,600			U

Department of the Army
FY 2019 President's Budget
Exhibit R-1 FY 2019 President's Budget
Total Obligational Authority
(Dollars in Thousands)

18 Jan 2018

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

Line No	Program Element Number	Item	Act	FY 2018 Emergency Requests** Emergency	FY 2018 Less Enacted Div B P.L.115-96*** MDDE + Ship Repairs	FY 2018 Remaining Req Emergency	FY 2018 Total PB Requests* with CR Adj Base + OCO + Emergency**	FY 2018 Less Enacted DIV B P.L.115-96*** MDDE + Ship Repairs	FY 2018 Remaining Req with CR Adj Base + OCO + Emergency	Sec
65	0603790A	NATO Research and Development	04				2,588		2,588	U
66	0603801A	Aviation - Adv Dev	04				14,055		14,055	U
67	0603804A	Logistics and Engineer Equipment - Adv Dev	04				35,333		35,333	U
68	0603807A	Medical Systems - Adv Dev	04				33,491		33,491	U
69	0603827A	Soldier Systems - Advanced Development	04				20,239		20,239	U
70	0604017A	Robotics Development	04				39,608		39,608	U
71	0604020A	Cross Functional Team (CFT) Advanced Development & Prototyping	04							U
72	0604100A	Analysis Of Alternatives	04				9,921		9,921	U
73	0604113A	Future Tactical Unmanned Aircraft System (FTUAS)	04							U
74	0604114A	Lower Tier Air Missile Defense (LTAMD) Sensor	04				76,728		76,728	U
75	0604115A	Technology Maturation Initiatives	04				115,221		115,221	U
76	0604117A	Maneuver - Short Range Air Defense (M-SHORAD)	04				20,000		20,000	U
77	0604118A	TRACTOR BEAM	04				10,400		10,400	U
78	0604120A	Assured Positioning, Navigation and Timing (PNT)	04				164,967		164,967	U
79	0604121A	Synthetic Training Environment Refinement & Prototyping	04				1,600		1,600	U

Department of the Army
FY 2019 President's Budget
Exhibit R-1 FY 2019 President's Budget
Total Obligational Authority
(Dollars in Thousands)

18 Jan 2018

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

Line No	Program Element Number	Item	Act	FY 2019 Base	FY 2019 OCO	FY 2019 Total	Sec
65	0603790A	NATO Research and Development	04	3,687		3,687	U
66	0603801A	Aviation - Adv Dev	04	10,793		10,793	U
67	0603804A	Logistics and Engineer Equipment - Adv Dev	04	14,248		14,248	U
68	0603807A	Medical Systems - Adv Dev	04	34,284		34,284	U
69	0603827A	Soldier Systems - Advanced Development	04	18,044		18,044	U
70	0604017A	Robotics Development	04	95,660		95,660	U
71	0604020A	Cross Functional Team (CFT) Advanced Development & Prototyping	04	38,000		38,000	U
72	0604100A	Analysis Of Alternatives	04	9,765		9,765	U
73	0604113A	Future Tactical Unmanned Aircraft System (FTUAS)	04	12,393		12,393	U
74	0604114A	Lower Tier Air Missile Defense (LTAMD) Sensor	04	120,374		120,374	U
75	0604115A	Technology Maturation Initiatives	04	95,347		95,347	U
76	0604117A	Maneuver - Short Range Air Defense (M-SHORAD)	04	95,085	23,000	118,085	U
77	0604118A	TRACTOR BEAM	04	52,894		52,894	U
78	0604120A	Assured Positioning, Navigation and Timing (PNT)	04				U
79	0604121A	Synthetic Training Environment Refinement & Prototyping	04	77,939		77,939	U

Department of the Army
FY 2019 President's Budget
Exhibit R-1 FY 2019 President's Budget
Total Obligational Authority
(Dollars in Thousands)

18 Jan 2018

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

Line No	Program Element Number	Item	Act	FY 2017 (Base + OCO)	FY 2018 PB Request with CR Adj Base	FY 2018 Total PB Requests* with CR Adj Base	FY 2018 PB Request with CR Adj OCO	FY 2018 Total PB Requests+ with CR Adj OCO	Sec
80	0604319A	Indirect Fire Protection Capability Increment 2-Intercept (IFPC2)	04		11,303	11,303			U
81	0305251A	Cyberspace Operations Forces and Force Support	04	29,336	56,492	56,492			U
82	1206120A	Assured Positioning, Navigation and Timing (PNT)	04						U
83	1206308A	Army Space Systems Integration	04		20,432	20,432			U
		Advanced Component Development & Prototypes		619,976	890,889	890,889	18,000	18,000	
84	0604201A	Aircraft Avionics	05	54,915	30,153	30,153			U
85	0604270A	Electronic Warfare Development	05	33,419	71,671	71,671			U
86	0604290A	Mid-tier Networking Vehicular Radio (MNVR)	05	9,363	10,589	10,589			U
87	0604321A	All Source Analysis System	05	11,958	4,774	4,774			U
88	0604328A	TRACTOR CAGE	05	12,525	17,252	17,252			U
89	0604601A	Infantry Support Weapons	05	63,842	87,643	87,643			U
90	0604604A	Medium Tactical Vehicles	05		6,039	6,039			U
91	0604611A	JAVELIN	05	19,241	21,095	21,095			U
92	0604622A	Family of Heavy Tactical Vehicles	05	10,989	10,507	10,507			U
93	0604633A	Air Traffic Control	05	3,326	3,536	3,536			U
94	0604641A	Tactical Unmanned Ground Vehicle (TUGV)	05	32,315					U
95	0604642A	Light Tactical Wheeled Vehicles	05	476	7,000	7,000			U

R-119PB: FY 2019 President's Budget (Published Version), as of January 18, 2018 at 15:06:20

Department of the Army
FY 2019 President's Budget
Exhibit R-1 FY 2019 President's Budget
Total Obligational Authority
(Dollars in Thousands)

18 Jan 2018

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

Line No	Program Element Number	Item	Act	FY 2018 Emergency Requests** Emergency	FY 2018 Less Enacted Div B P.L.115-96*** MDDE + Ship Repairs	FY 2018 Remaining Req Emergency	FY 2018 Total PB Requests* with CR Adj Base + OCO + Emergency**	FY 2018 Less Enacted DIV B P.L.115-96*** MDDE + Ship Repairs	FY 2018 Remaining Req with CR Adj Base + OCO + Emergency	Sec
80	0604319A	Indirect Fire Protection Capability Increment 2-Intercept (IFPC2)	04				11,303		11,303	U
81	0305251A	Cyberspace Operations Forces and Force Support	04				56,492		56,492	U
82	1206120A	Assured Positioning, Navigation and Timing (PNT)	04							U
83	1206308A	Army Space Systems Integration	04				20,432		20,432	U
		Advanced Component Development & Prototypes		8,700	-8,700		917,589	-8,700	908,889	
84	0604201A	Aircraft Avionics	05				30,153		30,153	U
85	0604270A	Electronic Warfare Development	05				71,671		71,671	U
86	0604290A	Mid-tier Networking Vehicular Radio (MNVR)	05				10,589		10,589	U
87	0604321A	All Source Analysis System	05				4,774		4,774	U
88	0604328A	TRACTOR CAGE	05				17,252		17,252	U
89	0604601A	Infantry Support Weapons	05				87,643		87,643	U
90	0604604A	Medium Tactical Vehicles	05				6,039		6,039	U
91	0604611A	JAVELIN	05				21,095		21,095	U
92	0604622A	Family of Heavy Tactical Vehicles	05				10,507		10,507	U
93	0604633A	Air Traffic Control	05				3,536		3,536	U
94	0604641A	Tactical Unmanned Ground Vehicle (TUGV)	05							U
95	0604642A	Light Tactical Wheeled Vehicles	05				7,000		7,000	U

R-119PB: FY 2019 President's Budget (Published Version), as of January 18, 2018 at 15:06:20

Department of the Army
FY 2019 President's Budget
Exhibit R-1 FY 2019 President's Budget
Total Obligational Authority
(Dollars in Thousands)

18 Jan 2018

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

Line No	Program Element Number	Item	Act	FY 2019 Base	FY 2019 OCO	FY 2019 Total	Sec
80	0604319A	Indirect Fire Protection Capability Increment 2-Intercept (IFPC2)	04	51,030		51,030	U
81	0305251A	Cyberspace Operations Forces and Force Support	04	65,817		65,817	U
82	1206120A	Assured Positioning, Navigation and Timing (PNT)	04	146,300		146,300	U
83	1206308A	Army Space Systems Integration	04	38,319		38,319	U
		Advanced Component Development & Prototypes		1,329,393	28,500	1,357,893	
84	0604201A	Aircraft Avionics	05	32,293		32,293	U
85	0604270A	Electronic Warfare Development	05	78,699		78,699	U
86	0604290A	Mid-tier Networking Vehicular Radio (MNVR)	05				U
87	0604321A	All Source Analysis System	05				U
88	0604328A	TRACTOR CAGE	05	17,050	12,000	29,050	U
89	0604601A	Infantry Support Weapons	05	83,155		83,155	U
90	0604604A	Medium Tactical Vehicles	05	3,704		3,704	U
91	0604611A	JAVELIN	05	10,623		10,623	U
92	0604622A	Family of Heavy Tactical Vehicles	05	11,950		11,950	U
93	0604633A	Air Traffic Control	05	12,347		12,347	U
94	0604641A	Tactical Unmanned Ground Vehicle (TUGV)	05				U
95	0604642A	Light Tactical Wheeled Vehicles	05	8,212		8,212	U

Department of the Army
FY 2019 President's Budget
Exhibit R-1 FY 2019 President's Budget
Total Obligational Authority
(Dollars in Thousands)

18 Jan 2018

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

Line No	Program Element Number	Item	Act	FY 2017 (Base + OCO)	FY 2018 PB Request with CR Adj Base	FY 2018 Total PB Requests* with CR Adj Base	FY 2018 PB Request with CR Adj OCO	FY 2018 Total PB Requests+ with CR Adj OCO	Sec
96	0604645A	Armored Systems Modernization (ASM) - Eng Dev	05	9,306	36,242	36,242			U
97	0604710A	Night Vision Systems - Eng Dev	05	76,491	108,504	108,504			U
98	0604713A	Combat Feeding, Clothing, and Equipment	05	1,975	3,702	3,702			U
99	0604715A	Non-System Training Devices - Eng Dev	05	33,888	43,575	43,575			U
100	0604741A	Air Defense Command, Control and Intelligence - Eng Dev	05	200,205	28,726	28,726			U
101	0604742A	Constructive Simulation Systems Development	05	17,363	18,562	18,562			U
102	0604746A	Automatic Test Equipment Development	05	8,503	8,344	8,344			U
103	0604760A	Distributive Interactive Simulations (DIS) - Eng Dev	05	10,150	11,270	11,270			U
104	0604768A	Brilliant Anti-Armor Submunition (BAT)	05		10,000	10,000			U
105	0604780A	Combined Arms Tactical Trainer (CATT) Core	05	14,538	18,566	18,566			U
106	0604798A	Brigade Analysis, Integration and Evaluation	05	101,927	145,360	145,360			U
107	0604802A	Weapons and Munitions - Eng Dev	05	75,845	145,232	145,232			U
108	0604804A	Logistics and Engineer Equipment - Eng Dev	05	76,374	90,965	90,965			U
109	0604805A	Command, Control, Communications Systems - Eng Dev	05	4,166	9,910	9,910			U

Department of the Army
FY 2019 President's Budget
Exhibit R-1 FY 2019 President's Budget
Total Obligational Authority
(Dollars in Thousands)

18 Jan 2018

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

Line No	Program Element Number	Item	Act	FY 2018 Emergency Requests** Emergency	FY 2018 Less Enacted Div B P.L.115-96*** MDDE + Ship Repairs	FY 2018 Remaining Req Emergency	FY 2018 Total PB Requests* with CR Adj Base + OCO + Emergency**	FY 2018 Less Enacted DIV B P.L.115-96*** MDDE + Ship Repairs	FY 2018 Remaining Req with CR Adj Base + OCO + Emergency	Sec
96	0604645A	Armored Systems Modernization (ASM) - Eng Dev	05				36,242		36,242	U
97	0604710A	Night Vision Systems - Eng Dev	05				108,504		108,504	U
98	0604713A	Combat Feeding, Clothing, and Equipment	05				3,702		3,702	U
99	0604715A	Non-System Training Devices - Eng Dev	05				43,575		43,575	U
100	0604741A	Air Defense Command, Control and Intelligence - Eng Dev	05				28,726		28,726	U
101	0604742A	Constructive Simulation Systems Development	05				18,562		18,562	U
102	0604746A	Automatic Test Equipment Development	05				8,344		8,344	U
103	0604760A	Distributive Interactive Simulations (DIS) - Eng Dev	05				11,270		11,270	U
104	0604768A	Brilliant Anti-Armor Submunition (BAT)	05				10,000		10,000	U
105	0604780A	Combined Arms Tactical Trainer (CATT) Core	05				18,566		18,566	U
106	0604798A	Brigade Analysis, Integration and Evaluation	05				145,360		145,360	U
107	0604802A	Weapons and Munitions - Eng Dev	05				145,232		145,232	U
108	0604804A	Logistics and Engineer Equipment - Eng Dev	05				90,965		90,965	U
109	0604805A	Command, Control, Communications Systems - Eng Dev	05				9,910		9,910	U

Department of the Army
FY 2019 President's Budget
Exhibit R-1 FY 2019 President's Budget
Total Obligational Authority
(Dollars in Thousands)

18 Jan 2018

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

Line No	Program Element Number	Item	Act	FY 2019 Base	FY 2019 OCO	FY 2019 Total	Sec
96	0604645A	Armored Systems Modernization (ASM) - Eng Dev	05	393,613		393,613	U
97	0604710A	Night Vision Systems - Eng Dev	05	139,614		139,614	U
98	0604713A	Combat Feeding, Clothing, and Equipment	05	4,507		4,507	U
99	0604715A	Non-System Training Devices - Eng Dev	05	49,436		49,436	U
100	0604741A	Air Defense Command, Control and Intelligence - Eng Dev	05	95,172	119,300	214,472	U
101	0604742A	Constructive Simulation Systems Development	05	22,628		22,628	U
102	0604746A	Automatic Test Equipment Development	05	13,297		13,297	U
103	0604760A	Distributive Interactive Simulations (DIS) - Eng Dev	05	9,145		9,145	U
104	0604768A	Brilliant Anti-Armor Submunition (BAT)	05	9,894		9,894	U
105	0604780A	Combined Arms Tactical Trainer (CATT) Core	05	21,964		21,964	U
106	0604798A	Brigade Analysis, Integration and Evaluation	05	49,288		49,288	U
107	0604802A	Weapons and Munitions - Eng Dev	05	183,100		183,100	U
108	0604804A	Logistics and Engineer Equipment - Eng Dev	05	79,706		79,706	U
109	0604805A	Command, Control, Communications Systems - Eng Dev	05	15,970		15,970	U

Department of the Army
FY 2019 President's Budget
Exhibit R-1 FY 2019 President's Budget
Total Obligational Authority
(Dollars in Thousands)

18 Jan 2018

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

Line No	Program Element Number	Item	Act	FY 2017 (Base + OCO)	FY 2018 PB Request with CR Adj Base	FY 2018 Total PB Requests* with CR Adj Base	FY 2018 PB Request with CR Adj OCO	FY 2018 Total PB Requests+ with CR Adj OCO	Sec
110	0604807A	Medical Materiel/Medical Biological Defense Equipment - Eng Dev	05	36,237	39,238	39,238			U
111	0604808A	Landmine Warfare/Barrier - Eng Dev	05	32,069	34,684	34,684			U
112	0604818A	Army Tactical Command & Control Hardware & Software	05	169,375	164,409	164,409			U
113	0604820A	Radar Development	05	15,368	32,968	32,968			U
114	0604822A	General Fund Enterprise Business System (GFEBS)	05	11,044	49,554	49,554			U
115	0604823A	Firefinder	05	6,177	45,605	45,605			U
116	0604827A	Soldier Systems - Warrior Dem/Val	05	11,929	16,127	16,127			U
117	0604852A	Suite of Survivability Enhancement Systems - EMD	05		98,600	98,600			U
118	0604854A	Artillery Systems - EMD	05	1,689	1,972	1,972			U
119	0605013A	Information Technology Development	05	70,104	81,776	81,776			U
120	0605018A	Integrated Personnel and Pay System-Army (IPPS-A)	05	149,597	172,361	172,361			U
121	0605028A	Armored Multi-Purpose Vehicle (AMPV)	05	177,133	199,778	199,778			U
122	0605029A	Integrated Ground Security Surveillance Response Capability (IGSSR-C)	05	4,789	4,418	4,418			U
123	0605030A	Joint Tactical Network Center (JTNC)	05	14,463	15,877	15,877			U
124	0605031A	Joint Tactical Network (JTN)	05	16,430	44,150	44,150			U
125	0605032A	TRACTOR TIRE	05	27,254	34,670	34,670	5,000	5,000	U

R-119PB: FY 2019 President's Budget (Published Version), as of January 18, 2018 at 15:06:20

Department of the Army
FY 2019 President's Budget
Exhibit R-1 FY 2019 President's Budget
Total Obligational Authority
(Dollars in Thousands)

18 Jan 2018

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

Line No	Program Element Number	Item	Act	FY 2018 Emergency Requests** Emergency	FY 2018 Less Enacted Div B P.L.115-96*** MDDE + Ship Repairs	FY 2018 Remaining Req Emergency	FY 2018 Total PB Requests* with CR Adj Base + OCO + Emergency**	FY 2018 Less Enacted DIV B P.L.115-96*** MDDE + Ship Repairs	FY 2018 Remaining Req with CR Adj Base + OCO + Emergency	Sec
110	0604807A	Medical Materiel/Medical Biological Defense Equipment - Eng Dev	05				39,238		39,238	U
111	0604808A	Landmine Warfare/Barrier - Eng Dev	05				34,684		34,684	U
112	0604818A	Army Tactical Command & Control Hardware & Software	05				164,409		164,409	U
113	0604820A	Radar Development	05				32,968		32,968	U
114	0604822A	General Fund Enterprise Business System (GFEBS)	05				49,554		49,554	U
115	0604823A	Firefinder	05				45,605		45,605	U
116	0604827A	Soldier Systems - Warrior Dem/Val	05				16,127		16,127	U
117	0604852A	Suite of Survivability Enhancement Systems - EMD	05				98,600		98,600	U
118	0604854A	Artillery Systems - EMD	05				1,972		1,972	U
119	0605013A	Information Technology Development	05				81,776		81,776	U
120	0605018A	Integrated Personnel and Pay System-Army (IPPS-A)	05				172,361		172,361	U
121	0605028A	Armored Multi-Purpose Vehicle (AMPV)	05				199,778		199,778	U
122	0605029A	Integrated Ground Security Surveillance Response Capability (IGSSR-C)	05				4,418		4,418	U
123	0605030A	Joint Tactical Network Center (JTNC)	05				15,877		15,877	U
124	0605031A	Joint Tactical Network (JTN)	05				44,150		44,150	U
125	0605032A	TRACTOR TIRE	05				39,670		39,670	U

Department of the Army
FY 2019 President's Budget
Exhibit R-1 FY 2019 President's Budget
Total Obligational Authority
(Dollars in Thousands)

18 Jan 2018

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

Line No	Program Element Number	Item	Act	FY 2019 Base	FY 2019 OCO	FY 2019 Total	Sec
110	0604807A	Medical Materiel/Medical Biological Defense Equipment - Eng Dev	05	44,542		44,542	U
111	0604808A	Landmine Warfare/Barrier - Eng Dev	05	50,817		50,817	U
112	0604818A	Army Tactical Command & Control Hardware & Software	05	178,693		178,693	U
113	0604820A	Radar Development	05	39,338		39,338	U
114	0604822A	General Fund Enterprise Business System (GFEBS)	05	37,851		37,851	U
115	0604823A	Firefinder	05	45,473		45,473	U
116	0604827A	Soldier Systems - Warrior Dem/Val	05	10,395		10,395	U
117	0604852A	Suite of Survivability Enhancement Systems - EMD	05	69,204		69,204	U
118	0604854A	Artillery Systems - EMD	05	1,781		1,781	U
119	0605013A	Information Technology Development	05	113,758		113,758	U
120	0605018A	Integrated Personnel and Pay System-Army (IPPS-A)	05	166,603		166,603	U
121	0605028A	Armored Multi-Purpose Vehicle (AMPV)	05	118,239		118,239	U
122	0605029A	Integrated Ground Security Surveillance Response Capability (IGSSR-C)	05	3,211		3,211	U
123	0605030A	Joint Tactical Network Center (JTNC)	05	15,889		15,889	U
124	0605031A	Joint Tactical Network (JTN)	05	41,972		41,972	U
125	0605032A	TRACTOR TIRE	05	41,166	66,760	107,926	U

R-119PB: FY 2019 President's Budget (Published Version), as of January 18, 2018 at 15:06:20

Department of the Army
FY 2019 President's Budget
Exhibit R-1 FY 2019 President's Budget
Total Obligational Authority
(Dollars in Thousands)

18 Jan 2018

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

Line No	Program Element Number	Item	Act	FY 2017 (Base + OCO)	FY 2018 PB Request with CR Adj Base	FY 2018 Total PB Requests* with CR Adj Base	FY 2018 PB Request with CR Adj OCO	FY 2018 Total PB Requests+ with CR Adj OCO	Sec
126	0605033A	Ground-Based Operational Surveillance System - Expeditionary (GBOSS-E)	05	4,838	5,207	5,207			U
127	0605034A	Tactical Security System (TSS)	05	2,792	4,727	4,727			U
128	0605035A	Common Infrared Countermeasures (CIRCM)	05	90,685	105,778	105,778	21,540	21,540	U
129	0605036A	Combating Weapons of Mass Destruction (CWMD)	05	2,008	6,927	6,927			U
130	0605037A	Evidence Collection and Detainee Processing	05		214	214			U
131	0605038A	Nuclear Biological Chemical Reconnaissance Vehicle (NBCRV) Sensor Suite	05		16,125	16,125			U
132	0605041A	Defensive CYBER Tool Development	05	32,535	55,165	55,165			U
133	0605042A	Tactical Network Radio Systems (Low-Tier)	05	14,198	20,076	20,076			U
134	0605047A	Contract Writing System	05	19,868	20,322	20,322			U
135	0605049A	Missile Warning System Modernization (MWSM)	05		55,810	55,810			U
136	0605051A	Aircraft Survivability Development	05	121,530	30,879	30,879	30,100	30,100	U
137	0605052A	Indirect Fire Protection Capability Inc 2 - Block 1	05	80,781	175,069	175,069			U
138	0605053A	Ground Robotics	05		70,760	70,760			U
139	0605054A	Emerging Technology Initiatives	05						U

R-119PB: FY 2019 President's Budget (Published Version), as of January 18, 2018 at 15:06:20

Department of the Army
FY 2019 President's Budget
Exhibit R-1 FY 2019 President's Budget
Total Obligational Authority
(Dollars in Thousands)

18 Jan 2018

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

Line No	Program Element Number	Item	Act	FY 2018 Emergency Requests** Emergency	FY 2018 Less Enacted Div B P.L.115-96*** MDDE + Ship Repairs	FY 2018 Remaining Req Emergency	FY 2018 Total PB Requests* with CR Adj Base + OCO + Emergency**	FY 2018 Less Enacted DIV B P.L.115-96*** MDDE + Ship Repairs	FY 2018 Remaining Req with CR Adj Base + OCO + Emergency	Sec
126	0605033A	Ground-Based Operational Surveillance System - Expeditionary (GBOSS-E)	05				5,207		5,207	U
127	0605034A	Tactical Security System (TSS)	05				4,727		4,727	U
128	0605035A	Common Infrared Countermeasures (CIRCM)	05				127,318		127,318	U
129	0605036A	Combating Weapons of Mass Destruction (CWMD)	05				6,927		6,927	U
130	0605037A	Evidence Collection and Detainee Processing	05				214		214	U
131	0605038A	Nuclear Biological Chemical Reconnaissance Vehicle (NBCRV) Sensor Suite	05				16,125		16,125	U
132	0605041A	Defensive CYBER Tool Development	05				55,165		55,165	U
133	0605042A	Tactical Network Radio Systems (Low-Tier)	05				20,076		20,076	U
134	0605047A	Contract Writing System	05				20,322		20,322	U
135	0605049A	Missile Warning System Modernization (MWSM)	05				55,810		55,810	U
136	0605051A	Aircraft Survivability Development	05				60,979		60,979	U
137	0605052A	Indirect Fire Protection Capability Inc 2 - Block 1	05				175,069		175,069	U
138	0605053A	Ground Robotics	05				70,760		70,760	U
139	0605054A	Emerging Technology Initiatives	05							U

Department of the Army
FY 2019 President's Budget
Exhibit R-1 FY 2019 President's Budget
Total Obligational Authority
(Dollars in Thousands)

18 Jan 2018

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

Line No	Program Element Number	Item	Act	FY 2019 Base	FY 2019 OCO	FY 2019 Total	Sec
126	0605033A	Ground-Based Operational Surveillance System - Expeditionary (GBOSS-E)	05	5,175		5,175	U
127	0605034A	Tactical Security System (TSS)	05	4,496		4,496	U
128	0605035A	Common Infrared Countermeasures (CIRCM)	05	51,178	2,670	53,848	U
129	0605036A	Combating Weapons of Mass Destruction (CWMD)	05	11,311		11,311	U
130	0605037A	Evidence Collection and Detainee Processing	05				U
131	0605038A	Nuclear Biological Chemical Reconnaissance Vehicle (NBCRV) Sensor Suite	05	17,154		17,154	U
132	0605041A	Defensive CYBER Tool Development	05	36,626		36,626	U
133	0605042A	Tactical Network Radio Systems (Low-Tier)	05	3,829		3,829	U
134	0605047A	Contract Writing System	05	41,928		41,928	U
135	0605049A	Missile Warning System Modernization (MWSM)	05	28,276		28,276	U
136	0605051A	Aircraft Survivability Development	05	21,965	34,933	56,898	U
137	0605052A	Indirect Fire Protection Capability Inc 2 - Block 1	05	157,710		157,710	U
138	0605053A	Ground Robotics	05	86,167		86,167	U
139	0605054A	Emerging Technology Initiatives	05	42,866		42,866	U

Department of the Army
FY 2019 President's Budget
Exhibit R-1 FY 2019 President's Budget
Total Obligational Authority
(Dollars in Thousands)

18 Jan 2018

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

Line No	Program Element Number	Item	Act	FY 2017 (Base + OCO)	FY 2018 PB Request with CR Adj Base	FY 2018 Total PB Requests* with CR Adj Base	FY 2018 PB Request with CR Adj OCO	FY 2018 Total PB Requests+ with CR Adj OCO	Sec
140	0605380A	AMF Joint Tactical Radio System (JTRS)	05	4,088	8,965	8,965			U
141	0605450A	Joint Air-to-Ground Missile (JAGM)	05	47,446	34,626	34,626			U
142	0605457A	Army Integrated Air and Missile Defense (AIAMD)	05	273,240	336,420	336,420			U
143	0605766A	National Capabilities Integration (MIP)	05	4,955	6,882	6,882			U
144	0605812A	Joint Light Tactical Vehicle (JLTV) Engineering and Manufacturing Development Ph	05	11,086	23,467	23,467			U
145	0605830A	Aviation Ground Support Equipment	05	2,060	6,930	6,930			U
146	0210609A	Paladin Integrated Management (PIM)	05	39,902	6,112	6,112			U
147	0303032A	TROJAN - RH12	05	4,273	4,431	4,431	1,200	1,200	U
148	0303267A	Auctioned Spectrum Relocation Fund	05	34,967					U
149	0303367A	Spectrum Access Research and Development	05	66,125					U
150	0304270A	Electronic Warfare Development	05	18,425	14,616	14,616			U
151	1205117A	Tractor Bears	05		17,928	17,928			U
		System Development & Demonstration		2,502,560	3,012,840	3,012,840	57,840	57,840	
152	0604256A	Threat Simulator Development	06	28,883	22,862	22,862			U
153	0604258A	Target Systems Development	06	18,518	13,902	13,902			U
154	0604759A	Major T&E Investment	06	93,668	102,901	102,901			U
155	0605103A	Rand Arroyo Center	06	19,863	20,140	20,140			U

R-119PB: FY 2019 President's Budget (Published Version), as of January 18, 2018 at 15:06:20

Department of the Army
FY 2019 President's Budget
Exhibit R-1 FY 2019 President's Budget
Total Obligational Authority
(Dollars in Thousands)

18 Jan 2018

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

Line No	Program Element Number	Item	Act	FY 2018 Emergency Requests** Emergency	FY 2018 Less Enacted Div B P.L.115-96*** MDDE + Ship Repairs	FY 2018 Remaining Req Emergency	FY 2018 Total PB Requests* with CR Adj Base + OCO + Emergency**	FY 2018 Less Enacted DIV B P.L.115-96*** MDDE + Ship Repairs	FY 2018 Remaining Req with CR Adj Base + OCO + Emergency	Sec
140	0605380A	AMF Joint Tactical Radio System (JTRS)	05				8,965		8,965	U
141	0605450A	Joint Air-to-Ground Missile (JAGM)	05				34,626		34,626	U
142	0605457A	Army Integrated Air and Missile Defense (AIAMD)	05				336,420		336,420	U
143	0605766A	National Capabilities Integration (MIP)	05				6,882		6,882	U
144	0605812A	Joint Light Tactical Vehicle (JLTV) Engineering and Manufacturing Development Ph	05				23,467		23,467	U
145	0605830A	Aviation Ground Support Equipment	05				6,930		6,930	U
146	0210609A	Paladin Integrated Management (PIM)	05				6,112		6,112	U
147	0303032A	TROJAN - RH12	05				5,631		5,631	U
148	0303267A	Auctioned Spectrum Relocation Fund	05							U
149	0303367A	Spectrum Access Research and Development	05							U
150	0304270A	Electronic Warfare Development	05				14,616		14,616	U
151	1205117A	Tractor Bears	05				17,928		17,928	U
		System Development & Demonstration					3,070,680		3,070,680	
152	0604256A	Threat Simulator Development	06				22,862		22,862	U
153	0604258A	Target Systems Development	06				13,902		13,902	U
154	0604759A	Major T&E Investment	06				102,901		102,901	U
155	0605103A	Rand Arroyo Center	06				20,140		20,140	U

R-119PB: FY 2019 President's Budget (Published Version), as of January 18, 2018 at 15:06:20

Department of the Army
FY 2019 President's Budget
Exhibit R-1 FY 2019 President's Budget
Total Obligational Authority
(Dollars in Thousands)

18 Jan 2018

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

Line No	Program Element Number	Item	Act	FY 2019 Base	FY 2019 OCO	FY 2019 Total	Sec
140	0605380A	AMF Joint Tactical Radio System (JTRS)	05	15,984		15,984	U
141	0605450A	Joint Air-to-Ground Missile (JAGM)	05	11,773		11,773	U
142	0605457A	Army Integrated Air and Missile Defense (AIAMD)	05	277,607		277,607	U
143	0605766A	National Capabilities Integration (MIP)	05	12,340		12,340	U
144	0605812A	Joint Light Tactical Vehicle (JLTV) Engineering and Manufacturing Development Ph	05	2,686		2,686	U
145	0605830A	Aviation Ground Support Equipment	05	2,706		2,706	U
146	0210609A	Paladin Integrated Management (PIM)	05				U
147	0303032A	TROJAN - RH12	05	4,521	1,200	5,721	U
148	0303267A	Auctioned Spectrum Relocation Fund	05				U
149	0303367A	Spectrum Access Research and Development	05				U
150	0304270A	Electronic Warfare Development	05	8,922		8,922	U
151	1205117A	Tractor Bears	05	23,170		23,170	U
		System Development & Demonstration		3,192,689	236,863	3,429,552	
152	0604256A	Threat Simulator Development	06	12,835		12,835	U
153	0604258A	Target Systems Development	06	12,135		12,135	U
154	0604759A	Major T&E Investment	06	82,996		82,996	U
155	0605103A	Rand Arroyo Center	06	19,821		19,821	U

R-119PB: FY 2019 President's Budget (Published Version), as of January 18, 2018 at 15:06:20

Department of the Army
FY 2019 President's Budget
Exhibit R-1 FY 2019 President's Budget
Total Obligational Authority
(Dollars in Thousands)

18 Jan 2018

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

Line No	Program Element Number	Item	Act	FY 2017 (Base + OCO)	FY 2018 PB Request with CR Adj Base	FY 2018 Total PB Requests* with CR Adj Base	FY 2018 PB Request with CR Adj OCO	FY 2018 Total PB Requests+ with CR Adj OCO	Sec
156	0605301A	Army Kwajalein Atoll	06	219,271	246,663	246,663			U
157	0605326A	Concepts Experimentation Program	06	24,668	29,820	29,820			U
158	0605502A	Small Business Innovative Research	06	230,691					U
159	0605601A	Army Test Ranges and Facilities	06	305,238	307,588	307,588			U
160	0605602A	Army Technical Test Instrumentation and Targets	06	70,523	49,242	49,242			U
161	0605604A	Survivability/Lethality Analysis	06	38,245	41,843	41,843			U
162	0605606A	Aircraft Certification	06	4,486	4,804	4,804			U
163	0605702A	Meteorological Support to RDT&E Activities	06	6,793	7,238	7,238			U
164	0605706A	Materiel Systems Analysis	06	21,510	21,890	21,890			U
165	0605709A	Exploitation of Foreign Items	06	12,415	12,684	12,684			U
166	0605712A	Support of Operational Testing	06	49,580	51,040	51,040			U
167	0605716A	Army Evaluation Center	06	55,460	56,246	56,246			U
168	0605718A	Army Modeling & Sim X-Cmd Collaboration & Integ	06	7,653	1,829	1,829			U
169	0605801A	Programwide Activities	06	50,971	55,060	55,060			U
170	0605803A	Technical Information Activities	06	29,905	33,934	33,934			U
171	0605805A	Munitions Standardization, Effectiveness and Safety	06	63,983	43,444	43,444			U
172	0605857A	Environmental Quality Technology Mgmt Support	06	2,048	5,087	5,087			U

