

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 1999
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BUDGET ACTIVITY 3 - Advanced Technology Development	PE NUMBER AND TITLE 0603302F Space and Missile Rocket Propulsion
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COST (\$ In Thousands)	FY 1998 Actual	FY 1999 Estimate	FY 2000 Estimate	FY 2001 Estimate	FY 2002 Estimate	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	Cost to Complete	Total Cost
Total Program Element (PE) Cost	15,407	23,982	11,231	10,863	11,498	12,269	22,992	22,472	Continuing	TBD
0003 Launch Vehicle Technology	608	584	0	0	0	0	0	0	0	TBD
4373 Launch and Orbit Transfer Propulsion Technology	13,240	21,598	9,457	9,374	10,003	10,766	21,457	20,905	Continuing	Continuing
6339 Tactical Propulsion Technology	144	292	288	0	0	0	0	0	0	TBD
6340 Satellite Control and Maneuvering Propulsion Technology	1,415	1,508	1,486	1,489	1,495	1,503	1,535	1,567	Continuing	Continuing
Quantity of RDT&E Articles	0	0	0	0	0	0	0	0	0	0

Note: Project 0003 transfers to PE 0603401F, Project 1026, starting in FY 2000. Strategic sustainment efforts have been consolidated in Project 4373; this involved moving the Post-Boost Control and Non-Destructive Evaluation efforts and associated funding from Project 6340 to Project 4373. The electric propulsion efforts, originally in Project 4373, have been moved to Project 6340. Efforts in Project 6339 will be terminated at the end of FY 2000. Finally, solar thermal efforts have been moved from Project 6340 to Project 4373.

(U) A. Mission Description: This Advanced Technology Development program develops and demonstrates advanced rocket propulsion and space launch technologies. This program provides the technological step necessary to transition the most promising rocket propulsion and space launch technologies to applications using full-scale, proof-of-principle demonstrations. The projects within this program are structured to support Air Force Space Command's and Air Combat Command's mission area requirements for space and missile technologies which include the goals established in the Integrated High Payoff Rocket Propulsion Technology Initiative, a multi-agency/industry effort to focus the development of U.S. rocket propulsion technology. New and improved components will be integrated with the environmentally improved propellants developed in this program to create new propulsion systems for the next generation of launch vehicles and satellites. Anticipated technological advances in this program will improve the performance of expendable systems' payload capabilities by 21% and reduce the launch and operations and support (O&S) costs by 28%. In a reusable launch system, the anticipated improvements are an increase in payload capability of 170% and a reduction in launch and O&S costs of 79%. The advances in propulsion in this program result from the achievement of the 2010 goals of the Integrated High Payoff Rocket Propulsion Technology Initiative. The development of these technologies has been coordinated with National Aeronautics and Space Administration (NASA) to eliminate duplication of efforts. The space launch and missile propulsion industry will leverage the technologies from this program to enhance the country's industrial competitiveness. Note: In FY 1999, Congress added \$3 million for Integrated High Payoff Rocket Propulsion Technology (IHPRPT).

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(U) **B. Budget Activity Justification:** This program is in Budget Activity 3, Advanced Technology Development, since it develops and demonstrates technologies for existing system upgrades and/or new system developments that have military utility and address warfighter needs.

(U) **C. Program Change Summary (\$ in Thousands):**

	<u>FY 1998</u>	<u>FY 1999</u>	<u>FY 2000</u>	<u>FY 2001</u>	<u>Total Cost</u>
(U) Previous President's Budget/FY 1999 PB	17,249	21,121	21,622	21,332	Cont
(U) Appropriated Value	18,147	24,121			
(U) Adjustments to Appropriated Value					
a. Congressional/General Reductions	-609	-139			
b. SBIR	-302				
c. Omnibus/Other Above Threshold Reprogrammings	-116				
d. Below Threshold Reprogrammings	-1,713				
(U) Adjustments to Budget Year Since FY 1999 PB			-10,391	-10,469	
(U) Current Budget Submit/FY 2000 PB	15,407	23,982	11,231	10,863	Cont

(U) **Significant Program Changes:** Changes to this program since the previous President's Budget are due to higher priorities within the Science and Technology (S&T) Program.

FY 1999: \$682 identified as a source for SBIR.

