AY 2020-2021

THE MUNITIONS INDUSTRIAL BASE OF THE UNITED STATES: A STRATEGIC OVERVIEW

EISENHOWER SCHOOL INDUSTRY STUDY

Munitions Industry Study

SEMINAR #13

Primary Instructor: Ned A. Krafchick, COL, USA

Assistant Instructor: Douglas "Lucky" Luccio, Lt Col, USMC

The Dwight D. Eisenhower School
for National Security and Resource Strategy
National Defense University
Fort McNair, Washington, DC 20319-5062

SLIDES ONLY

NO SCRIPT PROVIDED

TABLE OF CONTENTS

I. Preface

A. AY21 Munitions Industry Study Biographies

FACULTY

Colonel Ned A. Krafchick is the lead instructor for the Munitions Industry Study and Assistant Professor of Defense Strategy and Resourcing at the Dwight D. Eisenhower School for National Security and Resource Strategy. COL Krafchick served 13 of his 24 years as an Army Field Artillerymen before transitioning to the Nuclear and Counter Weapons of Mass Destruction in 2010. He has held numerous Army leadership and staff positions, including Battalion Maintenance Officer, Fire Support Officer, Battery Commander, Command Nuclear Planner, and CWMD Planner at the Defense Threat Reduction Agency. COL Krafchick completed two combat deployments to Iraq. COL Krafchick holds several advanced academic degrees, including a Master of Science Degree in National Security Strategy from the National War College.

LtCol Doug "Lucky" Luccio, USMC, is an Assistant Professor of Strategy at National Defense University. He also serves as the Deputy Course Director for the Munitions Industry Study at the Dwight D. Eisenhower School for National Security and Resource Strategy. "Lucky" is a Field Artillery Officer, with additional MOSs as Joint Terminal Attack Controller (JTAC) and Foreign Military Advisor. He has combat deployments to Iraq (2) and Afghanistan (1) as well as four Marine Expeditionary Unit (MEU) Special Operations Capable (SOC) deployments in support of 5th, 6th, and 7th Fleets. His joint tours include U.S. Special Operations Command (J-8), Joint Forces Staff College (Faculty), and the Eisenhower School (Faculty). He is a Doctoral Candidate at the George Washington University Graduate School of Education and Human Development. His dissertation explores the college professor's autonomy.

STUDENTS

Lt Col Sarah Abel is a 2000 graduate of Wright State University in Dayton, Ohio (ROTC, BS-Nursing). As a career Nurse Corp Officer for the last 21 years, Lt Col Abel spent 16 years specializing in Emergency Medicine/Critical Care and Trauma, holding advanced education and certifications as a Critical Care Clinical Nurse Specialist and an Acute Care Nurse Practitioner. Lt Col Abel has served in supervisory positions at the Flight, Squadron, and Group level and was most recently the Chief Nurse of National Defense University. She has deployed twice in support of combat operations in Iraq and Afghanistan, most recently in 2013/14 as the Nurse Manager of the Emergency Department at Bagram Airfield, Afghanistan. Lt Col Abel holds several advanced academic degrees, including a Doctor of Nursing Practice from the University of Alabama.

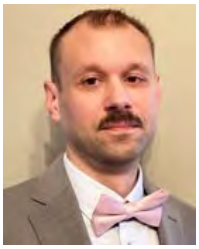
Colonel Alirio Aponte received his commission in the Colombian Army in 1995. A career Colombian Special Forces Officer with extensive counterinsurgency, counterterrorism, and reconnaissance experience, Col Aponte has held several distinguished positions, including Platoon Commander, Recon Team Commander, and Battalion Commander. Most recently, he served as the Commander of the second Regiment of Special Forces. Colonel Alirio Aponte has a Bachelor of Professional in Military Science degree in Colombia military Academy and Specialist in Security and National Defense from National War School of Colombia in 2017. He obtained a Master of Arts in Strategic Security Studies degree from the College of International Security Studies of the National Defense University.

LTC Elaine Bower is a 1999 graduate of Incarnate Word University in San Antonio, Texas, with a Bachelor in Business Administration and Management. Since receiving her commission through Officer Candidate School in 1999 at Ft Benning, Georgia, LTC Bower has been a career logistics officer, serving in the active duty, National Guard, and Reserve components. Most recently, she was the Commander of the 348th Terminal Transportation Battalion out of Houston, Texas. She has also held positions as Platoon Leader, Company Commander, Battalion Executive Officer, Quartermaster Detachment Commander, and branch level staff roles. Her operational assignments include tours in Puerto Rico, as well as a deployment to Iraq.