R-119PB: FY 2019 President's Budget (Published Version), as of January 18, 2018 at 15:06:20

Department of the Army
FY 2019 President's Budget
Exhibit R-1 FY 2019 President's Budget
Total Obligational Authority
(Dollars in Thousands)

18 Jan 2018

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

Line No	Program Element Number	Item	Act	FY 2018 Emergency Requests** Emergency	FY 2018 Less Enacted Div B P.L.115-96*** MDDE + Ship Repairs	FY 2018 Remaining Req Emergency	FY 2018 Total PB Requests* with CR Adj Base + OCO + Emergency**	FY 2018 Less Enacted DIV B P.L.115-96*** MDDE + Ship Repairs	FY 2018 Remaining Req with CR Adj Base + OCO + Emergency	Sec
156	0605301A	Army Kwajalein Atoll	06				246,663		246,663	U
157	0605326A	Concepts Experimentation Program	06				29,820		29,820	U
158	0605502A	Small Business Innovative Research	06							U
159	0605601A	Army Test Ranges and Facilities	06				307,588		307,588	U
160	0605602A	Army Technical Test Instrumentation and Targets	06				49,242		49,242	U
161	0605604A	Survivability/Lethality Analysis	06				41,843		41,843	U
162	0605606A	Aircraft Certification	06				4,804		4,804	U
163	0605702A	Meteorological Support to RDT&E Activities	06				7,238		7,238	U
164	0605706A	Materiel Systems Analysis	06				21,890		21,890	U
165	0605709A	Exploitation of Foreign Items	06				12,684		12,684	U
166	0605712A	Support of Operational Testing	06				51,040		51,040	U
167	0605716A	Army Evaluation Center	06				56,246		56,246	U
168	0605718A	Army Modeling & Sim X-Cmd Collaboration & Integ	06				1,829		1,829	U
169	0605801A	Programwide Activities	06				55,060		55,060	U
170	0605803A	Technical Information Activities	06				33,934		33,934	U
171	0605805A	Munitions Standardization, Effectiveness and Safety	06				43,444		43,444	U
172	0605857A	Environmental Quality Technology Mgmt Support	06				5,087		5,087	U

Department of the Army
FY 2019 President's Budget
Exhibit R-1 FY 2019 President's Budget
Total Obligational Authority
(Dollars in Thousands)

18 Jan 2018

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

Line No	Program Element Number	Item	Act	FY 2019 Base	FY 2019 OCO	FY 2019 Total	Sec
156	0605301A	Army Kwajalein Atoll	06	246,574		246,574	U
157	0605326A	Concepts Experimentation Program	06	30,430		30,430	U
158	0605502A	Small Business Innovative Research	06				U
159	0605601A	Army Test Ranges and Facilities	06	305,759		305,759	U
160	0605602A	Army Technical Test Instrumentation and Targets	06	62,379		62,379	U
161	0605604A	Survivability/Lethality Analysis	06	40,496		40,496	U
162	0605606A	Aircraft Certification	06	3,941		3,941	U
163	0605702A	Meteorological Support to RDT&E Activities	06	9,767		9,767	U
164	0605706A	Materiel Systems Analysis	06	21,226		21,226	U
165	0605709A	Exploitation of Foreign Items	06	13,026		13,026	U
166	0605712A	Support of Operational Testing	06	52,718		52,718	U
167	0605716A	Army Evaluation Center	06	57,049		57,049	U
168	0605718A	Army Modeling & Sim X-Cmd Collaboration & Integ	06	2,801		2,801	U
169	0605801A	Programwide Activities	06	60,942		60,942	U
170	0605803A	Technical Information Activities	06	29,050		29,050	U
171	0605805A	Munitions Standardization, Effectiveness and Safety	06	42,332		42,332	U
172	0605857A	Environmental Quality Technology Mgmt Support	06	3,216		3,216	U

Department of the Army
FY 2019 President's Budget
Exhibit R-1 FY 2019 President's Budget
Total Obligational Authority
(Dollars in Thousands)

18 Jan 2018

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

Line No	Program Element Number	Item	Act	FY 2017 (Base + OCO)	FY 2018 PB Request with CR Adj Base	FY 2018 Total PB Requests* with CR Adj Base	FY 2018 PB Request with CR Adj OCO	FY 2018 Total PB Requests+ with CR Adj OCO	Sec
173	0605898A	Army Direct Report Headquarters - R&D - MHA	06	49,287	54,679	54,679			U
174	0606001A	Military Ground-Based CREW Technology	06		7,916	7,916			U
175	0606002A	Ronald Reagan Ballistic Missile Defense Test Site	06		61,254	61,254			U
176	0606003A	CounterIntel and Human Intel Modernization	06						U
177	0606942A	Assessments and Evaluations Cyber Vulnerabilities	06						U
178	0303260A	Defense Military Deception Initiative	06	1,923	1,779	1,779			U
179	0909980A	Judgment Fund Reimbursement	06	7,893					U
180	0909999A	Financing for Cancelled Account Adjustments	06	6					U
	RDT&E	Management Support		1,413,481	1,253,845	1,253,845			
181	0603778A	MLRS Product Improvement Program	07	34,391	8,929	8,929			U
182	0603813A	TRACTOR PULL	07	3,960	4,014	4,014			U
183	0605024A	Anti-Tamper Technology Support	07	3,498	4,094	4,094			U
184	0607131A	Weapons and Munitions Product Improvement Programs	07	19,969	15,738	15,738			U
185	0607133A	TRACTOR SMOKE	07	4,479	4,513	4,513			U
186	0607134A	Long Range Precision Fires (LRPF)	07	36,322	102,014	102,014			U
187	0607135A	Apache Product Improvement Program	07	60,995	59,977	59,977			U

Department of the Army
FY 2019 President's Budget
Exhibit R-1 FY 2019 President's Budget
Total Obligational Authority
(Dollars in Thousands)

18 Jan 2018

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

Line No	Program Element Number	Item	Act	FY 2018 Emergency Requests** Emergency	FY 2018 Less Enacted Div B P.L.115-96*** MDDE + Ship Repairs	FY 2018 Remaining Req Emergency	FY 2018 Total PB Requests* with CR Adj Base + OCO + Emergency**	FY 2018 Less Enacted DIV B P.L.115-96*** MDDE + Ship Repairs	FY 2018 Remaining Req with CR Adj Base + OCO + Emergency	Sec
173	0605898A	Army Direct Report Headquarters - R&D - MHA	06				54,679		54,679	U
174	0606001A	Military Ground-Based CREW Technology	06				7,916		7,916	U
175	0606002A	Ronald Reagan Ballistic Missile Defense Test Site	06				61,254		61,254	U
176	0606003A	CounterIntel and Human Intel Modernization	06							U
177	0606942A	Assessments and Evaluations Cyber Vulnerabilities	06							U
178	0303260A	Defense Military Deception Initiative	06				1,779		1,779	U
179	0909980A	Judgment Fund Reimbursement	06							U
180	0909999A	Financing for Cancelled Account Adjustments	06							U
	RDT&E	Management Support					1,253,845		1,253,845	
181	0603778A	MLRS Product Improvement Program	07				8,929		8,929	U
182	0603813A	TRACTOR PULL	07				4,014		4,014	U
183	0605024A	Anti-Tamper Technology Support	07				4,094		4,094	U
184	0607131A	Weapons and Munitions Product Improvement Programs	07				15,738		15,738	U
185	0607133A	TRACTOR SMOKE	07				4,513		4,513	U
186	0607134A	Long Range Precision Fires (LRPF)	07				102,014		102,014	U
187	0607135A	Apache Product Improvement Program	07				59,977		59,977	U

Department of the Army
FY 2019 President's Budget
Exhibit R-1 FY 2019 President's Budget
Total Obligational Authority
(Dollars in Thousands)

18 Jan 2018

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

Line No	Program Element Number	Item	Act	FY 2019 Base	FY 2019 OCO	FY 2019 Total	Sec
173	0605898A	Army Direct Report Headquarters - R&D - MHA	06	54,145		54,145	U
174	0606001A	Military Ground-Based CREW Technology	06	4,896		4,896	U
175	0606002A	Ronald Reagan Ballistic Missile Defense Test Site	06	63,011		63,011	U
176	0606003A	CounterIntel and Human Intel Modernization	06	2,636		2,636	U
177	0606942A	Assessments and Evaluations Cyber Vulnerabilities	06	88,300		88,300	U
178	0303260A	Defense Military Deception Initiative	06				U
179	0909980A	Judgment Fund Reimbursement	06				U
180	0909999A	Financing for Cancelled Account Adjustments	06				U
	RDT&E	Management Support		1,322,481		1,322,481	
181	0603778A	MLRS Product Improvement Program	07	8,886		8,886	U
182	0603813A	TRACTOR PULL	07	4,067		4,067	U
183	0605024A	Anti-Tamper Technology Support	07	4,254		4,254	U
184	0607131A	Weapons and Munitions Product Improvement Programs	07	16,022	2,548	18,570	U
185	0607133A	TRACTOR SMOKE	07	4,577	7,780	12,357	U
186	0607134A	Long Range Precision Fires (LRPF)	07	186,475		186,475	U
187	0607135A	Apache Product Improvement Program	07	31,049		31,049	U

Department of the Army
FY 2019 President's Budget
Exhibit R-1 FY 2019 President's Budget
Total Obligational Authority
(Dollars in Thousands)

18 Jan 2018

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

Line No	Program Element Number	Item	Act	FY 2017 (Base + OCO)	FY 2018 PB Request with CR Adj Base	FY 2018 Total PB Requests* with CR Adj Base	FY 2018 PB Request with CR Adj OCO	FY 2018 Total PB Requests+ with CR Adj OCO	Sec
188	0607136A	Blackhawk Product Improvement Program	07	44,966	34,416	34,416			U
189	0607137A	Chinook Product Improvement Program	07	88,314	194,567	194,567			U
190	0607138A	Fixed Wing Product Improvement Program	07	765	9,981	9,981			U
191	0607139A	Improved Turbine Engine Program	07	111,638	204,304	204,304			U
192	0607140A	Emerging Technologies from NIE	07	2,278	1,023	1,023			U
193	0607141A	Logistics Automation	07	1,542	1,504	1,504			U
194	0607142A	Aviation Rocket System Product Improvement and Development	07		10,064	10,064			U
195	0607143A	Unmanned Aircraft System Universal Products	07		38,463	38,463			U
196	0607665A	Family of Biometrics	07	11,632	6,159	6,159			U
197	0607865A	Patriot Product Improvement	07	48,073	90,217	90,217			U
198	0202429A	Aerostat Joint Project - COCOM Exercise	07	6,178	6,749	6,749			U
199	0203728A	Joint Automated Deep Operation Coordination System (JADOCS)	07	29,412	33,520	33,520			U
200	0203735A	Combat Vehicle Improvement Programs	07	340,353	343,175	343,175			U
201	0203740A	Maneuver Control System	07	3,943	6,639	6,639			U
202	0203743A	155mm Self-Propelled Howitzer Improvements	07		40,784	40,784			U
203	0203744A	Aircraft Modifications/Product Improvement Programs	07	32,397	39,358	39,358			U

R-119PB: FY 2019 President's Budget (Published Version), as of January 18, 2018 at 15:06:20

Department of the Army
FY 2019 President's Budget
Exhibit R-1 FY 2019 President's Budget
Total Obligational Authority
(Dollars in Thousands)

18 Jan 2018

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

Line No	Program Element Number	Item	Act	FY 2018 Emergency Requests** Emergency	FY 2018 Less Enacted Div B P.L.115-96*** MDDE + Ship Repairs	FY 2018 Remaining Req Emergency	FY 2018 Total PB Requests* with CR Adj Base + OCO + Emergency**	FY 2018 Less Enacted DIV B P.L.115-96*** MDDE + Ship Repairs	FY 2018 Remaining Req with CR Adj Base + OCO + Emergency	Sec
188	0607136A	Blackhawk Product Improvement Program	07				34,416		34,416	U
189	0607137A	Chinook Product Improvement Program	07				194,567		194,567	U
190	0607138A	Fixed Wing Product Improvement Program	07				9,981		9,981	U
191	0607139A	Improved Turbine Engine Program	07				204,304		204,304	U
192	0607140A	Emerging Technologies from NIE	07				1,023		1,023	U
193	0607141A	Logistics Automation	07				1,504		1,504	U
194	0607142A	Aviation Rocket System Product Improvement and Development	07				10,064		10,064	U
195	0607143A	Unmanned Aircraft System Universal Products	07				38,463		38,463	U
196	0607665A	Family of Biometrics	07				6,159		6,159	U
197	0607865A	Patriot Product Improvement	07				90,217		90,217	U
198	0202429A	Aerostat Joint Project - COCOM Exercise	07				6,749		6,749	U
199	0203728A	Joint Automated Deep Operation Coordination System (JADOCS)	07				33,520		33,520	U
200	0203735A	Combat Vehicle Improvement Programs	07				343,175		343,175	U
201	0203740A	Maneuver Control System	07				6,639		6,639	U
202	0203743A	155mm Self-Propelled Howitzer Improvements	07				40,784		40,784	U
203	0203744A	Aircraft Modifications/Product Improvement Programs	07				39,358		39,358	U

R-119PB: FY 2019 President's Budget (Published Version), as of January 18, 2018 at 15:06:20

Department of the Army
FY 2019 President's Budget
Exhibit R-1 FY 2019 President's Budget
Total Obligational Authority
(Dollars in Thousands)

18 Jan 2018

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

Line No	Program Element Number	Item	Act	FY 2019 Base	FY 2019 OCO	FY 2019 Total	Sec
188	0607136A	Blackhawk Product Improvement Program	07	35,240		35,240	U
189	0607137A	Chinook Product Improvement Program	07	157,822		157,822	U
190	0607138A	Fixed Wing Product Improvement Program	07	4,189		4,189	U
191	0607139A	Improved Turbine Engine Program	07	192,637		192,637	U
192	0607140A	Emerging Technologies from NIE	07				U
193	0607141A	Logistics Automation	07				U
194	0607142A	Aviation Rocket System Product Improvement and Development	07	60,860		60,860	U
195	0607143A	Unmanned Aircraft System Universal Products	07	52,019		52,019	U
196	0607665A	Family of Biometrics	07	2,400		2,400	U
197	0607865A	Patriot Product Improvement	07	65,369		65,369	U
198	0202429A	Aerostat Joint Project - COCOM Exercise	07	1		1	U
199	0203728A	Joint Automated Deep Operation Coordination System (JADOCS)	07	30,954		30,954	U
200	0203735A	Combat Vehicle Improvement Programs	07	411,927		411,927	U
201	0203740A	Maneuver Control System	07				U
202	0203743A	155mm Self-Propelled Howitzer Improvements	07	40,676		40,676	U
203	0203744A	Aircraft Modifications/Product Improvement Programs	07	17,706		17,706	U

Department of the Army
FY 2019 President's Budget
Exhibit R-1 FY 2019 President's Budget
Total Obligational Authority
(Dollars in Thousands)

18 Jan 2018

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

Line No	Program Element Number	Item	Act	FY 2017 (Base + OCO)	FY 2018 PB Request with CR Adj Base	FY 2018 Total PB Requests* with CR Adj Base	FY 2018 PB Request with CR Adj OCO	FY 2018 Total PB Requests+ with CR Adj OCO	Sec
204	0203752A	Aircraft Engine Component Improvement Program	07	249	145	145			U
205	0203758A	Digitization	07	6,234	4,803	4,803			U
206	0203801A	Missile/Air Defense Product Improvement Program	07	24,925	2,723	2,723	15,000	15,000	U
207	0203802A	Other Missile Product Improvement Programs	07	8,283	5,000	5,000			U
208	0203808A	TRACTOR CARD	07	20,333	37,883	37,883			U
209	0205402A	Integrated Base Defense - Operational System Dev	07	3,450					U
210	0205410A	Materials Handling Equipment	07	119	1,582	1,582			U
211	0205412A	Environmental Quality Technology - Operational System Dev	07		195	195			U
212	0205456A	Lower Tier Air and Missile Defense (AMD) System	07	61,449	78,926	78,926			U
213	0205778A	Guided Multiple-Launch Rocket System (GMLRS)	07	21,196	102,807	102,807			U
214	0208053A	Joint Tactical Ground System	07	12,649					U
216	0303028A	Security and Intelligence Activities	07	15,719	13,807	13,807			U
217	0303140A	Information Systems Security Program	07	36,892	132,438	132,438			U
218	0303141A	Global Combat Support System	07	26,176	64,370	64,370			U
219	0303142A	SATCOM Ground Environment (SPACE)	07	18,761					U
220	0303150A	WWMCCS/Global Command and Control System	07	4,536	10,475	10,475			U

Department of the Army
FY 2019 President's Budget
Exhibit R-1 FY 2019 President's Budget
Total Obligational Authority
(Dollars in Thousands)

18 Jan 2018

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

Line No	Program Element Number	Item	Act	FY 2018 Emergency Requests** Emergency	FY 2018 Less Enacted Div B P.L.115-96*** MDDE + Ship Repairs	FY 2018 Remaining Req Emergency	FY 2018 Total PB Requests* with CR Adj Base + OCO + Emergency**	FY 2018 Less Enacted DIV B P.L.115-96*** MDDE + Ship Repairs	FY 2018 Remaining Req with CR Adj Base + OCO + Emergency	Sec
204	0203752A	Aircraft Engine Component Improvement Program	07				145		145	U
205	0203758A	Digitization	07				4,803		4,803	U
206	0203801A	Missile/Air Defense Product Improvement Program	07				17,723		17,723	U
207	0203802A	Other Missile Product Improvement Programs	07				5,000		5,000	U
208	0203808A	TRACTOR CARD	07				37,883		37,883	U
209	0205402A	Integrated Base Defense - Operational System Dev	07							U
210	0205410A	Materials Handling Equipment	07				1,582		1,582	U
211	0205412A	Environmental Quality Technology - Operational System Dev	07				195		195	U
212	0205456A	Lower Tier Air and Missile Defense (AMD) System	07				78,926		78,926	U
213	0205778A	Guided Multiple-Launch Rocket System (GMLRS)	07				102,807		102,807	U
214	0208053A	Joint Tactical Ground System	07							U
216	0303028A	Security and Intelligence Activities	07				13,807		13,807	U
217	0303140A	Information Systems Security Program	07				132,438		132,438	U
218	0303141A	Global Combat Support System	07				64,370		64,370	U
219	0303142A	SATCOM Ground Environment (SPACE)	07							U
220	0303150A	WWMCCS/Global Command and Control System	07				10,475		10,475	U

R-119PB: FY 2019 President's Budget (Published Version), as of January 18, 2018 at 15:06:20

Department of the Army
FY 2019 President's Budget
Exhibit R-1 FY 2019 President's Budget
Total Obligational Authority
(Dollars in Thousands)

18 Jan 2018

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

Line No	Program Element Number	Item	Act	FY 2019 Base	FY 2019 OCO	FY 2019 Total	Sec
204	0203752A	Aircraft Engine Component Improvement Program	07	146		146	U
205	0203758A	Digitization	07	6,316		6,316	U
206	0203801A	Missile/Air Defense Product Improvement Program	07	1,643	2,000	3,643	U
207	0203802A	Other Missile Product Improvement Programs	07	4,947		4,947	U
208	0203808A	TRACTOR CARD	07	34,050		34,050	U
209	0205402A	Integrated Base Defense - Operational System Dev	07		8,000	8,000	U
210	0205410A	Materials Handling Equipment	07	1,464		1,464	U
211	0205412A	Environmental Quality Technology - Operational System Dev	07	249		249	U
212	0205456A	Lower Tier Air and Missile Defense (AMD) System	07	79,283		79,283	U
213	0205778A	Guided Multiple-Launch Rocket System (GMLRS)	07	154,102		154,102	U
214	0208053A	Joint Tactical Ground System	07				U
216	0303028A	Security and Intelligence Activities	07	12,280	23,199	35,479	U
217	0303140A	Information Systems Security Program	07	68,533		68,533	U
218	0303141A	Global Combat Support System	07	68,619		68,619	U
219	0303142A	SATCOM Ground Environment (SPACE)	07				U
220	0303150A	WWMCCS/Global Command and Control System	07	2,034		2,034	U

R-119PB: FY 2019 President's Budget (Published Version), as of January 18, 2018 at 15:06:20

Department of the Army
FY 2019 President's Budget
Exhibit R-1 FY 2019 President's Budget
Total Obligational Authority
(Dollars in Thousands)

18 Jan 2018

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

Line No	Program Element Number	Item	Act	FY 2017 (Base + OCO)	FY 2018 PB Request with CR Adj Base	FY 2018 Total PB Requests* with CR Adj Base	FY 2018 PB Request with CR Adj OCO	FY 2018 Total PB Requests+ with CR Adj OCO	Sec
223	0305172A	Combined Advanced Applications	07		1,100	1,100			U
224	0305179A	Integrated Broadcast Service (IBS)	07						U
225	0305204A	Tactical Unmanned Aerial Vehicles	07	8,218	9,433	9,433	7,492	7,492	U
226	0305206A	Airborne Reconnaissance Systems	07	11,799	5,080	5,080	15,000	15,000	U
227	0305208A	Distributed Common Ground/Surface Systems	07	32,284	24,700	24,700			U
228	0305219A	MQ-1C Gray Eagle UAS	07	13,470	9,574	9,574			U
229	0305232A	RQ-11 UAV	07	1,613	2,191	2,191			U
230	0305233A	RQ-7 UAV	07	4,597	12,773	12,773			U
231	0307665A	Biometrics Enabled Intelligence	07	8,854	2,537	2,537	6,036	6,036	U
232	0310349A	Win-T Increment 2 - Initial Networking	07	4,680	4,723	4,723			U
233	0708045A	End Item Industrial Preparedness Activities	07	59,891	60,877	60,877			U
234	1203142A	SATCOM Ground Environment (SPACE)	07		11,959	11,959			U
235	1208053A	Joint Tactical Ground System	07		10,228	10,228			U
9999	9999999999	Classified Programs		4,625	7,154	7,154			U
		Operational Systems Development		1,296,107	1,877,685	1,877,685	43,528	43,528	
236	0901560A	Continuing Resolution Programs	20		-1,151,993	-1,151,993	222,988	222,988	U
		Undistributed			-1,151,993	-1,151,993	222,988	222,988	
Total Research, Development, Test & Eval, Army				8,852,507	8,273,447	8,273,447	342,356	342,356	

R-119PB: FY 2019 President's Budget (Published Version), as of January 18, 2018 at 15:06:20

Department of the Army
FY 2019 President's Budget
Exhibit R-1 FY 2019 President's Budget
Total Obligational Authority
(Dollars in Thousands)

18 Jan 2018

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

Line No	Program Element Number	Item	Act	FY 2018 Emergency Requests** Emergency	FY 2018 Less Enacted Div B P.L.115-96*** MDDE + Ship Repairs	FY 2018 Remaining Req Emergency	FY 2018 Total PB Requests* with CR Adj Base + OCO + Emergency**	FY 2018 Less Enacted DIV B P.L.115-96*** MDDE + Ship Repairs	FY 2018 Remaining Req with CR Adj Base + OCO + Emergency	Sec
223	0305172A	Combined Advanced Applications	07				1,100		1,100	U
224	0305179A	Integrated Broadcast Service (IBS)	07							U
225	0305204A	Tactical Unmanned Aerial Vehicles	07				16,925		16,925	U
226	0305206A	Airborne Reconnaissance Systems	07				20,080		20,080	U
227	0305208A	Distributed Common Ground/Surface Systems	07				24,700		24,700	U
228	0305219A	MQ-1C Gray Eagle UAS	07				9,574		9,574	U
229	0305232A	RQ-11 UAV	07				2,191		2,191	U
230	0305233A	RQ-7 UAV	07				12,773		12,773	U
231	0307665A	Biometrics Enabled Intelligence	07				8,573		8,573	U
232	0310349A	Win-T Increment 2 - Initial Networking	07				4,723		4,723	U
233	0708045A	End Item Industrial Preparedness Activities	07				60,877		60,877	U
234	1203142A	SATCOM Ground Environment (SPACE)	07				11,959		11,959	U
235	1208053A	Joint Tactical Ground System	07				10,228		10,228	U
9999	9999999999	Classified Programs					7,154		7,154	U
		Operational Systems Development					1,921,213		1,921,213	
236	0901560A	Continuing Resolution Programs	20				-929,005		-929,005	U
		Undistributed					-929,005		-929,005	
Total Research, Development, Test & Eval, Army				20,700	-20,700		8,636,503	-20,700	8,615,803	

R-119PB: FY 2019 President's Budget (Published Version), as of January 18, 2018 at 15:06:20

Department of the Army
FY 2019 President's Budget
Exhibit R-1 FY 2019 President's Budget
Total Obligational Authority
(Dollars in Thousands)

18 Jan 2018

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

Line No	Program Element Number	Item	Act	FY 2019 Base	FY 2019 OCO	FY 2019 Total	Sec
223	0305172A	Combined Advanced Applications	07	1,500		1,500	U
224	0305179A	Integrated Broadcast Service (IBS)	07	450		450	U
225	0305204A	Tactical Unmanned Aerial Vehicles	07	6,000		6,000	U
226	0305206A	Airborne Reconnaissance Systems	07	12,416	14,000	26,416	U
227	0305208A	Distributed Common Ground/Surface Systems	07	38,667		38,667	U
228	0305219A	MQ-1C Gray Eagle UAS	07				U
229	0305232A	RQ-11 UAV	07	6,180		6,180	U
230	0305233A	RQ-7 UAV	07	12,863		12,863	U
231	0307665A	Biometrics Enabled Intelligence	07	4,310	2,214	6,524	U
232	0310349A	Win-T Increment 2 - Initial Networking	07				U
233	0708045A	End Item Industrial Preparedness Activities	07	53,958		53,958	U
234	1203142A	SATCOM Ground Environment (SPACE)	07	12,119		12,119	U
235	1208053A	Joint Tactical Ground System	07	7,400		7,400	U
9999	9999999999	Classified Programs		5,955		5,955	U
		Operational Systems Development		1,922,614	59,741	1,982,355	
236	0901560A	Continuing Resolution Programs	20				U
		Undistributed					
Total Research, Development, Test & Eval, Army				10,159,379	325,104	10,484,483	

R-119PB: FY 2019 President's Budget (Published Version), as of January 18, 2018 at 15:06:20

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

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

Program Element Table of Contents (Alphabetically by Program Element Title)

FY 2019 RDT&E, ARMY PROGRAM ELEMENT DESCRIPTIVE SUMMARIES

Introduction and Explanation of Contents

1. **General.** The purpose of this document is to provide summary information concerning the Research, Development, Test and Evaluation, Army program. The descriptive summaries are comprised of R-2 (Army RDT&E Budget Item Justification – program element level), R-2A (Army RDT&E Budget Item Justification – project level), R-3 (Army RDT&E Cost Analysis), R-4 (Schedule Profile Detail) and R-5 (Termination Liability Funding for MDAPs) Exhibits, which provide narrative information on all RDT&E program elements and projects through FY 2019.

2. **Relationship of the FY 2019 Budget Submitted to Congress to the FY 2018 Budget Submitted to Congress.** This paragraph provides a list of program elements/projects that are major new starts, restructures, developmental transitions, and terminated programs. Explanations for these changes can be found in the narrative sections of the Program Element R-2A Exhibits.

A. New Start Programs:

Budget Activity	OSDPE / Project	Project Title
02	0602126A / XW8	TRACTOR JACK
02	0602787A / XV5	Medical Capabilities to Support Dispersed Ops
04	0604020A / CF1	CFT Advanced Development & Prototyping
04	0604113A / EX8	Future Tactical Unmanned Aircraft System (FTUAS)
06	0605898A / FJ2	Army SHARP RDTE
06	0606942A / FL2	Cyber Vulnerabilities Assessments and Evaluations
07	0305179A / EF4	Integrated Broadcast System
07	0305206A / EH7	Guardrail Common Sensor (GRCS) Payloads (MIP)
07	0305206A / EH2	EMARSS ADV DEV (MIP)

B. Program Element/Project Restructures:

Budget Activity	Old OSDPE / Project: Title	New OSDPE / Project: Title
02	0602105A / H84: Materials	0602105A / XW4: Manufacturing Science
02	0602270A / 906: Tactical Electronic Warfare Applied Research	0602270A / CYB: Applied Offensive Cyber
02	0602782A / 779: Command, Control And Platform Electronics Tech	0602782A / CY2: Applied Defensive Cyber
02	0602782A / H92: Communications Technology	0602782A / CY2: Applied Defensive Cyber
02	0602786A / 283: Airdrop Adv Tech	0602786A / XW5: Small Unit Expeditionary Maneuver Technology
02	0602786A / H99: Joint Service Combat Feeding Technology	0602786A / XW5: Small Unit Expeditionary Maneuver Technology
02	0602786A / VT4: Expeditionary Mobile Base Camp Technology	0602786A / XW5: Small Unit Expeditionary Maneuver Technology
03	0603001A / C07: Joint Service Combat Feeding Tech Demo	0603001A / XW6: Small Unit Expeditionary Maneuver
03	0603001A / VT5: Expeditionary Mobile Base Camp Demonstration	0603001A / XW6: Small Unit Expeditionary Maneuver
03	0603001A / 242: Airdrop Equipment	0603001A / XW6: Small Unit Expeditionary Maneuver
03	0603270A / K15: Advanced Comm Ecm Demo	0603270A / CY3: Offensive Cyber Demonstration
03	0603270A / K16: Non-Commo Ecm Tech Dem	0603270A / CY3: Offensive Cyber Demonstration
04	0603639A / EL7: Reduced Range Ammunition	0604802A / EP3: Reduced Range Ammunition - Small Caliber
04	0603639A / EL8: LIGHTWEIGHT CARTRIDGE CASE FOR SMALL CALIBER	0607131A / ER6: Direct Fire Technology
04	0603639A / EU1: Enhanced Lethality Cannon Munitions	0604802A / EU7: Enhanced Lethality Cannon Munitions
04	0603639A / EU1: Enhanced Lethality Cannon Munitions	0604802A / EU6: 155mm HE Rocket Assist Project Extended Range
04	0604120A / ED5: Assured Positioning, Navigation and Timing (PNT)	1206120A / FJ8: Assured Positioning, Navigation and Timing (PNT)
04	0604120A / EH8: DISMOUNTED	1206120A / FJ9: Dismounted A-PNT
04	0604120A / EH9: PSEUDOLITES	1206120A / FK1: Pseudolites
04	0604120A / EJ2: MOUNTED	1206120A / FK2: Mounted A-PNT
04	0604120A / EJ3: ANTI-JAM ANTENNA	1206120A / FK3: Anti-Jam Antenna
05	0210609A / ED8: Paladin Integrated Management (PIM)	0203743A / FF9: PIM Improvement Program
05	0604798A / FG7: Emerging Technology Initiatives	0604798A / FI3: Rapid Capability Development and Maturation
05	0604827A / S65: Platoon Power Generator	0604827A / EY3: Soldier Power Generator
05	0605053A / FB4: Common Robotic Systems	0605053A / FG8: Common Robotic Controller
07	0303028A / FG2: Counterintelligence & Human Intel Modernization	0606003A / FI9: Counterl Intel and Human Intel Modernization
07	0205402A / EF2: Integrated Base Defense	0605029A / EQ2: IntegGrdSecSurvRespC(IGSSR-C)
07	0205402A / EF2: Integrated Base Defense	0605033A / EQ3: Grnd-Based Opnl Surv Sys -Exped (GBOSS-E)
07	0303142A / 253: Dscs-Dcs (Phase II)	1203142A / FE1: Dscs-Dcs (Phase II)
07	0303142A / 456: MILSATCOM System Engineering	1203142A / FE2: MILSATCOM System Engineering
07	0303142A / EK8: Enroute Mission Command	1203142A / FE4: Enroute Mission Command

C. Program Terminations:

Budget Activity	OSDPE / Project	OSDPE Title / Project Title
01	0601103A / V72	University Research Initiatives / Minerva; project ends
01	0601104A / H50	University and Industry Research Centers / Network Sciences Cta; project ends
01	0601104A / H53	University and Industry Research Centers / Army High Performance Computing Research Center; project ends
01	0601104A / H54	University and Industry Research Centers / Micro-Autonomous Systems Technology (MAST) CTA; project ends
02	0602105A / H7G	Materials Technology / Nanomaterials Applied Research; project ends
02	0602120A / SA2	Sensors and Electronic Survivability / Biotechnology Applied Research; project ends
02	0602705A / H17	Electronics and Electronic Devices / Flexible Display Center; project ends
02	0602720A / 895	Environmental Quality Technology / Pollution Prevention; project ends
03	0603001A / 543	Warfighter Advanced Technology / Ammunition Logistics; project ends
03	0603015A / S28	Next Generation Training & Simulation Systems / Immersive Learning Environments; project ends
03	0603020A / DB1	TRACTOR ROSE / DDB1; project ends
03	0603606A / 683	Landmine Warfare and Barrier Advanced Technology / Area Denial Sensors; project ends
03	0603728A / 025	Environmental Quality Technology Demonstrations / Pollution Prevention Technology; project ends
04	0604115A / EX3	Technology Maturation Initiatives / Ground Vehicle Prototyping; project ends
05	0604290A / DW1	Mid-tier Networking Vehicular Radio (MNVR) / Mid-Tier Wideband Networking Vehicular Radio Mnvr; project ends
05	0604321A / B41	All Source Analysis System / CI/HUMINT Software Products (MIP); project ends
05	0604321A / B51	All Source Analysis System / Machine - Foreign Language Translation System; project ends
05	0604818A / 334	Army Tactical Command & Control Hardware & Software / Common Software; project ends
06	0303260A / FA9	Defense Military Deception Initiative / Security Initiatives; project ends
06	0604759A / FA4	Major T&E Investment / Warrior Injury Assessment Manikin (WIAMan); transitions to procurement
07	0202429A / EP8	Aerostat Joint Project - COCOM Exercise / COCOM Exercise; project ends
07	0203740A / 484	Maneuver Control System / Maneuver Control System; project ends
07	0303142A / EA3	SATCOM Ground Environment (SPACE) / Transportable Tactical Cmd Comms (T2C2); transitions to procurement
07	0303150A / EA5	WWMCCS/Global Command and Control System / Strategic and Joint Mission Command; transitions to procurement
07	0305219A / MQ1	MQ-1 Gray Eagle UAV / MQ-1 Gray Eagle - Army UAV (MIP); project ends
07	0607140A / ES7	Emerging Technologies from NIE / Emerging Technologies from NIE; project ends
07	0607141A / DY1	Logistics Automation / Logistics Information Warehouse (LIW); project ends

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

Exhibit R-2, RDT&E Budget Item Justification: PB 2019 Army											Date: February 2018	
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*							
COST ($ in Millions)	**Prior Years**	**FY 2017**	**FY 2018**	**FY 2019 Base**	**FY 2019 OCO**	**FY 2019 Total**	**FY 2020**	**FY 2021**	**FY 2022**	**FY 2023**	**Cost To Complete**	**Total Cost**
Total Program Element	-	11.936	12.010	11.585	-	11.585	11.779	12.017	12.262	12.504	Continuing	Continuing
91A: *ILIR-AMC*	-	11.035	11.069	10.626	-	10.626	10.800	11.018	11.242	11.464	Continuing	Continuing
F16: *ILIR-SMDC*	-	0.901	0.941	0.959	-	0.959	0.979	0.999	1.020	1.040	Continuing	Continuing

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 PE supports ILIR at the Army Materiel Command's (AMC) six Research, Development, and Engineering Centers (Project 91A), 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.