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RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)								DATE February 1999		
BUDGET ACTIVITY 3 - Advanced Technology Development					PE NUMBER AND TITLE 0603302F Space and Missile Rocket Propulsion				PROJECT 0003	
<i>COST (\$ In Thousands)</i>	FY 1998 Actual	FY 1999 Estimate	FY 2000 Estimate	FY 2001 Estimate	FY 2002 Estimate	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	Cost to Complete	Total Cost
0003 Launch Vehicle Technology	608	584	0	0	0	0	0	0	0	TBD
<p>(U) A. <u>Mission Description:</u> This project develops advanced and innovative launch vehicle technologies in the areas of structures (i.e., fairings, interstages, struts, thermal protection systems, etc.), tanks, and operations. Project 0003 transfers to PE 0603401F, Project 1026, starting in FY 2000.</p> <p>(U) <u>FY 1998 (\$ in Thousands):</u></p> <ul style="list-style-type: none"> – (U) \$125 Defined technological needs for future reusable military launch vehicles including lightweight airframe structures, durable composite cryogenic tanks, lightweight combined thermally protecting structures, and integrated acoustic attenuation. – (U) \$57 Defined technological needs for future expendable launch vehicles including operations technologies, lightweight structures, durable composite cryogenic tanks, secondary payload insertion structures, and integrated acoustic attenuation. – (U) \$426 Fabricated advanced composite launch vehicle structures including full-size interstage and grid stiffened shrouds. – (U) \$608 Total <p>(U) <u>FY 1999 (\$ in Thousands):</u></p> <ul style="list-style-type: none"> – (U) \$150 Continue to define technological needs for future reusable military launch vehicles including operations technologies, lightweight airframe structures, durable composite cryogenic tanks, and structure multifunctionality including thermal and acoustic tailorability. – (U) \$100 Continue to define technological needs for future expendable launch vehicles including operations technologies, lightweight airframe structures, durable composite cryogenic tanks, and structure multifunctionality including thermal and acoustic tailorability. – (U) \$317 Develop advanced composite launch vehicle structures including grid stiffened shrouds. – (U) \$17 Identified as a source for SBIR. – (U) \$584 Total <p>(U) <u>FY 2000:</u> Not Applicable.</p> <p>(U) <u>FY 2001:</u> Not Applicable.</p>										
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RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE
BUDGET ACTIVITY	PE NUMBER AND TITLE	PROJECT
3 - Advanced Technology Development	0603302F Space and Missile Rocket Propulsion	0003
<p>(U) B. <u>Project Change Summary - Description of Significant Changes:</u> In FY 2000, efforts currently in this project move to PE 0603401F, Project 1026.</p> <p>(U) C. <u>Other Program Funding Summary:</u></p> <p>(U) <u>Related Activities:</u></p> <ul style="list-style-type: none">- (U) PE 0602102F, Materials.- (U) PE 0602601F, Phillips Laboratory.- (U) PE 0603401F, Advanced Spacecraft Technology.- (U) PE 0603853F, Evolved Expendable Launch Vehicle Program.- (U) This project has been coordinated through the Reliance process to harmonize efforts and eliminate duplication. <p>(U) D. <u>Acquisition Strategy:</u> Not Applicable.</p> <p>(U) E. <u>Schedule Profile:</u> Not Applicable.</p>		
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BUDGET ACTIVITY 3 - Advanced Technology Development				PE NUMBER AND TITLE 0603302F Space and Missile Rocket Propulsion				PROJECT 4373		
COST (<i>\$ In Thousands</i>)	FY 1998 Actual	FY 1999 Estimate	FY 2000 Estimate	FY 2001 Estimate	FY 2002 Estimate	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	Cost to Complete	Total Cost
4373 Launch and Orbit Transfer Propulsion Technology	13,240	21,598	9,457	9,374	10,003	10,766	21,457	20,905	Continuing	Continuing
