

Government Built, Production Quality, Multi-Disciplinary, Multi-Fidelity Software for Acquisition Engineering Support

National Defense Industry Association Systems and Mission Engineering Conference 6-8 December 2021



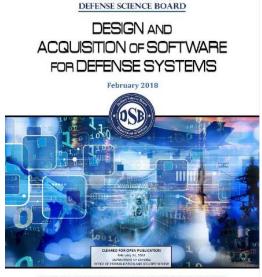
Dr. Scott A. Morton, Associate Director for CREATE DoD HPCMP, US Army ERDC/Information Technology Laboratory Scott.a.morton3.civ@mail.mil

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Computational Research & Engineering Acquisition Tools and Environments (CREATE)

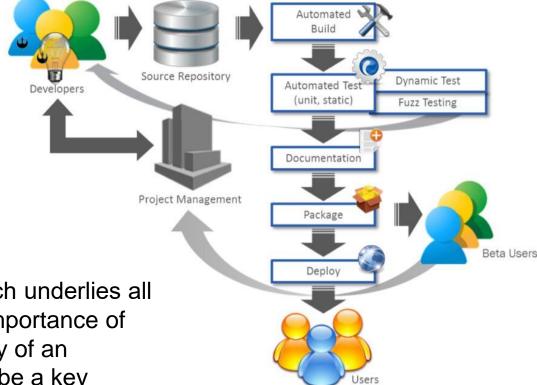


CREATE is an example of the ideal "Software Factory" described in Feb 2018 report of the Defense Science Board.



DEPARTMENT OF DEFENSE

FICE OF THE UNDER SECRETARY OF DEFENSE FOR RESEARCH AND ENGINEERING WASHINGTON, D.C. 20301-3140

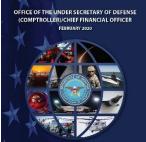


"Our base recommendation, which underlies all other recommendations, is the importance of the software factory – the efficacy of an offeror's software factory should be a key evaluation criterion in the source selection process for software."

Computational Research & Engineering Acquisition Tools and Environments (CREATE)



CREATE "Software Factory" delivers impactful technology to the DoD

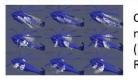


Directly Impacts Programs of Record

CREATE software products have been used to impact 38 Programs of Record in which the Department is scheduled to invest more than \$54 Billion in FY2021. In addition to the Programs noted in the chart below (extracted from Comptroller's Report), CREATE software products are being used in support of MANY other important programs, e.g., Future Vertical Lift, Future Attack Submarine, Next Generation Combat Vehicle.

FY2021 Base CREATE





CH-53K engine exhaust nozzle redesign (mitigation of Engine Gas Reingestion)

NAVAIR/Sikorsky, 2018-2019

Using HPCMP CREATETM Helios and HPC systems "...the combined cross-competency Tiger Team members [NAVAIR/Sikorsky] provided the CH-53K program a viable path forward to ensure continued development, execution of flight testing and completion of LRIP."