B. Program Change Summary ($ in Millions)	**FY 2017**	**FY 2018**	**FY 2019 Base**	**FY 2019 OCO**	**FY 2019 Total**
Previous President's Budget	12.381	12.010	11.594	-	11.594
Current President's Budget	11.936	12.010	11.585	-	11.585
Total Adjustments	-0.445	0.000	-0.009	-	-0.009
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-0.440	-			
• Adjustments to Budget Years	-	-	-0.009	-	-0.009
• FFRDC	-0.005	-	-	-	-

Exhibit R-2, RDT&E Budget Item Justification: PB 2019 Army	Date: February 2018
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*

Change Summary Explanation

DODI Funding and Execution Guidelines state the ILIR program should have a target ceiling of 2.5% of the total 6.1 budget. The reduction in funding is to better align the ILIR budget with DODI guidance.

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army			Date: February 2018
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 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
91A: *ILIR-AMC*	-	11.035	11.069	10.626	-	10.626	10.800	11.018	11.242	11.464	Continuing	Continuing

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 in new combat vehicle, armor, and robotics/autonomy.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Edgewood Chemical Biological Center	0.995	1.056	0.973
Description: Funds basic research in chemistry, biology, biotechnology, and aerosol for countering improvised explosive devices (IEDs), obscurants, and/or target defeat. Work in this Project provides theoretical underpinnings for Program Element (PE) 0602622A (Chemical, Smoke, and Equipment Defeating Technologies). ***FY 2018 Plans:*** Conduct fundamental research in synthetic biology focusing on understanding genetic drift, mutation rates, as well as the structure function relationships of proteins. Explorations into molecular toxicology focus on developing the use of human and animal pluripotent stem cells to derive toxicological end points rather than using whole animal studies. Physical and mathematical investigations into aerosol particle behaviors to help develop knowledge on their behavior during deposition into the atmosphere as well as in the respiratory tract. ***FY 2019 Plans:*** Will conduct fundamental research in hierarchical systems through selective deposition and growth of metal-organic frameworks; synthetic biology will focus on understanding genetic drift, mutation rates, as well as the structure function relationships of proteins; and will extend physical and mathematical investigations into aerosol particle charge behaviors that will help develop knowledge on their behavior during deposition into the atmosphere as well as in the respiratory tract. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** DODI Funding and Execution Guidelines state the ILIR program should have a target ceiling of 2.5% of the total 6.1 budget. The reduction in funding is to better align the ILIR budget with DODI guidance.			
Title: Armaments Research, Development and Engineering Center	1.498	1.417	1.435

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
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 2018 Plans:*** Perform basic research in light-weight thermoplastic composites, compact and more lethal warheads, synthesis and characterization of more powerful and less sensitive explosives, area denial technologies, advanced structural materials and new materials for electronic sensing devices. ***FY 2019 Plans:*** Will continue to conduct basic research that provides the underpinnings necessary for developing new explosives and propellants, smaller and more lethal warheads, lighter and stronger composite materials for guns and weapon platforms, algorithms for future intelligent munitions, and area denial technologies. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding level increase reflects growth due to inflation.			
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 2018 Plans:*** Conduct efforts to further basic research in areas of strategic importance to Army ground vehicles such as increased control/ mobility of autonomy enabled-systems involving latency compensation using innovative numerical techniques, teleoperation in high-speed, long distance scenarios, anticipatory dynamic Bayesian network for intelligent navigation, methods for detection of high velocity projectiles, real-time panorama generation in tele-immersive combat vehicle operations, deep incremental learning and trust algorithms, novel computationally-efficient numerical modeling of vehicle interactions with deformable terrain, diesel engine heat transfer model development, machine learning, and quantum modeling and computation. ***FY 2019 Plans:*** Will solicit research proposals to improve understanding and accelerate technology development focused on those topics of strategic importance to the Army ground vehicle community such as; semi-, fully-, and multiple autonomous vehicle operation and control, ground vehicle cybersecurity threat detection algorithms and resilience, lightweight materials and dissimilar material joining for thick section materials, advanced energy storage materials, corrosion modeling, and early detection mechanisms, and electrophoretic displays. ***FY 2018 to FY 2019 Increase/Decrease Statement:***	1.300	1.306	1.230

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
DODI Funding and Execution Guidelines state the ILIR program should have a target ceiling of 2.5% of the total 6.1 budget. The reduction in funding is to better align the ILIR budget with DODI guidance.			
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 2018 Plans:*** Explore the feasibility of creating a conductive fibrous platform through the integration of iridium oxide nanoparticles; characterize the structure and electrochemical properties of the iridium oxide nanoparticles and explore applicability to wearable sensing and power; design frequency selective surface antenna arrays tailored for chemical detection; explore discrimination of surface antenna arrays through numerical electromagnetic simulations that explore parameters such as individual antenna element shape/ dimensions, spacing between antenna elements, choice of metal, and spectral shifts produced by metal oxides. ***FY 2019 Plans:*** Will combine theoretical and experimental studies to investigate point contact antenna response to infrared/visible laser beams and understand photon-assisted tunneling (PAT), conductance, and rectification to advance future capability of lightweight, tunable visible/infrared Soldier borne power harvesting systems. Will explore creating liquid crystals with tunable melting points and establish an understanding of the phases, and phase transitions of liquid crystals when confined in polymer matrices to enable future development of lightweight ?smart? textiles that can efficiently respond to external stimuli. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** DODI Funding and Execution Guidelines state the ILIR program should have a target ceiling of 2.5% of the total 6.1 budget. The reduction in funding is to better align the ILIR budget with DODI guidance.	1.200	1.150	1.123
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 2018 Plans:*** Investigate chaotic dynamics in linear and piecewise linear systems; understand new paradigm in continuum electrodynamics by deriving self-consistent treatment that includes relativity and conservation of momentum and energy; conclude demonstration of proof-of-concept ultraviolet photocatalytic splitting of molecular bonds using plasmonic metal nanoparticles; complete investigation	2.392	2.439	2.345

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
on polarization-sensitive terahertz holographic imaging (for mapping strain in opaque materials); and explore efficient opto-electro-plasmonic devices through electromagnetic interactions at artificial surfaces. ***FY 2019 Plans:*** Will investigate optimal signal detection using mutual information to improve radar performance; will explore the connection between nonlinear dynamics and communication theory to engineer chaotic oscillators in wireless datalinks, radar, and acoustic sensor devices; design hybrid nano-antennas based on nested and nearly overlapping plasmonic resonant modes for enhanced sensing, detection, energy harvesting, and nanoscale light manipulation; will explore effects of low pressure collision broadening and interatomic forces for atom-based inertial navigation sensors; will investigate linear and nonlinear optical materials with dielectric constant near zero for accurate clocks used for GPS and inertial navigation. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** DODI Funding and Execution Guidelines state the ILIR program should have a target ceiling of 2.5% of the total 6.1 budget. The reduction in funding is to better align the ILIR budget with DODI guidance.			
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 2018 Plans:*** Conduct interactional aerodynamics investigations of the wake physics and inflow dynamics of multiple rotor configurations; explorer improved design of fluidic control actuators through boundary layer flow control studies; extend higher order unstructured grid solvers that leverage emerging exascale computer architecture to flow over complex geometries. ***FY 2019 Plans:*** Will conduct research on measurement techniques such as a hub-based camera system for rotor blade deformation measurements, microelectromechanical systems based sensors for unsteady airfoil pressure gradient measurements, and tomographic particle image velocimetry for volumetric flow measurements; will conduct research on parallel-in-time computational fluid dynamics algorithms to realize the computation speed benefits of emerging peta-scale computer architecture. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** DODI Funding and Execution Guidelines state the ILIR program should have a target ceiling of 2.5% of the total 6.1 budget. The reduction in funding is to better align the ILIR budget with DODI guidance.	1.400	1.411	1.337
Title: Communications-Electronics Research, Development, and Engineering Center	2.250	2.290	2.183

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
Description: Funds basic research for communication and network enabling technologies in the areas of antenna design, network management, power generation and storage, and sensors. Work in this Project provides theoretical underpinnings for PE 0602705A (Electronics and Electronic Devices). ***FY 2018 Plans:*** Conduct research on the intrinsic efficiencies of non-foster matching methods at radio frequencies with a focus on full stability analysis; splitting of radio network traffic over multipath to maximize throughput performance for traffic flows by using new fluid-flow models to support dynamic topology; research 3D printing of tunable coils and matching networks with precisely controlled impedance and resonant frequencies resulting in tunable structures that can be activated in a controlled manner to change the shape or configuration of the solid in response to an external stimulus; determine the most effective information visualization methods and/or perspectives for commander understanding of the cyber domain and its relationship to mission command in the physical domain; research high performance, rechargeable, safe Lithium Sulphur (LiS) battery chemistry; experimentally confirm the performance of synthesized catalysts that can promote the production of synthesis gas (carbon monoxide (CO) and hydrogen (H2)) from carbon dioxide and hydrogen with high CO selectivity and high yield; research novel optical properties of retro-reflections, with an emphasis on polarization, to characterize and discriminate between different objects; research active and passive longwave infrared (LWIR) detection with a long term goal of produce focal plane arrays capable of passive longwave and active 3D imaging; research novel molecular beam epitaxy growth techniques that mitigate antimony cross incorporation in Gallium-free superlattice detectors; research novel characterization techniques, investigate the inherent materials issues, and associated processes that limit the performance of LWIR focal plane arrays with diffraction-limited pixel-pitch. ***FY 2019 Plans:*** Will conduct research on techniques for reducing the computational complexity and burden associated with massive multiple input ? multiple output antenna arrays; will research the mathematical relationship between the electric permittivity, magnetic permeability and thickness of the metamaterial in a conformal antenna; will research energy harvesting which has a net zero or net positive effect on the metabolic rate by only harvesting energy during certain stages of the gait cycle; will research deep learning algorithms and confidence-based likelihoods associated with classification decisions; will innovate and create new integrable material solutions to enable smaller, lower cost phase shifters and tunable filters for use in radar, electronic warfare and communications systems; will research phase shifting diode networks to use with 2-dimensional planar phased array with integrated antennas that operate at 60GHz ~ 1 THz; and will research material parameters and device models for high fidelity simulation of III-V and II-VI optoelectronics. ***FY 2018 to FY 2019 Increase/Decrease Statement:***			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
DODI Funding and Execution Guidelines state the ILIR program should have a target ceiling of 2.5% of the total 6.1 budget. The reduction in funding is to better align the ILIR budget with DODI guidance.			
Accomplishments/Planned Programs Subtotals	11.035	11.069	10.626

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 2019 Army			Date: February 2018
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 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
F16: *ILIR-SMDC*	-	0.901	0.941	0.959	-	0.959	0.979	0.999	1.020	1.040	Continuing	Continuing

A. Mission Description and Budget Item Justification

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

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

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: SMDC In-house Laboratory Independent Research	0.901	0.941	0.959
Description: Funds basic research to investigate laser propagation phenomenology for application in modeling and simulation and future directed energy weapons design. Activities in this Project transition to High Energy Laser Technology in PE 0602307A (Advanced Weapons Technology). ***FY 2018 Plans:*** Complete experiments to understand the feasibility of a diode pumped Xenon gas laser; conduct an experiment of a direct diode concept to measure efficiency and beam quality and see how the results compare to traditional solid state lasers; and complete analysis of the beaconless adaptive optics approach for correcting a laser beam for propagation in the presence of particulates. ***FY 2019 Plans:*** Will complete data analysis and verification of engineering models to understand the viability of increasing the power to 10?s of watts for a diode pumped Xenon gas laser; will investigate a laboratory bench top experiment of a direct diode concept to combine 10?s of diode sources into a single laser beam at the milli-watt level to understand key laser metrics and begin to evaluate scalability of the approach to watt class; and will complete investigation of the beaconless adaptive optics approach for correcting a high energy laser beam (greater than 10kW) for propagation in the presence of particulates beyond 1km. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels increased due to inflation.			
Accomplishments/Planned Programs Subtotals	0.901	0.941	0.959

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601101A / *In-House Laboratory Independent Research*	**Project (Number/Name)** F16 / *ILIR-SMDC*

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 2019 Army											Date: February 2018	
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 2017**	**FY 2018**	**FY 2019 Base**	**FY 2019 OCO**	**FY 2019 Total**	**FY 2020**	**FY 2021**	**FY 2022**	**FY 2023**	**Cost To Complete**	**Total Cost**
Total Program Element	-	286.086	263.590	276.912	-	276.912	290.545	294.807	303.913	309.996	0.000	2,025.849
305: *ATR Research*	-	2.026	2.102	2.142	-	2.142	2.186	2.231	2.276	2.322	0.000	15.285
31B: *Infrared Optics Rsch*	-	4.146	3.742	3.748	-	3.748	3.752	3.753	3.812	3.889	0.000	26.842
52C: *Mapping & Remote Sens*	-	2.028	2.101	2.141	-	2.141	2.185	2.228	2.273	2.318	0.000	15.274
53A: *Battlefield Env & Sig*	-	3.769	3.892	3.971	-	3.971	4.055	4.135	4.218	4.303	0.000	28.343
74A: *Human Engineering*	-	13.022	14.057	15.532	-	15.532	15.852	16.136	16.445	16.774	0.000	107.818
74F: *Pers Perf & Training*	-	5.345	5.485	5.586	-	5.586	5.699	5.812	5.930	6.049	0.000	39.906
ET6: *BASIC RESCH IN CLINICAL & REHABILITATIVE MED*	-	4.039	4.780	4.866	-	4.866	1.260	1.034	1.048	1.069	0.000	18.096
F20: *Adv Propulsion Rsch*	-	4.164	3.460	3.545	-	3.545	3.637	3.726	3.818	3.894	0.000	26.244
F22: *Rsch In Veh Mobility*	-	0.691	0.735	0.749	-	0.749	0.765	0.778	0.795	0.811	0.000	5.324
H42: *Materials & Mechanics*	-	8.502	9.748	12.211	-	12.211	12.262	12.556	12.868	13.125	0.000	81.272
H43: *Research In Ballistics*	-	8.352	11.319	11.723	-	11.723	12.032	12.304	12.659	12.912	0.000	81.301
H44: *Adv Sensors Research*	-	9.222	8.899	9.915	-	9.915	10.590	10.861	11.099	11.321	0.000	71.907
H45: *Air Mobility*	-	2.273	2.410	2.458	-	2.458	2.506	2.556	2.608	2.660	0.000	17.471
H47: *Applied Physics Rsch*	-	4.197	5.689	5.848	-	5.848	5.434	5.559	5.676	5.790	0.000	38.193
H48: *Battlespace Info & Comm Rsc*	-	27.497	31.394	32.292	-	32.292	36.816	37.397	38.249	39.014	0.000	242.659
H52: *Equip For The Soldier*	-	1.131	1.156	1.178	-	1.178	1.204	1.228	1.252	1.277	0.000	8.426
H57: *Single Investigator Basic Research*	-	91.394	96.081	101.427	-	101.427	104.903	106.378	110.626	112.839	0.000	723.648
H66: *Adv Structures Rsch*	-	2.053	3.108	3.153	-	3.153	3.197	3.240	3.285	3.350	0.000	21.386
H67: *Environmental Research*	-	0.893	1.036	1.065	-	1.065	1.085	1.107	1.130	1.155	0.000	7.471
S13: *Sci BS/Med Rsh Inf Dis*	-	11.118	11.039	11.272	-	11.272	11.509	11.501	12.253	12.498	0.000	81.190
S14: *Sci BS/Cbt Cas Care Rs*	-	5.520	5.296	5.610	-	5.610	7.945	8.578	9.082	9.264	0.000	51.295

Exhibit R-2, RDT&E Budget Item Justification: PB 2019 Army													Date: February 2018
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*								
S15: *Sci BS/Army Op Med Rsh*	-	6.600	7.116	6.443	-	6.443	9.654	9.093	8.710	8.884	0.000	56.500
T14: *BASIC RESEARCH INITIATIVES - AMC (CA)*	-	40.000	0.000	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	40.000
T22: *Soil & Rock Mech*	-	4.405	4.606	4.695	-	4.695	4.788	4.883	4.982	5.082	0.000	33.441
T23: *Basic Res Mil Const*	-	1.708	1.781	1.815	-	1.815	1.850	1.887	1.929	1.968	0.000	12.938
T24: *Signature Physics And Terrain State Basic Research*	-	1.641	1.685	1.720	-	1.720	1.755	1.792	1.828	1.865	0.000	12.286
T25: *Environmental Science Basic Research*	-	6.853	6.708	6.845	-	6.845	6.990	7.139	7.797	7.953	0.000	50.285
T63: *Robotics Autonomy, Manipulation, & Portability Rsh*	-	8.468	8.847	9.546	-	9.546	11.112	11.281	11.516	11.746	0.000	72.516
T64: *Sci BS/System Biology And Network Science*	-	2.860	3.025	3.079	-	3.079	3.139	3.203	3.268	3.333	0.000	21.907
VR9: *Surface Science Research*	-	2.169	2.293	2.337	-	2.337	2.383	2.431	2.481	2.531	0.000	16.625

Note

There is a realignment of funding from Project H7G under PE 0602105 (which is in Budget Authorization 2) to Project H42.

A. Mission Description and Budget Item Justification

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

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

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 2019 Army	Date: February 2018
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 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total
Previous President's Budget	253.116	263.590	277.166	-	277.166
Current President's Budget	286.086	263.590	276.912	-	276.912
Total Adjustments	32.970	0.000	-0.254	-	-0.254
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	40.000	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-6.945	-			
• Adjustments to Budget Years	-	-	-0.254	-	-0.254
• FFRDC	-0.085	-	-	-	-

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2017	FY 2018
Project: T14: *BASIC RESEARCH INITIATIVES - AMC (CA)*		
Congressional Add: *Congressional Program Increase*	40.000	-
Congressional Add Subtotals for Project: T14	40.000	-
Congressional Add Totals for all Projects	40.000	-

Change Summary Explanation

Funding increase to support increased investments in robotics, sensors, materials, battlespace information and communication sciences, human-machine teaming, and the extramural single investigator program.

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army											Date: February 2018	
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 2017**	**FY 2018**	**FY 2019 Base**	**FY 2019 OCO**	**FY 2019 Total**	**FY 2020**	**FY 2021**	**FY 2022**	**FY 2023**	**Cost To Complete**	**Total Cost**
305: *ATR Research*	-	2.026	2.102	2.142	-	2.142	2.186	2.231	2.276	2.322	0.000	15.285

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. 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 United States (U.S.) Army Armaments Research, Development, and Engineering Center (ARDEC); the U.S. Army Communications-Electronics Research, Development, and Engineering Center (CERDEC); and the U.S. Army Edgewood Chemical Biological Center (ECBC).

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

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: ATR Algorithms	2.026	2.102	2.142
Description: Investigate new algorithms to improve aided/unaided target detection and identification.			
FY 2018 Plans: Investigate approaches for image and video analytics and scene understanding at the tactical edge using resource constrained computation platforms for Soldiers and unmanned vehicle/robotic systems; investigate joint text and video approaches for semantic summarization of unconstrained videos; create methods for augmented 3-D scene segmentation and unsupervised			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
labeling of objects viewed at different perspectives in geo-located areas of interest; and create algorithms for producing and fusing photogrammetry-based point clouds and hyperspectral data collected from multiple flying platforms. ***FY 2019 Plans:*** Will investigate approaches for image and video analytics and scene understanding at the tactical edge using resource constrained computation platforms for Soldiers and unmanned vehicle/robotic systems; will investigate joint text and video approaches for semantic summarization of unconstrained videos; will create algorithms for producing and fusing photogrammetry-based point clouds and multimodal image data collected from multiple flying platforms; will investigate light-field based image processing for enhancing situational awareness in degraded visibility environments. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels increased due to inflation.			
Accomplishments/Planned Programs Subtotals	2.026	2.102	2.142

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 2019 Army											Date: February 2018	
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 2017**	**FY 2018**	**FY 2019 Base**	**FY 2019 OCO**	**FY 2019 Total**	**FY 2020**	**FY 2021**	**FY 2022**	**FY 2023**	**Cost To Complete**	**Total Cost**
31B: *Infrared Optics Rsch*	-	4.146	3.742	3.748	-	3.748	3.752	3.753	3.812	3.889	0.000	26.842

A. Mission Description and Budget Item Justification

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

Work in this Project supports key Army needs and provides the technical underpinning to Program Element (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.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Optoelectronic and Integrated Photonic Materials and Device Research	4.146	1.005	1.000
Description: Conduct research into materials and structures used for infrared (IR) devices, ultraviolet (UV) emitters and detectors, and integrated photonic devices to increase situational awareness in open and complex terrains; improve target detection, identification, and discrimination; and create new device functionality while reducing size, weight, and power requirements.			
FY 2018 Plans:			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
Perform fundamental studies of carrier transport and vertical light emission in near-UV heterostructures in III-Nitrides to address the challenges associated with device efficiency; demonstrate reduction in surface and side-wall charge accumulation in IR devices through novel passivation using atomic layer deposition; design and develop semiconductor-based integrated photonic devices using new metamaterial or device architectures to obtain new and multiple functionalities such as processing microwave signals in the optical domain. ***FY 2019 Plans:*** Will explore the deposition of cadmium telluride (CdTe) passivation layers by low temperature atomic layer deposition (ALD) to reduce leakage currents in mercury cadmium telluride (MCT) based infrared detectors; will investigate carrier transport studies on semi-polar and non-polar III-Nitride semiconductor heterostructures to improve radiative and injection efficiencies in ultraviolet light emitting structures; and will perform fundamental studies on chip-scale integrated photonic structures with the goal of identifying critical features, such as interaction length for appropriate Stimulated Brillouin Scattering (SBS), then will examine a parametric trade space of photonic structures and materials capable of providing needed response to achieve narrowband filtering over a large RF photonic bandwidth. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels decreased to enable support of Advanced Materials research.			
Title: Advanced Materials	-	2.737	2.748
Description: Investigation of the fundamental physics of energy, charge, and spin materials with an emphasis on understanding the transport along and across novel designed surfaces and active heterogeneous interfaces to achieve new electronic/ optoelectronic device functionalities. Additionally, study beta-photovoltaic and beta-voltaic energy capture. ***FY 2018 Plans:*** Explore surface properties of Indium Arsenide Antimonide (InAsSb) to study the topological state phenomenon on the surfaces of this material; study the external field dependence of topological insulator phase transition of Indium Nitride (InN) structures as a function of gate bias and study the bulk bandgap tunability and its effect on bulk conductivity; study the role of hot electron effects which affect the current and catalytic over-potential in a photoelectrode necessary for water splitting; study the relevant electrical properties of Gallium Nitride Antimonide (GaNSb) for water splitting power generation applications; study diamond surface conduction channels to enable ultra-high frequency and high power-density RF devices; explore complex crystal properties in hybrid one-dimensional (1D) molecular chains and two-dimensional (2D) van der Waals-stacked layered solids to serve as building blocks for high performance and low power electronics; and investigate beta-photovoltaic and beta-voltaic hybrid energy conversion efficiencies. ***FY 2019 Plans:*** Will measure the transport properties, triple-point topological state characteristics, and bulk bandgap tunability and conductivity of indium-containing quantum well structures; will investigate Indium Gallium Nitride (InGaN) electrodes integrated with catalysts to			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
understand and quantify photovoltage boost under photo-electrochemical conditions and study doping characteristics of GaNSb for energy production applications utilizing water splitting; will study transport properties and defect chemistries of intrinsic vacancy materials developed using atomic layer deposition; and will investigate diamond-based semiconductor devices to exceed Gallium Nitride (GaN) performance in frequency and power handling of RF energy. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Increase due to inflation			
Accomplishments/Planned Programs Subtotals	4.146	3.742	3.748

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 2019 Army			Date: February 2018
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 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
52C: *Mapping & Remote Sens*	-	2.028	2.101	2.141	-	2.141	2.185	2.228	2.273	2.318	0.000	15.274

A. Mission Description and Budget Item Justification

This Project increases knowledge of terrain and human geography with a focus on improving the generation, management, analysis/reasoning, and modeling of geospatial data, and the exploitation of multi-source 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 operating environment. Results of this research are used to: extract and characterize natural and man-made features from reconnaissance imagery in near-real time; understand socio-cultural influences; exploit terrain analysis and reasoning techniques; and explore the potential of space, airborne, and terrestrial geospatial sensor technologies to provide real-time geospatial intelligence to all Army Warfighting functions. This research uses terrain and socio-cultural data to improve situational awareness and enhance information dominance, leading to increased survivability, lethality, and mobility.

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

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Sensor Phenomenology and Spatial-Temporal Pattern Discovery	2.028	2.101	2.141
Description: Conduct fundamental research to inform the development of applications, techniques, and tools to improve the tactical commander's knowledge of the operating environment.			
FY 2018 Plans: Characterize seismic sources caused by human activity; link biogeochemical measurements and remote sensing signals from permafrost bog systems that are in transition and from stable bogs; and explore the radiometric complexities between illumination and look angles of natural soils.			
FY 2019 Plans: Will statistically analyze collected laboratory data to examine for spectral and angular differences between undisturbed and disturbed soil samples and determine if relationships found in laboratory data apply to collected field data, and will quantitatively discriminate emitted dust particle size distributions by emission mechanism to better quantify and inform dust transport models and impacts on military operations.			
FY 2018 to FY 2019 Increase/Decrease Statement:			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
Funding levels increased due to inflation.			
Accomplishments/Planned Programs Subtotals	2.028	2.101	2.141

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 2019 Army			Date: February 2018
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 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
53A: *Battlefield Env & Sig*	-	3.769	3.892	3.971	-	3.971	4.055	4.135	4.218	4.303	0.000	28.343

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.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Predictive Modeling of the Boundary Layer	3.769	3.892	3.971
Description: Increase survivability and improve situational awareness for a variety of sensors, optics, and flying objects (e.g., projectiles, unmanned aircraft systems, etc.) through fundamental research to enhance accuracy of predictive modeling of the atmospheric boundary layer and improve the ability to function effectively in adverse conditions. ***FY 2018 Plans:*** Identify new methods of enhancing electro-optical communication signal transmission through atmospheric ?channels? that are created by ultra-short laser pulses; create an approach to conduct multi-modal wind sensing by merging Doppler wind Light Detection and Ranging (LiDAR) and radar data together to create highly accurate and detailed, remotely-sensed wind observations; investigate a new capability to optically trap atmospheric aerosol particles, allowing very precise measurement			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
and characterization of their composition; research numerical techniques for estimating atmospheric effects on the propagation of acoustic signals; investigate and incorporate a comprehensive atmospheric radiation algorithm into a microscale numerical weather prediction model, enhancing the accuracy of the forecasts by accounting for both dense urban and forest canopy domains; expand datasets and investigate correlations between meteorological conditions/observations and significant threat activities; and explore microscale model initialization and physics refinements based on boundary layer urban and complex terrain discoveries from the Meteorological Sensor Array and other high-resolution atmospheric sensing experiments. ***FY 2019 Plans:*** Will gather and apply Meteorological Sensor Array (MSA) data to: study near-surface processes that impact the flux of sediment, causing wind erosion and dust emission, will investigate fixed-wing and multi-rotor instrumented unmanned aircraft system (UAS) sampling strategies. Will study and enhance the understanding of atmospheric effects on high data rate optical communications between systems. Will expand radiative transfer modeling into environments with forest canopy; will begin coupling radiative transfer model and land surface energy budget in urban domains; will develop initial concepts in constraining machine learning for environmental prediction using physical modeling; will explore new environmental remote sensing techniques of atmospheric parameters, exploiting advances in Stimulated Raman Gain capabilities; will identify new methodologies to accelerate the characterization and analysis of ambient atmospheric aerosol composition. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels increased due to inflation.			
Accomplishments/Planned Programs Subtotals	3.769	3.892	3.971

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 2019 Army											Date: February 2018	
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 2017**	**FY 2018**	**FY 2019 Base**	**FY 2019 OCO**	**FY 2019 Total**	**FY 2020**	**FY 2021**	**FY 2022**	**FY 2023**	**Cost To Complete**	**Total Cost**
74A: *Human Engineering*	-	13.022	14.057	15.532	-	15.532	15.852	16.136	16.445	16.774	0.000	107.818

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).

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

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
Title: Translational Neuroscience	3.553	3.715	3.813
Description: Integrating neuroscience with traditional approaches to understanding Soldier behavior to enable systems designs that maximize Soldier performance. ***FY 2018 Plans:*** Identify novel functional models of visual search using combined measures of gaze position and neural activity in real-word tasks to quantify the effect of cognitive state on task performance; investigate data-driven classification methods to predict emergent behavior in complex tasks with time-evolving brain states; and utilize innovations in community detection analyses to link allegiance and flexibility of functional brain networks to variability in task performance. ***FY 2019 Plans:*** Will identify predictive models of visual search with Army-relevant stimulus luminance properties based on cognitive modeling of brain states and naturalistic eye movements; will investigate the impact of naturalistic sleep fluctuations on functional brain networks and task performance in a variety of cognitive tasks; and will understand the controllability of neural nodes and networks with electrical neurostimulation and functional brain activity to estimate impact on task performance. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels increased due to inflation and to expand research to examine the controllability of neural nodes and networks.			
Title: Human System Integration ? Cybernetics	5.031	5.205	5.207
Description: Apply a cybernetic approach (i.e., a 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 communications 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 2018 Plans:*** Understand the complexity of conceptual and theoretical closed-loop models of complex, functional, and adaptive behaviors focused on large-scale computational and neuronal models, including exploration of high-performance computing implementations; identify statistical models to improve human performance characterization and prediction, leveraging temporal dependencies inherent to closed-loop systems in human perception and human-system interactions; explore closed-loop (e.g., neuro- and bio-feedback, augmented reality) human-computer interactions for adaptive interfaces that account for individual differences in brain and behavioral dynamics; and apply machine learning and big data approaches to capture higher dimensional features in complex data for implementation in novel cybernetic approaches to human-system communications and interactions. ***FY 2019 Plans:***			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
Will leverage novel models of complex, functional, and adaptive behaviors to improve understanding of the underlying neural mechanisms involved in human information processing, including perception and sensorimotor control; will examine the role of temporal information integration in the adaptive changes underlying human perception, including how individuals adapt to changes in the relationships among multiple sensory inputs; will investigate how closed-loop (e.g., neuro- and bio-feedback, augmented reality) human-computer interactions can mediate cognitive task performance under varying conditions affecting neural, physiological, and/or cognitive state; and will apply statistical modeling approaches, including machine learning and big data approaches, to account for state-based changes in human behavior and physiology within novel cybernetic approaches to enhance human-system communications and interactions. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding increased due to inflation			
Title: Continuous Multi-Faceted Soldier Characterization for Adaptive Technologies ***Description:*** This effort will investigate technologies that provide the foundation for future Army systems to adapt to individual Soldier?s states, behaviors, and intentions in real-time. Enable high fidelity, continuous prediction that can account for continuous changes in Soldier?s physical, cognitive, and social states, such as stress, fatigue, task difficulty, trust, and situational awareness. ***FY 2018 Plans:*** Identify algorithms to predict changes in task performance in controlled environments on the basis of behavioral, physiological, environmental, and task-based factors; develop algorithms for interpreting state variability in pseudo-controlled environments; collect novel longitudinal, low-resolution, multi-faceted dataset from a large cohort (N > 50) of individuals for several months to characterize state variability in real-world environments ***FY 2019 Plans:*** Will understand prediction of individual task performance over time through analysis of longitudinal, multi-faceted, real-world dataset; will examine behavioral, physiological, environmental, and task-based factors influencing social dynamics; will identify methods to enable modeling of state variability over time using multi-level, systems-based approaches. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels increased to understand prediction of human performance.	3.228	3.873	4.227
Title: Training and Soldier Performance ***Description:*** Research relationship between training environment fidelity/level of immersion and Soldier performance and behavior. Understand the level of physical, perceptual, and cognitive interaction necessary for a simulated environment to affect performance similar to that in an 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 representative of the operational environment, implementation of these guidelines will enhance training effectiveness.	1.210	1.264	1.285

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
FY 2018 Plans: Explore the impact of state and trait measures in empirically-driven conceptual models that describe and predict the relationships between training environment design elements, individual user differences, and training outcomes. ***FY 2019 Plans:*** Will identify models of the impact of presence and other state/trait measures on relationships between immersion, gamification, other training environment design elements, individual user differences, and training outcomes. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels increased due to inflation.			
Title: Novel Forms of Joint Human-Intelligent Agent Decision Making ***Description:*** This effort will develop novel methods for joint human / intelligent agent learning and decision making so that strengths of individual humans and intelligent agents are accentuated and weaknesses are mitigated for improved, emergent group performance, emphasizing deep learning approaches that function under conditions of limited, mismatched, or dynamic data. ***FY 2019 Plans:*** Will develop a novel human-in-the-loop method of training artificial intelligence that outperforms standard AI training methods after similar amounts of trained time and data. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** New start effort to enable pursuit of knowledge for joint human / intelligent agent learning and decision making.	-	-	1.000
Accomplishments/Planned Programs Subtotals	13.022	14.057	15.532

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 2019 Army											Date: February 2018	
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 2017**	**FY 2018**	**FY 2019 Base**	**FY 2019 OCO**	**FY 2019 Total**	**FY 2020**	**FY 2021**	**FY 2022**	**FY 2023**	**Cost To Complete**	**Total Cost**
74F: *Pers Perf & Training*	-	5.345	5.485	5.586	-	5.586	5.699	5.812	5.930	6.049	0.000	39.906

Note

In Fiscal Year (FY) 2015 and 2016 the funding for Clinical and Rehabilitative Medicine is in Project S14. The Clinical and Rehabilitative Medicine basic research effort moves to Project ET6 starting in FY17.There is also a realignment of funding from Project H7G under PE 0602105 (which is in Budget Authorization 2) to Project H42.