<p>(U) A. <u>Mission Description:</u> This project develops advanced and innovative, low-cost rocket turbomachinery and components, low-cost space and missile launch propulsion system manufacturing technologies, and advanced propellants. Characteristics such as environmental acceptability, affordability, reliability, reduced weight, reduced operation and launch costs, and increased life and performance of propulsion systems are emphasized in this project. Technological advances developed in this program will improve the performance of expendable systems' payload capabilities by 21% and reduce the launch and operations and support (O&S) costs by 28%. The advances in propulsion in this program will result from the achievement of the 2010 goals of the Integrated High Payoff Rocket Propulsion Technology Initiative.</p> <p>(U) <u>FY 1998 (\$ in Thousands):</u></p> <ul style="list-style-type: none"> - (U) \$8,004 Developed propulsion technologies for existing and future launch vehicles. Fabricated and tested cryogenic engine turbomachinery that provide higher reliability for large liquid engines. - (U) \$1,336 Developed propulsion technologies for existing and future upper stage and orbit transfer vehicles. Fabricated and tested combustion chamber for liquid upper stage engines, solar electric propulsion, and solar thermal propulsion. - (U) \$3,900 Developed technologies for the sustainment of strategic systems. Initiated a multi-use, less detonable (Class 1.3) solid propellant project which meets all Intercontinental Ballistic Missile (ICBM) requirements, reduces hardware costs by 25%, and sustains current performance levels. - (U) \$13,240 Total <p>(U) <u>FY 1999 (\$ in Thousands):</u></p> <ul style="list-style-type: none"> - (U) \$14,889 Continue to develop propulsion technologies for existing and future launch vehicles. Complete fabrication and testing of oxygen and hydrogen turbopump assemblies and preburner components for integration into an advanced liquid booster engine. - (U) \$3,096 Continue to develop propulsion technologies for existing and future upper stage and orbit transfer vehicles. Complete component testing and begin integration of components into demonstrator engine. Demonstrate solar thermal propulsion technology in ground test to prove performance increase up to 800 seconds specific impulse (Isp). - (U) \$3,000 Develop technologies for the sustainment of strategic systems. Continue development of a multi-use, less detonable (Class 1.3) solid propellant which meets all ICBM requirements, reduces hardware costs by 25%, and sustains current performance levels. - (U) \$613 Identified as a source for SBIR. - (U) \$21,598 Total 										
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RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 1999
BUDGET ACTIVITY 3 - Advanced Technology Development	PE NUMBER AND TITLE 0603302F Space and Missile Rocket Propulsion	PROJECT 4373
<p>(U) <u>FY 2000 (\$ in Thousands):</u></p> <ul style="list-style-type: none"> - (U) \$3,864 Begin developing propulsion components for existing and future launch vehicles. Initiate fabrication and assembly of combustion chamber and injector for use in large liquid engines. - (U) \$3,000 Continue testing of oxygen and hydrogen turbopump assemblies and preburner components for integration into an advanced liquid booster engine. Testing will demonstrate a 1% increase in performance of cryogenic engines. - (U) \$2,593 Develop propulsion technologies for existing and future upper stage and orbit transfer vehicles. Complete integration of components into high-pressure cryogenic upper stage test bed engine. - (U) \$9,457 Total <p>(U) <u>FY 2001 (\$ in Thousands):</u></p> <ul style="list-style-type: none"> - (U) \$7,374 Initiate the Phase II cryogenic booster engine demonstration by performing engine concept selection. This engine has the goal of reducing costs by 50%, reducing weight by 40%, and increasing thrust to weight by 60%. - (U) \$1,000 Begin preliminary design of Phase II cryogenic booster engine. - (U) \$1,000 Begin investigating new materials and fabrication processes that can reduce the cost of the Phase II cryogenic booster. - (U) \$9,374 Total <p>(U) B. <u>Project Change Summary - Description of Significant Changes:</u> Changes to this program since the previous President's Budget are due to higher priorities within the Science and Technology (S&T) Program.</p> <p>(U) C. <u>Other Program Funding Summary:</u></p> <p>(U) <u>Related Activities:</u></p> <ul style="list-style-type: none"> - (U) PE 0602601F, Phillips Laboratory. - (U) PE 0603853F, Evolved Expendable Launch Vehicle Program. - (U) This project has been coordinated through the Reliance process to harmonize efforts and eliminate duplication. <p>(U) D. <u>Acquisition Strategy:</u> Not Applicable.</p> <p>(U) E. <u>Schedule Profile:</u> Not Applicable.</p>		
Project 4373	Page 6 of 10 Pages	Exhibit R-2A (PE 0603302F)