LTC Steve Cheadle received a direct commission in 1999 into the U.S. Army Transportation Corp following the Transportation Officer Basic and Advanced Courses. Before attending NDU, his most recent assignments were as the Joint Taskforce Logistical Officer, J4, Oklahoma National Guard. He has held several positions within the Oklahoma National Guard, including Commander of the 345th Combat Sustainment Support Battalion; Support Operations Officer, Operations Officer, Contracting Officer, Company Commander, and Platoon Leader. LTC Cheadle's Operational Deployments include two tours to Iraq and once to Afghanistan. LTC Cheadle holds bachelor's and Master of Arts Degrees in Human Resources Counseling, both from East Central University, Oklahoma.

Colonel Peter de Boer entered the Royal Netherlands Air Force in 1991. Colonel de Boer has held multiple positions throughout his career, including assignments as an intelligence officer at all levels of the Royal Netherlands Air Force. He has also been the Commander of both the Woensdrecht Air Base and the Royal Military School of the Air Force, responsible for the initial training and education of all Air Force personnel. Before arriving at NDU, Colonel de Boer served at the Ministry of Defense in the Principle Directorate of General Policy Affairs as a strategic advisor on intelligence, hybrid warfare, cyber and national security. He has also deployed in support of combat operations in Europe, Africa, and Asia. Colonel de Boer holds a master's degree in Political Science from the Free University in Amsterdam.

Ms. Denise Faldowski is a civil engineering professional with extensive experience in both the private and government sectors. During her government service, Ms. Faldowski has held numerous positions within the Department of the Army, including Infrastructure Branch Chief, Engineering Division Chief, and Supervisory Engineer. Most recently, she was the Supervisory General Engineer at G-9, Department of the Army, at the Pentagon. Ms. Faldowski a Bachelor of Science Degree in Civil Engineering from Ohio University and a Master of Science in Engineering Project Management from the University of Maryland College Park.



Commander Ryan Hinz entered the U.S. Navy in 2002 through a direct commission from the U.S. Merchant Marine Academy, graduating with U.S. Coast Guard certification as Third Assistant Engineer, Unlimited Tonnage (Gas Turbine, Steam, and Diesel). CDR Hinz graduated from Surface Warfare Officers' School Command in 2003, and afloat deployments and operational staff tours concentrated primarily in the USCENTCOM Area of Responsibility. His operational experience includes time with USCENTCOM's J3 Force Protection Assessments Division and an extended tour as Integrated Air and Missile Defense Planner for the Commander, U.S. Fifth Fleet/U.S. Naval Forces Central Command. His most recent assignment was as a NATO plans officer at the United Kingdom Strike Force. CDR Hinz holds a Bachelor of Arts in Marine Engineering and a Master of Arts in Military Operational Arts and Sciences from the U.S Air Force's Air Command and Staff College.

Colonel Jaroslav Jiru is an International Fellow from the Czech Republic. He began his Army career in 1988 after graduating from the Military Academy at Brno as a Maintenance Officer in the Artillery Brigade. Colonel Jiru has held several positions, including Chief of Logistics at the Battalion, Branch, and Division levels. He has also served as Ammunition Base Commander. Before coming to NDU, Colonel Jiru served as the Deputy Director, Logistics Division for the Ministry of Defense. He has also completed several advanced academic courses, including the General Staff Course at the University of Defense Brno and the Senior Course at the NATO Defense College in Rome, Italy.

Lt Col Nicholas Lofthouse is a 2003 graduate of the U.S. Air Force Academy, Colorado Springs, Colorado, with a Bachelor of Science Degree in Military History. A career pilot, Lt Col Lofthouse is a Command Pilot with over 1,200 flying hours in the F-15 A/B/C/D and F-22A. Before coming to NDU, Lt Col Lofthouse served as the Commander of the 3rd Operations Support Squadron at Joint Base Elmendorf-Richardson, Alaska. Previous assignments include Legislative Liaison for Alaskan Command and 11th Air Force, Requirements Officer on the Air Staff, and Director of Operations for the 90th Fighter Squadron. Lt Col Lofthouse has several deployments, most recently to Baghdad, Iraq, in 2017 as the Team Leader for the Air Defense Liaison Team serving in the Iraqi Air Defense Operations Center. Lt Col Lofthouse also holds a Master of Science Degree in Quantitative Finance from the University of London and a Master of Arts in Military Operational Science from the Air Force's Air Command and Staff College.

Colonel Mellami Lukumay is a member of the Army of Tanzania under the Logistics and Engineering branch. He is the Director of Ammunition, Arms/Armament, and Explosives (DAA&E). He has served the country of Tanzania for 28 years. He earned an advanced diploma in Ammunition Engineering from the Ordnance Engineering College in Shishazhung City, China, in 2009. In 2010, he earned a law degree from the Open University of Tanzania. He has also completed several courses of instruction in logistics and administration.