A. Mission Description and Budget Item Justification

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

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

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Personnel Measures (previously Human Behavior)	1.805	1.915	1.914
Description: Basic research to develop innovative theories, models, and methods to improve personnel assessment, training, and leader development. ***FY 2018 Plans:*** Conduct research to advance theoretical knowledge of leadership development during deployment and in garrison. ***FY 2019 Plans:*** Will conduct research to identify job-performance measures that can inform assignment and to examine the validity of using non-traditional data for personnel assessment. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels decreased to enable support of improved knowledge to support Soldier Lethality for enhanced resilience. Funding decrease will result in a focusing of measures from theoretical understanding to specific job-performance measures.			
Title: Climate, Readiness, and Resilience (previously Human in Complex Organizations)	3.540	3.570	3.672

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
Description: 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 2018 Plans:*** Conduct research to advance theoretical understanding of how best to apply the learning of complex tactical/technical and interpersonal skills (in both formal & informal learning environments) to on-the-job performance to maximize unit readiness. ***FY 2019 Plans:*** Will conduct research to advance theoretical understanding of learning methods and principles to maximize development and transfer of complex cognitive skills; will conduct research to identify methods and computational models to better understand organizational processes and dynamics (e.g., team resilience, trust development, and adaptive flexibility). ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels increased to enable improved knowledge to Soldier Lethality for Soldier readiness and resilience.			
Accomplishments/Planned Programs Subtotals	5.345	5.485	5.586

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 2019 Army			Date: February 2018
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*	Project (Number/Name) ET6 / *BASIC RESCH IN CLINICAL & REHABILITATIVE MED*	

COST ($ in Millions)	Prior Years	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
ET6: *BASIC RESCH IN CLINICAL & REHABILITATIVE MED*	-	4.039	4.780	4.866	-	4.866	1.260	1.034	1.048	1.069	0.000	18.096

A. Mission Description and Budget Item Justification

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

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

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

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Clinical and Rehabilitative Medicine	4.039	4.780	4.866
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), genitalia (organs of reproduction), and abdomen.			
FY 2018 Plans: Investigate stem-cell released factors to identify promising and innovative therapies to regenerate damaged eye tissue. Characterize cellular mechanisms leading to vision dysfunction. Define and characterize cellular mechanisms that encourage growth of microvasculature (part of the circulatory system made up of the smallest vessels) for multiple tissue types such as hand transplants. Develop innovative biologics (pharmaceutical drug made from biological sources) to encourage improved regeneration of craniofacial tissues. Define biological markers for prognosis (predicting the likely outcome) of wound healing and scarring. Analyze immunomodulatory (modification of the immune response/immune system functioning) technologies that reduce the need for long term immune suppression following transplantation.			
FY 2019 Plans:			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** ET6 / *BASIC RESCH IN CLINICAL & REHABILITATIVE MED*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Will investigate the ability of a magnetic field to pull specialized therapeutic cells with metallic beads into the correct location to optimize the healing of key cellular layers necessary to restore vision. Will further investigate and characterize the pattern of molecules that impact immune response in the eye after injury to understand the timing of clinical impacts. Will further characterize cellular mechanisms leading to vision dysfunction. Will advance studies of cellular mechanisms that encourage growth of microvasculature (part of the circulatory system made up of the smallest vessels) for multiple tissue types muscle or bone. Will continue exploring innovative biologics (potential pharmaceuticals made from biological sources) to encourage improved regeneration of craniofacial tissues. Will define biological markers for prognosis (predicting the likely outcome) of wound healing and scarring. Will continue analysis of immunomodulatory (modification of the immune response/immune system functioning) technologies that reduce the need for long term immune suppression following transplantation. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Increase due to inflation adjustment.			
Accomplishments/Planned Programs Subtotals	4.039	4.780	4.866

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 2019 Army			Date: February 2018
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 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
F20: *Adv Propulsion Rsch*	-	4.164	3.460	3.545	-	3.545	3.637	3.726	3.818	3.894	0.000	26.244

A. Mission Description and Budget Item Justification

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

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

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Thermal Materials ***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.	4.164	-	-
Title: Vehicle Propulsion & Power Research ***Description:*** Basic research investigating engine and drivetrain technologies for Army manned-and-unmanned vehicles. Research investigates concepts and theories to provide enhanced tools, methods, and innovative concepts to enable improvements in propulsion power density, energy efficiency, reliability, and lifecycle cost for increased performance and capabilities in future Army systems. ***FY 2018 Plans:*** Investigate engine and drivetrain technologies to enable improved performance and reduced maintenance costs for Army vehicles including: 1) fuel ignition behavior at Army-relevant altitude and low-temperature conditions for fundamental understanding of multi-regime, multi-mode high-pressure turbulent combustion; 2) tailored gradient ceramic coating concepts for high-temperature, low thermal conductivity, sand resistance, and low particulate adherence for Army turboshaft engine hot section component performance and debris tolerance; and 3) advanced lubricant additives and corresponding chemistry interactions to protect highly-	-	3.460	3.545

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
loaded mechanical interfaces, such as gear and bearing surfaces, to meet Army needs for extended operation during loss-of-lubrication events. ***FY 2019 Plans:*** Will investigate propulsion engine and drivetrain technologies that will enable multi-fuel tolerant combustion in extreme environments, with improved debris tolerance, and thermal management/energy recovery of highly-loaded mechanical interfaces. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding increased to account for inflation and expand research into multi-fuel combustion.			
Accomplishments/Planned Programs Subtotals	4.164	3.460	3.545

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 2019 Army			Date: February 2018
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 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
F22: *Rsch In Veh Mobility*	-	0.691	0.735	0.749	-	0.749	0.765	0.778	0.795	0.811	0.000	5.324

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 (PE) 0602601A (Combat Vehicle and Automotive Technology).

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Advanced Mathematical Algorithms for Improved Vehicle Efficiency	0.691	0.735	0.749
Description: Research in support of advanced military mobility technologies with emphasis on Terramechanics (vehicle-terrain interaction), and complex vehicle dynamics and simulation. Research is directed at understanding advanced mathematical and computational methodologies using state-of-the-art analytical and empirical procedures. ***FY 2018 Plans:*** Further the development of the framework for the next-generation NATO Reference Mobility Model methodology with the end objective of establishing it as a NATO Standardization Agreement (STANAG document) for use by all NATO nations in development of tools that predict more accurate, operational evaluations for mobility and traversability. The research activity focuses on 6 key thrust areas: Geographic Information System (GIS) Terrain and Mobility Map, Simple Terramechanics, Mobility Standards, Complex Terramechanics, Intelligent Vehicle, Uncertainty treatment, and Verification and Validation. ***FY 2019 Plans:*** Will identify multi-scale computational algorithms that can model a large ground vehicle traversing over fine soil particles to their true size and geometry in one integrated mobility simulation robustly and hyper efficiently; will investigate Deep Learning to supplement high fidelity simulations in generating a Go/No-Go Mobility Map for a large geographic region; will develop human cognitive models to represent behavioral dynamics to work side-by-side with control algorithms in a semi-autonomous robotic system engaged in extreme mobility scenarios, thereby replacing the need for ?real human?-in-the-loop assessments; will assess how ?shared control? and ?control authority? will work, and how to benchmark full algorithmic control against human operators. The mobility performance is affected by the computational challenges faced by the autonomous algorithm; will address the			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** F22 / *Rsch In Veh Mobility*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
computationally intensive autonomy algorithms and extreme mobility scenarios that demand exceptional performance from the on-board computer such as accurate solutions in real time. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels increased due to inflation.			
Accomplishments/Planned Programs Subtotals	0.691	0.735	0.749

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 2019 Army											Date: February 2018	
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 2017**	**FY 2018**	**FY 2019 Base**	**FY 2019 OCO**	**FY 2019 Total**	**FY 2020**	**FY 2021**	**FY 2022**	**FY 2023**	**Cost To Complete**	**Total Cost**
H42: *Materials & Mechanics*	-	8.502	9.748	12.211	-	12.211	12.262	12.556	12.868	13.125	0.000	81.272

Note

There is a realignment of funding from Project H7G under PE 0602105 (which is in Budget Authorization 2) to Project H42.

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).

Funding for this Project is increased due to the need to facilitate discovery and exploitation of biologically-enabled manufacturing of complex nanomaterials with substantial potential to improve material behaviors that could support Army capabilities. The increase results from a realignment of funds from Project H7G under PE 0602105 (which is in Budget Authorization 2).

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Microscopic/Nanostructural Materials	2.314	3.072	3.143
Description: Devise new materials and design capabilities based upon fundamental concepts derived at the microscopic and nanostructural levels for the future force.			
FY 2018 Plans: Complete the development of an advanced computational model that will predict optimal processing parameters and chemistries for alloys and ceramics with improved strength and fracture toughness; and fully characterize a series of model fibers to determine the structure-property relationship as a function of processing.			
FY 2019 Plans:			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
Will synthesize nanostructured alloy systems to validate model predictions of grain size and grain boundary effects on mechanical response; and will investigate if nanostructured metal coatings can provide a 10-fold increase in corrosion protection with other tailorable properties using electrochemical processing from ionic liquids. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels increased due to inflation and to expand research into synthesis of nanostructured alloy systems.			
Title: High Deformation Rate Materials ***Description:*** Develop the fundamental understanding necessary to design, process, and characterize materials specifically intended for high loading-rate applications, as in armor and armaments. ***FY 2018 Plans:*** Develop and validate a fully coupled model that predicts the evolution of a failure event based on the dependence of initial microstructure and viscoelastic behavior of an alloy undergoing high-rate and extreme loading. ***FY 2019 Plans:*** Will investigate martensitic transformations in novel strain glass alloys for unique deformation mechanisms and identify a strategy for formulation of novel compositions; will demonstrate novel modeling strategies that link molecular dynamics simulations to continuum models of microfibril structure within single fibers of ultrahigh molecular weight polyethylene (UHMWPE). ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels increased due to inflation.	3.068	3.211	3.260
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 2018 Plans:*** Produce bulk material from optimized metal powders using hot-isostatic-press and fully characterize its microstructure and mechanical properties. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Effort ended due to technology maturation.	1.061	1.110	-
Title: Materiel Research and Processing Using High Energy Fields	2.059	2.355	2.437

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
Description: Explore interactions between materials and intense energy fields (magnetic, electric, pressure, etc.) to discover new pathways and mechanisms for controlling and altering material structure, enabling the development of new materials with unique property combinations and abilities to respond adaptively to battlefield conditions. ***FY 2018 Plans:*** Characterize new ceramic armor material produced using experimental parameters identified by preliminary models and iteratively refine models based on validation results. ***FY 2019 Plans:*** Will validate models using novel experiments to demonstrate enhanced fracture resistance in two-phase ceramic materials under electromagnetic fields; will develop new models to simulate the manipulation of intermolecular interactions with electromagnetic fields. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels increased to enable pursuit of novel materials to underpin future operational capabilities including Next Generation Combat Vehicles, Future Vertical Lift, and Soldier Lethality.			
Title: 1D and 2D Materials and Processing Research ***Description:*** Discover novel building block materials that provide disruptive protection mechanisms. Research includes synthesis, processing, characterization, and modeling to discover new 1-dimensional (1D) and 2-dimensional (2D) building block materials and associated assembly into protective membranes, smart fibers and films, and other molecular composite architectures. ***FY 2019 Plans:*** Will identify synthesis methods for novel 2D polymer molecules assembled with intermolecular hydrogen bonding to create graphene-like materials with enhanced toughness relative to graphene. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** New start effort to enable pursuit of knowledge to support novel materials for future operational capabilities.	-	-	1.645
Title: Precision Materials Synthesis and Assembly ***Description:*** Explore new biology-based methods for controlled synthesis and assembly to create materials with precise chemistries, microstructures, properties, and responsive functionalities through controlled molecular placement, spatial architectures, and interfacial structures. This research utilizes biological platforms that can act as micro-environments to control thermodynamics and govern reactions, thereby providing completely new pathways for materials discovery. ***FY 2019 Plans:***	-	-	1.726

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
Will explore scalable cell-free synthesis of enzymes and subsequent site-specific synthesis of rudimentary polymers that will serve as a foundation for dictating morphology in defense-relevant polymer fibers and membranes. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** New start effort to enable pursuit of knowledge to support novel materials for future operational capabilities.			
Accomplishments/Planned Programs Subtotals	8.502	9.748	12.211

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 2019 Army			Date: February 2018
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 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
H43: *Research In Ballistics*	-	8.352	11.319	11.723	-	11.723	12.032	12.304	12.659	12.912	0.000	81.301

A. Mission Description and Budget Item Justification

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

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

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Advanced Energetics Initiative	3.135	3.565	3.567
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 2018 Plans:*** Explore experimental techniques to maximize energy release of chemical formulations for either propulsive or energetic applications; explore methods for larger-scale production: create new computational models which can be used to predict solid-state reaction rates for energetic materials at extreme conditions for upscaling to higher-order models; and develop and validate detailed reaction chemistry representations of plasticizer blends for propulsive applications. ***FY 2019 Plans:*** Ultrafast laser based techniques will be applied to a variety of energetics in order to obtain a more fundamental understanding of detonation event. Will investigate the complexity of deflagration or combustion reactions using ballistic imaging. Will assess experimental characterization methods to measure detonation properties from a minimal amount of material and will validate them with large scale measurements. Will explore novel systems as candidates for disruptive-type energetic/propellant materials to increase the power of explosives and range/velocities of projectiles. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding increased due to inflation.			
Title: Launch and Flight of Gun Launched Projectiles as well as Missiles	1.978	2.892	2.976

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
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 2018 Plans:*** Derive mathematical frameworks and proofs of convergence for estimation of flight vehicle swarm states in absence of global positioning system; and conduct numerical experiments to demonstrate increased maneuverability of air vehicles using thrust-vector control or enhanced aerodynamic control. ***FY 2019 Plans:*** Will obtain fundamental understanding of flow mechanisms necessary to mitigate undesired vortex interactions or flow separation to ultimately enhance vehicle maneuver control; will establish theory for distributed estimation of multi-agent, high-speed systems with union of heterogeneous sensor signals. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels increased to enable improved knowledge to support Long Range Precision Fires for projectile launch.			
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 2018 Plans:*** Further advance computational methods that predict and explain simultaneous deformation and failure occurring under various ballistic and blast loading conditions; and perform recently developed experiments to validate multi-scale computations that quantify the cause of high-rate deformation. ***FY 2019 Plans:*** Will create new anisotropic/asymmetric model for flow and localization, and implement into ALE3D. Will perform ballistic model experiments on lightweight metals variants to probe range of flow behaviors exhibited. Will conduct additional experiments at the Dynamic Compression Sector. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels increased due to inflation.	2.505	3.711	3.786
Title: Humans in Extreme Ballistic Environments Research ***Description:*** Provide physics-based discovery of novel protection mechanisms through increased understanding of wave propagation through tissue, and the resulting deformation and damage of tissue during ballistic and blast events. ***FY 2018 Plans:***	0.734	1.151	1.394

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
Experimentally evaluate blast effects on tissues; model simulation techniques to produce three-dimensional (3D) shock environments; and experimentally evaluate 3D shock model and use results to refine model. ***FY 2019 Plans:*** Will develop a computational framework to study the effects of mechanical loading on voltage sensitive ion channels of the brain. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels increased to enable improved knowledge to support Soldier Lethality for enhanced human performance and survivability.			
Accomplishments/Planned Programs Subtotals	8.352	11.319	11.723

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 2019 Army			Date: February 2018
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 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
H44: *Adv Sensors Research*	-	9.222	8.899	9.915	-	9.915	10.590	10.861	11.099	11.321	0.000	71.907

A. Mission Description and Budget Item Justification

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

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

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

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Improving Sensor Research (previously Improving Sensor and Photonics Research (Nano))	2.339	1.547	1.597
Description: Create more survivable and secure sensors and displays, and investigate new magnetic- and electric-field sensor technologies for personnel, activity, and improvised explosive device (IED) detection. Develop novel algorithms and electromagnetic models to investigate radio frequency (RF) propagation and exploitation in complex clutter environments for improved RF and radar sensing.			
FY 2018 Plans:			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
Investigate notch-filling techniques in the RF spectrum for wideband radar application; investigate micro-Doppler effects and algorithms for threat unmanned air system (UAS) modeling and detection research; apply infrasound propagation theory and develop new algorithms to enhance localization accuracy and classification in complex wind and flow environments and propagation channels; develop modeling and simulation techniques and algorithms for electrical- and magnetic-field sensing of targets, terrain, power lines, sensors and sensor platforms influenced by complex field interaction; explore distributed change detection by fusion of sensor and open source text; and research adaptive distributed multiple target tracking over bandwidth constrained networks. ***FY 2019 Plans:*** Will investigate the development of new methods to efficiently solve extremely complex quasi-static electric/magnetic-field boundary-element problems on DoD supercomputers for wide-area power lines; will research joint estimation and fusion of human generated measurements for crowd sourcing applications; will research distributed deep learning fusion with low cost, low energy electro-optic sensors for robust target classification; will research decentralized quickest change detection algorithms and performance metrics; and will develop fundamental electro-magnetic models and signal processing algorithms to support airborne sensing of ground-based concealed targets using networked based distributed sensing concepts. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels increased due to inflation			
Title: Multi-scale Modeling for Novel Materials ***Description:*** Explore and develop multi-scale modeling techniques to support fundamental studies of electronic and structural materials properties from the atomistic to the continuum. Resulting models will be used to design and develop materials for more efficient, longer lifetime sensors and power and energy devices, and lighter materials for vehicle and soldier protection. This effort includes research that leverages two 5-year Collaborative Research Alliances (CRAs): the Materials in Extreme Dynamic Environments CRA and the Multi-scale/Multidisciplinary Modeling of Electronic Materials CRA. These CRAs are funded under PE 0601104A/Project VS2 (Multi-scale Materials Modeling Centers). ***FY 2018 Plans:*** Create numerical methods and algorithms to enable new high-fidelity multi-scale computer simulations of materials capable of taking full advantage of emerging large-scale heterogeneous computing environments; and develop computational methodologies to advance the state-of-the-art of at-scale computer models of materials, from the electronic scale through atomistic- and meso-scale to continuum, to take full advantage of emerging large-scale heterogeneous computing environments. ***FY 2019 Plans:***	2.776	2.899	2.936

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
Will explore uncertainty of model predictions; will explore approaches to employing state-of-the-art computing architectures, which enable large-scale numerical processing; and will advance the bridging of at-scale models, across the electronic- to atomic- to meso- to macro-scales. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels increased due to inflation.			
Title: Biological and Bio-inspired Materials and Devices Research ***Description:*** Create synthetic biological materials for devices and sensors that can be used by the Army to improve force protection and reduce logistical burden. ***FY 2018 Plans:*** Explore improved large-scale models of microbial consortia in concert with improved experimental protocols monitoring consortium evolution for future applications such as waste-to-energy; identify second generation bioinformatic and modeling tools that integrate experimentally monitored dynamics of the diversity of synthetic peptide library development for inorganic and multifunctional materials; establish synthetic biology methods to engineer cell systems for improved and programmable control of interactions of biological/abiological heterogeneous interfaces; develop protocols for systems-level analysis of multi-organism communities; extend metabolic and transcriptional network reconstruction to additional organisms; and research available systems biology tools for use in microbial consortia members. ***FY 2019 Plans:*** Will investigate computational and experimental routes to functional, stable microbial interactions for biologically enabled devices and processes; and will explore mechanistic and evolutionary responses of engineered bacteria to environmental factors for improved bio-hybrid materials, sensors, and electronic devices. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels decreased to enable support of Living Materials research.	4.107	4.453	2.075
Title: Living Materials ***Description:*** Research the concept of responsive materials imparting living functions for operation in Army relevant environments thus enabling disruptive capabilities, such as self-healing, adaptation, protection, and situational awareness. Perform research to enable design and synthesis of materials both enabled by and including biological entities to provide these living functions. ***FY 2019 Plans:*** Will perform innovative synthetic biology research in novel hosts to move technology into Army relevant environments; and will investigate pioneering tools for dynamic control of biological / abiological hybrid assemblies. ***FY 2018 to FY 2019 Increase/Decrease Statement:***	-	-	3.307

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
New start effort to enable pursuit of knowledge to support Next Generation Combat Vehicles, Soldier Lethality, and Future Vertical Lift.			
Accomplishments/Planned Programs Subtotals	9.222	8.899	9.915

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 2019 Army											Date: February 2018	
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 2017**	**FY 2018**	**FY 2019 Base**	**FY 2019 OCO**	**FY 2019 Total**	**FY 2020**	**FY 2021**	**FY 2022**	**FY 2023**	**Cost To Complete**	**Total Cost**
H45: *Air Mobility*	-	2.273	2.410	2.458	-	2.458	2.506	2.556	2.608	2.660	0.000	17.471

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 (PE) 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.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Rotary Wing Aerodynamics	2.273	2.410	2.458
Description: Create robust experimental and computational approaches for understanding, modeling, and predicting the complex fluid flow and aerodynamics of next generation rotorcraft concepts. This research includes innovative numerical methods for capturing the details of steady state and non-steady state aerodynamics and acoustics occurring with multi-rotor, rotor-propeller, and rotor hub configurations; and associated experimental techniques needed to verify modeling results.			
FY 2018 Plans: Conduct experimental investigations to better understand the flow field surrounding a rotor hub to enable drag reduction using active and passive flow control technology; continue computational aero-science investigations on both high-fidelity and mid/low fidelity numerical methods including work on validation and developmental testing of the physical assumptions forming the building blocks of the underlying theory.			
FY 2019 Plans: Will conduct experimental research in acoustics and interactional aerodynamics of multi-rotor and rotor-propeller configurations; will explore the possibility of active flow control for adverse force reduction on rotorcraft empennage structure; will conduct computational sciences research on higher-order accuracy in time for improved flow computations of maneuvering rotorcraft; will leverage high performance computing tools for fundamental studies of unsteady aerodynamics and rotor flow fields in hover and forward flight.			
FY 2018 to FY 2019 Increase/Decrease Statement:			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
Funding levels increased due to inflation.			
Accomplishments/Planned Programs Subtotals	2.273	2.410	2.458

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 2019 Army			Date: February 2018
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 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
H47: *Applied Physics Rsch*	-	4.197	5.689	5.848	-	5.848	5.434	5.559	5.676	5.790	0.000	38.193

A. Mission Description and Budget Item Justification

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

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

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Nanoelectronic Devices and Sensors	1.799	1.490	1.552
Description: Conduct research on advanced battery materials; fuel cells and reformers for Soldier and vehicle power; electronic materials structures and defects in high-temperature, wide-bandgap semiconductors for high-power electronic and photonic applications; materials for advanced nano- and micro-devices; and integration of nano-energetics and Micro-Electro-Mechanical Systems (MEMS) for fusing and micro-robotic applications.			
FY 2018 Plans: Investigate underlying reliability limitations of ultra-wide band gap materials and devices; research and compare electron mobilities in state-of-the-art dielectrics on gallium nitride (GaN) for gate dielectric and passivation in 600-Voltage class devices; develop computational transport models for bipolar ionic conducting membranes for use in high energy density fuel cells using liquid fuels; analyze techniques for improving piezoelectric material properties and integration strategies to enable tunable, adaptable radio frequency (RF) MEMS devices and inertial sensors; study radiative efficiency in microcavities for high power, single aperture near-			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
ultraviolet (UV) lasers; and study indium gallium nitride on gallium nitride substrates (InGaN on GaN) devices for improved gain in near-UV lasers. ***FY 2019 Plans:*** Will initiate improvements in charge trapping dielectrics models to cover a broader range of wide band gap materials; will evaluate characterization results of the gallium nitride (GaN) power devices and develop improved understanding of the dielectric/semiconductor interaction under high field, high temperature condition; will develop an approach to couple variational thermodynamic theory with stochastic models; will apply this approach to heterogeneous materials systems with distributed structure & properties; will develop modeling approaches for simulations of concentrated aqueous electrolytes for energy storage applications; will apply developed approaches and quantum chemistry methods to guide development of safe lithium-ion and zinc-based batteries; will develop, verify, and validate modeling and simulation methodologies to enable research of advanced energy harvesting and (photo)electrochemical energy storage/conversion technologies; will explore theory to directly bridge scales (e.g., molecular to continuum); will analyze 2-D and three-dimensional (3-D) fabrication techniques for achieving both piezoelectric materials properties and integration strategies to enable tunable, adaptable RF MEMS devices, inertial sensors, and position/ navigation aiding sensors; and will investigate processes and structures for improving the near ultraviolet and deep ultraviolet quantum efficiency of silicon carbide (SiC) detectors to enable low-cost and compact chemical and biological agent detection and identification. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels increased to enable pursuit of knowledge to support Next Generation Combat Vehicles, Future Vertical Lift and Tactical Unit Power Independence.			
Title: Fundamentals for Energy Efficient Electronic Components (previously Advanced Energy Efficient Science Research) ***Description:*** This program addresses the power draw of radio frequency (RF) front ends for communication and the digital back-end from electronic materials. This work explores new materials with inherently higher energy efficiencies, while improving upon the current state-of-the-art. These materials will be used in conjunction with advances in circuits and systems to provide improvements in power efficiencies, linearity and noise at the subsystem level which are unique needs of the military. Conduct materials, components, and multi-scale modeling research that will lead to advances in energy storage, harvesting, conversion, and efficiency for a wide range of Army applications such as Soldier and vehicle power, microgrids, communications, radar and electronic warfare. ***FY 2018 Plans:*** Explore chip level integration of active devices made using 2D and surface conduction electron transport for high conductivity channels that enable more efficient RF performance; develop underlying principles for vertical gallium nitride (GaN) device/ material issues (more efficient vs lateral); investigate high-electron-mobility transistor (HEMT) devices in multiple geometries. ***FY 2019 Plans:***	2.398	1.880	1.909

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
Will integrate front-side optical filter and backside scattering reflector into a photovoltaic (PV) cell to fully match the emission spectrum of the microburner/selective emitter; will experimentally investigate the dramatic power density improvement at reduced temperatures via near-field coupling between the emitter and PV cells having separations less than the peak blackbody wavelength; will investigate non-linear energy conversion in metal oxide conformal thin-film coatings to boost areal power density; will investigate new ferroelectric materials and composites and evaluate properties for greatly enhanced pyroelectric energy conversion; will explore micro-compression effects on the dislocation density motion in gallium nitride (GaN) materials; will develop phase change and surface enhanced semiconductor-based RF switches with superior power handling, lifetime, and insertion loss; and will investigate magneto-dielectric material research for ultra-thin (<1mm) multiband antennas. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels increased due to inflation.			
Title: Fundamentals for Precision Measurement for Contested Environments ***Description:*** Develop new materials, novel device architectures, and unique processing techniques to successfully maintain communication and information sharing protocols in global positioning system (GPS)-denied, actively jammed, or austere environments. ***FY 2018 Plans:*** Explore new materials and novel device architectures to reduce the phase noise and environmental sensitivity of microwave-photonic oscillators in order to improve the performance of the Army's radar and position, navigation, and timing (PNT) systems; investigate a compensation locking concept to interlock oscillator cavities with different characteristics to increase long-term timing stability of the overall system. ***FY 2019 Plans:*** Will explore new materials and novel device architectures to realize compact field-capable oscillators that are environmentally insensitive; and will identify issues associated with propagation of the timing pulses. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels increased to enable improved knowledge to support Networks/C3I for enhanced communications.	-	0.539	0.591
Title: Fundamentals for Alternative Energy ***Description:*** Explore novel concepts in energy generation and capture, and in technologies for efficient conversion of ambient energy to electrical energy for use and storage. Design novel structures to include microscale power devices for multimodal harvesting and efficient distributed power conversion. Focus areas include: energy storage and release from atomic nuclei, new materials for topological insulators for energy conversion, and new designs for solar cells. ***FY 2018 Plans:***	-	1.780	1.796

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
Investigate atomic-nuclear effect by isomer depletion, and study the nuclear structure for enhanced energy release; explore semiconductor structures by substrate and epitaxial growth conditions; investigate new materials to optimize plasmonically augmented performance; investigate the mechanism of plasmonic enhancement found in the structures built previously; develop 3-D plasmonic arrays and examine alternative field effects to enhance plasmonic reactions and decouple the electron transfer process to further elucidate the mechanism; and investigate electrochemical oxidation of high energy density liquid fuels with carbon-carbon bonds at low temperatures. ***FY 2019 Plans:*** Will demonstrate a 1-microwatt per square centimeter 3D etched nuclear-to-electric direct energy converter using a tritium-loaded carrier as the energy source; will determine the efficiency limits for 3D nano-pillared gallium nitride direct energy conversion using promethium-147 isotope; will design a 1-microwatt, 10 cubic centimeter, 10 gram isomer power source using indirect energy conversion; will explore ion solvation, ion-ion interaction and new liquid structure in the new aqueous electrolytes; will establish relation between electrochemical properties and the liquid structure at super-concentrations; will explore light-matter interactions at plasmonically-enhanced electrocatalytic interfaces tailored for carbon-carbon oxidation; will initiate development of light initiated surface chemical reactions and measure scattering and/or absorption spectra of select photo-electrodes to evaluate efficiency; will explore chip level integration of active devices made using 2D and surface conduction electron transport for high conductivity channels that enable more efficient radio frequency (RF) performance; will develop underlying principles for vertical gallium nitride (GaN) device/material issues (more efficient vs lateral); will test high electron mobility transistor devices in multiple geometries; will model and demonstrate acoustic (ultrasonic) power transfer and design enhanced acoustic coupled with inductive transfer of approximately 1W; will develop the technology to co-fabricate piezo-transformers with matching networks at -40 dBm of power; and will quantify cell performance improvements resulting from a new ?greenhouse? solar cell design which captures recombination luminescence that is lost in traditional cells. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels increased due to inflation.			
Accomplishments/Planned Programs Subtotals	4.197	5.689	5.848

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** H47 / *Applied Physics Rsch*

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army											Date: February 2018	
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 2017**	**FY 2018**	**FY 2019 Base**	**FY 2019 OCO**	**FY 2019 Total**	**FY 2020**	**FY 2021**	**FY 2022**	**FY 2023**	**Cost To Complete**	**Total Cost**
H48: *Battlespace Info & Comm Rsc*	-	27.497	31.394	32.292	-	32.292	36.816	37.397	38.249	39.014	0.000	242.659

A. Mission Description and Budget Item Justification

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

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

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Communications in Complex Dynamic Networks	1.910	1.110	1.098
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 2018 Plans:*** Create theories, algorithms, and models to enable cognitive hybrid networks that utilize radio frequencies (RF) (e.g. Very High Frequency (VHF) and ultra-high frequency (UHF)), as well as higher frequencies ranges in non-RF bands; research novel energy efficient methods for controlling autonomous communications infrastructures to maintain network operations in disruptive environments; develop adaptive point-and-track algorithms and techniques for the modeling and design of multiplexed			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
systems for networking both RF and non-RF physical layer technologies; and develop formal theories, models and algorithms for decentralized and distributed software-defined networking control plane architectures across heterogeneous mobile networks. ***FY 2019 Plans:*** Will investigate and create adaptive networking and algorithms that extends previous research in joint physical, media access control (MAC) and network layer optimization to consider higher layer performance requirements. Will develop directional networking algorithms that consider radio frequency (RF) & non-RF channels. Will extend energy efficient methods to operate more effectively in an adversarial (contested) and congested operating environments, will extend software defined networking control plane algorithms to work across contested hybrid channels. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels decreased to enable support of Machine Learning for Intelligent Agent and Human Decision Making research.			
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 the transformation of data into actionable intelligence to support decision-making under uncertainty. Perform research to utilize real-time, tactical, soldier-centric information for improved decision-making and situational awareness. Perform research in support of rapidly enhancing long-duration, complex, dynamic decision-making capabilities of individual Warfighters and units through the integration of cognitive augmentation and course of action recommender technologies. ***FY 2018 Plans:*** Explore techniques for utilizing active and passive feedback from information consumers to enhance and customize multi-media information processing, knowledge presentation and querying for improved decision-making, situational awareness and computational reasoning; research text and video analytic approaches to associate information from text with information derived from video sources to improve the collection, processing and exploitation of tactical battlefield data. ***FY 2019 Plans:*** Will investigate methods for incorporating online and continuous learning of decision-relevant feedback and preferences stemming from interactions with multi-sourced, multi-media information and knowledge representations; Will investigate methods for developing belief-state models of intelligence, surveillance, and reconnaissance tasks which teams of agents can use to autonomously select actions such as observations, motions, and interactions. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels increased due to inflation.	4.381	5.055	5.107
Title: Information Protection for Mobile Dynamic Networks	5.829	4.704	3.923