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RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)								DATE February 1999		
BUDGET ACTIVITY 3 - Advanced Technology Development				PE NUMBER AND TITLE 0603302F Space and Missile Rocket Propulsion				PROJECT 6339		
<i>COST (\$ In Thousands)</i>	FY 1998 Actual	FY 1999 Estimate	FY 2000 Estimate	FY 2001 Estimate	FY 2002 Estimate	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	Cost to Complete	Total Cost
6339 Tactical Propulsion Technology	144	292	288	0	0	0	0	0	0	TBD
<p>(U) A. <u>Mission Description:</u> This project develops highly energetic propellants and propulsion systems. Improved case, insulation, and propellant interfaces as well as better performing nozzles will be developed. Technology such as thrust vector control, thrust modulation, signature characterization, and signature reduction will be developed in this project. The emphasis in this project is on rocket propulsion system affordability and weight reduction. Anticipated payoffs from these developments, identified through the Integrated High Payoff Rocket Propulsion Technology Initiative (IHPRPT), include a 49% range increase, 50% size reduction, 100% payload increase, and 21% reduction in time-to-target.</p> <p>(U) <u>FY 1998 (\$ in Thousands):</u></p> <ul style="list-style-type: none"> – (U) \$144 Developed and evaluated advanced solid propellants, in small quantities, that can be incorporated into the design and manufacturing of future tactical missile systems. These propellants have acceptable hazards, higher performance, lower environmental impact, and reduced exhaust signature characteristics. After propellant development, began to characterize solid propellant formulations in lab-size quantities. In conjunction with France, Germany, and the United Kingdom, downselected to two propellant formulations and scale-up to gallon quantities for further evaluation. Initiated propellant scale-up for rheological and hazards properties. Provided initial propellant formulations and ingredient samples to the France, Germany, and the United Kingdom for their internal evaluation. – (U) \$144 Total <p>(U) <u>FY 1999 (\$ in Thousands):</u></p> <ul style="list-style-type: none"> – (U) \$283 Begin scale-up of selected solid propellant formulations that can be incorporated into the design and manufacture of future air-to-air missile systems for the U.S., France, Germany, and the United Kingdom. These propellants will have acceptable hazards, higher performance, lower environmental impact, and reduced exhaust signature characteristics. Complete solid propellant scale-up and finalize rheological and hazards properties. Complete ballistic performance evaluation in U.S. test motors (15 lbs.) and manufacture initial European test motors for their internal evaluation. – (U) \$9 Identified as a source for SBIR. – (U) \$292 Total 										
Project 6339			Page 7 of 10 Pages			Exhibit R-2A (PE 0603302F)				