- PMA-261 Gold Star Award, May 2019

Waljor Vecapor Systems - Summary Aircraft and Related Systems - Joint Service End F35 Jont Strike Fighter V22 Oaprey C-130J Hercules MG-16 MQ-10 NG-16 Predator/ray Eagle MG-3 Resper MG-3 Resper MG-47 Tracroftood Heav/HATO AGS Arread Tracroftood Related Systems - US Amy USA Arread Overwatch / Targeling Arread Apacher Arread Related Systems - US Amy USA USA Black Hawk Arcraft and Related Systems - US Nary Interview Build CH-47 Chronok Interview Build CH-47	t (S in M)	Software Used to Support	Service			
F35 Jord Strike Fighter V32 Opprey C-150J Hercules MC-16 / MQ-10 Predistor/Gray Eagle. MC-39 Resper MC-46 / RQ-4 Tribun/Diabal Hawk/NATO AOS Africerts and Related Systems – US Army Armed Overwatch / Targeting VISA Armed Network / Targeting Africerts and Related Systems – US Army Dimook UH-40 Dimook CH-47 Ohnook CH-47 Ohnook CH-47 Ohnook CH-47 Ohnook UH-80 Black Hawk Africerts and Related Systems – US Nary USA Storgray F2-16 Storgray F2-17 CH-53K Africerts and Related Systems – US Air Force Poseidon F3-18 Super Homet E3D Abanced Hawkeye P-8A Possidon F3-18 Bander F3-19 Bander F3-	budget (+ mm)		GMD	Ground-based Midcourse Defense		
F35 Jord Strike Fighter V32 Opprey C-150J Hercules MC-16 / MQ-10 Predistor/Gray Eagle. MC-39 Resper MC-46 / RQ-4 Tribun/Diabal Hawk/NATO AOS Africerts and Related Systems – US Army Armed Overwatch / Targeting VISA Armed Network / Targeting Africerts and Related Systems – US Army Dimook UH-40 Dimook CH-47 Ohnook CH-47 Ohnook CH-47 Ohnook CH-47 Ohnook UH-80 Black Hawk Africerts and Related Systems – US Nary USA Storgray F2-16 Storgray F2-17 CH-53K Africerts and Related Systems – US Air Force Poseidon F3-18 Super Homet E3D Abanced Hawkeye P-8A Possidon F3-18 Bander F3-19 Bander F3-		Program	THAAD	Terminal High Altitude Area Defense		
V22 Daprey C-130J Hercules MC-16/ MQ-1C Prediator/Gry Eagle MC-36 / MQ-1C Prediator/Gry Eagle MC-36 / MQ-1C Prediator/Gry Eagle MC-47 / RQ-4 Tracritical/bail Hawk/MATO AOS Arcent and Related Systems - US Army Ammed Overwatch / Targeting Arcent and Related Systems - US Army Apache: RemanufactureNew Build CH-47 Chinook CH-48 Super Homet E-41 Advanced Hawkeye F8-48 Super Homet E-20 Advanced Hawkeye F8-8 Bernbers CCH-53K Fore Arcent and Related Systems - US Air Fore Control CG-52 Bernbers KC-46A Tarker Pall Rader E-18 Bagle CR-14 Cont			Aegis	Aegis Ballistic Missile Defense		
C-130.1 Hercules MG-16 Predator/Gray Engle MG-16 / MG-16 / MG-16 Predator/Gray Engle MG-16 / Respire MG-16 / R	11,400	AV/RF	Missile Defeat and Defense Programs – USA			
NG-16 / IKQ-1C Predator/Gray Engle MC3 / RMA-0 Resper MC3-0 Resper MC3-0 Armed Overwatch / Targeting Armed Overwatch / Targeting Armed Overwatch / Targeting Armed Overwatch / Targeting Armed Overwatch / Targeting Art-At-E Apacher RemanufactureNew Build CH-47 Chinook CH-47 Chinook CH-48 Apacher RemanufactureNew Build CH-47 Chinook CH-48 Black Hank Arcraft and Related Systems - US Nary Armed Verset VD2-5 Storgary FXL19 Super Homet EX0 Abuerd Hankye P-8A Poseidon CCH-53CK Storgary FXL19 Super Homet EX0 Abuerd Hankye P-8A Poseidon FXL19 Super Homet EX0 Abuerd Hankye P-8A Poseidon FXL19 Bubers FXL19 Bubers EX0 Abuerd Filet Training CH-53 Engle FXL1 Advanced Filet Training C4 Systems - USA Hardheid, Manpack, and Smail Form Fit Radoos Cyberespace Comband Rescue Helicopter <td>1,828</td> <td>AV</td> <td></td> <td></td> <td></td> <td></td>	1,828	AV				
MG-8 MG-8 MG-8 MG-8 MG-8 MG-8 MG-8 MG-8	1,232	AV	Patriot / PAC-3	Patriot Advanced Capability	-	
MQ-46 / RQ-4 Trion/Global HawKWATO AGS Arrent and Related Systems – US Army (USA) Arrent Area Related Systems – US Army (USA) Area RenandactureNew Build Art-4E Apache: RemanufactureNew Build CH-47 Ch-troods Black Istack Apache: RemanufactureNew Build CH-47 Chronok CH-55 C	72	AV / RF	PAC-3/MSE	PAC-3/Missile Segment Enhancement Missile		
Arreed Overwatch / Targeting Arreed Overwatch / Targeting Arteadt Arteadt Arteadt Apacher RemanufactureNew Build CH-17 Chicook Black Hawk Arcraft and Related Systems – US Nary USA) Black Hawk Arcraft and Related Systems – US Nary USA) Black Hawk Arcraft and Related Systems – US Nary E-20 Advanced Hawkeye PA Pade Pasedon Arcraft and Related Systems – US Air Forer UAN CU-SCSC Arcraft and Related Systems – US Air Forer UAN PA Pase B-1 B-20 Bornbers KC-40A Tarker PAR Presidential Arcraft Recapitalization F22 Radier E-15 E-26 Carbat Rescue Helscopter T-7A Advanced Pikit Traing Cell Systems – USA Win-1 Tactical Network Traingort Cell Systems – Joint Service Hardheld, Manpack, and Small Form Fit Radios	468	RF	Missiles and Munitions – Joint Service			
Aircraft and Related Systems – US Army (USA) Aricel: Apache: RemanufactureNew Build CH-47 Chinook: Black Hank. Mi-25 Singray Kr-18 Black Hank. Discret Hank. Di	631	AV/RF	JDAM	Joint Direct Attack Munition	280	AV/RF
USA) Apache: Remanufacture/New Build CH-47 Dinook CH-47 Dinook Black Hawk Marcett and Related Systems – US Nay USN) US Marine Corps (USMC) Black Hawk V02-25 Strigray EXD Advanced Hawkye P-8A Poseidon CCH-535K CCH-535K			Helfire	Helfire Missiles	131	AV
Alt-64E Apoche Remanufacture/New Build CH-47 Chinook CH-47 Chinook CH-47 Chinook CH-47 Chinook CH-47 Chinook Black Hawk Black Apoche Remanufacture/New Build CH-47 Chinook Black Hawk Black Apoche CH-45 CH-			SDBI	Small Diameter Bornb I	46	AV
CH-47 Dinook Black Hawk Child			SDB II	Small Diameter Bomb II	432	AV
UH-40 UH-40 UH-40 Black Hawk Alicraft and Related Systems - US Navy US Marine Corps (USMC) Alicraft and Related Systems - US Navy CH-53K CH-53K CH-53K Advanced Hawkeye PaA Posedon CH-53K Arcraft and Related Systems - US Air Force (USAT) CH-53K CH-	1,157	AV	JASSM	Joint Air-to-Surface Standoff Missile	546	AV
Aircraft and Related Systems – US Navy UG25: Strigray GA25: Strigray FA18: Super Homet E30: Advanced Hawkye P-BA Poseidon CCH-53K CCH-53K Advanced Hawkye E31: Rader B-1, B-2, B-22: Bornbers B-1, B-2, B-82: Bornbers B-1, B-2, B-82: Bornbers RC-46A Tanker FAR Presidential Arcraft Recaptalization F-22: Raytor F-15: Eagle CRH Combat Rescue Helicopter F-16: Eagle CRH Combat Rescue Helicopter F-17: A Advanced Pilot Training CCH Systems – USA Traftic Advanced Pilot Training Combat Service HAS Hardheld, Manpack, and Small Form F4 Rados Cyberspace Ground Systems – USA Marry Ammered Mulb-Purpose Vehicle MAPY Facing Vehicles FMTV Family of Heavy Tractical Vehicles FMTV Family of Heavy Tracti	241	AV	AIM-9X	Air Intercept Missile - 9X		