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
Description: Perform research on protecting information in highly mobile, wireless tactical environments, where networks must operate under severe bandwidth, energy, and processing constraints, and without reliance on centralized security services. . ***FY 2018 Plans:*** Investigate distributed, energy efficient techniques to enhance network survivability in the presence adversarial attacks at both the physical and network layers; develop quantitative models of information semantics trust and quality; create models, theories and algorithms for secure, content-based software-defined networking in dynamic coalition environments; investigate and create secure techniques for distributed composition, positioning, and adapting of information services based on user context and state, device processing capabilities, and security policies; explore and quantify cyber risk accurately in real-time to provide security and mission assurance; explore dynamically risk, exploit likelihood, and impact of vulnerability exploitation, as cyber sensor observations are received for a system with known vulnerabilities; investigate, detect, analyze, and assess temporal and spatial causality of cyber events representing attacker activities, attack provenance, exploits, and vulnerabilities, and investigate methods to attribute the authorship of source code and binary samples using machine learning techniques. ***FY 2019 Plans:*** Will enhance distributed energy efficient techniques that minimize the radio frequency (RF) signatures and are resilient to coordinated attacks on both the physical layer and network layer; will identify techniques for the distributed composition, positioning, and adapting of information services based on user context and state & device processing capabilities that is resilient in the presence of adversary disruption of portions of the information layer; will develop provably secure networking techniques that enable authenticated, private & reliable networks. Will explore and develop metrics for characterizing risk, and cyber-attack effects on mission performance; will investigate techniques for cyber-physical systems security; will research generation-after-next cyber tools for intrusion detection and active defense of Army systems; will investigate behaviors of attackers and defenders for possible attribution and anomaly detection. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels decreased to enable support of Machine Learning for Intelligent Agent and Human Decision Making research.			
Title: Naturalistic Behavior for Shared Understanding and Explanation with Intelligent Systems ***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 2018 Plans:***	1.105	1.158	1.178

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
Investigate machine learning techniques that support rapid, high quality text analysis in sparse data environments; and investigate knowledge representation techniques for automated dialect identification, linguistic analysis, and summarization for low-resource languages and social media data. ***FY 2019 Plans:*** Will research semantic meaning, object recognition, and information extraction; will understand natural language approaches to support tactical communication in human-intelligent agent interaction. Will develop algorithmic approaches to derive tactical meaning from heterogeneous data sources. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels increased due to inflation.			
Title: Advanced Computing Architectures and Algorithms ***Description:*** Investigate advanced computing and high performance computing (HPC) networking architectures, memory/storage architectures, algorithms and visualization techniques to support advanced battle command applications for command, control, communications, computers, and intelligence (C4I) systems. ***FY 2018 Plans:*** Identify gaps in the next generation computing hardware systems in relation to power, performance, portability, and programmability; create interdisciplinary mathematical algorithms and models for execution on advanced and high performance computing systems; investigate the use of traditional high-level to low-level compiler transformations and approaches to reduce the time for algorithm deployment on advanced systems; perform fundamental research into novel applications that will benefit from the deployment of tactical high performance computers for increased Soldier effectiveness and algorithms devoted to scalable and temporal data analytics for machine learning, real-time detection, and predictive analytics. ***FY 2019 Plans:*** Will pioneer compiler techniques for re-using non-parallel software and porting / compiling for new low-power high-core density architectures; will perform fundamental research on memory and processor architecture to simulate and estimate performance characteristics of next-gen computer systems; will investigate expanding usability for neuromorphic processors thru use of innovative programming techniques beyond machine learning; will create interdisciplinary mathematical algorithms and models devoted to scalable and temporal data analytics for machine learning, real-time detection, increased, and predictive analytics to increase Soldier effectiveness, situational awareness, and decision-making. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels increased due to inflation.	4.004	4.186	4.240
Title: Quantum Information Sciences	5.203	5.402	5.461

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
Description: Perform research to enable quantum networks, which necessitates research in efficient light / matter interfaces and long-lived, robust quantum memories. Additionally, the study of quantum techniques for sensing and ultra-precise navigation, timing, and communications will be undertaken. Conventional techniques for sensing magnetic fields, gravity, and timing have reached a plateau in their performance, and will be severely impacted in future contested-battlefield environments. This research brings new insights regarding the use of quantum science to enhance Warfighter effectiveness. ***FY 2018 Plans:*** Investigate optical nanofibers with strong evanescent fields embedded in cold atom systems; investigate cold-atom ensembles in optical cavities; investigate nanophotonic integration with solid-state defects; investigate solid-state stoichiometric crystals in cryogenic environments; investigate qubit (a unit of quantum information) manipulation in ion trap systems and solid-state defects; use an advanced control system for qubit manipulation for benchmark standardization; examine methods for coupling these different platforms via wavelength conversion; theoretically analyze experimental systems; and study theoretically and computationally the enhancements to sensing using distributed, entangled sensors; and investigate protocols and algorithms for quantum networks to increase the quantum channel capacity using exotic spatial modes of light. ***FY 2019 Plans:*** Will investigate experimentally and theoretically nanophotonic interactions with quantum systems and cold atoms in exotic electronic states strongly coupled to laser beams; will investigate experimentally and theoretically highly-efficient light-matter interactions in four physical platforms for quantum memories and coherent manipulations, including rare-earth materials, ion traps, and solid-state defects; will investigate experimental and theoretical methods for coupling different quantum systems using frequency conversion and multiplexed interactions using higher-order light modes; and will investigate advantages and limitations of distributed quantum systems through theoretical modeling. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels increased due to inflation.			
Title: Experimental Methods in Network Science ***Description:*** Supports in-house Network Science studies in conjunction with the Network Sciences Collaborative Technology Alliance and Distributed Analytics and Information Science for United States / United Kingdom (U.S. / U.K.) Coalition Operations Information (PE 0601104A). ***FY 2018 Plans:*** Investigate methods for network design that consider tradeoffs between current optimality and long-term behavior as well as adversarial dynamics; explore the impact of quality-of-information and semantics knowledge on distributed decision-making in physical and virtual agents as network size increases; develop optimal methods to configure multi-genre networks in the presence of highly dynamic operational environment based on the information quality requirements derived from semantic understanding	5.065	4.443	2.237

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
of the mission; develop novel techniques to model and influence the evolution of complex adaptive groups and networks, and the diffusion of opinions in dynamic multi-genre networks; and develop formal theories, techniques and frameworks to enable multi-level integrated fusion of disparate information sources in context of decision support objectives in coalition operations. ***FY 2019 Plans:*** Will investigate models, techniques and fundamental limits for dynamically adapting analytics processing (code and data) in a tactical coalition environment as missions and coalitions change to support distributed analytics in coalitions; will develop models, theories and algorithms for dynamically adapting information and network configurations in multi-genre networks to support mission based information quality requirements and enable improved distributed decision-making; will identify methods and techniques for simulating and emulating large scale software defined wireless networks; will develop techniques, algorithms for discovering hidden network processes in multilayer time-evolving networks under incomplete information; will investigate deep learning based algorithms for pattern discovery, classification and prediction in multi-genre networks. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels decreased to enable support of Machine Learning for Intelligent Agent and Human Decision Making research.			
Title: Assured Operations in the Physical, Social and Cyber Domain	-	4.283	4.730
Description: Conduct research that will enhance the survivability of information by radically dispersing and continuously moving data across a multitude of inter-networked devices. This effort seeks to address the growing demands on information assurance, reliability and transmission in resource constrained environments. Theories and methods will be developed for securing information across heterogeneous devices/sources and networks, detecting and creating information obfuscation and deception techniques, managing risk of information quality and trust, and fusing and regenerating needs-relevant information from highly fragmented and dispersed data. ***FY 2018 Plans:*** Identify and extend models that characterize the complex trade-offs inherent in radical dispersion of information among mobile tactical edge devices, such as communications, energy consumption, and security; investigate approaches to minimize impact of dispersion on timely, secure, and efficient re-gathering of information, especially semantic-based techniques, that support situational awareness that is timely and mission relevant; formulate requirements for formal models, theories and methods to execute and manage successful obfuscation of information within an environment of highly dispersed information; explore algorithms for adversarial-context-adaptive aggregation and presentation of information from distributed sources. ***FY 2019 Plans:*** Will investigate the impact of computational reasoning over machine learning outputs inherent in notions of quality and value of information; formulate characteristics for integrating formal models to prevent/detect information tampering while enabling deception detection and adaptive hardening against adversarial machine learning techniques; will develop formal models, theories and methods for information obfuscation and deception across the network of tactical edge devices that adapt to			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
adversarial activity in the network; will develop models and theories for characterizing the impact of information dispersal on trust & information quality; will investigate machine learning based approaches for information dispersion that optimizes the tradeoff between security and timely re-gathering of mission relevant information; will identify context aware algorithms for the timely aggregation and presentation of radically dispersed information. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels increased to enable improved knowledge to support Networks/C3I for enhanced communications.			
Title: Mobile Network Modeling ***Description:*** This research focuses on techniques that enable predictions of performance and stability of large, complex communications networks. It takes into account the impact of Soldiers' information needs, modalities of access and use of communication networks in complex adversarial environments, high mobility, and adversarial effects such as jamming or cyber-attacks. Also to be considered are computational modeling approaches that capture dynamics of information that flows through the network and/or is stored within the network, and undergoes continual changes as new information arrives and other information ages or is refuted/superseded by newly arrived information. ***FY 2018 Plans:*** Develop scalable, high fidelity models for high capacity aerial networks in contested and benign environments; develop high performance computing (HPC) enabled finite difference time domain (FDTD) based approach to directly solve Maxwell?s equations in the time domain in order to provide high fidelity propagation loss models in complex environments, e.g., through large buildings, urban canyons, indoor/outdoor, tree canopy and tunnels; develop heterogeneous network models that encapsulate the diverse characteristics and configurations of nodes supporting multimodal (RF and non?RF) waveforms based on actual multi-user channel measurements; develop appropriate metrics and analytical tools to characterize node- and network-level performance metrics such as data throughput, security, priority, and latency. ***FY 2019 Plans:*** Will demonstrate high fidelity simulations for communications in unconventional frequency bands with specific focus on high frequency (HF) and very high frequency (VHF) bands; will develop key enablers for multi-wavelength uninterrupted communications and networking capability in infrastructure-poor austere environments with novel localization techniques; will demonstrate concepts for low power systems for autonomous networking and control. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels increased due to inflation.	-	1.053	1.070
Title: Machine Learning for Intelligent Agent and Human Decision Making ***Description:*** This effort will research methodologies and algorithms for machine learning with incomplete, unstructured, potentially deceptive and heterogeneous information, enabling joint decision making for Intelligent Agent-Human teams which	-	-	3.248

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
adapt to unknown environments and missions. Research will include methods for learning and decision making that occur under short time frames and constrained resources (computation, power, spectrum and networks). ***FY 2019 Plans:*** Will develop novel methods for joint human / intelligent agent learning and decision making to capitalize on individual strengths of humans and intelligent agents to improve emergent group performance; will identify approaches for rapid, cooperative decision making and learning utilizing machine learning approaches; will investigate the training of deep networks from sparsely labeled data under time constraints; will investigate learning approaches with statistically mismatched data. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** New start effort to enable pursuit of knowledge to support Next Generation Combat Vehicles and Future Vertical Lift.			
Accomplishments/Planned Programs Subtotals	27.497	31.394	32.292

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 2019 Army			Date: February 2018
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 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
H52: *Equip For The Soldier*	-	1.131	1.156	1.178	-	1.178	1.204	1.228	1.252	1.277	0.000	8.426

A. Mission Description and Budget Item Justification

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

Work in this Project provides theoretical underpinnings for Program Element (PE) 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.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Equipment for the Soldier	1.131	1.156	1.178
Description: This Project supports basic research to achieve technologies that support the Soldier of the future. Research areas include mathematical modeling, physical and cognitive performance, polymer science/textile technology, nanotechnology, biotechnology, and combat rations.			
FY 2018 Plans: Examine the potential use of single-layer graphene as a universal substrate for flexible, conformable sensors with future application to textiles, wearable materials, food safety, and Soldier performance sensing platforms; create materials with orthogonal functionalities using nanoparticles and thin films to understand the molecular and surface structural phenomena which define compatibility; continue to explore the effects of silver nanowire in hydrogel substrates on conductive and thermal properties with a focus on 3D architecture arrangements.			
FY 2019 Plans: Will begin to understand the role of surface patterning, structure and surface area on functional performance of seemingly incompatible functionalities (e.g. water repellency and catalysis) with a long term goal of developing orthogonal multifunctional systems for Soldier protection. Will explore fundamental phenomena that influence diffusion and surface segregation of metal oxide nanoparticles within polymer matrices. Will create a 3D dynamic knee OpenSim model informed by biomechanics load			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
carriage and magnetic resonance imaging data to enable prediction of the effects of equipment load and augmentation on Soldier performance. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels increased due to inflation.			
Accomplishments/Planned Programs Subtotals	1.131	1.156	1.178

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 2019 Army										Date: February 2018		
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 2017**	**FY 2018**	**FY 2019 Base**	**FY 2019 OCO**	**FY 2019 Total**	**FY 2020**	**FY 2021**	**FY 2022**	**FY 2023**	**Cost To Complete**	**Total Cost**
H57: *Single Investigator Basic Research*	-	91.394	96.081	101.427	-	101.427	104.903	106.378	110.626	112.839	0.000	723.648

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, life sciences, and social sciences), the engineering sciences (i.e., mechanical sciences, electronics, materials science, and environmental science , 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 800 active, ongoing research grants and contracts with leading academic researchers and approximately 1,600 graduate students yearly, supporting research at nearly 210 institutions in 50 states.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Basic Research in Life Sciences	8.583	5.605	6.068
Description: Pursues fundamental discoveries in life sciences with the ultimate goal of facilitating the development of novel biomaterials to greatly enhance Soldier protection and performance. More specifically, i) molecular genetics research pursues fundamental studies in molecular and systems biology, and genetics, ii) neurosciences research investigating the physiology underlying perception, neuro-motor output, and potential methods of monitoring cognitive states during activity, iii) biochemistry research focuses on studies in structural and cell biology, metabolic processes, and biophysics, iv) research in microbiology pursues studies in microbial physiology, ecology, and evolution, v) social science research aims to elucidate the social, cultural, and other influences to human actions, and vi) auditory and signal processing research to map the cognitive implications of multisensory information integration.			
FY 2018 Plans: Develop a yeast-based system using a non-canonical amino acid incorporation technique to impart chemical modifications into putative adhesive proteins for the generation and selection of novel adhesive properties that, if successful, may enable new adhesive proteins for future uses ranging from next-generation therapeutics or transdermal drug delivery patches on or near the battlefield; investigate and validate new candidate brain circuits, predicted to be involved in sleep and wake cycles, by identifying the distribution and dynamics of transcription-factor binding (as a proxy to assess gene expression), that if successful may reveal physiological functions of sleep-regulatory regions in a manner that has never been done before and, in the long term, may enable non-invasive methods for reducing sleep deficit and sleep need for Soldiers who operate in conditions not conducive to restful			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** H57 / *Single Investigator Basic Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
sleep; investigate the potential of the insect-specific cysteine in acetylcholinesterase as a unique, unexplored, and viable target to develop insecticides with reduced insecticide resistance and minimal toxicity to mammals for the control of disease vectors, that if successful this should lead to new and more effective methods to control the spread of diseases such as malaria and Zika virus; identify the proteins and pathways in the bacterium A. baumanii, responsible for maintaining cell viability under conditions of desiccation to review new methods for the engineering of bacterial cells capable of surviving harsh environmental conditions, that if successful may enable the development of sustainable in-field bio manufacturing processes. ***FY 2019 Plans:*** Will use digital polymerase chain reaction to quantify copy numbers of barcoding markers and single-copy nuclear genes in pollen samples of known counts, thereby allowing estimates of both isolation and copy number biases, ultimately enabling the genetic mapping and identification of various pollen species, that if successful, will enable new forensic capabilities for personnel and materiel; will genetically integrate a protein switch isolated from cephalopod reflectin protein that can reversibly switch between assembled and disassembled states into a related protein that is naturally unable to disassemble once assembled, that if successful, may enable a wide range of future electro-optical applications relevant to the Army and DoD, including systems that are more energy-efficient, lightweight, or exhibit adaptive concealment capabilities; will understand a multiple-target visual search experimental system and test results versus traditional laboratory assessments to evaluate and validate the effectiveness of laboratory-based searches as compared to real-world searches, that if successful, will lead to new designs and validation methods for new standard operating procedures to improve accuracy in visual search tasks (e.g., to ID contraband) known to be susceptible to dangerously high miss rates; within a biofilm of the bacterium P. aeruginosa, which produces redox-active electron shuttles called phenazines, will explore how biofilm of the bacterium P. aeruginosa is affected by the presence of non-phenazine producing species, that if successful, in the long term may lead to the creation of precisely balanced microbial communities for the control of energy generation within electrode-laden biofilms in microbial fuel cells. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels increased to enable pursuit of novel bio-derived materials through extramural basic research.			
Title: Basic Research in Environmental Sciences	1.503	0.578	0.309
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 2018 Plans:*** Design and utilize chamber experiments to determine partition coefficients for volatile organic compounds (VOCs) between soil, air, and airborne particles under various temperatures, and relative humidity settings that mimic real world conditions, that if successful, will provide data that may ultimately enable new tools for protecting the Soldier and other first-responders from			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** H57 / *Single Investigator Basic Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
exposure to toxic chemicals, or to sequester and remove VOCs; design and synthesize simulated soil using synthetic colloids, demonstrate tunable inter-particle attraction to then examine the mechanical properties and flow of earth surface materials such as soils in dynamic environments that if successful may ultimately lead to future methods for safer infrastructure development, economical erosion control, efficient route planning. ***FY 2019 Plans:*** Will investigate the fundamental surface photo-reactivity of organic compounds during reaction with gaseous and bulk aqueous phases of environmental relevance, that if successful, will provide new methods for protecting the Soldier and other first-responders from exposure to toxic chemicals; will develop a city-scale model of how heat is stored by urban typical urban surfaces, transferred by runoff and dissipated by evaporation following a rainfall event, allowing better prediction of how UAVs will be affected by updrafts caused by spatial variations in ground temperature and how environmental conditions affect sensor performance. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels decreased to enable support of Chemical Sciences, Life Sciences, Network Sciences, and Social Sciences research.			
Title: Basic Research in Chemical Sciences	12.529	13.761	14.040
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 2018 Plans:*** Devise a new approach to fabricate precise conjugated polymers with controlled monomer sequences that in the long term, if successful, may lead to new semi-conducting materials with applications in sensing and detection; establish the relationship between the 3D interphase structure, the interface impedance, and the electrochemical behavior of all-garnet solid-state systems, to enable the characterization of different sources of interfacial resistance and advance the current understanding of the solid-solid electrode/electrolyte interface that, if successful, could lead to new solid-state high-performance batteries with increased safety and reduced weight; devise new methods to fabricate multifunctional nanostructures with features that can be dynamically regulated in space and time that in the long term, if successful, may ultimately lead to novel materials with applications in protection such as dynamic camouflage; prepare a population of molecular hydrogen and determine the quantum state of the ensemble using multiphoton ionization-mass spectrometry that, if successful, may provide results ultimately leading to new methods in quantum computation for ultra-secure communication. ***FY 2019 Plans:***			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** H57 / *Single Investigator Basic Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Will develop mechanistic descriptions of catalysis by metal nanostructures when excited with photons, electrons and ions, that if successful, will provide an improved understanding of photoelectrocatalysis that is essential to reducing soldier-borne weight associated with power storage and generation; will use new high-resolution methods to image dissociation of designated compounds to directly observe and characterize roaming mechanisms for the first time, that if successful may enable improved control and development of next-generation propellants and explosives; will design and synthesize polymer-protein hybrid materials and ascertain the design rules necessary for achieving hybrid materials with optimal protein stabilization in non-natural environments, that if successful, may lead to methods for sensing, energy conversion. optical nonlinearity; will devise a versatile method to immobilize enzymes to abiological substrates while preserving biological structure and function, that if successful will provide new methods for detecting and neutralizing harmful chemicals. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels increased to enable pursuit of unique Chemical Sciences knowledge through extramural basic research.			
Title: Basic Research in Physics	17.102	17.861	19.293
Description: Focuses on research in many subfields of physics, including condensed matter physics, optical physics, atomic and molecular physics and quantum information, with an emphasis on discovering new realms of quantum and optical phenomena. Pursuit of fundamental physics in these subfields provides new opportunities for future developments in superior optics, ultra-sensitive sensors, and novel electronic architectures for classical and quantum computing. ***FY 2018 Plans:*** Investigate a new class of photonic structures called photonic topological metamaterials that, if successful, will provide for better control of light in materials and in the long term will enable the design and creation of metamaterials to bend light in ways previously impossible and with lower loss, potentially providing new tools for microscopy, sensing, and power harvesting; induce and demonstrate superconductivity in a material in which electrons behave in a way not achievable in traditional semiconductors, that in the long term may enable new electronics with dramatically-reduced power consumption; use ultra-cold atoms in highly-excited states, called Rydberg atoms, to achieve quantum simulation of the Ising model of optical lattices (gaseous-phase atoms in a specialized ordered state) whereby certain atoms are in competition for spin state, that if successful may provide a method for predicting and measuring defects in materials, enabling the rapid development of new materials with desired properties; demonstrate entanglement between neutral atoms and microwave photons in a superconducting cavity that, if successful, may enable the development hybrid quantum systems for use in ultra-secure communication devices. ***FY 2019 Plans:*** Will modify graphene to induce an optical nonlinearity (e.g., emitting light at a different frequency than was introduced) that in the long term may enable the creation of new materials with greatly enhanced functionalities; will create theoretical models of the quantum phases and dynamics of periodically driven ultra-cold atomic gases that, if successfully validated, may provide a method for predicting and measuring defects in materials and enable the rapid development of new materials with desired			

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Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** H57 / *Single Investigator Basic Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
properties; will explore the quantum limits of spectroscopy and control of single molecular ions using atomic ions as qubit probes, that if successful may enable capabilities beyond those possible with classical systems in the application areas of resource optimization, efficient C4ISR (Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance) and maximal logistical support; will utilize optical laser beams to discover energy-release channels for several nuclear isomers, that if successful may reveal new methods for long-lived energy source sources, such as batteries. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels increased to enable pursuit of unique physics knowledge through extramural basic research.			
Title: Basic Research in Electronics and Photonics	10.895	8.634	7.340
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 2018 Plans:*** Investigate photocurrent generation in new nanohybrid, carbon-based systems for ultraviolet (UV) and infrared (IR) detection; create aluminium gallium nitride (AlGaN) nanowire arrays for deep UV electrically controlled lasers; identify complementary metal-oxide-semiconductor (CMOS) nano-electrode arrays that interface with mammalian neuronal networks for potential restoration of neural functions; create new capabilities for beam steering, beam forming, and waveform control in the terahertz range, by use of electrically switchable metasurfaces. ***FY 2019 Plans:*** Will exploit exotic electromagnetic phenomena in solid-state structures which require theoretical formulations beyond Maxwell?s equations (such as axion electrodynamics, chiral anomaly and spontaneous symmetry breaking) and interfacial proximity effects in quantum heterostructures; will establish the nano-specific functionality of electrical currents and fields unique to the interior of a single cell for stimulation, sensing, and manipulation of the critical functions within and surrounding individual biological cell structures; will incorporate materials, microcavity, and metamaterial design advances to exceed the mobility and resistive loss limitations of electron transport for enhanced computational processing and data communications; will elucidate the transition between notably different forms of energy (such as magnetic, phononic, as well as hybrid physical regimes involving magnons, polarons, and surface plasmon polaritons) to develop novel devices manifesting these phenomena. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels decreased to enable support of Chemical Sciences, Life Sciences, Network Sciences, and Social Sciences research.			
Title: Basic Research in Materials Sciences	7.996	7.882	8.744

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** H57 / *Single Investigator Basic Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
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 2018 Plans:*** Establish the design and directed assembly of nano-building blocks into complex, hierarchical 3D architectures capable of long-range control over multifunctional behavior and smart/dynamic responses using an additive 3D material assembly approach (for applications in manufacturing, novel electronics and communications); create new systems exhibiting the physics of anyons (a type of quasiparticle that only occurs in two-dimensional systems) and topologically protected states (for unique communication, sensing and logic applications); and develop a novel theory-experiment feedback loop to accelerate discovery of optimized novel polymer nanocomposites (PNCs) (for structural, durability, and light-weighting applications). ***FY 2019 Plans:*** Will design and synthesize selective quantum grade quality novel host materials with desired color centers exhibiting unique quantum properties and elucidate the physical mechanisms responsible for the observed novel quantum properties (e.g. spin coherence) and governing composition- processing- defect- property relationships; will employ theory and integrated modeling/ simulations to guide experimental efforts and explore new quantum science opportunities such as collective states; will develop spectroscopic and other applicable characterization methods for direct observation of plasma/material interactions and the dynamics of the consolidation process; will refine or modify plasma and materials processing tools to achieve bulk manipulation and scalable consolidation of first-of-their-kind 3D macrostructures. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels increased to enable pursuit of novel materials through extramural basic research.			
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 2018 Plans:*** Create a new set of algorithms and software environments to perform scientific and geometric computations on heterogeneous processors to address issues related to load balancing between central processing unit (CPU) and graphics processing unit (GPU) cores, programmability, and power management that can be applied to enhance data processing capabilities for Army big data challenges; establish new methodologies for modeling multimodal neural activity to design closed-loop adaptive algorithms	8.281	6.761	6.952

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** H57 / *Single Investigator Basic Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
for optimized brain-computer communication; and develop novel cyber system adaptation techniques that will make Department of Defense (DoD) cyber systems more resilient and robust against potential cyber attacks. ***FY 2019 Plans:*** Will create computational methods to ensure that critical timing constraints are met for real-time mixed-criticality workloads on multicore platforms augmented with graphics processing units (GPUs) for acceleration; will establish a framework for robust, decentralized processing of sensing data that leads to enhanced performance under dynamic and constrained environments to support processing algorithms that exploit geographically distributed and contaminated big data for near optimal inference and decision making; will explore new cyber deception approaches that rely on both obfuscation and decoy techniques that can confuse adversaries and divert cyber attacks to the wrong targets. The particular workloads of interest are emerging safety-critical embedded Army systems where autonomous functionality is required such as in unmanned airplanes and helicopters, battlefield robots, unmanned ground vehicles, and various autonomous weapon systems. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels increased to enable pursuit of novel approaches for decentralized processing of sensing data.			
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 man-made and naturally occurring networks. This understanding will have a direct impact on net-centric force operations, such as better communication system design and operations, and more efficient logistics or communications support. ***FY 2018 Plans:*** Compare the performance of a reservoir computer, a novel neuromorphic self-timed computer architecture to state-of-the-art time series analysis and prediction methods using nonlinear Gaussian process regression to understand dynamics of systems with multiple time scales, multivariate data, and whether a hybrid reservoir Gaussian regression architecture surpasses the performance of either algorithm alone; develop new algorithms and tools to design/re-design teams for improved performance over time, and discover the underlying mechanisms behind cyber flash mob behaviors as a manifestation of interconnected networks; investigate the use of the software defined networking paradigm to adapt to rapidly changing network conditions without operator intervention to enable delay intolerant communications (voice, real-time video, and facilitate robotic control), and improve overall throughput to maximize situational awareness; and discover game theory principles in the world of biochemistry as it relates to strategies for leading tumor cells to degrade to a benign state. ***FY 2019 Plans:*** Will develop state-of-the-art modeling for opinion dynamics over multiple, coupled networks focused on the role of human interactions for shaping people's opinions, beliefs, and actions; research the adaptation of information theoretical free energy minimization principles in brain theory into the formation of natural and man-made networks; will investigate algorithms,	10.235	11.574	12.769

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** H57 / *Single Investigator Basic Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
routing methodologies, and software defined network derivatives resulting from free energy related approaches for maximizing information delivered in networks; will investigate applications of network analysis and control to study the organization and functional principles of the human brain. Existing analytical methods based on graph theory and statistics fail to take system dynamics into account. Research will focus on investigating new theories of network evolution describing interactions in population dynamics, especially using Lotka-Volterra dynamical system models to elucidate high-level properties of community structure. The impact of network structure on Mean Field Games will be investigated, as well as hybrid games that combine discrete and continuous games with application to opinion dynamics. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels increased to enable pursuit of novel networking protocols, components, and theoretical networking understanding through extramural basic research.			
Title: Basic Research in Mechanical Sciences	6.752	6.556	6.848
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 2018 Plans:*** Investigate an electrokinetic instability mechanism as an explanation for observed banding of microparticles which may lead to a novel process for microscale self-assembly of particles based on surface charge characteristics rather than bulk properties for novel material characteristics; develop a detailed liquid-phase decomposition mechanism of RDX (a white solid explosive) which includes only elementary reactions which in turn will be used to predict the burn-rate and flame structure of RDX and the burn-rate modifier for future design of enhanced energetic materials; derive a hierarchy of tractable analytical models of actuated elastica to enable distributed estimation and control of the intrinsic curvature and contact deformation/adhesion properties of continuous media which will lead to enhanced robotic mobility; investigate mechanics of dynamically growing crack interacting with an interface and associated stress wave attenuation in transparent layered material for potential development of blast resistant transparent material systems for future soldier system protection. ***FY 2019 Plans:*** Will investigate underlying fluid-structure interaction mechanisms governing vortex-induced galloping of rectangular prisms, which may lead to controlled stability for suspension lines in precision airdrop systems; will develop and demonstrate the fundamentals of a predictive, computational method for modeling damage due to propagating localized bands of plastic deformation in metals, in particular shear bands, under both high temperature and room temperature conditions which will lead to enhanced structures; will develop and validate a new theoretical foundation for describing multi-modal combustion under autoignition conditions achieving a new general, computationally efficient combustion model for Large Eddy Simulation (LES) models that can account			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** H57 / *Single Investigator Basic Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
for all three modes of combustion (premixed, non-premixed and autoignition) involved in turbulent lifted flame stabilization which will lead to broad fuel flexibility for vehicles; will develop a predictive framework for minimum energy legged locomotion pathways in heterogeneous and cluttered terrain using methods from nonequilibrium statistical mechanics and scattering to enable fast, efficient, and robust autonomous vehicle maneuverability in environments complicated by complex topographies, dense vegetation, or significant debris. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels increased to enable pursuit of mechanical scientific knowledge underpinnings through extramural basic research.			
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 2018 Plans:*** Initiate and conduct basic research efforts to develop the stochastic mathematics that underlie and enable the analysis of mean field games, and develop interdisciplinary approaches to reduce the order of the huge systems of equations generated for modeling the control of open quantum systems. Development of these new mathematical areas is expected to provide new mathematical tools to social scientists for modeling strategic decisions in reasoning about cultural norms and emergence of non-state adversarial groups among large populations and enable the design of more efficient quantum computation algorithms. ***FY 2019 Plans:*** Will initiate and conduct basic research efforts to develop the stochastic mathematics that underlie and enable the analysis of mean field games, and will continue to investigate interdisciplinary approaches to reduce the order of the huge systems of equations generated for modeling the control of open quantum systems. Development of these new mathematical areas is expected to provide new mathematical tools to social scientists for modeling strategic decisions in reasoning about cultural norms and emergence of non-state adversarial groups among large populations and enable the design of more efficient quantum computation algorithms. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels increased to enable pursuit of stochastic mathematics underpinnings through extramural basic research.	5.517	5.750	5.891
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,	2.001	2.032	2.131

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** H57 / *Single Investigator Basic Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
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 simulation and training. This research will also include extensive studies to discover and map the neural circuitry that enables cognitive adaptation, and the dynamic mechanisms of neural network modification need to be established. ***FY 2018 Plans:*** Perform data fusion of electroencephalogram and functional magnetic resonance imaging data to yield spatial and temporal resolution of brain activity during search tasks, to test candidate mechanism developed in prior year in which data suggested area of brain was previously thought not to be involved in visual search may have role in camouflage-breaking, that in the long term, if validated, may provide new simulation methods for camouflaging personnel and materiel, and new training methods to help observers detect hidden objects; develop and validate new models of risks of error in human interaction in complex systems to determine risk points at which human behavior undermines system performance that in the long term, if successful, may lead to new automated methods to detect and mitigate human error in complex systems that could otherwise lead to catastrophic failures. ***FY 2019 Plans:*** Will identify numerous candidate genes found to have increased expression in key sleep-promoting nuclei that if successful, may reveal new methods to reduce sleep deficit and requirements for Soldiers who operate in conditions that are not conducive to restful sleep, that in term would have a positive impact on the maintenance of operational tempo and cognitive resilience; will identify points of divergence between human behavior, task model behavior, and technological systems requirements through the development of computational models that scale to large-scale complex systems that integrate a number of different discrete technologies, that if successful, may enable more effective design methods for user interfaces in Army equipment, training paradigms, and methods to mitigate operator error. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels increased to enable pursuit of improved knowledge of brain structure and neuronal connectivity for enhanced human performance through extramural basic research.			
Title: Expeditionary Materials Processing Science ***Description:*** Basic research coupling materials, innovative design, and manufacturing science to enable conversion of resources for meeting an expeditionary Army?s requirements. This research will enable predictive material-to-materiel models for high-confidence, certifiable article production, high-fidelity expeditionary and versatile material-to-materiel processing capabilities, and a new generation of materials responsive to applied field for shape shifting and phase transformation. ***FY 2018 Plans:*** Demonstrate proof-of-concept through design, synthesis, and validation of adaptive compounds that elicit activated remodeling via mechanochemistry to create synthetic materials with stress-responsive behavior analogous to that observed in biological systems.	-	5.117	5.391