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RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE
BUDGET ACTIVITY	PE NUMBER AND TITLE	PROJECT
3 - Advanced Technology Development	0603302F Space and Missile Rocket Propulsion	6339
<p>(U) <u>FY 2000 (\$ in Thousands):</u></p> <ul style="list-style-type: none">- (U) \$288 Integrate component technologies and an advanced tactical missile propellants that improve missile thrust and reduce plume exhaust signatures. Manufacture European test motors and selected propellant samples incorporating an advanced high performance, acceptable hazards, low environmental impact, and reduced signature propellant. Ship these rocket test motors to our European partners (France, Germany, and the United Kingdom) and participate in their evaluations of performance, signature, hazards, mechanical, and aging properties.- (U) \$288 Total <p>(U) <u>FY 2001:</u> Not Applicable.</p> <p>(U) B. <u>Project Change Summary - Description of Significant Changes:</u> Changes to this program since the previous President's Budget are due to higher priorities within the Science and Technology (S&T) Program.</p> <p>(U) C. <u>Other Program Funding Summary:</u></p> <p>(U) <u>Related Activities:</u></p> <ul style="list-style-type: none">- (U) PE 0602601F, Phillips Laboratory.- (U) PE 0602303A, Missile Technology.- (U) PE 0603313A, Missile and Rocket Advanced Technology.- (U) PE 0603792N, Advanced Technology Transition.- (U) This project has been coordinated through the Reliance process to harmonize efforts and eliminate duplication. <p>(U) D. <u>Acquisition Strategy:</u> Not Applicable.</p> <p>(U) E. <u>Schedule Profile:</u> Not Applicable.</p>		
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BUDGET ACTIVITY 3 - Advanced Technology Development				PE NUMBER AND TITLE 0603302F Space and Missile Rocket Propulsion				PROJECT 6340		
<i>COST (\$ In Thousands)</i>	FY 1998 Actual	FY 1999 Estimate	FY 2000 Estimate	FY 2001 Estimate	FY 2002 Estimate	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	Cost to Complete	Total Cost
6340 Satellite Control and Maneuvering Propulsion Technology	1,415	1,508	1,486	1,489	1,495	1,503	1,535	1,567	Continuing	Continuing
<p>(U) A. <u>Mission Description:</u> Chemical, electric, and solar rocket propulsion system technologies for station keeping and on-orbit maneuvering applications are developed in this project. Technology areas investigated include ground demonstrations of compact, lightweight, advanced propulsion systems, higher efficiency energy conversion systems (derived from an improved understanding of combustion fundamentals), and high-energy chemical propellants. The payoffs for the Integrated High Payoff Rocket Propulsion Technology Initiative (IHPRPT) include a seven-year increase in satellite on-orbit time, a 50% increase in satellite maneuvering capability, a 25% reduction in orbit transfer operational costs, and a 15% increase in satellite payload.</p> <p>(U) <u>FY 1998 (\$ in Thousands):</u></p> <ul style="list-style-type: none"> - (U) \$215 Flight-qualified water resistojet for use on the first flight of the MightySat space demonstration. - (U) \$200 Performance goals of a water resistojet were successfully evaluated for use on the first flight of the MightySat space demonstration. - (U) \$1,000 Initiated the Non-Destructive Evaluation (NDE) data processing technologies project to predict solid rocket motor service life to ten years with a 90% confidence level. The NDE project will avoid the current necessity of condemning an entire population of motors when only a few are unacceptable. - (U) \$1,415 Total <p>(U) <u>FY 1999 (\$ in Thousands):</u></p> <ul style="list-style-type: none"> - (U) \$500 Complete plume diagnostic experiment, flight qualification testing, spacecraft integration, and test of a water resistojet for the MightySat space demonstration. - (U) \$175 Launch the high power 30kW Class ammonia arcjet thruster aboard the ARGOS satellite, collect flight data, and correlate with ground test data to assess on-orbit performance and spacecraft interaction. Evaluate possibilities of using arcjet in flight systems. - (U) \$410 Complete Critical Design Review (CDR) and fabricate a high performance Hall thruster system for ground demonstration of system life. - (U) \$380 Continue the development of NDE data processing technologies project to predict solid rocket motor service life to ten years with a 90% confidence level. Finalize the NDE system specification, finalize the test imager design, and begin software development. - (U) \$43 Identified as a source for SBIR. - (U) \$1,508 Total 										
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RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 1999
BUDGET ACTIVITY 3 - Advanced Technology Development	PE NUMBER AND TITLE 0603302F Space and Missile Rocket Propulsion	PROJECT 6340
<p>(U) <u>FY 2000 (\$ in Thousands):</u></p> <ul style="list-style-type: none"> - (U) \$455 Launch the MightySat space flight experiment with water resistojet for primary propulsion. Perform in-flight measurements of thruster performance and satellite contamination for comparison to ground measurements. - (U) \$131 Complete component tests, integration of components, and scheduled ground demonstration of a flight-qualified high performance Hall thruster system. Engine demonstration will prove 1% performance specific impulse (Isp) improvement for integration into future upper stage engines. - (U) \$900 Continue engine testing of the high-pressure cryogenic upper stage engine. - (U) \$1,486 Total <p>(U) <u>FY 2001 (\$ in Thousands):</u></p> <ul style="list-style-type: none"> - (U) \$517 Demonstrate solar electric propulsion technologies for satellite stationkeeping, repositioning, and orbit transfer. Analyze data from MightySat space flight and validate against ground measurements. Develop models for spacecraft interaction with water resistojet propulsion exhaust. - (U) \$472 Complete engine testing of the high-pressure cryogenic upper stage engine. - (U) \$500 Begin analysis of test data from high-pressure cryogenic upper stage engine, focusing on potential improvements for the Phase II upper stage engine demonstrations. - (U) \$1,489 Total <p>(U) B. <u>Project Change Summary - Description of Significant Changes:</u> Not Applicable.</p> <p>(U) C. <u>Other Program Funding Summary:</u></p> <p>(U) <u>Related Activities:</u></p> <ul style="list-style-type: none"> - (U) PE 0602601F, Phillips Laboratory. - (U) This project has been coordinated through the Reliance process to harmonize efforts and eliminate duplication. <p>(U) D. <u>Acquisition Strategy:</u> Not Applicable.</p> <p>(U) E. <u>Schedule Profile:</u> Not Applicable.</p>		
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