UBN/ US Namice Corps (USMC) Storgray K2-25 Storgray FA-18 Super Homet E-20 Advanced Hawkeye FA-18 Pasedon E-20 Advanced Hawkeye P-A Pasedon CCH-533K Pasedon Arcreft and Related Systems - US Air Force (UA) Radder B-21 Radder B-21 Radder B-21 Radder B-21 Radder FX Radder FX Radder FX Bornbers KC-46A Tarker FX Eagle CRH Combat Rescue Helscopter FX-15 Eagle CRH Combat Rescue Helscopter TX-7A Advanced Fikit Training Cd Systems - USA Indetwork Trainiport CH Systems - Joint Service Indetwork Trainiport Hall Combat Rescue Helscopter TX-7 Advanced Fikit Trainiport CH Systems - Joint Service Indetwork Trainiport	1,014	AV	AMRAAM	Advanced Medium Range Air-to-Air Missile	876	AV
M2-26 Striggry FIA-16 Super Hornet E20 Advanced Hankeye FAA Posedon FAA Posedon CCH-535K Arcraft and Related Systems - US AIF Force (USA7) E371 Raider			Chem-Demil	Chemical Demilitarization		
FX-19 Byer Homet E-20 Advanced Hawkeye E-20 Advanced Hawkeye Posedon Posedon Arcrift and Related Systems - US Air Force Image: CE+C53K Arcrift and Related Systems - US Air Force Image: CE+C53K Arcrift and Related Systems - US Air Force Image: CE+C53K Arcrift and Related Systems - US Air Force Image: CE+C53K Arcrift and Related Systems - US Air Force Image: CE+C53K Barl Rader Image: CE+C53K F2 Barl Rader F2 Rador Image: CE+C53K F3 Eagle Image: CE+C53K CRH Combat Rescue Helcopter Image: CE+C53K T7.7 Advanced File Training Image: CE+S54K CH Systems - USA Image: CE+S54K Image: CE+S54K MIPV Ambrield, Manpack, and Small Form Fit Rados Image: CE+S54K MIPV Amored Multi-Puppose Vehicle Image: CE+S54K MIPV Amored Multi-Puppose Vehicle Image: CE+S54	267		JAGM	Joint Air-to-Ground Missile	+	
E-20 Advanced Hawkeye P-BA Possidan P-BA Possidan CCH-5C3K Aircraft and Related Systems – US Air Force R-21 Bander B-21 Bander B-21 Bander B-21 Bander B-21 Bander B-21 Bander B-22 Bander F-22 Bayter F-23 Banders F-23 Banders F-23 Banders F-24 Bayter CH-1 Combits Rescue Helicopter T-7A Advanced Pict Training C41 Systems – USA C41 Syste	2,062	AV	LRASM	Long Range Anti-Ship Missile	224	RF
PAA Poseidon CCH-53K Arcraft and Related Systems – US Air Force ULSAF) Arcraft and Related Systems – US Air Force ULSAF) Arcraft and Related Systems – US Air Force DS-71 Raider B-1, B-2, B-52 Rauder RAC 46A Tarker Presidential Arcraft Recapitalization F-22 Rayfor F-23 Rayfor F-23 Rayfor F-23 Rayfor F-23 Rayfor F-23 Rayfor Combat Rescue Helicopter F-24 Rayfor Combat Rescue Helicopter F-25 CRH Combat Rescue Helicopter F-25 CRH Combat Rescue Helicopter F-26 CRH Combat Rescue Helicopter F-27 Rayfor Coherspace Coherspace Coherspace Coherspace Coherspace Armored Multi-Purpose Vehicle Armored Multi-Purpose Vehicle Armored Multi-Purpose Vehicle ARSV Mev1 Armored Multi-Purpose Vehicle ARSV Herd Greenation Signad Vegoon PM PAM Paladin Integrated Management FMTV Family of Headyn Tactical Vehicles Family of Headyn Tactical Vehicles FMTV Family of Headyn Tactical Vehicles FMT Family of Headyn Tactical	2,062	AV	Missiles and Munitions – USA			
CH-53K Interact and Related Systems - US Air Force Interact and Related Systems - US Air Force B-21 Rader B-21 Rader B-21 Bornbers KC-49A Tarker PAR Presidential Arcraft Recapitalization F-22 Raptor F-15 Eagle CRH Combits Rescue Helicopter T-7A Advanced Piot Training CEI Systems - USA Tactical Network Trainingont VIN-T Tactical Network Trainingont CII Systems - Joint Service Optempace Arrow - USA Joint Light Tactical Vehicle Marrow - USA Joint Light Tactical Vehicle Marrow - Joint Service Joint Light Tactical Vehicle MAPV Amored Multi-Puopose Vehicle MAPV Amored Multi-Puopose Vehicle MAPV Amored Multi-Puopose Vehicle MSSW Heddam Integrated Maragement FMTV Family of Medoam Tactical Vehicles FMTV Family of Medoam Tactical Vehicles FMTV Family of Medoam Tactical Vehicles		AV	GMLRS	Guided Multiple Launch Rocket System		
Aircraft and Related Systems – US Air Force ISAF USAF Raider 9-71 Raider 9-1, B-2, B-52 Bombers CX-46A Tarker Presidential Arcraft Recapitalization Fragoritalia F-72 Raytor F-73 Raytor F-74 Combait Rescue Helicopter F-75 Eagle CRH Combait Rescue Helicopter F-74 Advanced Fild Training Cd Systems – USA Inclicul Network Trainsport FLS Cyberspace Coround Systems – Joint Service Inclicul Network Trainsport ILTV Advanced Fild Tactical Vehicle Ground Systems – USA Inclusion Light Tactical Vehicle MIPY Amored Multi-Purpose Vehicle VGSW Net Generation Signad Velapon PIM Paladin Integrated Management FMTV Family of Medum Tactical Vehicles	269	AV	lauelin	Javelin Advanced Anti-Tank Weapon	+ +	
B-21 Badder B-1, B-2, B-32 Bombers KX-4BA Tarker PAR Presidential Arcraft Recapitalization F-2 Raptor F-15 Eagle CRH Combit Rescue Helicopter T-7A Advanced Pilot Training C4I Systems - USA Combit Rescue Helicopter VIN-T Tactical Network Transport C4I Systems - Joint Service Cyberspace Ground Systems - Joint Service Cyberspace JUTV Joint Light Tactical Vehicle MPV Amored Muß-Piloton-Vigrades MPV Amored Muß-Puppoe Vehicle NSW Netdigenterning Squad Velopin PM Platidin Infragenter FMTV Family of Medum Tactical Vehicles FMTV Family of Medum Tactical Vehicles			Standard	Standard Missile-6		
B-1, B-2, B-32 Bombers B-1, B-2, B-32 Bombers KC-46A Tariker FXR Presidential Arcraft Recapitalization F-22 Raptor F-23 Raptor F-24 Raptor F-25 Eagle CRH Combat Rescue Helicopter L7A Advanced Pikit Transgoot Cd Systems - USA Eagle VIN-T Tactical Network Transgoot Cd Systems - Joint Service Eagle VIN-T Tactical Network Transgoot Cyberspace Cyberspace Ground Systems - USA Eagle MFV Joint Light Tactical Vehicle Ground Systems - USA Eagle MPV Amored Multi-Purpose Vehicle VGSW Next Generation Squad Velopon PIM Palidin Intrigented Management FMTV Family of Mealum Tactical Vehicles FMTV Family of Nexton			RAM	Rolling Airframe Missile	+ +	