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** H57 / *Single Investigator Basic Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
If successful, this approach may provide a method for creating materials that enhance protection for the Soldier by strengthening or changing shape in response to external stresses. ***FY 2019 Plans:*** Will establish the fundamental relations between morphology and composition of single-function nanostructures that can be seamlessly integrated into hierarchical multifunctional systems and incorporate dynamic components capable of inducing actuation of the material across a wide range of length scales; will create materials that incorporate sensory elements, propagate waves of information through coupled reaction-diffusion and mechanical processes, and integrate feedback loops and energy transduction mechanisms. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels increased to enable pursuit of novel materials processing approaches for point-of-need manufacturing through extramural basic research.			
Title: Basic Research in Social Sciences	-	3.970	5.651
Description: Social science research focuses on generating fundamental understanding of how social dynamics unfold, taking into account individual-level biophysiological factors contributing to social interaction (e.g., genetics, health, cognition, perception), group processes (e.g., interpersonal forces that determine influence, power, conformity), and the impacts of social institutions (e.g., economic processes, legal/governance structures, religious/belief systems, kin networks), with attention to the interconnections among these levels of analyses, and to the physical and natural environments in which human social dynamics are situated. This scientific understanding will improve situational awareness for Warfighters and analysts, improving efficacy of decision-making to achieve mission objectives. ***FY 2018 Plans:*** Research to improve measurement and modeling of social dynamics by tying biometric measurement (e.g., facial thermography, neural imaging, nervous system monitoring, voice acoustic sensing) to interpersonal dynamics and perception networks in small and large groups in localized and dispersed environments; develop new analytic approaches to capture interdependence of actions and precursors of action as well as spatial and temporal dependencies across levels of analyses (i.e., individual-to-group-to-society) to improve predictive accuracy of models of social interaction; advance ecological modeling approaches developed to capture organizational and group dynamics to better understand human social dynamics at population levels; assess impact of media and information technology on cross-cultural diffusion of information, opinion, and influence. ***FY 2019 Plans:*** Will establish methods to validate and measure social dynamics by demonstrating the relationship between vocal patterns in the nonverbal acoustic band and status, dominance, and prestige dynamics and will develop models capturing these relationships,			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** H57 / *Single Investigator Basic Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
that in the long term may enable the rapid detection of the most influential members in a social network, to measure the degree of group cohesiveness, and therefore could provide new capabilities in detecting and improving group performance in Army units. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels increased to enable pursuit of novel social scientific understanding, including genetics, group processes, and impacts of social institutions, through extramural basic research.			
Accomplishments/Planned Programs Subtotals	91.394	96.081	101.427

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 2019 Army										Date: February 2018		
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 2017**	**FY 2018**	**FY 2019 Base**	**FY 2019 OCO**	**FY 2019 Total**	**FY 2020**	**FY 2021**	**FY 2022**	**FY 2023**	**Cost To Complete**	**Total Cost**
H66: *Adv Structures Rsch*	-	2.053	3.108	3.153	-	3.153	3.197	3.240	3.285	3.350	0.000	21.386

A. Mission Description and Budget Item Justification

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

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

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

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2017**	**FY 2018**	**FY 2019**
Title: Structural Analysis and Vibration Methods	2.053	-	-
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.			
Title: Air Vehicle Structures & Dynamics Research	-	2.104	2.153

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
Description: Conduct basic research in advanced analytical methodologies and techniques for understanding and predicting the health and performance of rotorcraft structures. Develop and experimentally validate technologies, models, and approaches to increase the reliability, useful life, or performance of components in vertical takeoff and landing systems. ***FY 2018 Plans:*** Investigate rotor blade morphing technology by comparing and improving analytical predictions with data collected from low speed wind tunnel tests as an approach to reduce vibration and potentially enable swashplateless flight. Investigate structure fatigue models to correlate damage indicators and more accurately predict the remaining useful life of structural components and improve theoretical computational algorithms to more accurately predict structural durability and damage tolerance. ***FY 2019 Plans:*** Novel methods will be developed using concepts such as material self-awareness for the detection and identification of precursors to damage under different types of loading conditions. Will investigate the capability to manufacture mission-specific multifunctional and tailored materials/components. Will explore complex systems, which will enable the prediction of complex dynamics behavior in real-life conditions and increase rotor performance through better understanding of rotor system aeromechanics processes. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels increased to understand materials with self-aware mechanisms suitable for use as damage precursors.			
Title: Reconfigurable Platform Mechanics & Propulsion	-	1.004	1.000
Description: Conduct basic research in reconfigurable platform mechanics and propulsion science technologies to enable high-speed Vertical Take-off and Landing (VTOL). Investigate reconfigurable technologies for improved performance, stability and handling qualities across different flight regimes in all operational environments. ***FY 2018 Plans:*** Investigate aeromechanics characteristics of morphing structures and reconfigurable propulsion concepts such as engine cycles and propulsor drive system configurations. ***FY 2019 Plans:*** Will investigate wide-operability propulsion for future vehicles, including multi-fuel-responsive combustion, tailoring of magnetic properties of materials for aviation electric motors, and extended temperature range smart materials. Propulsion theories associated with achieving the dynamic response of flight stability and maneuverability will also be explored, in addition to fundamental research on the effect of interfacial interaction on mechanical response which would enable reconfigurable platform sub-systems. ***FY 2018 to FY 2019 Increase/Decrease Statement:***			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
Funding levels decreased to enable support of Air Vehicle Structures & Dynamics research.			
Accomplishments/Planned Programs Subtotals	2.053	3.108	3.153

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 2019 Army			Date: February 2018
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 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
H67: *Environmental Research*	-	0.893	1.036	1.065	-	1.065	1.085	1.107	1.130	1.155	0.000	7.471

A. Mission Description and Budget Item Justification

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

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

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Industrial Pollution Prevention	0.893	1.036	1.065
Description: This effort conducts research on innovative environmentally-friendly technologies that support the warfighter (focusing on pollution prevention technologies).			
FY 2018 Plans: Investigate and perform basic research on the development of novel energetics for the reduction of hazardous materials in the processing of energetics. Additional research includes the investigation of airborne lead reduction for Army weapon systems as well as investigating new advanced surface coating products to minimize human health, environmental and long-term sustainable risks.			
FY 2019 Plans: Will investigate and perform basic research to formulate new environmentally friendly propellants, pyrotechnics, and explosives, which reduce the generation of hazardous materials during processing. The focus areas will be the replacement of high explosives including RDX, TNT, and hazardous binders and plasticizers. Will investigate novel materials to minimize human health, environmental, and long-term sustainable risks from Army weapon systems.			
FY 2018 to FY 2019 Increase/Decrease Statement:			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
Funding levels increased due to inflation.			
Accomplishments/Planned Programs Subtotals	0.893	1.036	1.065

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 2019 Army			Date: February 2018
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 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
S13: *Sci BS/Med Rsh Inf Dis*	-	11.118	11.039	11.272	-	11.272	11.509	11.501	12.253	12.498	0.000	81.190

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's response effective, preventing diseases caused by infectious agents. Understanding the biological characteristics of infectious organisms also enables the development of point-of-care and laboratory-based diagnostic tools (used to identify the nature and cause of a particular disease). Understanding of disease transmission by insects and other organisms helps in developing new interventions to prevent transmission of such diseases. Infectious disease threats from malaria, diarrhea, and dengue (a severe debilitating disease transmitted by mosquitoes), common where Warfighters are stationed across all Unified Combatant Commands, are the highest priorities for basic research.

Research conducted in this project focuses on military-relevant infectious diseases in the following four areas:

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

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

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

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Basic Research on drugs and vaccines against parasitic diseases	6.467	6.188	6.351
Description: Malaria, which can cause fatal and chronic disease, is the most significant military infectious disease threat. This effort seeks to better understand the biology of malaria and leishmaniasis (a skin-based disease transmitted by sand flies predominantly exhibited as skin sores) parasites and to gain the necessary foundation for discovering medical countermeasures to protect military personnel from infection. Because the malaria parasite becomes resistant to drugs over time, it is necessary to continually search for parasite weaknesses that can be exploited by different drugs and vaccines. This effort seeks to better			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
understand small molecule therapeutics and prophylactics, to overcome drug resistant organisms and identify new proteins in the design of candidate vaccines for various types of malaria including the severe form (caused by Plasmodium falciparum) and the less severe but relapsing form (caused by Plasmodium vivax). In FY17 the Prevention/Treatment of Parasitic Diseases research area and the Vaccines for Prevention of Malaria research area were merged into one task area titled Parasitic Diseases ? Drugs and Vaccines. ***FY 2018 Plans:*** Assess new lead candidates from the Triazine class of compounds. Identify and assess new lead candidates from the pyrimidinylguanidine class of compounds (a newly discovered family of similar chemical compounds that are active against malaria parasites in experimental animals) and a new primaquine-like compound used to prevent or treat malaria. Continue to monitor for emergence of drug resistant malaria in Asia, Africa and South America. Fabricate newly discovered malaria proteins (artificially produced via genetic engineering) to characterize their ability to prevent malaria in experimental animals. Continue to identify new formulations or delivery methods of malaria proteins for inclusion into malaria vaccines. ***FY 2019 Plans:*** Will formulate and analyze triazine class compounds intended for oral administration in humans. Will develop analysis methods for projected pyrimidinylguanidine class of compounds (a newly discovered family of similar chemical compounds that are active against malaria parasites in animal models) and primaquine-like compounds used to prevent or treat malaria. Methods will be developed for projected clinical trials and to assess drug distribution and efficacy in experimental animals and humans. Will continue to identify and assess new lead candidates from additional chemical classes for treatment and prevention of malaria. Will continue to monitor for emergence of drug resistant malaria in Asia, Africa and South America. Will fabricate newly discovered malaria proteins (artificially produced via genetic engineering) to characterize their ability to prevent malaria in experimental animals. Will continue to identify new formulations or delivery methods of malaria proteins for inclusion into malaria vaccines. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels increased due to inflation.			
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 2018 Plans:*** Characterize the newly-identified antigens (substances derived from the agent which stimulate immune systems to produce antibodies) from Campylobacter, Shigella, and ETEC which together are responsible for most of the cases of diarrhea in deployed	1.505	1.582	1.604

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
Warfighters. Review epidemiology data from deployed populations to determine which pathogens should be included in future vaccines. Continue to discover/identify indicators of vaccine effectiveness (correlates of protection) identified in animal models of bacterial diarrhea for protection from disease. ***FY 2019 Plans:*** Will characterize previously identified antigens (substances derived from the agent which stimulate immune systems to produce antibodies) from Campylobacter, Shigella, and enterotoxigenic E. coli. (ETEC) which together are responsible for most of the cases of diarrhea in deployed Warfighters. Will continue to characterize various types of Shigella, ETEC and Campylobacter to inform vaccine development efforts. Will further investigate previously identified indicators of vaccine effectiveness (correlates of protection) in animal models of bacterial diarrhea for protection from disease. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Increase due to inflation adjustment.			
Title: Viral Threats Research	1.624	1.688	1.712
Description: This effort is to better understand highly lethal or incapacitating viruses, including those that cause hemorrhagic diseases (viral infection that causes severe internal bleeding) such as dengue hemorrhagic fever (life-threatening form if disease caused by the Dengue virus, transmitted by mosquitoes) and Hantaviral pulmonary syndrome (caused by hantavirus infection resulting in internal bleeding; can be transmitted by exposure to rodents or their droppings). Basic research includes understanding risk to the Warfighter of contracting a viral disease based on its prevalence in the respective area of operations, viral biology (structure, function, life cycle of the virus and its ecological factors), the disease process, and disease interaction (symptomology) with the human body. ***FY 2018 Plans:*** Continue to characterize the role of human cells and antibodies recovered from patients vaccinated during dengue vaccine trials in Asia and Latin America and dengue human infection model studies conducted in the United States to identify new methods of vaccine formulations. Continue assessment of host immune responses against dengue virus proteins from patient populations enrolled in expanded Food and Drug Administration (FDA) safety/efficacy/dosing vaccine studies and dengue virus challenge studies in humans to understand protection mechanisms. Use molecular approaches (recombinant Deoxyribonucleic Acid (DNA) based techniques) to determine structures of protective antibodies against dengue. Identify vaccine technologies to produce antibody products that might be used to prevent or treat disease by lethal viruses such as Hantavirus, South American and African Hemorrhagic viruses. ***FY 2019 Plans:*** Will continue to formulate new attenuated (weakened) dengue viruses for use in dengue human challenge trials as part of vaccine testing and studying virus induced host damage and immune cell mediated protection. Will characterize immune cells and antibodies in samples from humans in novel inactivated virus/ live attenuated virus vaccinations against dengue. Will continue			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
computer based assessments of human immune responses to dengue vaccination and dengue infection. Will continue to identify and characterize vaccine technologies to produce antibody products that might be used to prevent or treat disease by lethal viruses such as Hantavirus, South American and African Hemorrhagic viruses. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Increase due to inflation adjustment.			
Title: Vector Identification and 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 identification of infectious disease pathogens in vectors and disease surveillance capabilities in the field. This research will help to direct new interventions into preventing disease transmission. ***FY 2018 Plans:*** Identify unique biological markers (e.g., proteins, genes) that can be used to produce improved detection tools that can identify multiple pathogens in a vector population. Identify technology in vector-borne disease risk assessment tools to manage data and support decision making for vector control operations. Explore integrated vector control strategies to include new insecticides or unique formulations, application equipment, and non-chemical control methods. ***FY 2019 Plans:*** Will continue to develop knowledge keys to identify and characterize new species of vectors. Will continue to explore integrated vector control strategies to include new insecticides or unique formulations, application equipment, and non-chemical control methods. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Increase due to inflation adjustment.	1.522	1.581	1.605
Accomplishments/Planned Programs Subtotals	11.118	11.039	11.272

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 2019 Army											Date: February 2018	
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 2017**	**FY 2018**	**FY 2019 Base**	**FY 2019 OCO**	**FY 2019 Total**	**FY 2020**	**FY 2021**	**FY 2022**	**FY 2023**	**Cost To Complete**	**Total Cost**
S14: *Sci BS/Cbt Cas Care Rs*	-	5.520	5.296	5.610	-	5.610	7.945	8.578	9.082	9.264	0.000	51.295

A. Mission Description and Budget Item Justification

This Project supports basic research to understand the fundamental mechanisms of severe trauma to advance treatment and surgical procedures to save lives and improve medical outcomes for the Warfighter. Experimental models are being developed to support in-depth trauma research studies. This project includes studies of predictive indicators and decision aids for life-support systems; studies to heal and repair burned or traumatically injured hard and soft tissues of the eye, face, mouth, and extremities; studies to control severe bleeding; and studies on traumatic brain injury (TBI). Such efforts will minimize lost duty time and provide military medical capabilities for far- forward medical/surgical care of injuries.
Research conducted in this project focuses on combat casualty care in the following four areas:

(1) Damage Control Resuscitation
(2) Combat Trauma Therapies
(3) Combat Critical Care Engineering
(4) TBI

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

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Damage Control Resuscitation	1.581	1.669	1.652
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 2018 Plans: Use cell culture (cells grown under controlled conditions) techniques to understand the potential blood-clotting and anti-inflammatory effects of stem cells. Use cell culture methods to screen small-volume cytoprotectant (protect blood-deprived cells from further damage and restore normal function) drugs. Characterize response of tissue capillary (smallest of the body?s blood vessels) function to traumatic bleeding.			
FY 2019 Plans:			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
Will study effects of hypotensive (lower than normal blood pressure) resuscitation on human physiology. Will identify candidate key additives for improving platelet storage. Will study changes in the blood clotting system that occur after traumatic injury. Will study biomechanical aspects of blood vessels relevant to bleeding control. As a following on to the FY18 effort, will use cell culture techniques to better understand stem cell safety and effects of stem cells on blood-clotting and inflammation. Will continue use of cell culture methods to screen candidate small-volume drugs for ability to protect blood- and oxygen-deprived cells from further damage and restore normal function. Will continue characterization of response of tissue capillaries to traumatic bleeding. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding decrease to support prolonged field care.			
Title: Combat Trauma Therapies ***Description:*** This effort conducts studies of trauma to tissues and organs, including dental (facial and oral) injuries, extremity wounds and fractures, and burns, and ways to mitigate and/or repair this damage. ***FY 2018 Plans:*** Build upon work from FY17 to perform genetic analyses of wound bacteria to aid in identifying improved products to prevent or treat infected facial, mouth, and extremity wounds. Continue to identify wound healing agents (including re-purposed drugs and combination products) that mitigate wound infection. Begin work to identify ways to reduce injury progression and mitigate eschar (dead necrotic tissue formed on the surface of the skin after burn injury)-induced inflammation, and/or resolve dysregulated (impairment of a physiological regulatory mechanism) inflammation in burn wounds when early debridement (surgical removal of dead tissue) is not possible. ***FY 2019 Plans:*** Will perform studies to determine factors associated with composite bone-muscle injury that lead to impaired healing. Will characterize cell /tissue scaffolds and stem cells as potential candidates for skin substitute. Will continue work to identify wound healing agents and means to reduce injury progression and mitigate eschar (dead skin tissue formed as result of burn injury)-induced inflammation when early debridement (surgical removal of dead tissue) is not possible. Will study burn wound fluid to identify potential biomarkers that signal adequacy of wound healing. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels increased due to inflation.	1.817	1.432	1.483
Title: Combat Critical Care Engineering ***Description:*** This effort conducts basic science studies of vital sign (e.g. heart rate, blood pressure, blood oxygen concentration) responses to trauma as predictors of medical outcomes and as a basis for developing life-saving interventions. This effort also conducts basic science studies to support development of technologies to preserve function of vital organs following traumatic injury.	0.824	0.868	0.894

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
FY 2018 Plans: Progress FY17 efforts to identify new methods to improve prehospital airway management and detection of tension pneumothorax (a life threatening condition caused by a collapsed lung). Advance work from FY17 to develop animal models in which to study impact of pain and pain drugs on resuscitation and stabilization outcomes following traumatic injury. Perform research to identify lung stem cells that may be used to treat lung injuries. ***FY 2019 Plans:*** Will characterize new coating materials for Extracorporeal Life Support circuits that will prevent blood clotting within the system. Will study stem cells to identify potential therapeutic capabilities. Will study biology of airway stem cells. Will conduct studies to characterize effects of partial aortic occlusion on vital organs. Will determine the correlation between blood pressure and renal oxygenation/function, the threshold of hypotension (low blood pressure) for ischemia (lack of blood flow) or reperfusion (resumed blood flow)-induced kidney injury, and correlated ischemia tolerance time of the kidneys. Will assess feasibility of new approaches to enable combat medics to provide basic critical care in austere, out-of-hospital settings. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Increase is due to inflation adjustment.			
Title: Traumatic Brain Injury ***Description:*** This effort conducts basic research in poly-trauma (multiple injuries)/TBI model, mechanisms of cell death, and the discovery of novel drugs and medical procedures to mitigate the effects of TBI. ***FY 2018 Plans:*** Apply systems biology methods to identify new proteins that appear in blood as a result of TBI. Examine metabolic changes (changes in the way the neuron assimilates nutrients and converts them to energy to support nerve function) as mechanisms or markers of TBI. ***FY 2019 Plans:*** Will identify proteins in blood that may be of benefit in diagnosing TBI. Will explore the basic biology underlying how and why the brain continues to degenerate in the weeks and months following severe TBI. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Increase is due to inflation adjustment.	1.298	1.327	1.366
Title: Prolonged Field Care ***Description:*** This effort performs basic research to study the physiological implications of delayed medical evacuation and limited access to definitive surgical care in severely injured casualties.	-	-	0.215

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
FY 2019 Plans: Will study physiological effects of reintroducing circulation to a limb after long-term administration of oxygen-carrying blood substitutes. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** New effort starting in FY19 examining physiological implications of delayed medical evacuation and limited access to definitive surgical care in severely injured casualties.			
Accomplishments/Planned Programs Subtotals	5.520	5.296	5.610

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 2019 Army			Date: February 2018
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 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
S15: *Sci BS/Army Op Med Rsh*	-	6.600	7.116	6.443	-	6.443	9.654	9.093	8.710	8.884	0.000	56.500

A. Mission Description and Budget Item Justification

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

Research conducted in this Project focuses on military operational medicine in 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 (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.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Injury Prevention and Reduction	1.287	1.229	2.227
Description: This effort identifies biological patterns of change in Warfighters during states of physical exertion, identifies physiological (human physical and biochemical functions) mechanisms of physical injury and exertion that will predict musculoskeletal (muscle, bone, tendons, and ligaments) injury. Also includes the characterization of ocular injury pathways resulting from blast exposure in small animal models.			
FY 2018 Plans: Use computational analysis and modeling to define the inflammatory and regenerative response to tissue injury. Formulate blast injury scaling laws for the eyes across species, completing studies on larger animals (rabbits, pigs), with the ultimate goal of developing a surrogate human ocular injury model. Identify biochemical, physiological, and genetic markers of pro- and anti-			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
inflammatory events in skeletal muscle and bone using cell, animal, and human models for eventual transition to clinical trials. Identify molecular, pharmacological, and (or) nutritional interventions to reduce musculoskeletal injury and promote repair. ***FY 2019 Plans:*** Will continue to identify risk factors for musculoskeletal injury in DoD personnel and identify leading candidates of biomarkers that can diagnose injury from overuse. Will continue to determine injury mechanisms and scaling laws from repeated blast in animal models to refine pre-clinical models of low level blast induced mild Traumatic Brain Injury (mTBI). ***FY 2018 to FY 2019 Increase/Decrease Statement:*** In FY19, increased funding for Injury Prevention and Reduction is due to: 1) high priority of the program and 2) normal and planned progression of the effort.			
Title: Physiological Health ***Description:*** This effort conducts research on the physiological mechanisms of sleep, fatigue, and nutrition on Soldier performance, readiness and well-being. Also, efforts will contribute to human health and performance optimization and enhancement. ***FY 2018 Plans:*** Characterize role of sleep in resilience to, and recovery from, mild Traumatic Brain Injury (mTBI) events. Characterize the impact of blast and/or impact-acceleration on the gut microbiome. Investigate the impact of nutritionally optimized products on indicators of immune function in laboratory studies. ***FY 2019 Plans:*** Will characterize the impact of sleep on operational performance by designing field-based methodologies to assess sleep, fatigue and performance. Will investigate nutritional support for metabolic recovery and immune function. Will define inflammatory regulation of nutrient absorption and metabolism. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding reduced to support higher priority Injury Prevention and Reduction.	3.420	3.611	2.031
Title: Environmental Health and Protection ***Description:*** This effort involves the understanding of physiological (human physical and biochemical functions) mechanisms of exposure to extreme heat, cold, altitude, and other environmental stressors. This effort establishes scientific evidence for specific and sensitive diagnostics of exertional heat illness to optimize Warfighter performance in austere environments. ***FY 2018 Plans:*** Use animal models to identify novel circulating biomarkers of organ damage following exertional heat injury (EHI) and exertional heat stroke (EHS) for the diagnosis and assessment of severity of heat injury. Discover biomarkers that are specific to the	0.810	1.053	1.126

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
type and extent of organ damage during EHI/EHS exposure and recovery. Determine the predictive power of various clinical biomarkers for the type and extent of organ damage that is observed at 7 days of recovery. Target biomarkers for EHI/ EHS assessment to characterize sensitivity and specificity in military working dogs. ***FY 2019 Plans:*** Will establish criteria to down-select biomarkers of multi-organ injury to improve diagnosis of exertional heat injury severity in male and female rats at 1, 2, 3 and 7 days of recovery as a model for human health effects. Will investigate dose response modeling for identifying latent hepatic, renal, and cardiac injury after toxic metal and/or toxic industrial chemical exposure during training and operations, including emerging megacities and other multi-domain battle scenarios. Will identify novel circulating biomarkers of organ damage in military working dogs following heat injury for improved medical readiness and recovery assessment. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels increased due to inflation.			
Title: Psychological Health and Resilience ***Description:*** This effort conducts research into the basic mechanisms of the ability to overcome traumatic events including determination of underlying neurobiological mechanisms (nervous system control of cellular and molecular processes) related to Post-Traumatic Stress Disorder (PTSD) and depression. ***FY 2018 Plans:*** Screen for additional compounds for the treatment of PTSD in an animal model, including investigating the ability of the compounds to inhibit adverse memory formation and related disorders. Identify additional vulnerable factors and diagnostic indicators of PTSD and co-existing mental health problems that overlap or complicate PTSD. Use an established rat model of mTBI with or without the addition of stress to identify nutritional and other targets for improved resolution or resilience to the trauma. Identify at least two novel compounds that are active at the nociceptin/orphanin peptide (NOP) receptor (a receptor involved in the regulation of numerous brain activities, particularly instinctive and emotional behaviors) for their ability to mitigate the adverse behavioral effects of traumatic stress and for their impact on PTSD-related symptoms in an animal model. ***FY 2019 Plans:*** Will screen for additional compounds for the treatment of PTSD in an animal model, including investigating the ability of the compounds to inhibit adverse memory formation and related disorders. Will complete specific refinements to animal model behavioral test procedures and expand capacity for bench pharmacological assays for PTSD. Will use an established animal model of mild Traumatic Brain Injury (mTBI) with or without the addition of stress to identify dietary supplements for improved resolution or resilience to brain trauma. Will characterize markers and time course of nervous and endocrine systems response and recovery following trauma exposure in rats. ***FY 2018 to FY 2019 Increase/Decrease Statement:***	1.083	1.223	1.059

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
Funding reduced to support higher priority efforts.			
Accomplishments/Planned Programs Subtotals	6.600	7.116	6.443

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 2019 Army			Date: February 2018
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 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
T14: *BASIC RESEARCH INITIATIVES - AMC (CA)*	-	40.000	0.000	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	40.000

Note

Congressional Interest Item funding provided for Defense Research Sciences.

A. Mission Description and Budget Item Justification

Congressional Interest Item funding provided for Defense Research Sciences.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018
Congressional Add: Congressional Program Increase	40.000	-
FY 2017 Accomplishments: N/A		
Congressional Adds Subtotals	40.000	-

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 2019 Army			Date: February 2018
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 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
T22: *Soil & Rock Mech*	-	4.405	4.606	4.695	-	4.695	4.788	4.883	4.982	5.082	0.000	33.441

A. Mission Description and Budget Item Justification

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

Work in this Project provides the basis for applied research in Program Element (PE) 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.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Military Engineering Basic Research	2.114	2.212	2.260
Description: Conduct fundamental research to determine how physical and chemical characteristics of materials affect their interactions with environment. ***FY 2018 Plans:*** Construct a mechanistic process synthesis model for graphene-carbon nanotube metal nano-composites; investigate new mass and energy transfer models across land-atmosphere boundaries; evaluate novel wave breaking shape prediction models with in-situ experiments; and conduct surf zone transit experiments using an experimental vessel. ***FY 2019 Plans:*** Will reduce non-physical oscillations from high-order nonlinear finite element models of environmental flows by devising entropy viscosity numerical methods for hydrodynamics and numerical methods for a new class of continuum formulations that will be the foundation for new models for mass and energy transfer across land-atmosphere boundary, and will devise a capability for the creation, synthesis, and evaluation of lattice dislocations and surface functionalization for graphene, Carbon Nanotube-metal composites with significantly improved dynamic strength and durability. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels increased due to inflation.			
Title: Materials Modeling for Force Protection	2.291	2.394	2.435

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
Description: Conduct fundamental research on material interactions at the micro- and nano-scales to determine how they affect macroscale properties ***FY 2018 Plans:*** Investigate and validate fuzzy logic tools to improve understanding of data fusion frameworks for predictive models; characterize in-vivo and in-vitro microtubule morphologies to investigate relationships between microscale structure and macroscale material performance; create synthetic analogues of alkali-silica reaction gels; and determine silica fume effects on hydration, rheology, and hardened properties in cementitious materials. ***FY 2019 Plans:*** Will create scalable fuzzy logic tools combined with Geographic Information System multi-criteria decision analysis for geospatial data fusion that will enhance knowledge of environmental parameters with reduced uncertainty in limited knowledge conditions. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels increased due to inflation.			
Accomplishments/Planned Programs Subtotals	4.405	4.606	4.695

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 2019 Army			Date: February 2018
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 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
T23: *Basic Res Mil Const*	-	1.708	1.781	1.815	-	1.815	1.850	1.887	1.929	1.968	0.000	12.938

A. Mission Description and Budget Item Justification

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

Work in this Project provides the basic research basis for applied research in Program Element (PE) 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.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Facilities Research	1.708	1.781	1.815
Description: Conduct fundamental research on innovative infrastructure technologies to optimize facility mission performance, through enhanced security and reduction in resource requirements, design errors and omissions, and environmental burdens. ***FY 2018 Plans:*** Fabricate nanopillar arrays on silicon substrates using nanosphere lithography and functionalize nanopillars with organic and inorganic compounds to investigate bactericidal properties; create controlled oxide growth method and investigate thickness effect on adhesion; and tune bacteriophage and crystalized nanofibers to understand how energy scavenging operates. ***FY 2019 Plans:*** Will determine the aspects of geopolymer chemistry that affect metal bonding and adhesion, and will examine martensite formation in dual phase stainless steels and the impact of this formation on material durability in corrosive environments. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels increased due to inflation.			
Accomplishments/Planned Programs Subtotals	1.708	1.781	1.815

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** T23 / *Basic Res Mil Const*

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 2019 Army			Date: February 2018
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 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
T24: *Signature Physics And Terrain State Basic Research*	-	1.641	1.685	1.720	-	1.720	1.755	1.792	1.828	1.865	0.000	12.286

A. Mission Description and Budget Item Justification

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

Work in this Project provides a foundation for applied research in Program Element (PE) 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.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Analysis for Signal and Signature Phenomenology (Previously titled - Terrain State and Signature Physics)	1.641	1.685	1.720
Description: Conduct fundamental research to examine the effects of environmental parameters on electromagnetic, acoustic, and seismic signatures as well as energy propagation with regard to terrain state and near surface atmosphere. ***FY 2018 Plans:*** Investigate seismic and acoustic wave transmission and reflection at the land-water boundary to characterize lake or river boundary effects on wave propagation; derive empirical expressions of the boundary effects by wave type, wave shape, polarization, and amplitude; and determine if the liquid water contents of frozen soils can be detected remotely (e.g., with airborne sensors) by exploiting polarization phenomena. ***FY 2019 Plans:*** Will conduct full-scale field measurements of multimodal wave transmission across a land/water boundary to identify the waves reflected, transmitted, and converted to different types at a land-water interface; and will advance the understanding of military relevant urban radiofrequency (RF) propagation by investigating urban structures both as materially heterogeneous and geometrically rough, considering both the surface and interior characteristics of urban structures, and explicitly considering			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
multipath effects (fading) by performing wideband channel sounding measurements inside and outside buildings, alleys, and narrow streets. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels increased to enable full-scale field measurements of multi-modal wave transmission across land/water boundaries.			
Accomplishments/Planned Programs Subtotals	1.641	1.685	1.720

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 2019 Army			Date: February 2018
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 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
T25: *Environmental Science Basic Research*	-	6.853	6.708	6.845	-	6.845	6.990	7.139	7.797	7.953	0.000	50.285

A. Mission Description and Budget Item Justification

This Project supports basic research to investigate fundamental scientific principles and phenomena necessary to ensure efficient development of the technologies needed to address Army sustainment issues in the restoration, compliance, conservation, and non-industrial pollution prevention areas. These efforts include: investigating and monitoring contaminated sites, including chemical contamination and unexploded ordnance (UXO) detection and discrimination; better characterization of contaminants through improved risk-based assessment; destruction, containment, or neutralization of organics resulting from military activities in water, soil, and sediments; 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 (PE) 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.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Environmental and Ecological Fate of Explosives, Energetics, and Other Contaminants	3.659	3.446	3.518
Description: Conduct fundamental research to examine the effects of Army relevant compounds on the environment			
FY 2018 Plans: Correlate munition constituent environmental fate processes with soil horizon types and compare models to results from intact soil columns; understand fundamentals of photo-degradation pathways and kinetics of insensitive munitions formulations and individual components through a combination of computational chemistry methods, controlled lab experiments, and outdoor sample analysis; and construct and test an estrogen responsive promoter memory circuit and create and test an arsenic responsive yeast memory circuit.			
FY 2019 Plans: Will determine if sub-lethal exposures to an environmental toxicant can negatively impact an animal?s ability to thrive in the ecosystem, will assess interactive feedbacks on individual stamina and cognition after exposure to sublethal concentrations, and will evaluate spatial scaling effects on individual level cognition after exposure to sublethal concentrations.			
FY 2018 to FY 2019 Increase/Decrease Statement:			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
Funding levels increased due to inflation.			
Title: Fundamental Understanding of Explosives, Energetics and UXO in the Environment ***Description:*** Conduct fundamental research to increase the understanding of the physical and chemical characteristics of insensitive munitions ***FY 2018 Plans:*** Determine chemical kinetic parameters for each insensitive munitions compound on different natural soils; functionalize and characterize cellulose and chitin using electron donating molecules; determine role of electrode surface area in electrode charging; and determine mechanisms of zone dispersion and their limits. ***FY 2019 Plans:*** Will identify biogeochemical parameters that stimulate horizontal gene transfer that will increase the understanding of degradation processes, will identify the sources and mechanisms of photo-activated insensitive munitions toxicity, and will determine the environmental relevance of photo-activated insensitive munitions toxicity. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels increased due to inflation.	1.020	1.066	1.089
Title: Training Land Natural Resources ***Description:*** Conduct fundamental research on the molecular interactions of plants and animals with environmental stimuli. ***FY 2018 Plans:*** Understand anuran olfactory receptor-odorant interaction at the molecular level; define and assess the composition and stability of the lizard microbiome; and determine effects of contaminants on microbiome composition. ***FY 2019 Plans:*** Will explore the interrelationships between surface affinity and photocatalytic degradation, including orientation, kinetics, selectivity, and mechanistic pathway; and will determine the feasibility, mechanisms, photonic efficiency and fundamental processes of a novel, indirect excitation of photocatalyst using evanescent waves. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels increased due to inflation.	1.284	1.249	1.276
Title: Network Science ***Description:*** Conduct fundamental research to examine the behavior of environmental networks to inform data models and algorithms	0.890	0.947	0.962

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
FY 2018 Plans: Understand information propagation through imperfect biological networks and how biology adapts to overcome obstacles; and determine the relationship between path length, information flow, and perturbation parameters in full-scale networks. ***FY 2019 Plans:*** Will compare nectar defense in generalist and specialist plants that are in pollination networks, and will model crowd confusion and evacuation in complex networks. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels increased due to inflation.			
Accomplishments/Planned Programs Subtotals	6.853	6.708	6.845

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 2019 Army			Date: February 2018
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 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
T63: *Robotics Autonomy, Manipulation, & Portability Rsh*	-	8.468	8.847	9.546	-	9.546	11.112	11.281	11.516	11.746	0.000	72.516

A. Mission Description and Budget Item Justification

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

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

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Robotics Autonomy and Human Robotic Interface Research	1.945	1.899	1.930

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
Description: In-house research with a focus on enabling robust autonomous mobility for small robotic systems, including autonomous operations in Global Positioning System (GPS) denied areas, planning, behaviors, intelligent control, and the interface of perception technologies to accomplish Army missions in the area of unmanned systems. These efforts include research activities in micromechanics conducted in association with the Micro Autonomous Systems and Technology Collaborative Technology Alliance (PE 0601104A/Project H54). ***FY 2018 Plans:*** Explore techniques for recognizing novel behaviors and circumstances that support generalized learning and long-term adaptability. Continue efforts towards creating machine understanding of the purpose or intent for objects and behaviors. Explore the bridging of a cognitive architecture and control technology for disparate robotic systems. ***FY 2019 Plans:*** Will research methods to improve the ability of robots to have a deeper understanding of the world, increasing their capability to learn from limited, dirty, dynamic, and complex data. This includes the development of a shared-world model with a single probabilistic framework and a unified probabilistic knowledge base for robotic data. Cognitive approaches to perceptions will also be explored. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels increased due to inflation.			
Title: Intelligent Systems	4.976	5.346	6.016
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 2018 Plans:*** Develop novel techniques to simplify the semantic labeling methodology and increase its scalability using an on-line learning framework; and develop intelligent system algorithms for prioritizing decisions based on the context of mission objectives. ***FY 2019 Plans:*** Will investigate methods to enable the teaming of intelligent systems with Soldiers by developing techniques for online semantic learning from sparse datasets and for intelligent exploration of complex environments. Will explore using sparse representations			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
to map high-dimensional physical problems into low-dimensional ones that can be solved using existing techniques. Will investigate perceptual and intelligence methods to enable an autonomous system to participate in squad level missions. Will explore semantic vector spaces to bridge symbolic and metric representations to develop common representations between humans and intelligent agents. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels increased to enable pursuit of knowledge to support Next Generation Combat Vehicles and Future Vertical Lift for Manned-Unmanned Teaming.			
Title: Unmanned Air Vehicle Research ***Description:*** Conduct basic research focused on topics that contribute to the body of knowledge required to create future intelligent s that can effectively team with manned aircraft. Emphasis will be placed upon topics of control and aeromechanics that will expand the flight envelope for unmanned systems, manipulation of objects, and specialized topics relating to perception, reasoning, and creation of a common model of the surrounding environment and planning for behaviors in adversarial environments at high tempo.. ***FY 2018 Plans:*** Explore application of a cognitive architecture to manned-unmanned teaming of aircraft systems by initially using virtual environments. ***FY 2019 Plans:*** Will develop and explore methods and architectures that enable unmanned air vehicles to interact with the environment while airborne, including perception models for manipulation and flight control methods for robust performance in extreme environments and kinetic/kinematic simulations of unmanned air system (UAS) swarm behavior to enable human-agent teaming. Algorithms for real-time control system adaptation due to conditions such as platform reconfiguration will be developed, where probabilistic methods to access material state awareness will be explored to enable risk-informed maneuver. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels decreased due to decreased emphasis on application of cognitive architectures while maintaining research on fundamental underpinnings of cognitive architectures.	1.547	1.602	1.600
Accomplishments/Planned Programs Subtotals	8.468	8.847	9.546

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** T63 / *Robotics Autonomy, Manipulation, & Portability Rsh*

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army			Date: February 2018
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 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
T64: *Sci BS/System Biology And Network Science*	-	2.860	3.025	3.079	-	3.079	3.139	3.203	3.268	3.333	0.000	21.907

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 (PE) 0602787A (Medical Technology).