KC-48A Tarter PAR Presidential Arcraft Recapitalization PAR Presidential Arcraft Recapitalization -22 Raptor F-15 Engle CR1 Combat Rescue Helicopter IT-7A Advanced Pilot Training CAI Systems - USA Tractical Network Trainingont VNI-T Tractical Network Trainingont C4I Systems - Joint Service Opherspace Ground Systems - Joint Service Introduction Stand From Fit Radios U/Nerropace Opherspace Ground Systems - Joint Service Introduction Vision U/N Joint Light Tactical Vehicle MIPV Joint Light Tactical Vehicle VISW Paldon Intrograted Management VISW Paldon Integrated Management PMTV Panity of Medium Tractical Vehicles PMTV Family of Medium Tractical Vehicles	884	AV/RF	Tomahawk	Tactical Tomahawk Cruise Missile	++	
PAR Presidential Arcraft Recapitalization PAR Presidential Arcraft Recapitalization PAR Report PAR Report PAR	2,981	AV/RF	Missiles and Munitions – USAF			
F-22 Raptor F-25 Eagle F-15 Eagle Cambal Rescue Helcopter F F-7A Advanced Piki Transg Call Systems – USA F WB-1 Tactical Network Transport CAI Systems – Joint Service F Ground Systems – Joint Service F UTV Aorraced Rule Park And Small Form Fit Rados Operapace Operapace Ground Systems – Joint Service F UTV Aorraced Rule Park And Small Form Fit Rados VGWV Aorraced Rule Park And Small Form Fit Rados VGWV Aorraced Rule Park And Small Form Fit Rados VGWV Aorraced Rule Park And Small Form Fit Rados VGWV Network Concentration Status Velocite MIPV Amored Multi-Park Rue Velocite PM Paladin Integrated Management FMTV Family of Headum Tractical Velocies FMTV Family of Network Tractices		747714	GBSD	Ground Based Strategic Deterrent	+ +	
F-15 Eagle CRH Combat Rescue Helicopter CFA Combat Rescue Helicopter T/TA Advanced Pilot Transport C4I Systems – USA Tactical Network Transport VIB-T Opterspace Ground Systems – Joint Service Image: Vision VisionVision Vision Vision VisionVision Vision Vision Vision VisionVisi	1,059	AV / RF	B61	B61 Tail Kit Assembly	+ +	
CRH Combat Rescue Helicopter TA Advanced Pilot Training Advanced Pilot Training With-T Tactical Network Trainingont NTV Amores Multi-Purpose Vehicle NSW Net Generation Sigual Velopin Not Pilot Palidin Integrated Management PMTV Family of Neory Tactical Vehicles FMTV Family of Neory Tactical Vehicles	2,414	AV/RF	LRSO	Long Range Stand-Off Missile	+	
T/A Advanced Plet Tranng C4I Systems - USA C4I Systems - USA C4I Systems - Joint Service Tactic al Network Transport C4I Systems - Joint Service Opterspace Cyberspace Opterspace Ground Systems - Joint Service Joint Light Tactical Vehicle I/TV Joint Light Tactical Vehicle WFV Amoreol Multi-Purpose Vehicle WSW Nexoreous Seventor Sigual Weapon PM Paludin Integrated Management FMV Family of Medul Tactical Vehicles FMTV Family of Medul Tactical Vehicles	2,414	AV / RP	Shipbuilding and Maritime Systems – USN			
C4I Systems – USA VIN-T Tactical Network Transport VIN-T Tactical Network Transport VIN-T Tactical Network Transport VIN-T Tactical Network Transport VIN- VIN-C VIN-VIN-VIN-VIN-VIN-VIN-VIN-VIN-VIN-VIN-			CVN 78	Gerald R. Ford Class Nuclear Aircraft Carrier	3.024	SH
WIN-T Tactical Network Transport C4I Systems - Joint Service			SSBN 826	Columbia Class Submarine	4,412	SH
C4I Systems - Joint Service Inarchield, Manpack, and Small Form Fit Radios AUS Handheid, Manpack, and Small Form Fit Radios Operapace Cyberspace Ground Systems - Joint Service Joint Light Tactical Vehicle MPV Joint Light Tactical Vehicle V-1 Atrams Tark Modification/Upgrafes MIPV Amored Multi Purpose Vehicle VSSW Next Generation Sigual Weapon PM Paladin Integrated Management FMTV Family of Heaum Tactical Vehicles FMTV Family of Heaum Tactical Vehicles			SSN 774	Virginia Class Submarine	4,658	SH
HatS Handheid, Manpack, and Small Form Fit Radios Cyberspace Cyberspace Ground Systems – Joint Service Image: Cyberspace UTV Joint Light Tactical Vehicle Ground Systems – USA Image: Cyberspace M-1 Abrarms Tank Modification/Upgrades M/PV Amored Mulb Purpose Vehicle VGSW Nex Generation Squad Velopon PM Paladin Integrated Management FMTV Family of Meayn Tactical Vehicles FMTV Family of Meayn Tactical Vehicles			DDG 51	Arleigh Burke Class Destroyer	3,492	SH
Opterspace Opterspace Greund Systems - Joint Service Image: Systems - USA UTV Joint Light Tactical Vehicle Ground Systems - USA Image: Systems - USA M-1 Airmins Tarkin Modification/Upgrades MPV Ammore Multi-Purpose Vehicle NGSW Next Generation Squad Weapon PM Paladin Integrated Management FMTV Family of Heavin Tactical Vehicles FHTV Family of Heavin Tactical Vehicles			FFG(X)	Guided Missile Frigate	1,135	
Ground Systems – Joint Service Joint Light Tactical Vehicle U.TV Joint Light Tactical Vehicle Revend Systems – USA Amore Multi-Purpose Vehicle M/PV Amored Multi-Purpose Vehicle GSW Next Generation Squad Veapon PM Paladin Integrated Management PMTV Family of Medum Tactical Vehicles FMTV Family of Heaint Tactical Vehicles			CVN	Refueing Complex Overhaul	1,135	SH
JUTV Joint Light Tactical Vehicle Ground Systems – USA					07	
Ground Systems – USA Abrams Tank Modification/Upgrades M-1 Abrams Tank Modification/Upgrades MPV Amored Multi-Purpose Vehicle NGSW Next Generation Squad Weapon PM Paladin Integrated Management FMTV Family of Meavin Tactical Vehicles FHTV Family of Heavy Tactical Vehicles			T-AO 205	John Lewis Class Fleet Replenishment Oiler	95	SH
4-1 Abrams Tark Modification/Upgrades MPV Amored Multi-Purpose Vehicle SSW Nex Generation Squad Vexpon 98 Paladin Integrated Management MTV Panky of Medum Tactical Vehicles MTV Family of Heavy Tactical Vehicles MTV Family of Heavy Tactical Vehicles	1,364	GV	T-ATS	Towing, Salvage, and Rescue Ship		
MAPV Armored Multi-Purpose Vehicle NGSW Next Generation Squad Weapon PM Paladin Integrated Management MTV Family of Heavy Tactical Vehicles FHTV Family of Heavy Tactical Vehicles			USV	Unmanned Surface Vehicle	464	SH
NGSW Next Generation Squad Weapon PM Paladin Integrated Management MTV Family of Heavy Tactical Vehicles FHTV Family of Heavy Tactical Vehicles			LPD	San Antonio class Amphibious Transport Dock ship	1,220	SH
PM Patadin Integrated Management FMTV Family of Medium Tactical Vehicles FHTV Family of Heavy Tactical Vehicles	290	GV	Space Based Systems – USSF		$ \rightarrow $	
FMTV Family of Medium Tactical Vehicles FHTV Family of Heavy Tactical Vehicles			NSSL	National Security Space Launch	+	
FHTV Family of Heavy Tactical Vehicles	863	GV	GPS II	Global Positioning System III and Projects		
	122	GV	OPIR	SBIRS and Next Gen OPIR		
	184	GV	SATCOM	Satellite Communications Projects		
GMV Ground Mobility Vehicle				TOTAL Budget (Impacted by CREATE Products	\$54,377	
Stryker Stryker Ground Systems – USMC						

ssile Defeat and Defense Programs – Joir

Computational Research & Engineering Acquisition Tools and Environments (CREATE)



- Paradigm change:
 - <u>From</u> reliance on physical test as the driver for design iteration and primary source for "actionable engineering data", e.g. support warrant holder requirements, system certifications, etc.
 - <u>To</u> using physics-informed analysis and virtual test to drive design iterations and as a source of actionable engineering data.

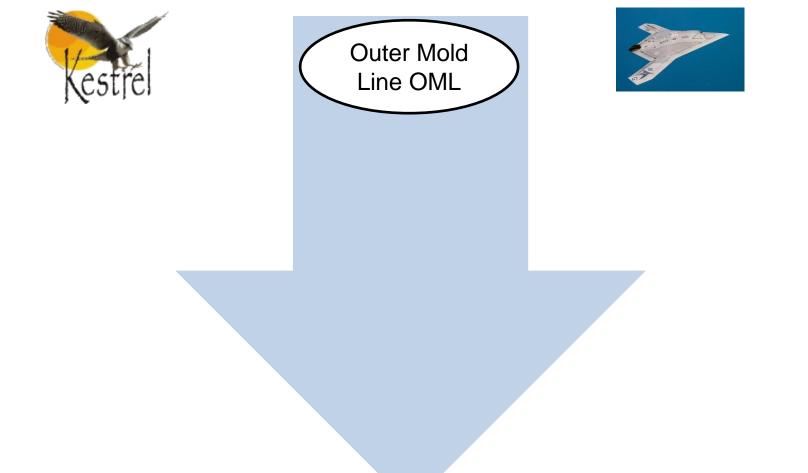


Use physical test to validate the result



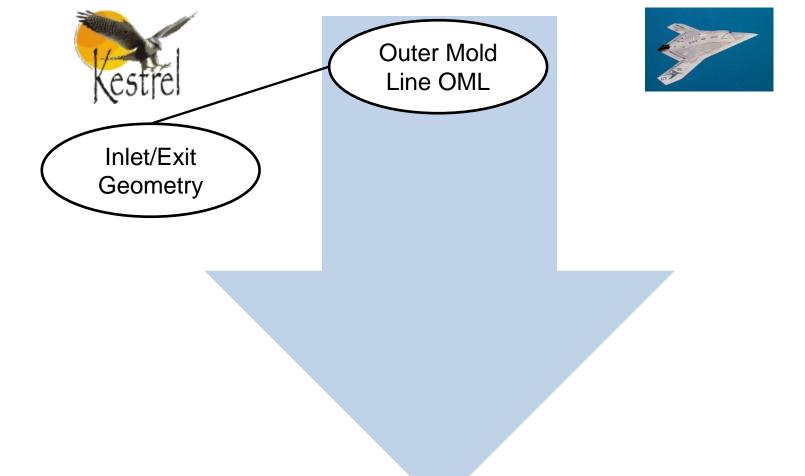
Increasing Multi-disciplinary





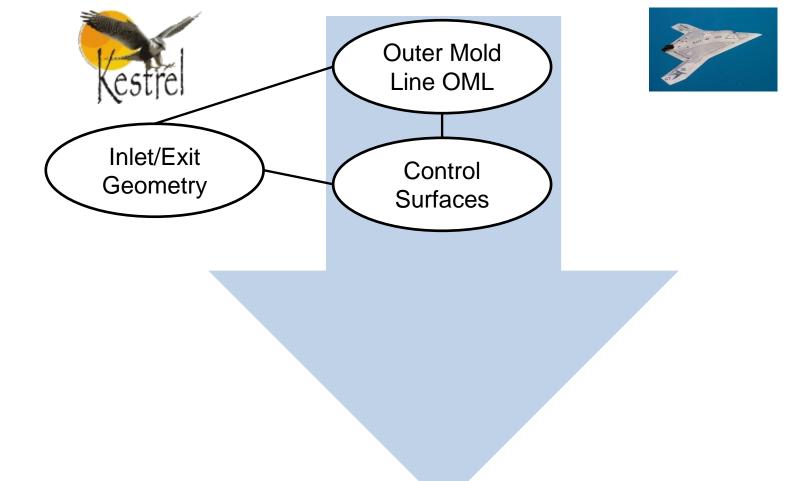
Increasing Multi-disciplinary





Increasing Multi-disciplinary



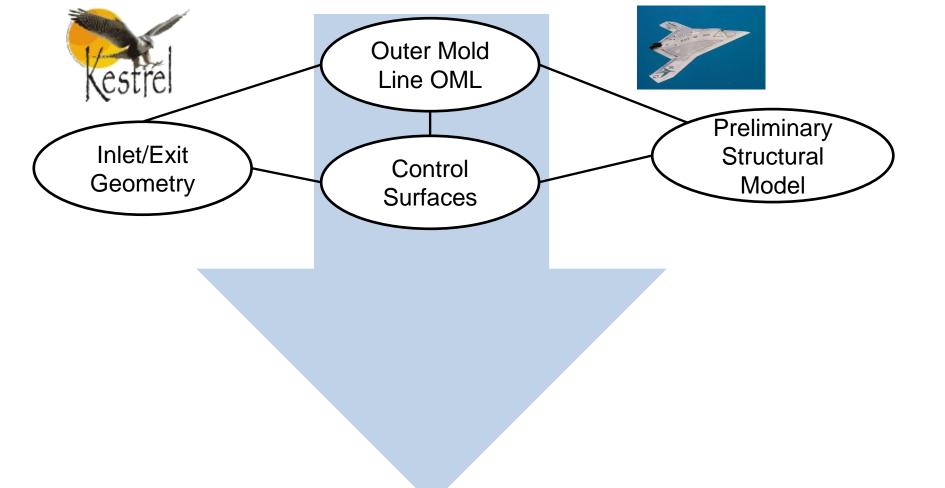




Detail/Accuracy

Increasing

 During the design process we can eliminate poor design choices by increasing the fidelity of the PBAs as more information is known (objects and connection notional)



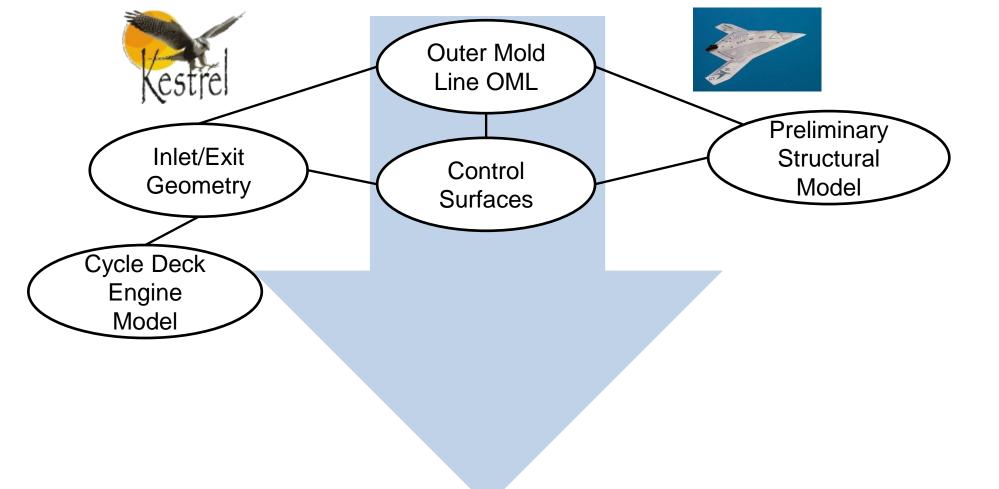
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Detail/Accuracy

Increasing

 During the design process we can eliminate poor design choices by increasing the fidelity of the PBAs as more information is known (objects and connection notional)



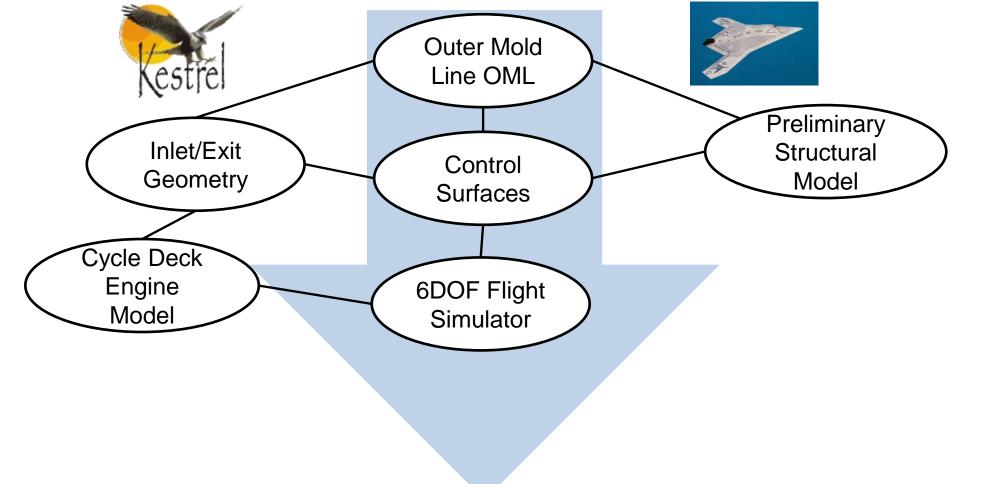
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Detail/Accuracy

Increasing

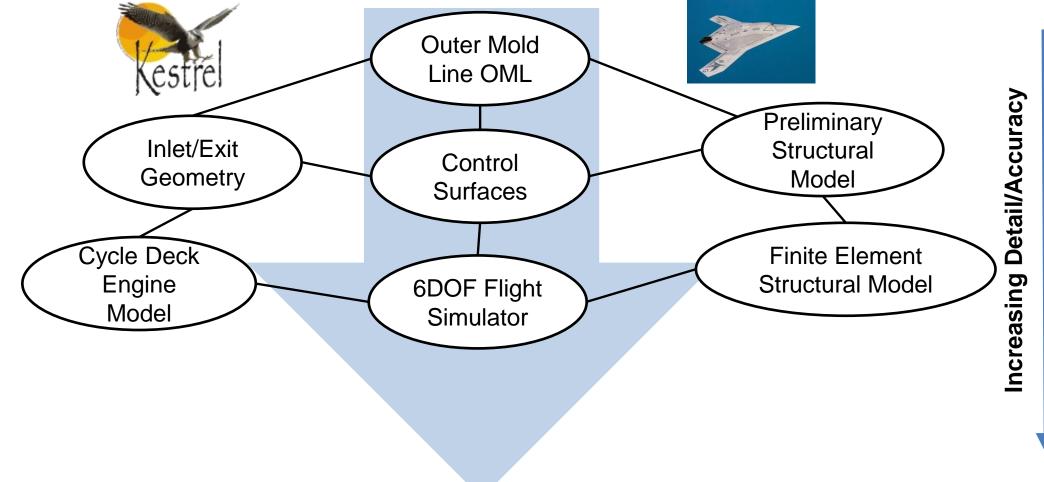
 During the design process we can eliminate poor design choices by increasing the fidelity of the PBAs as more information is known (objects and connection notional)



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 During the design process we can eliminate poor design choices by increasing the fidelity of the PBAs as more information is known (objects and connection notional)

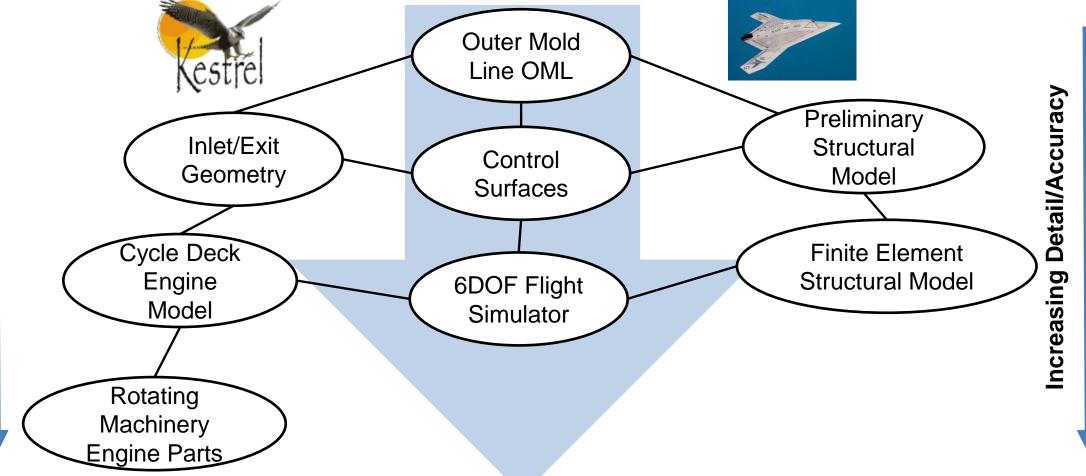


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Increasing Multi-disciplinary