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Network Sciences Initiative	2.860	3.025	3.079
Description: This basic research effort involves the use of mathematical models and algorithms to extract medical information from large-scale datasets (generated from the study of cellular genetic makeup, protein structures and function, and whole organism responses) to improve understanding, prevention, diagnostics, and treatments of post-traumatic stress disorder (PTSD), uncontrolled bleeding, infectious diseases, hard-to-diagnose pulmonary disease, and exposure to environmental stressors and hazards.			
FY 2018 Plans: Design algorithms to identify the impact of load-carriage and activity intensity in stress-related bone fracture in Warfighters during basic combat training. Formulate computational algorithms to investigate the association of genetic factors with neurological disorders, e.g., PTSD. Develop models to (a) predict drug targets for enhancing antibiotic sensitivity in wound pathogens that tend to be more antibiotic-resistant because they form biofilms (a group of microorganisms that stick to each other and adhere to a surface), (b) understand how antibody responses may lead to neutralization or enhancement of viral infection, and (c) identify molecular biomarkers of viral infection. Develop algorithms to model blood clotting processes under coagulopathic (inability for blood to clot) conditions and assess the ability of pharmacological (drug) interventions to mitigate trauma-induced coagulopathy (blood?s ability to form clot is impaired).			
FY 2019 Plans: Will design algorithms to identify the impact of bone size, structure and function on the risk of stress-related bone fracture in Warfighters during basic combat training; will improve and refine computational algorithms to investigate the association of			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
genetic factors with psychiatric disorders such as PTSD; will refine models to understand how antibody responses may lead to neutralization or enhancement of viral infection; will improve algorithms to predict biomarkers indicative of toxic chemical exposure and organ damage; will extend capabilities to understand blood clotting processes under coagulopathic conditions and assess the effects of shape changes in blood vessels, biochemical pathways, and pharmacological (drug) interventions on trauma-induced coagulopathy (blood?s ability to form clot is impaired); will develop mathematical models of upper respiratory airflow patterns for the non-invasive diagnosis of pulmonary (lung) diseases. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Increase due to inflation adjustment.			
Accomplishments/Planned Programs Subtotals	2.860	3.025	3.079

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 2019 Army			Date: February 2018
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 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
VR9: *Surface Science Research*	-	2.169	2.293	2.337	-	2.337	2.383	2.431	2.481	2.531	0.000	16.625

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 (PE) 0602622A (Chemical, Smoke and Equipment Defeating Technology).

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Surface Science Research	2.169	2.293	2.337
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 2018 Plans: Conduct fundamental research on chemical and biochemical phenomena occurring at or near solid surfaces and material interfaces; the effects of binding energy, reactions, transport and deposition; study 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 and surface group properties.			
FY 2019 Plans: Will further fundamental research on chemical and biochemical phenomena occurring at or near solid surfaces and material interfaces; will probe the connection between low frequency vibrational modes and macroscopic behavior of metal organic frameworks; will investigate the effects of binding energy, reactions, transport and deposition, theory and modeling of processes at complex surfaces, and experimental work focused on the systematic understanding of surface structure, morphology and surface group properties.			
FY 2018 to FY 2019 Increase/Decrease Statement:			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
Funding levels increased due to inflation.			
Accomplishments/Planned Programs Subtotals	2.169	2.293	2.337

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 2019 Army											Date: February 2018	
Appropriation/Budget Activity 2040: *Research, Development, Test & Evaluation, Army* / BA 1: *Basic Research*					R-1 Program Element (Number/Name) PE 0601103A / *University Research Sciences*							
COST ($ in Millions)	**Prior Years**	**FY 2017**	**FY 2018**	**FY 2019 Base**	**FY 2019 OCO**	**FY 2019 Total**	**FY 2020**	**FY 2021**	**FY 2022**	**FY 2023**	**Cost To Complete**	**Total Cost**
Total Program Element	-	66.506	67.027	65.283	-	65.283	65.858	67.214	68.552	69.923	0.000	470.363
D55: *University Research Initiative*	-	63.547	66.201	65.283	-	65.283	65.858	67.214	68.552	69.923	0.000	466.578
V72: *Minerva*	-	2.959	0.826	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	3.785

A. Mission Description and Budget Item Justification

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

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

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

B. Program Change Summary ($ in Millions)	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total
Previous President's Budget	69.166	67.027	65.283	-	65.283
Current President's Budget	66.506	67.027	65.283	-	65.283
Total Adjustments	-2.660	0.000	0.000	-	0.000
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-2.627	-			
• FFRDC	-0.033	-	-	-	-

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army			Date: February 2018
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601103A / *University Research Sciences*	Project (Number/Name) D55 / *University Research Initiative*	

COST ($ in Millions)	Prior Years	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
D55: *University Research Initiative*	-	63.547	66.201	65.283	-	65.283	65.858	67.214	68.552	69.923	0.000	466.578

A. Mission Description and Budget Item Justification

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

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

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Multidisciplinary University Research Initiative (MURI)	51.083	53.153	53.102
Description: MURI programs are typically 5 years in length at a cost of $1.25 million per year. ***FY 2018 Plans:*** Provide support for MURI awards made in prior years and identify six to eight new FY18 MURI awards to support basic science and/or engineering research at institutions of higher education that is of critical importance to national defense. ***FY 2019 Plans:*** Will provide support for MURI awards made in prior years and will identify six to eight new FY 19 MURI awards to enable advances in select interdisciplinary basic science and/or engineering research areas determined to be of critical importance to national defense. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels decreased to enable support of Presidential Early Career Awards for Scientists and Engineers (PECASE) program and the Army Single Investigator Basic Research Program.			
Title: Presidential Early Career Awards for Scientists and Engineers (PECASE)	4.373	4.574	4.581

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601103A / *University Research Sciences*	**Project (Number/Name)** D55 / *University Research Initiative*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Description: Supports PECASE investigators started in prior years. ***FY 2018 Plans:*** Support prior year awardees and select four new PECASE candidates. ***FY 2019 Plans:*** Will support prior year awardees and will select four new PECASE candidates. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels increased due to inflation.			
Title: Defense University Research Instrumentation Program (DURIP) ***Description:*** Supports basic research through competitive grants for research instrumentation. ***FY 2018 Plans:*** Evaluate proposals to award competitive grants for research instrumentation to enhance universities' capabilities to conduct world class research critical to Army transformation. ***FY 2019 Plans:*** Will evaluate and award competitive grants for research instrumentation to enhance universities' capabilities to conduct world class research and enhance educational capabilities critical to Army transformation. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding level decreased to enable support of the Army Single Investigator Basic Research Program.	8.091	8.474	7.600
Accomplishments/Planned Programs Subtotals	63.547	66.201	65.283

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 2019 Army			Date: February 2018
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601103A / *University Research Sciences*	Project (Number/Name) V72 / *Minerva*	

COST ($ in Millions)	Prior Years	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
V72: *Minerva*	-	2.959	0.826	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	3.785

Note

This project terminates in FY18.

A. Mission Description and Budget Item Justification

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

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: The Minerva Research Initiative (MRI)	2.959	0.826	-
Description: The MRI is a university-based social science research program initiated by the Secretary of Defense. It focuses on areas in the social sciences of strategic importance to national security policy. It seeks to increase the Department's intellectual capital in the social sciences and improve its ability to address future challenges and build bridges between the Department and the social science community. Minerva will bring together universities, research institutions, and individual scholars and support multidisciplinary and cross-institutional projects addressing specific topic areas determined by the Department.			
FY 2018 Plans: Create new quantitative models to detect vulnerabilities in government systems throughout the world that engender sociopolitical instability and susceptibility to hostile movements from both within a nation and from outside. The models focus on shifts in population movement that arise from interdependencies between economic markets, health, and natural resources needed			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601103A / *University Research Sciences*	**Project (Number/Name)** V72 / *Minerva*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
to support social communities. This research will enable a capacity to detect emerging conflict zones before they erupt, and enabling an early capacity to stabilize at-risk regions. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Program ended and funds re-directed to support Social Scientific research, an underpinning knowledge base for enhanced Soldier performance leading to augmented Soldier Lethality.			
Accomplishments/Planned Programs Subtotals	2.959	0.826	-

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 2019 Army											Date: February 2018	
Appropriation/Budget Activity 2040: *Research, Development, Test & Evaluation, Army* / BA 1: *Basic Research*					R-1 Program Element (Number/Name) PE 0601104A / *University & Industry Rsch Ctrs*							
COST ($ in Millions)	**Prior Years**	**FY 2017**	**FY 2018**	**FY 2019 Base**	**FY 2019 OCO**	**FY 2019 Total**	**FY 2020**	**FY 2021**	**FY 2022**	**FY 2023**	**Cost To Complete**	**Total Cost**
Total Program Element	-	108.688	87.395	92.115	-	92.115	88.203	89.772	91.572	93.406	0.000	651.151
EA6: *Cyber Collaborative Research Alliance*	-	3.155	3.338	4.886	-	4.886	4.982	5.082	5.186	5.290	0.000	31.919
F17: *Neuroergonomics Collaborative Technology Alliance*	-	5.126	4.923	4.720	-	4.720	4.830	4.943	5.044	5.145	0.000	34.731
FF5: *Distributed Collaborative Intelligent Systems CTA*	-	0.000	4.178	5.820	-	5.820	6.131	6.295	6.436	6.565	0.000	35.425
FF7: *Internet of Battlefield Things CTA*	-	0.000	3.068	4.179	-	4.179	6.020	6.084	6.175	6.299	0.000	31.825
H04: *HBCU/MI Programs*	-	1.429	1.536	1.591	-	1.591	1.629	1.671	1.704	1.738	0.000	11.298
H05: *Institute For Collaborative Biotechnologies*	-	6.341	5.999	5.999	-	5.999	5.998	5.997	6.150	6.273	0.000	42.757
H09: *Robotics CTA*	-	3.884	4.136	4.240	-	4.240	2.957	3.076	3.139	3.202	0.000	24.634
H50: *Network Sciences Cta*	-	8.814	6.466	5.828	-	5.828	0.000	0.000	0.000	0.000	0.000	21.108
H53: *Army High Performance Computing Research Center*	-	4.234	0.000	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	4.234
H54: *Micro-Autonomous Systems Technology (MAST) CTA*	-	6.531	0.000	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	6.531
H59: *International Tech Centers*	-	6.346	6.682	6.556	-	6.556	6.742	7.081	7.225	7.370	0.000	48.002
H73: *Automotive Research Center (ARC)*	-	3.057	3.235	3.296	-	3.296	3.361	3.427	3.498	3.568	0.000	23.442
J08: *Institute For Creative Technologies (ICT)*	-	5.948	6.308	6.440	-	6.440	6.569	6.701	6.837	6.974	0.000	45.777
J12: *Institute For Soldier Nanotechnology (ISN)*	-	5.947	5.999	5.999	-	5.999	5.998	5.997	6.057	6.178	0.000	42.175

Exhibit R-2, RDT&E Budget Item Justification: PB 2019 Army													Date: February 2018
Appropriation/Budget Activity 2040: *Research, Development, Test & Evaluation, Army* / BA 1: *Basic Research*					R-1 Program Element (Number/Name) PE 0601104A / *University & Industry Rsch Ctrs*								
J13: *UNIVERSITY AND INDUSTRY INITIATIVES (CA)*	-	18.000	0.000	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	18.000	
J14: *Army Educational Outreach Program*	-	9.484	10.047	10.272	-	10.272	10.466	10.675	10.893	11.111	0.000	72.948	
J15: *Network Sciences ITA*	-	3.921	4.082	4.111	-	4.111	4.151	4.233	4.320	4.406	0.000	29.224	
J17: *Vertical Lift Research Center Of Excellence*	-	2.959	3.130	3.186	-	3.186	3.249	3.313	3.381	3.449	0.000	22.667	
VS2: *Multi-Scale Materials Modeling Centers*	-	8.511	9.047	8.754	-	8.754	8.739	8.688	8.886	9.064	0.000	61.689	
VS3: *Center For Quantum Science Research*	-	5.001	5.221	6.238	-	6.238	6.381	6.509	6.641	6.774	0.000	42.765	

A. Mission Description and Budget Item Justification

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

Exhibit R-2, RDT&E Budget Item Justification: PB 2019 Army	Date: February 2018
Appropriation/Budget Activity 2040: *Research, Development, Test & Evaluation, Army* / BA 1: *Basic Research*	**R-1 Program Element (Number/Name)** PE 0601104A / *University & Industry Rsch Ctrs*

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

B. Program Change Summary ($ in Millions)	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total
Previous President's Budget	94.280	87.395	92.115	-	92.115
Current President's Budget	108.688	87.395	92.115	-	92.115
Total Adjustments	14.408	0.000	0.000	-	0.000
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	18.000	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-3.546	-			
• FFRDC	-0.046	-	-	-	-

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2017	FY 2018
Project: J13: *UNIVERSITY AND INDUSTRY INITIATIVES (CA)*		
Congressional Add: *Congressional Program Increase - basic research*	13.000	-
Congressional Add: *Materials in extreme dynamic environments*	5.000	-
Congressional Add Subtotals for Project: J13	18.000	-
Congressional Add Totals for all Projects	18.000	-

Change Summary Explanation

Funding increase to support additional collaboration between Army and university researchers in the areas of cyber science, internet of battlefield things, distributed collaborative intelligent systems, and quantum science.

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army			Date: February 2018
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601104A / *University & Industry Rsch Ctrs*	Project (Number/Name) EA6 / *Cyber Collaborative Research Alliance*	

COST ($ in Millions)	Prior Years	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
EA6: *Cyber Collaborative Research Alliance*	-	3.155	3.338	4.886	-	4.886	4.982	5.082	5.186	5.290	0.000	31.919

A. Mission Description and Budget Item Justification

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

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

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Cyber Security Collaborative Research Alliance	3.155	3.338	4.886
Description: The Cyber Security Collaborative Research Alliance (CSEC CRA) supports basic research to enable capabilities for rapid development and adaptation of cyber tools for dynamically assessing cyber risks, detecting hostile activities on friendly networks, and supporting agile maneuver in cyber space in spite of the continuous evolution and emergence of novel threats.			
FY 2018 Plans: Develop a science of resilient detection in adversarial settings, leading to models of decision-making under uncertainty; develop theories, models and algorithms to execute maneuver at the software, system and network layers; research behavioral and game theoretical models to model user-defender-adversary interactions; enhance the analytical framework, integrating detection and			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University & Industry Rsch Ctrs*	**Project (Number/Name)** EA6 / *Cyber Collaborative Research Alliance*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
risk assessment, to provide choices of agility maneuvers that minimize risk; experimentally validate the analytical framework on realistic testbeds. ***FY 2019 Plans:*** Will enhance fundamental theories and methods to streamline development of new models and algorithms of dynamic cyber threats; will develop new approaches and theoretical frameworks needed to provide resilient and automated capabilities for software, network and system components and overall system function; will research methods for more agile human behavior models and human-machine agent functionality in increasingly complex adversarial environments; will incorporate realistic experimental validation methods for developing new operationally feasible methods. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels increased to enable pursuit of knowledge to support Networks/C3I for improved communications and sensing.			
Accomplishments/Planned Programs Subtotals	3.155	3.338	4.886

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 2019 Army											Date: February 2018	
Appropriation/Budget Activity 2040 / 1					R-1 Program Element (Number/Name) PE 0601104A / *University & Industry Rsch Ctrs*				Project (Number/Name) F17 / *Neuroergonomics Collaborative Technology Alliance*			
COST ($ in Millions)	**Prior Years**	**FY 2017**	**FY 2018**	**FY 2019 Base**	**FY 2019 OCO**	**FY 2019 Total**	**FY 2020**	**FY 2021**	**FY 2022**	**FY 2023**	**Cost To Complete**	**Total Cost**
F17: *Neuroergonomics Collaborative Technology Alliance*	-	5.126	4.923	4.720	-	4.720	4.830	4.943	5.044	5.145	0.000	34.731

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.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Neurocognitive performance in operational environments	1.892	1.821	1.794
Description: This effort is intended to understand fundamental principles underlying Soldier neurocognitive performance in operational environments.			
FY 2018 Plans:			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University & Industry Rsch Ctrs*	**Project (Number/Name)** F17 / *Neuroergonomics Collaborative Technology Alliance*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Utilize behavioral, physiological, and neural measures to explore emotional state and the emotional tone of interpersonal communication; develop novel methods for improved trust and successful communication between vehicle operators, passengers, and autonomous agents based on emotional state. ***FY 2019 Plans:*** Will utilize computational techniques on large-scale heterogeneous datasets to discover robust relationships between complex cognitive states and subsequent performance across a range of Army-relevant tasks; will investigate the relationship between individual brain network connectivity profiles and task performance. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels decreased to enable support of high priority S&T areas including intelligent systems research, internet of battlefield things research, and quantum sciences research for manned-unmanned teaming (Next Generation Combat Vehicles/Future Vertical Lift), Networks/C3I, and communications, respectively.			
Title: Computational neural analysis ***Description:*** This effort advances computational approaches for the analysis and interpretation of neural functioning. ***FY 2018 Plans:*** Develop experimental paradigms and computational techniques to understand the brain circuits underlying shifts between decision-making and task-related actions; develop novel methods for identifying changes in the statistics of the operational environment, task constraints, and arousal level. ***FY 2019 Plans:*** Will elucidate the underlying components responsible for physiological signal degradation in ambulatory environments via novel multi-layered sensor systems; will develop theoretical models and adaptive algorithms for optimal signal acquisition and noise mitigation. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels decreased to enable support of high priority S&T areas including intelligent systems research, internet of battlefield things research, and quantum sciences research for manned-unmanned teaming (Next Generation Combat Vehicles/Future Vertical Lift), Networks/C3I, and communications, respectively.	1.560	1.477	1.362
Title: Neurotechnologies ***Description:*** This effort provides a fundamental advancement in neurotechnologies that enhance Soldier-system interactions and performance. ***FY 2018 Plans:***	1.674	1.625	1.564

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University & Industry Rsch Ctrs*	**Project (Number/Name)** F17 / *Neuroergonomics Collaborative Technology Alliance*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Develop computational frameworks and systems for asynchronous brain-computer communication; identify, separate, and interpret brain activity during naturally occurring periods of stable eye position in both seated and ambulatory environments. ***FY 2019 Plans:*** Will investigate the application of computation frameworks for the prediction of behavioral performance in operationally-relevant tasks with increased temporal complexity and multifaceted objectives; will develop approaches to combine information, derived from brain activity, across individuals to improve situational awareness. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels decreased to enable support of high priority S&T areas including intelligent systems research, internet of battlefield things research, and quantum sciences research for manned-unmanned teaming (Next Generation Combat Vehicles/Future Vertical Lift), Networks/C3I, and communications, respectively.			
Accomplishments/Planned Programs Subtotals	5.126	4.923	4.720

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 2019 Army			Date: February 2018
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601104A / *University & Industry Rsch Ctrs*	Project (Number/Name) FF5 / *Distributed Collaborative Intelligent Systems CTA*	

COST ($ in Millions)	Prior Years	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
FF5: *Distributed Collaborative Intelligent Systems CTA*	-	0.000	4.178	5.820	-	5.820	6.131	6.295	6.436	6.565	0.000	35.425

A. Mission Description and Budget Item Justification

This Project fosters basic research through the highly Distributed and Collaborative Intelligent Systems and Technology (DCIST) Collaborative Research Alliance (CRA), a competitively selected university consortium which leverages world-class research necessary to address future force and Army Transformation needs. The CRA links a broad range of government technology agencies, as well as industrial and academic partners with the Army Research Laboratory (ARL). The DCIST CRA focuses on systems with a large number of heterogeneous intelligent agents, including Soldiers that can be distributed over large areas and are required to move through contested environments and against peer capabilities at op-tempo. To meet these goals innovative research is performed in three main technical areas: distributed intelligence, large heterogeneous group control, and adaptive and resilient behaviors. The payoff to the warfighter will be extended reach, situational awareness, and operational effectiveness against dynamic threats in contested environments, and technical and operational superiority through intelligent, resilient and collaborative behaviors of Soldiers and intelligent systems. The CRA 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.

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 2017	FY 2018	FY 2019
Title: Distributed Collaborative Intelligent Systems Technology	-	4.178	5.820
Description: Extend reach, situational awareness, and operational effectiveness against dynamic threats in contested environments through intelligent, resilient and collaborative behaviors of heterogeneous teams of Soldiers, intelligent systems, smart sensors, and knowledge sources.			
FY 2018 Plans: Explore and develop the underpinning science and technology for highly distributed and collaborative intelligent systems along technical areas to include distributed intelligence, large heterogeneous group control, and adaptive and resilient behaviors.			
FY 2019 Plans: Will establish the theoretical foundations of multi-faceted distributed networked intelligent systems combining autonomous agents, sensors, tactical super-computing, knowledge bases in the tactical cloud, and human experts to acquire and apply knowledge to affect and inform decisions of the collective team. Will develop theory and algorithms for control of large autonomous teams with			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University & Industry Rsch Ctrs*	**Project (Number/Name)** FF5 / *Distributed Collaborative Intelligent Systems CTA*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
varying levels of heterogeneity and modularity across sensing, computing, platforms, and degree of autonomy. Will develop theory and methods for heterogeneous teams to carry out tasks under dynamic and varying conditions in the physical world. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels increased to support the university consortia included in Collaborative Research Alliance on intelligent, resilient and collaborative behaviors of Soldiers and intelligent systems.			
Accomplishments/Planned Programs Subtotals	-	4.178	5.820

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 2019 Army			Date: February 2018
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601104A / *University & Industry Rsch Ctrs*	Project (Number/Name) FF7 / *Internet of Battlefield Things CTA*	

COST ($ in Millions)	Prior Years	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
FF7: *Internet of Battlefield Things CTA*	-	0.000	3.068	4.179	-	4.179	6.020	6.084	6.175	6.299	0.000	31.825

A. Mission Description and Budget Item Justification

This Project will foster research performed through the Internet of Battlefield Things (IoBT) Collaborative Research Alliance (CRA), a competitively selected consortium formed to advance the theoretical foundations of the Internet of Things in the context of Army Operations. The CRA will comprise academia, industry and government researchers working jointly with the objective of developing a fundamental understanding of phenomena of Internet of Things and cyber-physical systems in tactically relevant environments. The CRA will facilitate collaboration across organizations to provide multi-disciplinary perspectives on basic research challenges, as well as the use of state-of-the-art facilities and equipment at the participating organizations. This research focuses on three interrelated aspects of pervasive and converged cyber-physical complex information systems and is conducted using a trans-disciplinary approach that takes into account the information-theoretic and human elements of Army IoBT interactions. The three aspects of the emergent Internet of Battlefield Things topical areas addressed are: 1) dynamic discovery and adaptation of cyber-physical devices, networks, and information sources, 2) resilient re-purposing and re-tasking of devices and information capabilities, and 3) algorithmic, distributed and centralized information-stream processing. Overarching goals of the basic research on Army IoBT are to investigate foundational cross-cutting theories and methods leading towards a science of heterogeneous, self-adapting, complex cyber-physical systems. This research will lead to optimized real-time adversarial situation estimates in information-enabled warfare and greatly enhance the speed and precision for complex military operations involving converged sensing, communications, and resilient actuation.

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

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Internet of Battlefield Things Collaborative Research Alliance (IoBT CRA)	-	3.068	4.179
Description: The Internet of Battlefield Things (IoBT) Collaborative Research Alliance (CRA), seeks to gain fundamental understanding of IoT phenomena and its performance in tactical environments, ranging from sparse, remote settings to complex, dense urban environments. To enable an IoBT capability, research needs to address intelligent resourcing and influence in complex, constrained and uncertain networks (demand from massive numbers of dynamically connected devices, limited and unpredictable connectivity, shared civilian networks, computation at or near the device), heterogeneous sensing and actuation devices (efficient, smart devices with self-organizing/preservation/directing capabilities), and variable, and unreliable provenance and dynamisms of information and device signals.			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University & Industry Rsch Ctrs*	**Project (Number/Name)** FF7 / *Internet of Battlefield Things CTA*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
FY 2018 Plans: Competitively select a consortium consisting of academia, industry and government researchers; investigate new theories for complex system effects that can be applied to dynamic, heterogeneous, adaptive systems-of-systems where the boundaries of control extend beyond personal, organizational, and political borders; explore universal theoretical principles that span the multiple levels at which self-configuring and resilient systems can exist?from systems to enterprises; e.g., formalisms to support diverse nonlinear emergent system behaviors; investigate methods for determining how to incorporate human behavior models into the formal methodology of feedback and just-in-time control; and study theoretical foundations for information, leading to an understanding of tradeoffs (amount of information collected, opportunity for tampering, resource consumption, latency, etc.) and thus predictive resource allocation (sensing, computing, communications, etc.) taking into account risk and uncertainty. ***FY 2019 Plans:*** Will investigate theoretical foundations, models, and methods of autonomic complex systems that deliver adaptive cyber-physical capabilities and services necessary to enable effective command and control across military, adversary, and non-combatant domains; will research the scientific principles, theories, and methods and predictive processing, analytics, and anomaly detection of broadly heterogeneous and varied data that may be unknown combinations of sparse and voluminous; will investigate methods to augment goal-driven decision-making. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding increased to support the university consortia involved with the Collaborative Research Alliance that will create the underlying science base of heterogeneous, self-adapting complex cyber-physical systems.			
Accomplishments/Planned Programs Subtotals	-	3.068	4.179

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 2019 Army			Date: February 2018
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601104A / *University & Industry Rsch Ctrs*	Project (Number/Name) H04 / *HBCU/MI Programs*	

COST ($ in Millions)	Prior Years	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
H04: *HBCU/MI Programs*	-	1.429	1.536	1.591	-	1.591	1.629	1.671	1.704	1.738	0.000	11.298

A. Mission Description and Budget Item Justification

This Project supports basic research through the Partnered Research Initiative (PRI), the Army's research initiative focused on partnerships with Historically Black Colleges and Universities and Minority Institutions (HBCU/MI). The focus of this effort is to enhance programs and capabilities of high-interest scientific and engineering disciplines through innovative research performed in collaboration with Collaborative Technology Alliances and Collaborative Research Alliances (CTA/CRAs). The CTA/CRAs work with Army, industry, and other academic partners to transition research to technology demonstration. In addition, the Centers of Excellence (CoEs) and CTA/CRA partnerships provide opportunities to recruit, educate, and train outstanding students and post-doctoral researchers in science and technology areas relevant to the Army.

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

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Centers of Excellence for Battlefield Capability Enhancements (BCE)	1.429	1.536	1.591
Description: Five new Partnership in Research Transition (PIRT) Centers of Excellence were established in 2011 at: Hampton Univ. (Lower Atmospheric Research Using Light Detection and Ranging (Lidar) Remote Sensing); NCA&T State Univ. (Nano to Continuum Multi-Scale Modeling Techniques and Analysis for Cementitious Materials Under Dynamic Loading); Delaware State Univ. (Center for Advanced Algorithms); Howard Univ.(2) (Bayesian Imaging and Advanced Signal Processing for Landmine and Improvised Explosive Device (IED) Detection Using Ground Penetrating Radar (GPR), and Extracting Social Meaning From Linguistic Structures in African Languages). These Centers were selected to: enhance programs and capabilities through Army-relevant, topic-focused, near-transition-ready innovative research; strengthen the capacity of the HBCUs to provide excellence in education; and to conduct research critical to the national security functions of the DoD.			
FY 2018 Plans: Conduct research with HBCU/MIs begun in FY17 and perform in collaboration with ARL?s CTA/CRAs. Projects are within the scope of CTA/CRAs and pursue high quality, collaborative research in areas of strategic importance to the Army. Areas of			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University & Industry Rsch Ctrs*	**Project (Number/Name)** H04 / *HBCU/MI Programs*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
research include: network science, cognition and neuroergonomics, multiscale modeling of materials, robotics, and/or cyber security. ***FY 2019 Plans:*** Will continue to conduct research with HBCU/MIs performed in collaboration with ARL?s CTA/CRAs. Projects are within the scope of CTA/CRAs and will pursue high quality, collaborative research in areas of strategic importance to the Army. Areas of research will include: network science, cognition and neuroergonomics, multiscale modeling of materials, robotics and/or cyber security. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels increased to support research executed through academia and preparation of a competent future STEM workforce.			
Accomplishments/Planned Programs Subtotals	1.429	1.536	1.591

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 2019 Army			Date: February 2018
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601104A / *University & Industry Rsch Ctrs*	Project (Number/Name) H05 / *Institute For Collaborative Biotechnologies*	

COST ($ in Millions)	Prior Years	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
H05: *Institute For Collaborative Biotechnologies*	-	6.341	5.999	5.999	-	5.999	5.998	5.997	6.150	6.273	0.000	42.757

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, Deoxyribonucleic Acid (DNA) sequence identification and detection tools, and the capability for recognition of viral pathogens. A second ICB objective is to educate and train outstanding students and post-doctoral researchers in revolutionary areas of science to support Army Transformation. The ICB has many industrial partners, such as International Business Machine (IBM) and Science Applications International Corporation (SAIC), and has strong collaborations with Argonne, Lawrence Berkley, Lawrence Livermore, Los Alamos, Oak Ridge, and Sandia National Laboratories, the Army's Institute for Soldier Nanotechnologies, the Institute for Creative Technologies, and Army Medical Research and Materiel Command (MRMC) laboratories.