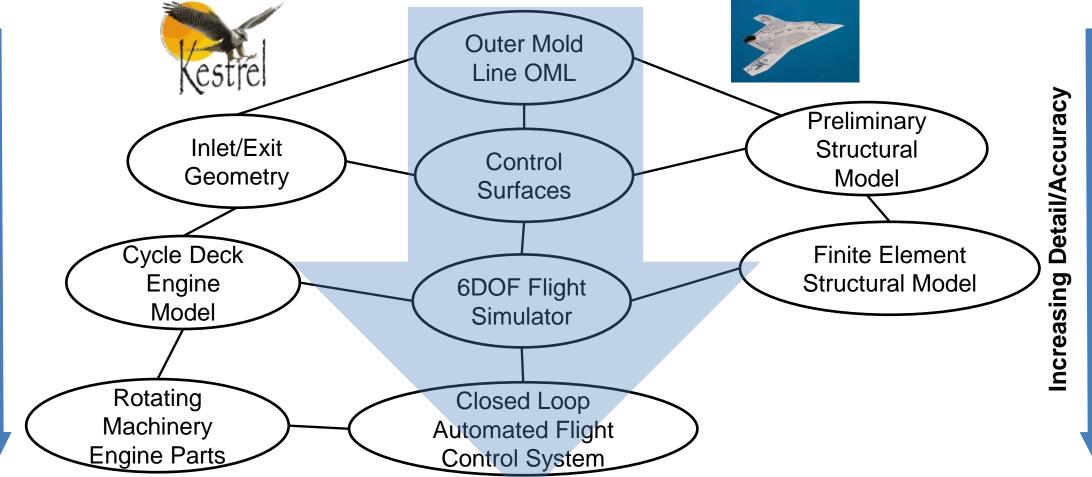
During the design process we can eliminate poor design choices by increasing the fidelity of the PBAs as more information is known (objects and connection notional)



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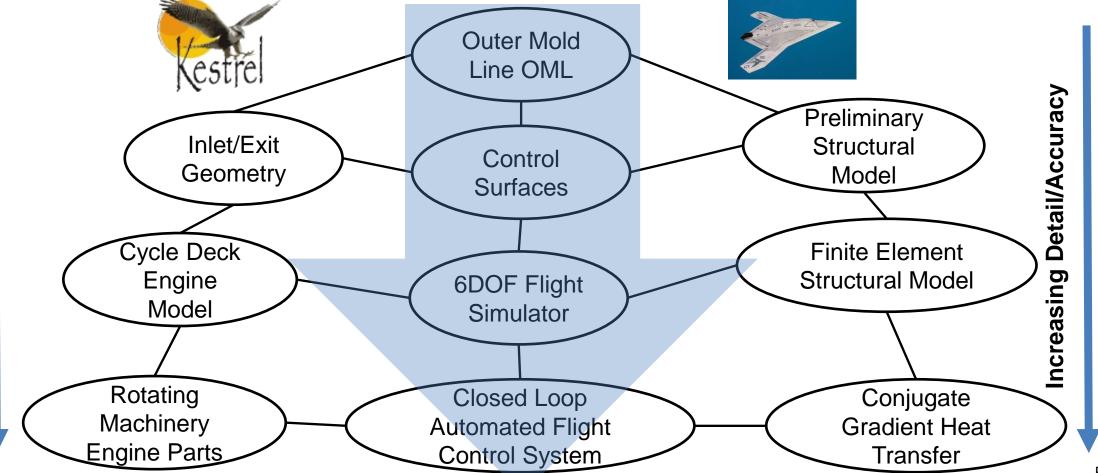
Increasing Multi-disciplinary





Increasing Multi-disciplinary





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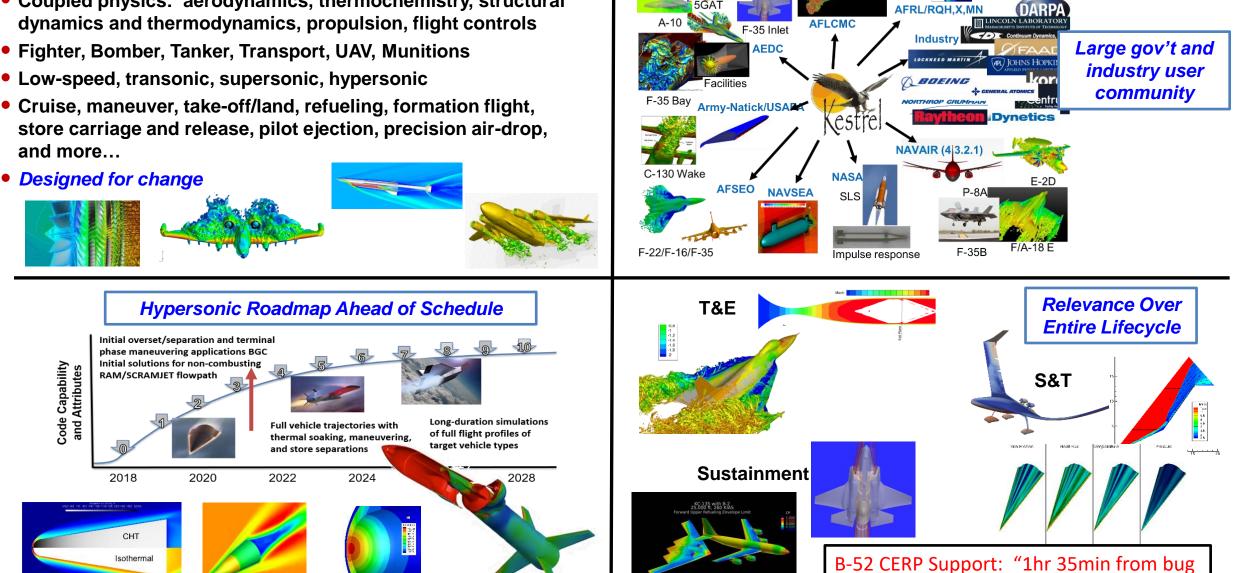
CREATE-AV Kestrel



- Coupled physics: aerodynamics, thermochemistry, structural dynamics and thermodynamics, propulsion, flight controls
- Fighter, Bomber, Tanker, Transport, UAV, Munitions
- Low-speed, transonic, supersonic, hypersonic

Code Capability and Attributes

 Cruise, maneuver, take-off/land, refueling, formation flight, store carriage and release, pilot ejection, precision air-drop, and more...



report to installed fix."

Kestrel Architecture



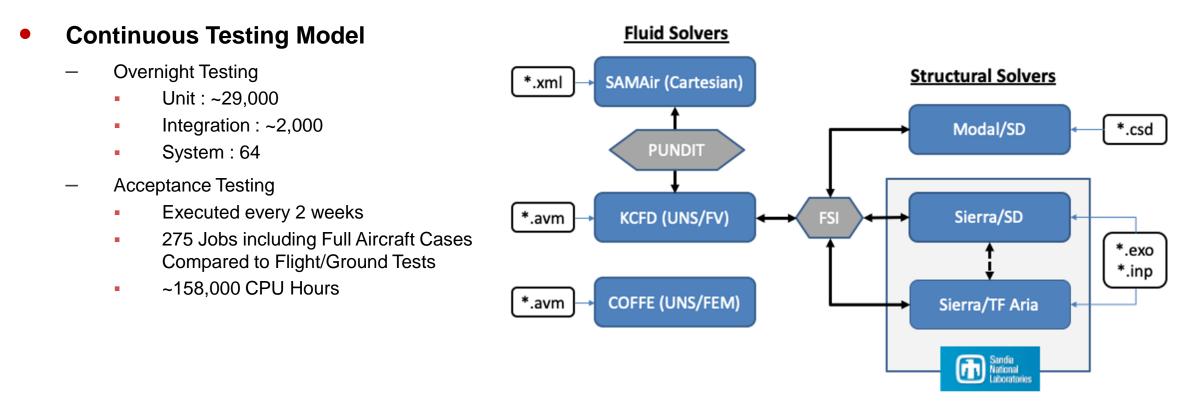
- CREATE-AV/Kestrel: <u>Production-quality, high-fidelity, multiphysics</u> simulation of fixed-wing aircraft by DoD acquisition professionals
 - Coupled physics: aerodynamics, thermochemistry, structural dynamics and thermodynamics, propulsion, 6DOF, S&C
 - Low-speed to hypersonic flight regimes, all aircraft types and ground test facilities
 - Cruise, maneuver, take-off/landing, refueling and formation flight, store carriage and release, ...
- Designed for change in anticipation of new requirements, models
 - Complexity maintained in focused, modular components and managed through an event-based paradigm
 - Language-neutral data warehouse (WAND) **Common Scalable** Users have choices for best approach to solve their problem Infrastructure (CSI) Components Job Inputs Log Files (*.xml) Python in at brintees to be at **Kestrel User** Fluid Mesh F90 Interface Viz Files (KUI) Structures Kestrel User Interfac **Tracking Files** In Situ/Extracts Motion Straketo
 Berketov
 Berketov< Engine

Kestrel Architecture



Designed for Multi-fidelity, Multidisciplinary Interactions

- Easy for Users to choose between various fidelity Aero, Structural, and Thermal solvers
- Modules can be replaced by surrogates to execute with precomputed solutions
- User Interface makes it easy for Users to choose between various modules

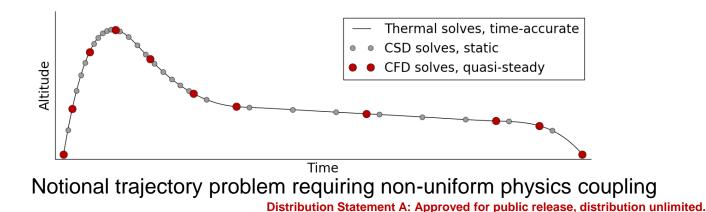


Approach to Multiphysics Simulations

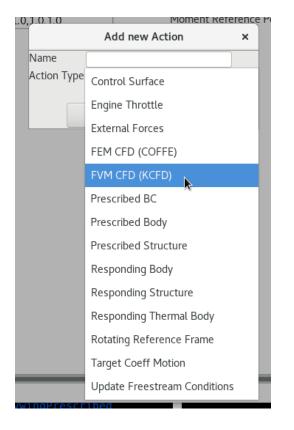
- Coupling previously driven by an unsteady, CFD-focused approach
 - Non-CFD physics integrated into simulation via Kestrel "actions" in context of CFD solution
 - Notional hypersonic trajectory problems intractable in this context
 - Unable to run simulations without high-fidelity CFD

New approach (v11) moves towards a fully-flexibly coupling paradigm

- CFD solutions integrated via time-based Kestrel actions like other physics capabilities
- Action-based CFD allows for steady / unsteady solution types
- "Iteration" defined as a monotonically increasing value independent of CFD solvers
- Freestream conditions independent from a particular CFD solver and introduction of an action to change freestream conditions in time
- Per-action recurrence settings and automatic convergence detection







Example: Hypersonic Trajectory

• 2D hollow cylinder with aero-heating during notional hypersonic trajectory

Solid

- 2D structured grid with ~77k quad elements
- Inner wall at radius = 1 inch, isothermal boundary at 294.4 K
- Outer wall radius = 1.5 inches, fluid-thermal interface
- 321 stainless steel with constant material properties
- Time-accurate thermal solution at $\Delta t = 0.01$ sec for 15 min (900 sec)using heat flux distribution from most recent fluid solution

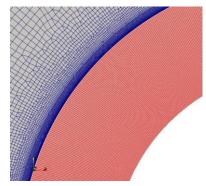
Fluid

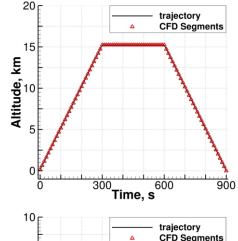
- 2D quad-dominant grid with ~80k triangle cells and ~1.16M quad cells
- Air modeled as perfect gas
- KCFD flow solver with Mentor SST turbulence model
- Local time stepping with CFL = 1000 until converged (max 10k iterations) every 10 sec using T distribution from most recent thermal solution

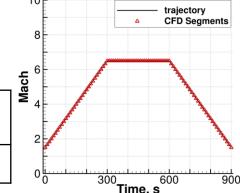
Wall time (44 core, onyx at ERDC DSRC)

Present Work	No Convergence	Couple every iteration	Couple every iteration	
	Detection	Δt=0.001 (predicted)	∆ t=0.00001 (predicted)	
28 hrs	54 hrs	87.5 hrs	8,750 hrs	





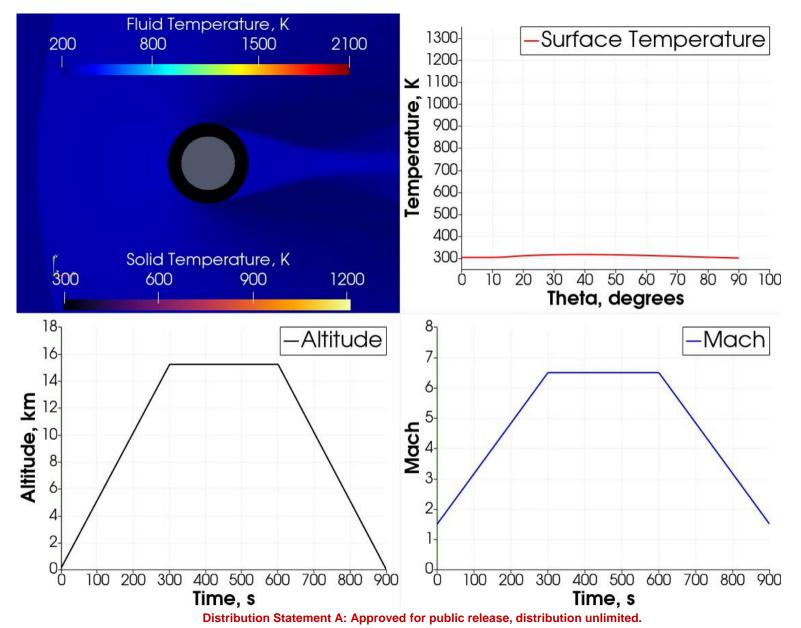




age-19

Example: Hypersonic Trajectory



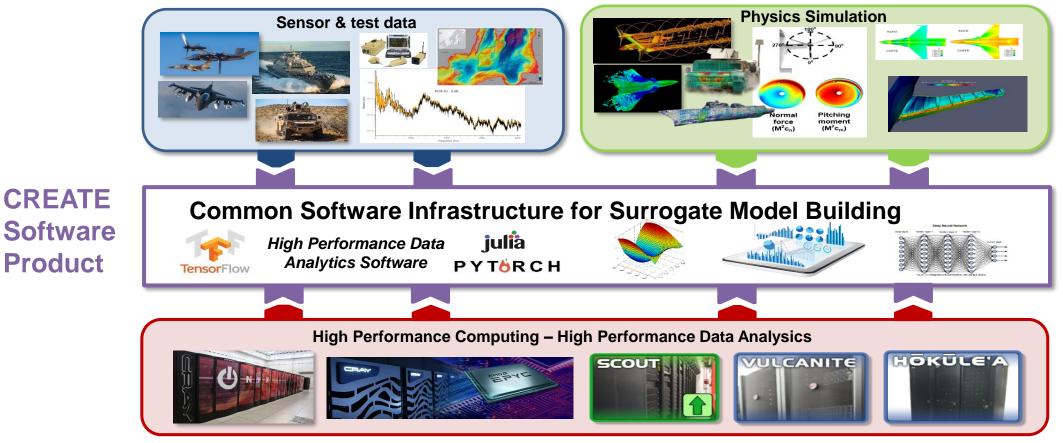


Surrogate Building



Software infrastructure to enable ^{*}surrogate model generation from datadriven analytics and physics-based analytics for DoD Air, Land, and Sea Vehicles