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Institute for Collaborative Biotechnologies	5.646	5.342	5.345
Description: Perform sustained multidisciplinary basic research supporting technology to provide the Army with bio-inspired materials and biomolecular sensor platforms.			
FY 2018 Plans: Continue to support basic research efforts in synthetic and systems biology, biotechnology tools, and designing microbial consortia. Cellular structural materials, and photonic and electronic materials projects are being combined into new bio-inspired materials effort. On-going research efforts will include bio-inspired optical and photonic materials for potential applications in controlling infrared response and improved energy conversion and storage; novel nanomaterial platform for in situ biomarker detection; and engineering microbial consortia for bio-production.			
FY 2019 Plans:			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University & Industry Rsch Ctrs*	**Project (Number/Name)** H05 / *Institute For Collaborative Biotechnologies*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Will support new set of basic research projects in synthetic and systems biology, bio-inspired materials, and biotechnology tools. The new efforts will include creating novel inorganic-organic hybrid materials with novel photo and ion-conducting properties, mechanistic study of IR detection system of rattlesnakes, and engineering novel biocatalysts for abiological chemistry. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels increased due to inflation.			
Title: Neuroscience ***Description:*** Perform multidisciplinary basic research in the area of neuroscience. ***FY 2018 Plans:*** Continue to support basic cognitive neuroscience research efforts to better understand the effect of fatigue and stress on cognition and on decision-making, and identification of neural indicators/biomarkers for optimal decision-making; and develop neuro-engineering techniques to make inferences about a human?s cognitive and attentional states that are particularly relevant to challenges faced by the Soldier. ***FY 2019 Plans:*** Will support a new set basic research projects in cognitive neuroscience including new mapping strategies for the neural systems for planning skills, understanding the cognitive priority control, and development of multiscale hierarchical framework for analysis of dynamic neuroscience data. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels decreased to enable support of biological research.	0.695	0.657	0.654
Accomplishments/Planned Programs Subtotals	6.341	5.999	5.999

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 2019 Army			Date: February 2018
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601104A / *University & Industry Rsch Ctrs*	Project (Number/Name) H09 / *Robotics CTA*	

COST ($ in Millions)	Prior Years	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
H09: *Robotics CTA*	-	3.884	4.136	4.240	-	4.240	2.957	3.076	3.139	3.202	0.000	24.634

A. Mission Description and Budget Item Justification

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

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

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Autonomous Systems	3.884	4.136	4.240
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 2018 Plans: Research the algorithmic infrastructure necessary to enable peer-to-peer teaming through intuitive mechanisms, e.g., communication of perceptual information and intelligent machine behaviors through language. Explore methods to generalize machine intelligence for adaptation to new situations.			
FY 2019 Plans:			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University & Industry Rsch Ctrs*	**Project (Number/Name)** H09 / *Robotics CTA*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Will create a framework to demonstrate integrated cognitive, perceptual, motion and manipulation planning, and human multi-modal interface capabilities to assess ability for robots to maneuver in unstructured environments, team with humans to execute complex missions, and perform autonomous mobile manipulation in ad hoc scenarios. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding increase to expand the research from robotic peer-to-peer teaming to human-robot teaming.			
Accomplishments/Planned Programs Subtotals	3.884	4.136	4.240

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 2019 Army			Date: February 2018
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601104A / *University & Industry Rsch Ctrs*	Project (Number/Name) H50 / *Network Sciences Cta*	

COST ($ in Millions)	Prior Years	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
H50: *Network Sciences Cta*	-	8.814	6.466	5.828	-	5.828	0.000	0.000	0.000	0.000	0.000	21.108

Note

The Mobile Network Modeling Institute moves to in-house basic research in Fiscal Year (FY) 2018 under Program Element (PE) 0601102A (Defense Research Sciences) \ H48 (Battlespace Info & Comm Rsc).

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. Many of the results of the NS CTA provide a foundation for a new Collaborative Research Alliance for the Internet of Battlefield Things to begin in FY18.

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.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Network Sciences Collaborative Technology Alliance (NS CTA)	7.820	6.466	5.828
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			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University & Industry Rsch Ctrs*	**Project (Number/Name)** H50 / *Network Sciences Cta*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
model, analyze, predict, and control the behavior of secure tactical communication networks as an enabler for information and C2 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 2018 Plans:*** Explore game-theoretic and dynamic programming formulations for network redesign under adversarial dynamics by characterized and establishing conditions for pure and mixed equilibria and formulating algorithms that trades-off current optimality for long-term behavior; develop a theory of reliable real-time social sensing for information extraction by constructing models of social media as noisy communication channels, establishing fundamental bounds on accuracy, and developing real-time algorithms for reliable information extraction; obtain insights on the co-evolution of opinion diffusion and social networks by developing theoretical models of opinion diffusion in dynamic social networks and the impact of cultural and structural properties. ***FY 2019 Plans:*** Will explore machine learning techniques that can classify different types of networks, including social networks, using deep network signatures to identify networks of special interest (e.g. adversarial) in early stages of their growth. Will develop techniques to jointly model changes in information streams and multi-genre networks to enable the prediction of the impact of external events and anomalies in dynamic networks. Techniques for combining user-oriented multidimensional summarization mechanisms with information-centric networking offers the potential to enable effective analytics in combined communications, information, and social networks. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels decreased to enable support of high priority S&T areas including intelligent systems research, internet of battlefield things research, and quantum sciences research for manned-unmanned teaming (Next Generation Combat Vehicles/Future Vertical Lift), Networks/C3I, and communications, respectively. With FY19 being the final year of the CTA, research efforts are concluding as research goals are met.			
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 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. In FY18, the funding for this research is in project 0601102A\ H48.	0.994	-	-

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University & Industry Rsch Ctrs*	**Project (Number/Name)** H50 / *Network Sciences Cta*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Accomplishments/Planned Programs Subtotals	8.814	6.466	5.828

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 2019 Army			Date: February 2018
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601104A / *University & Industry Rsch Ctrs*	Project (Number/Name) H53 / *Army High Performance Computing Research Center*	

COST ($ in Millions)	Prior Years	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
H53: *Army High Performance Computing Research Center*	-	4.234	0.000	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	4.234

Note

This project ended in FY17.

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 program ends in Fiscal Year (FY) 17.

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 2017	FY 2018	FY 2019
Title: Army High Performance Computing Research Center (AHPCRC)	4.234	-	-
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. The cooperative agreement for the AHPCRC terminates in FY17.			
Accomplishments/Planned Programs Subtotals	4.234	-	-

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 2019 Army			Date: February 2018
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601104A / *University & Industry Rsch Ctrs*	Project (Number/Name) H54 / *Micro-Autonomous Systems Technology (MAST) CTA*	

COST ($ in Millions)	Prior Years	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
H54: *Micro-Autonomous Systems Technology (MAST) CTA*	-	6.531	0.000	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	6.531

Note

This project ended in FY17.

A. Mission Description and Budget Item Justification

This Project fosters basic research through the Micro Autonomous Systems and Technology (MAST) Collaborative Technology Alliance (CTA), a competitively selected industry-university consortium which leverages world-class research necessary to address future force and Army Transformation needs. The CTA links a broad range of government technology agencies, as well as industrial and academic partners with the Army Research Laboratory (ARL). The MAST CTA focuses on innovative research in four main technical areas related to the coherent and collaborative operation of multiple micro autonomous platforms: microsystem mechanics, processing for autonomous operation, microelectronics, and platform integration. Payoff to the warfighter will be advanced technologies to support future force requirements in situational awareness. The CTA facilitates the exchange of people among the collaborating organizations to provide cross-organizational perspectives on basic research challenges, and to make available to the Alliance state-of-the-art facilities and equipment at the participating organizations. The MAST cooperative research alliance terminates in Fiscal Year (FY) 17.

Work in this Project complements and is fully coordinated with the United States (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.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Micro-Autonomous Systems Technology (MAST) CTA	6.531	-	-
Description: Enhance tactical situational awareness in urban and complex terrain by enabling the autonomous operation of a collaborative ensemble of multifunctional mobile microsystems. The MAST cooperative research alliance terminates in FY17.			
Accomplishments/Planned Programs Subtotals	6.531	-	-

C. Other Program Funding Summary ($ in Millions)

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University & Industry Rsch Ctrs*	**Project (Number/Name)** H54 / *Micro-Autonomous Systems Technology (MAST) CTA*

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 2019 Army			Date: February 2018
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601104A / *University & Industry Rsch Ctrs*	Project (Number/Name) H59 / *International Tech Centers*	

COST ($ in Millions)	Prior Years	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
H59: *International Tech Centers*	-	6.346	6.682	6.556	-	6.556	6.742	7.081	7.225	7.370	0.000	48.002

A. Mission Description and Budget Item Justification

This Project funds the International Technology Centers (ITCs) and the Foreign Technology (and Science) Assessment Support (FTAS) program.

The nine ITCs located in in North America, South America, Asia, and Europe 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. Highly promising research will be awarded seed funding by the ITC through a grant, contract, or cooperative agreement. The FTAS program also 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 determine the appropriateness of these technology areas identified by the TIPs as having potential relevance to the Army. These efforts will provide information useful in making early assessments of the technology's potential contributions to the Army's S&T strategy.

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: International Technology Centers (ITC)	6.346	6.682	4.452
Description: This project funds the technology search function of the International Technology Centers (ITCs). Research and/or technologies that have possible interest to the Army are described by a technology information papers (TIP). Review of these TIPs by the research community will provide useful information in making early assessments of the technology's potential contributions to the Army's science and technology (S&T) strategy. Highly promising international basic research will be provided seed funding by the ITC for further evaluation through a grant, contract, or cooperative agreement, typically to a university.			
FY 2018 Plans: Continue to solicit projects and build on the success of the Foreign Technology (and Science) Assessment Support (FTAS) Program; and continue to enhance and refine technology search capabilities using customer feedback (RDECs, PMs and labs) to focus on near- and long-term capabilities.			
FY 2019 Plans:			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University & Industry Rsch Ctrs*	**Project (Number/Name)** H59 / *International Tech Centers*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
The ITCs will continue to seek out foreign science and technologies that may have U.S. Army interest within their area of responsibility. Highly promising international basic research will be awarded seed funding for further evaluation through a grant, contract, or cooperative agreement, typically to a university. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels decreased to enable support of foreign technology assessments to ensure knowledge and awareness of worldwide S&T developments.			
Title: Foreign Technology (and Science) Assessment Support (FTAS) ***Description:*** This Project funds the Foreign Technology (and Science) Assessment Support (FTAS) program. The FTAS program builds upon the technology information papers (TIPs) submitted by the U.S. Army laboratories and International Technology Centers (ITCs). In some cases a TIP is truly unique and may well meet an Army requirement or potentially support ongoing Army Science & Technology (S&T) investments. In such cases, the FTAS program can provide initial resources (seed money) to determine the appropriateness of technology areas identified by the TIPs to meet Army needs. These efforts will provide information useful in making early assessments of the technology's potential contributions to the Army's S&T strategy. ***FY 2019 Plans:*** Will solicit projects and build on the success of the FTAS Program. Once scientific quality of candidate projects is assessed by the U.S. Army Senior Scientist Corps, up to $150K in seed funding will be provided to U.S. Army laboratories to further determine the appropriateness of technology areas identified by the TIPs as having potential relevance to the Army. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** New start effort to enable pursuit of knowledge of foreign-generated technology and ensure technological overmatch for future operations.	-	-	2.104
Accomplishments/Planned Programs Subtotals	6.346	6.682	6.556

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 2019 Army			Date: February 2018
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601104A / *University & Industry Rsch Ctrs*	Project (Number/Name) H73 / *Automotive Research Center (ARC)*	

COST ($ in Millions)	Prior Years	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
H73: *Automotive Research Center (ARC)*	-	3.057	3.235	3.296	-	3.296	3.361	3.427	3.498	3.568	0.000	23.442

A. Mission Description and Budget Item Justification

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

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

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Automotive Research Center (ARC)	3.057	3.235	3.296
Description: The ARC is an U.S. Army Center of Excellence for Modeling and Simulation of ground Vehicles. The Center relies on the collaboration of researchers from multiple universities and disciplines in order to bridge fundamental technology gaps in five research thrust areas of strategic importance to the Army, associated with conversion and management of power and energy within vehicles, mobility and survivability of the complete vehicle system, including the human operator, and vehicle integration/ optimization.			
FY 2018 Plans: Continue to focus on dynamics and control of vehicles with emphasis on autonomy-enabled systems, and ground vehicle system integration of advanced powertrains, storage systems and lightweight structures/materials. Research and develop modeling and simulation methodologies for vehicle dynamics-conscious real-time hazard avoidance in autonomous ground vehicles (AGV), improving inherent mobility through innovative latency compensation techniques and robotrust algorithms, increasing energy efficiency and mobility of connected vehicles, adaptive powertrain thermal management based on active monitoring and control,			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University & Industry Rsch Ctrs*	**Project (Number/Name)** H73 / *Automotive Research Center (ARC)*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
superior engine heat rejection using advanced materials, new fatigue reliability and random vibration methods for linear and nonlinear systems, etc. Solicit proposals for continuing and new projects from all ARC consortium researchers in the first quarter of Fiscal Year (FY) 2018. ***FY 2019 Plans:*** Will continue advanced modeling and simulation research on ground vehicle power generation, storage, and distribution while expanding more into autonomy and mobility problems for ground vehicles. Topics will include teleoperated, semi-autonomous, fully-autonomous, and multiple autonomous vehicle operation and control, high fidelity simulation environments for operational evaluations of autonomy related technologies, high performance terramechanics models, perception in degraded sensor environments, machine learning, robotic trust, etc. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels increased due to inflation.			
Accomplishments/Planned Programs Subtotals	3.057	3.235	3.296

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 2019 Army											Date: February 2018	
Appropriation/Budget Activity 2040 / 1					R-1 Program Element (Number/Name) PE 0601104A / *University & Industry Rsch Ctrs*				Project (Number/Name) J08 / *Institute For Creative Technologies (ICT)*			
COST ($ in Millions)	**Prior Years**	**FY 2017**	**FY 2018**	**FY 2019 Base**	**FY 2019 OCO**	**FY 2019 Total**	**FY 2020**	**FY 2021**	**FY 2022**	**FY 2023**	**Cost To Complete**	**Total Cost**
J08: *Institute For Creative Technologies (ICT)*	-	5.948	6.308	6.440	-	6.440	6.569	6.701	6.837	6.974	0.000	45.777

A. Mission Description and Budget Item Justification

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Immersive Environments	2.258	2.394	2.550
Description: Conduct basic research in immersive environments, to include virtual humans, three-dimensional (3D) sound and visual media, to achieve more efficient and affordable training, modeling, simulation and application solutions and tools. Research includes investigation of techniques and methods to address the rapid development of synthetic environments and the study of perception and cognition to help direct the development of new technologies and techniques that evoke more realistic responses from users. Perform research into auditory aspects of immersion to provide the sound stimulus for increasing the realism for military training and simulation devices. ***FY 2018 Plans:*** Incorporate semantic, nonverbal human behaviors with verbal messages to increase realism of simulated face-to-face conversations between humans and virtual humans. Develop algorithms to automatically analyze social simulation models for			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University & Industry Rsch Ctrs*	**Project (Number/Name)** J08 / *Institute For Creative Technologies (ICT)*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
proactively identifying potential data gaps and eliciting data from both online and expert sources to fill in the identified gaps. Create end-to-end neural network-inspired solutions for modeling entrainment for groups of individuals (mixed with virtual agents). ***FY 2019 Plans:*** Will examine characteristics of virtual humans that promote trust in domains such as persuasion tasks, social dilemmas and interviews (with sensitive questions) and will examine differences between normative influence (emphasizing social norms) and informational influence (e.g. conveying expert information); these areas have potential applications for not only virtual humans but also robotics. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels increased to enable improved knowledge to support Soldier Lethality for enhanced human performance and team cohesion.			
Title: Graphics and Animations ***Description:*** Conduct basic research to identify new computational techniques in graphics for achieving real-time photo-realistic rendering of physical and synthetic environments for training and simulations. Research innovative methods for automatically generating animations and gestures for virtual humans based on what is being communicated. Research new technologies for scanning real people and rapidly generating virtual humans which look like these people significantly reducing the time, expense and effort required to develop virtual humans and virtual environments. ***FY 2018 Plans:*** Research hybrid approaches to tracking and creating high-definition facial and body performances of virtual humans for increased realism within virtual and mixed reality environments; investigate techniques to rapidly capture and recreate objects and scenes within virtual reality environments; and develop models for animated characters that include relevant aspects of actual human personalities such as gait, posture, and gestures. ***FY 2019 Plans:*** Will research virtual reality and augmented reality-driven teleportation system that will use detailed 3D models created in prior research to in-person, photo-realistic communication for remote participants; Will research techniques for rapidly capturing movement and speech animations that are specific to individuals. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels decreased due to reduced emphasis on creating detailed 3D models as a result of prior year progress.	1.379	1.462	1.260
Title: Techniques and Human-Virtual Human Interaction ***Description:*** Basic research to investigate methods and techniques for creating virtual human computer-generated characters that look, communicate and behave like real people, meaning the virtual humans will be autonomous, use verbal and non-verbal	2.311	2.452	2.630

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University & Industry Rsch Ctrs*	**Project (Number/Name)** J08 / *Institute For Creative Technologies (ICT)*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
communication, exhibit emotions, model their own beliefs, desires and intentions as well as those of others, and reason using advanced artificial intelligence. Investigate methods and techniques for improving the perception, communication, understanding, and responsiveness of virtual humans when interacting with live humans and explore how people relate to virtual humans. ***FY 2018 Plans:*** Examine and formalize multiple pathways that leaders can use to influence the emotions and motivations of others (in both negotiation and leadership settings). Create models of motivation and personality within a cognitive architecture for virtual humans. Develop a new theory of human-machine teaming focused on gaining a better understanding of the human-machine social relationships. Evaluate the use of meta-dialogue, on-line learning, story, culture, and knowledge-based interaction-enhanced capabilities within the context of long-term interactions between humans and artificial agents ***FY 2019 Plans:*** Will study how extended interaction occurs in groups larger than a dyad, investigate how information can span multiple conversations, and research how to endow virtual humans with these capabilities. Will develop techniques that will allow virtual humans to automatically identify strategic emotional manipulation and defend against it. Will leverage Sigma cognitive architecture?s combined neural and symbolic representations to create a model of question answering. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels increased to enable improved knowledge to support Soldier Lethality for enhanced human performance.			
Accomplishments/Planned Programs Subtotals	5.948	6.308	6.440

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 2019 Army			Date: February 2018
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601104A / *University & Industry Rsch Ctrs*	Project (Number/Name) J12 / *Institute For Soldier Nanotechnology (ISN)*	

COST ($ in Millions)	Prior Years	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
J12: *Institute For Soldier Nanotechnology (ISN)*	-	5.947	5.999	5.999	-	5.999	5.998	5.997	6.057	6.178	0.000	42.175

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

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Nanomaterials and Nanotechnologies for Soldier Application (formerly Nanomaterials)	1.479	5.999	5.999
Description: Nanomaterials research efforts focus on light-weight, multifunctional nanostructured fibers and materials.			
FY 2018 Plans: Support new basic research projects in nanomaterials that can lead to development of novel nanophotonic and optical sensing and energy conversion platforms, and personal medicine platforms for the Soldier Explore novel nanomaterials and composites to improve Soldier protection against blast and ballistic threats, mitigate shock, and improve impact absorption. Investigate multiscale modeling efforts for fracture process in novel nanomaterials. Study novel strategies for treatment of incompressible wounds and improved vaccination/infection control strategies by leveraging targeted nano-therapies.			
FY 2019 Plans: Will support continuing basic research projects in nanomaterials to improve protection against blast and ballistic threats. Will continue to support nano-optoelectronics and novel light-matter interactions for optical sensing and energy conversion platforms.			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University & Industry Rsch Ctrs*	**Project (Number/Name)** J12 / *Institute For Soldier Nanotechnology (ISN)*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Will continue to support battle field medicine through novel strategies for treatment of incompressible wounds, and improved vaccination/infection control strategies by leveraging targeted nano-therapies.			
Title: Blast Effects on Soldier ***Description:*** Blast Effects on Soldier research involves the areas of Battle Suit Medicine and Blast and Ballistic Protection. Will be discontinued as a separate task and will be merged with Nanomaterials and Nanotechnologies for Soldier Application task in Fiscal Year (FY) 18.	2.982	-	-
Title: Soldier Protection ***Description:*** Soldier Protection research efforts focused on Soldier Survivability and Protection and Nanosystems Integration. Will be discontinued as a separate task and will be merged with Nanomaterials and Nanotechnologies for Soldier Application task in FY18.	1.486	-	-
Accomplishments/Planned Programs Subtotals	5.947	5.999	5.999

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 2019 Army			Date: February 2018
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601104A / *University & Industry Rsch Ctrs*	Project (Number/Name) J13 / *UNIVERSITY AND INDUSTRY INITIATIVES (CA)*	

COST ($ in Millions)	Prior Years	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
J13: *UNIVERSITY AND INDUSTRY INITIATIVES (CA)*	-	18.000	0.000	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	18.000

Note

Congressional Increase

A. Mission Description and Budget Item Justification

Congressional Interest Item funding provided for University and Industry Initiatives.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018
Congressional Add: Congressional Program Increase - basic research ***FY 2017 Accomplishments:*** N/A	13.000	-
Congressional Add: Materials in extreme dynamic environments ***FY 2017 Accomplishments:*** N/A	5.000	-
Congressional Adds Subtotals	18.000	-

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 2019 Army											Date: February 2018	
Appropriation/Budget Activity 2040 / 1					R-1 Program Element (Number/Name) PE 0601104A / *University & Industry Rsch Ctrs*				Project (Number/Name) J14 / *Army Educational Outreach Program*			
COST ($ in Millions)	**Prior Years**	**FY 2017**	**FY 2018**	**FY 2019 Base**	**FY 2019 OCO**	**FY 2019 Total**	**FY 2020**	**FY 2021**	**FY 2022**	**FY 2023**	**Cost To Complete**	**Total Cost**
J14: *Army Educational Outreach Program*	-	9.484	10.047	10.272	-	10.272	10.466	10.675	10.893	11.111	0.000	72.948

A. Mission Description and Budget Item Justification

This Project supports science, technology, engineering, and mathematics (STEM) activities that encourage elementary/middle/high school and undergraduate youths to develop an interest in and pursue education and employment in the STEM fields. These activities are coordinated 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 and expose them to DoD careers. AEOP increases interest and involvement of students and teachers across the nation in STEM at all proficiency levels and backgrounds to include under-represented and economically disadvantaged groups through exposure to Army sponsored research, education, competitions, internships, and practical experiences. This Project utilizes Army STEM assets to contribute to a STEM literate citizenry as well as enhances the national pool of science and engineering personnel that in turn supports defense industry and Army laboratory and research, development, and engineering center needs.

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: eCYBERMISSION	3.672	3.821	-
Description: This program supports a nation-wide, web-based STEM competition for students in grades 6 through 9, designed to stimulate interest and encourage continued education in these areas among middle and high school students nationwide. ***FY 2018 Plans:*** 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. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding eliminated so as to increase support of Army Educational Outreach Program (AEOP) Cooperative Agreement.			
Title: Educational Outreach and Workforce Development	2.309	2.200	2.000
Description: This effort aims to broaden STEM competencies through various outreach and workforce development initiatives at participating Army labs and research centers. ***FY 2018 Plans:***			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University & Industry Rsch Ctrs*	**Project (Number/Name)** J14 / *Army Educational Outreach Program*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Continue AEOP support and outreach to under-represented and economically disadvantaged areas to enhance STEM education through student experiences in Army labs and academic partner institutions, and mentor students to broaden their interest in and their development of STEM education. ***FY 2019 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. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels decreased to enable support of Army Educational Outreach Program (AEOP) Cooperative Agreement, thereby increasing program initiatives while decreasing marketing initiatives.			
Title: Army Educational Outreach Program (AEOP) Cooperative Agreement ***Description:*** The Army Educational Outreach Program Cooperative Agreement encompasses a variety of outreach activities under AEOP. This activity supports a strong partnership with government, academia and industry to address the shortfall of clearable STEM skilled talent preparing for the workforce. These activities include Army-sponsored research, education, competitions, internships and practical experiences designed to engage and guide students and teachers in Army sponsored STEM programs. AEOP has targeted efforts to reach and engage underserved and underrepresented communities in STEM initiatives to build the pool of diverse STEM competitive talent. ***FY 2018 Plans:*** Continue Army lab and research center sponsorship of students and STEM education opportunities; provide incentives in STEM competitions that include scholarships, experiences and mentorships as well as expose students to DoD career opportunities; streamline processes, leverage funding and build educational partnerships; and perform annual comprehensive review and educational assessments to support future decisions and best practices. FY18 evaluation efforts include assessments that speak to the STEM education investments impact on teaching 21st century skills. ***FY 2019 Plans:*** Will continue Army lab and research center sponsorship of students and STEM education opportunities; provide incentives in STEM competitions that include scholarships, experiences and mentorships as well as expose students to DoD career opportunities; streamline processes, leverage funding and build educational partnerships; and perform annual comprehensive review and educational assessments to support future decisions and best practices. ***FY 2018 to FY 2019 Increase/Decrease Statement:***	3.205	3.711	7.954

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University & Industry Rsch Ctrs*	**Project (Number/Name)** J14 / *Army Educational Outreach Program*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Funding levels increased to support outreach to STEM populations to ensure a competent technical workforce into the future.			
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 2018 Plans:*** Conduct West Point cadet research internship program to enhance cadet training through field experience in Army research labs and centers. ***FY 2019 Plans:*** Will conduct West Point cadet research internship program to enhance cadet training through field experience in Army research labs and engineering centers. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels increased due to inflation.	0.298	0.315	0.318
Accomplishments/Planned Programs Subtotals	9.484	10.047	10.272

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 2019 Army			Date: February 2018
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601104A / *University & Industry Rsch Ctrs*	Project (Number/Name) J15 / *Network Sciences ITA*	

COST ($ in Millions)	Prior Years	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
J15: *Network Sciences ITA*	-	3.921	4.082	4.111	-	4.111	4.151	4.233	4.320	4.406	0.000	29.224

A. Mission Description and Budget Item Justification

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

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Distributed Analytics and Information Science for U.S./U.K. Coalition Operations Information (formerly Network and Information Science Basic Research for U.S./U.K. Coalition Operations Information)	3.921	4.082	4.111
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 adaptive, goal-driven, semantically-aware, distributed analytics for situational understanding in coalition operations.			
FY 2018 Plans: Model complex, adaptive human systems including group and sub-group reactions to external and internal stimuli to recognize and discriminate behaviors of interest. Investigate software-defined information-centric networking that supports secure coalition operations via logically distributed and decentralized control plane architectures across heterogeneous, mobile networks; create formal theories, techniques, and frameworks to enable multi-level integrated fusion of disparate information sources in the context of decision-support objectives; and identify distributed learning techniques to compose and adapt distributed services in dynamic coalitions.			
FY 2019 Plans: Will investigate and formally model new generative policy techniques in which elements can generate their policies under a loose set of guidance from a central coalition commander, will investigate algorithms that ensure consistency and coherence in the			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University & Industry Rsch Ctrs*	**Project (Number/Name)** J15 / *Network Sciences ITA*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
operation of such a system to enable ad hoc and dynamic coalition formation; will investigate fundamental limits and models for agile code and agile data to support distributed analytics in coalitions with mechanisms that dynamically adapt analytics processing in a tactical coalition environment as missions and coalitions change; will develop deep learning techniques for multi-layer situational understanding with information fusion at varying levels of semantic granularity to obtain situational understanding in complex multi-layer coalition environments. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels increased due to inflation.			
Accomplishments/Planned Programs Subtotals	3.921	4.082	4.111

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 2019 Army			Date: February 2018
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601104A / *University & Industry Rsch Ctrs*	Project (Number/Name) J17 / *Vertical Lift Research Center Of Excellence*	

COST ($ in Millions)	Prior Years	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
J17: *Vertical Lift Research Center Of Excellence*	-	2.959	3.130	3.186	-	3.186	3.249	3.313	3.381	3.449	0.000	22.667

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.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Vertical Lift Research Center of Excellence (VLRCOE)	2.959	3.130	3.186
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 2018 Plans: Execute the second year of the five year cooperative agreements with the Centers of Excellence at Georgia Institute of Technology, Pennsylvania State University, and University of Maryland. Conduct basic research in areas of long term interest for the future vertical lift program, such as hub drag reduction, aeroelastic stability, and reduced order modeling for flight dynamics. Conduct the first annual review by a group of government organizational leaders and subject matter experts (SME's) from the Army, the Navy and NASA to evaluate the research progress and provide technical direction. The basic research at the Centers is highly collaborative in nature with government subject-matter-experts closely tied into the research performed at the universities.			
FY 2019 Plans: Will execute the third annual review of the VLRCOE program with a diverse team of Government subject matter experts (SMEs) and organizational leaders from the Army, the Navy and NASA, to provide technical direction for the research tasks. Will execute the cooperative agreement with the Centers of Excellence at Georgia Institute of Technology, Pennsylvania State University, and University of Maryland incorporating the reviewers' feedback to realign the research tasks with the Army's strategic science and technology plans. The Centers will conduct a robust experimental and analytic basic research program in close collaboration			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University & Industry Rsch Ctrs*	**Project (Number/Name)** J17 / *Vertical Lift Research Center Of Excellence*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
with government SMEs in areas relevant to future vertical lift to include nanocomposites to enhance fatigue life of rotorcraft components, optimal control allocation methods and advanced cueing & flight control algorithms. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels increased due to inflation.			
Accomplishments/Planned Programs Subtotals	2.959	3.130	3.186

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 2019 Army			Date: February 2018
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601104A / *University & Industry Rsch Ctrs*	Project (Number/Name) VS2 / *Multi-Scale Materials Modeling Centers*	

COST ($ in Millions)	Prior Years	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
VS2: *Multi-Scale Materials Modeling Centers*	-	8.511	9.047	8.754	-	8.754	8.739	8.688	8.886	9.064	0.000	61.689

A. Mission Description and Budget Item Justification

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

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

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Collaborative Research Alliances in Materials in Extreme Dynamic Environments and Multiscale Multidisciplinary Modeling of Electronic Materials.	8.511	9.047	8.754
Description: Research will focus on the following areas: two-way multiscale modeling for predicting performance and designing materials, investigating analytical and theoretical analyses to effectively define the interface physics across length scales; advancing experimental capabilities for verification and validation of multiscale physics; and modeling and strategies for the synthesis of high loading rate tolerant materials so that all of the latter lead to the development of a comprehensive set of metrics that define high loading rate tolerant material systems. The multiscale modeling capability will be applied across multiple disciplines to facilitate revolutionary advances in materials for coupled environments (electromagnetic, high rate, high pressure and other extreme environments).			
FY 2018 Plans:			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University & Industry Rsch Ctrs*	**Project (Number/Name)** VS2 / *Multi-Scale Materials Modeling Centers*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Create data-sharing protocols and interfaces for sharing fundamental materials research data related high-strain materials. Complete integrated multiscale models for high rate deformation and failure in four material classes, specifically metals, ceramics, polymers and composites. Explore and characterize microstructure, high strain-rate behavior and failure mechanisms of the 1st iteration of the designed (controlled) materials. Investigate grain boundary modification as related to icosahedral borides and their dynamic properties, and pioneer nanomechanical testing for microfibrils of polymer fibers that have been extracted from macrofibers. Explore uncertainty quantification techniques created for specific materials, and examine their applicability across different materials classes and applications. Integrate the ab initio calculations, atomistic and coarse?grained molecular dynamics (MD) simulations, and continuum level modeling into multiscale modeling framework that facilitates the design of novel: a) Si-based nanostructured anodes and b) three-dimensional (3D) interdigitated anode/cathode nanostructure for batteries. Develop a framework and related codes to carry out simulations of materials and nanostructures from first principles and the description of electronic excitations. Develop computationally efficient models to study non?ideal behavior of materials, specifically, the study of point and extended defects, interfaces and nano/microstructures in electronic and optoelectronic materials. Develop multiscale modeling tools that accurately capture the coupling of redox reactions, the charge transport mechanisms, and the mesoscale morphological features in membrane structure. ***FY 2019 Plans:*** Will implement data-sharing protocols and processes for sharing fundamental materials research data within the program. Will complete integrated multiscale models for high rate deformation and failure in all three material classes: metals, ceramics and composites. Will investigate solid solution strengthening of magnesium and the effects on spall strength, and the design of interface behavior and increased matrix strain in glass epoxy composites. Will implement uncertainty quantification techniques across the three materials classes and applications; design and implement algorithms and tools for coupled multiscale modeling capable of enhancing/optimizing the design of individual components and systems across the three electronic materials research areas; develop methodologies for Uncertainty Quantification-driven bridging/mapping between models and simulation techniques and assessment of reliability of simulation-predicted outcomes for polymer membranes and electrode/electrolytes interfaces; and extend the Nonequilibrium Green's function code (inclusion of carrier-carrier scattering and parallel implementation) to evaluate key quantities not accessible to other simulation approaches, e.g. phonon-assisted Auger-induced leakage, trap- and phonon-assisted tunneling for electro-optical materials. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels decreased due to reduced emphasis on one of the four material systems being studied, namely polymers.			
Accomplishments/Planned Programs Subtotals	8.511	9.047	8.754

C. Other Program Funding Summary ($ in Millions)

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University & Industry Rsch Ctrs*	**Project (Number/Name)** VS2 / *Multi-Scale Materials Modeling Centers*

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 2019 Army			Date: February 2018
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601104A / *University & Industry Rsch Ctrs*	Project (Number/Name) VS3 / *Center For Quantum Science Research*	

COST ($ in Millions)	Prior Years	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
VS3: *Center For Quantum Science Research*	-	5.001	5.221	6.238	-	6.238	6.381	6.509	6.641	6.774	0.000	42.765

A. Mission Description and Budget Item Justification

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

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Center for Distributed Quantum Information	5.001	5.221	6.238
Description: This work supports critical quantum science basic research at the United States (U.S.) ARL exploiting quantum effects to greatly enhance computing, communications, imaging, sensing, and security, ensuring Army dominance on the future battlefield. ***FY 2018 Plans:*** Entangle two physically separate nodes, improve interfacing between nodes, and apply initial networking protocols. Complete construction of third physical node within a quantum network. ***FY 2019 Plans:*** Will simultaneously entangle three or more physically separate quantum nodes and investigate quantum networking algorithms and protocols. Quantum-state transfer, node-to-node entanglement, error protection protocols, and frequency conversion will continue to be refined and improved. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels increased to enable pursuit of knowledge to support Networks/C3I for improved communications and sensing.			
Accomplishments/Planned Programs Subtotals	5.001	5.221	6.238

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University & Industry Rsch Ctrs*	**Project (Number/Name)** VS3 / *Center For Quantum Science Research*

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A