*Surrogate = approximate model used when a full-physics computational model is intractable

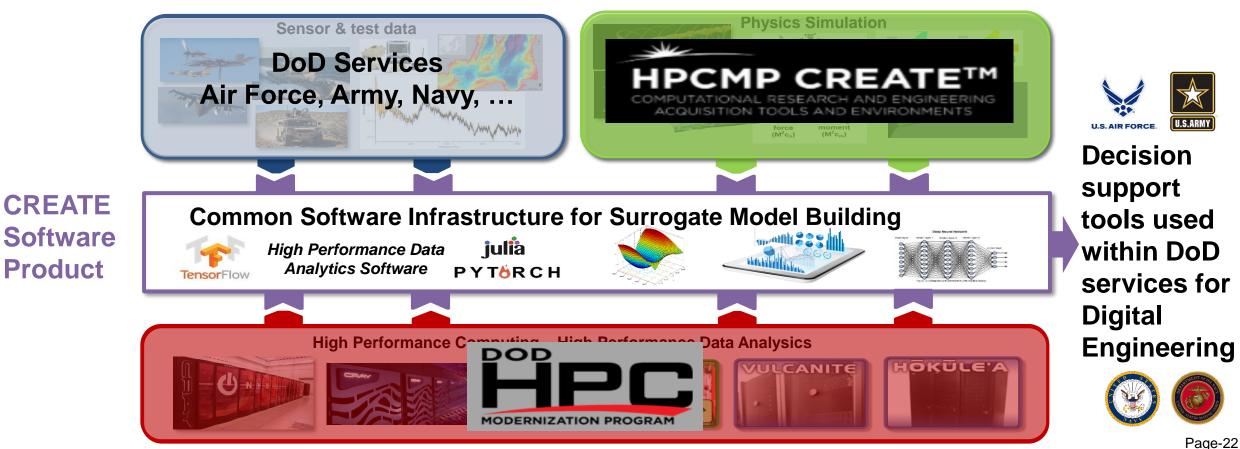


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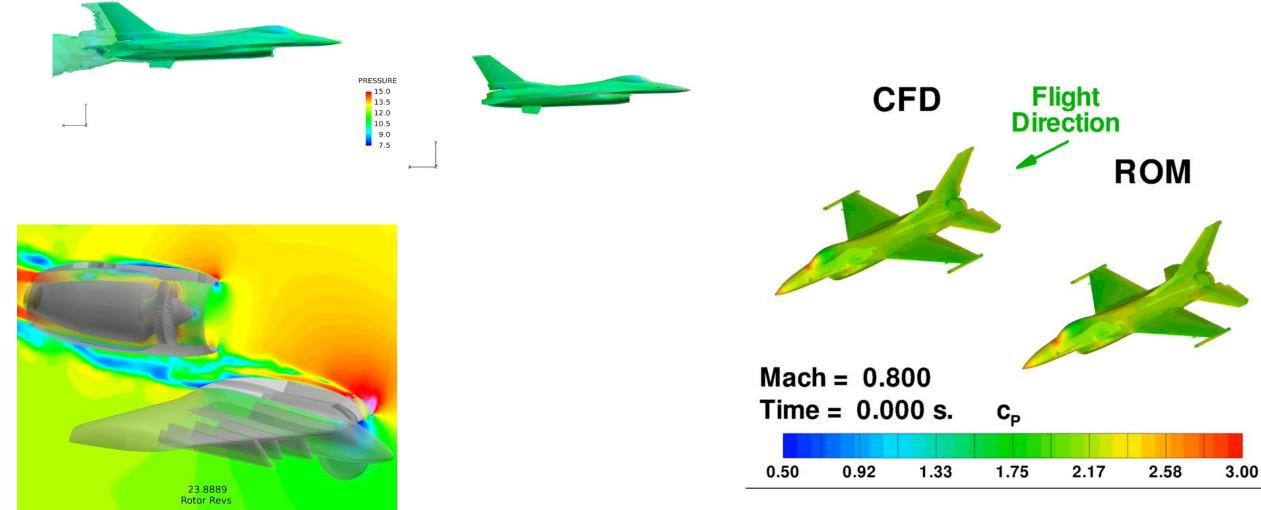


Distribution Statement A: Approved for public release, distribution unlimited.



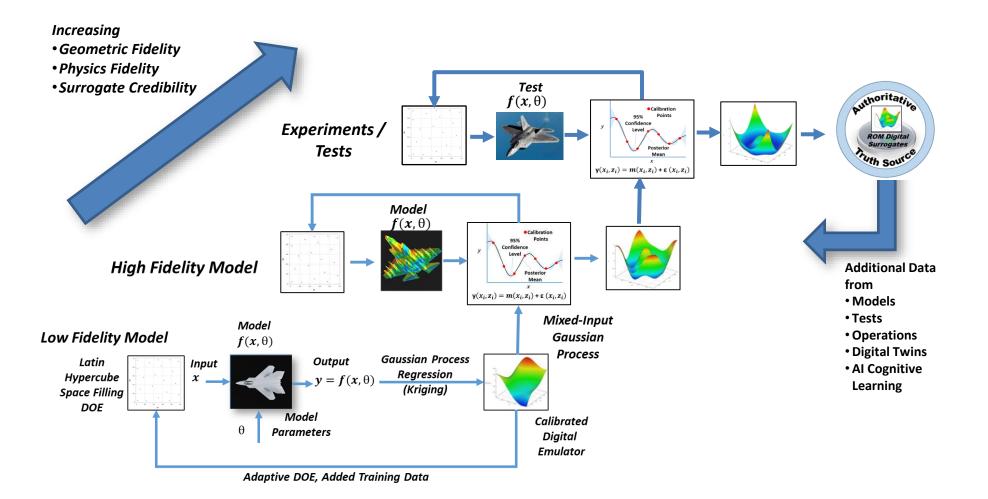
Example of Surrogate Building Elements Reduced-Order Modeling





Example of Developing an Authoritative Digital Surrogate Reduced Order Model for Aerodynamics





Edward M. Kraft, "Development and Application of a Digital Thread / Digital Twin Aerodynamic Performance Authoritative Truth Source," AIAA-2018-4003. Aviation Systems Conference, Atlanta, GA, June 25-29, 2018

Concluding Remarks and Discussion



- CREATE is a 13+ year program created to meet the needs of the acquisition community moving towards Virtual Test and Digital Engineering
- Kestrel is a production-quality multidisciplinary simulation tool for fixed-wing air vehicles targeting DoD acquisition professionals
- Kestrel strives to fill the gaps between high-fidelity physics modeling and engineering decisions while balancing usability, robustness, accuracy, and maintainability
- Modifications to allow a less CFD centric approach have opened up simulation capability that includes more disciplines and variations in fidelity – Direct impact on OEM developers
- Authoritative digital surrogates are required by the DoD Programs of Record and their creation is possible with the current and future CREATE capabilities

Acknowledgements



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Questions?