LTC (P) Rebekah "Becky" Lust graduated from the Edinboro University of Pennsylvania with a Bachelor of Arts Degree in Speech Communications and was commissioned through the Army ROTC program into the Adjutant General's Corps. Before coming to NDU, LTC Lust was the Assistant Chief of Staff, G1 for the 25th Infantry Division from June 2018 to June 2020, and Assistant Director, Force Management in the Office of the Assistant Secretary of Defense for Manpower and Reserve Affairs, Military Personnel Policy, Officer and Enlisted Personnel Management from June 2016 to June 2018. She has also held numerous human resource positions at the Battalion and Brigade level. She has also deployed twice to Iraq and once to Afghanistan. LTC Lust holds two Master of Arts Degrees from Webster University, one in Human Resources Development and the other in Computer Resources and Information Management.

Dr. Jung Ormerod is an Information Technology professional currently working with the Department of the Army. Before coming to NDU, she served as the Director of the Knowledge Management Office (KMO) for the U.S. Army in Africa. Dr. Ormerod has extensive experience as both a contractor and within federal civilian service, with postings in Camp Arifjan, Kuwait, Seoul, South Korea, and Bagram, Afghanistan. She earned a Bachelor of Science in Business Administration and Computer Information Technology from American InterContinental University with honors, a Master of Science in Management of Information System from Boston University, Executive Certificate in Leadership and Management from Massachusetts Institute of Technology (MIT), and Ph.D. in Organizational Leadership from The Chicago School of Professional Psychology. Her military education includes Air Command and Staff College (ACSC), Cyber 100 and 200 from Air Force Institute of Technology (AFIT), Army Civilian Education System (CES) Advance, and Army Knowledge Management Qualification course (AKMQC).

Lt Col Andrew Peterson received his commission in the U.S. Air Force in 2002. He began his career in contracting at McConnell AFB, KS. Following that assignment, he was a contract administrator, later earning an unlimited contracting officer warrant at Los Angeles AFB, CA. After attending the Naval Postgraduate School in Monterey, CA, he was the Deputy Director of Staff for the newly established Air Force Installation Contracting Agency at Wright Patterson AFB, OH. He commanded the 81st Contracting Squadron and was the 81st Mission Support Group Deputy Commander at Keesler AFB, MS. His most recent position was serving as the executive officer to the Deputy Assistant Secretary (Contracting). Lt Col Peterson has a Bachelor of Science in Finance from The Ohio State University, a Master of Business Administration from Webster University, a Master of Business Administration with an emphasis in Strategic Purchasing from the Naval Postgraduate School Master of Military Operational Art and Science from Air University. He is DAWIA Level III Certified in Contracting.

Mr. Ben Phillips is an engineering professional serving with the Department of the Air Force since 2001. Before coming to NDU, Mr. Phillips served as the Chief of the Technology Insertion and Innovation Branch of Engineering and Technical Management Division, Engineering Directorate, Operating Location-Hill, Air Force Sustainment Center, Hill AFB, UT. He helped lead in the development & sustainment of the scientist & engineering workforce and technical policies & processes across Hill AFB. Mr. Phillips holds both a bachelor's and Master of Science Degrees in Chemical Engineering from the University of Dayton, Dayton, Ohio, and a Master of Arts in Military and Operational Science from the Air Force's Air Command and Staff College.

LTC (P) Leon L. Rogers earned his commission through Army ROTC in 1999 from Eastern Illinois University. As an Armor Officer, LTC Rogers served as a Platoon Leader, Executive Officer, and Squadron Maintenance Officer in Ft Riley, Kansas, and Korea. He transitioned into the Acquisitions Corps in 2006 and has been a career Acquisitions Officer since, serving in several different positions, managing large contracting portfolios and programs, both deployed and in garrison. Before coming to NDU, LTC Rogers took command as the Director of Contracting, Battalion Commander, of the Regional Contracting Center Qatar in May of 2017. After Battalion Command, LTC Rogers was assigned to Arlington National Cemetery, where he worked as the ACofS, G4, and Program Integrator. He holds a Master of Business Administration from Eastern Illinois University and a Master of Science Degree in Management of Information Systems from the Florida Institute of Technology.

LTC (P) Matthew Western was commissioned into the Transportation Corps upon graduation from Montana State University in 1999. He most recently served as the Commander of the 58th Transportation Battalion at Ft Leonard Wood, Missouri, until May of 2019. Following command, he served as the Deputy Commanding Officer of the 7th Transportation Brigade (Expeditionary) Joint Base Langley-Eustis, Virginia. LTC Western has held several other positions, including Platoon Leader, Company Commander, Battalion Executive Officer, and a staff assignment at the Army Human Resources Command. LTC Western has deployed to both Iraq and Afghanistan. He holds a Bachelor of Science Degree in Economics from Montana State University and a Master of Arts in National Security and Strategy from the Naval War College.

B. Virtual Presenters and Field Studies

Facility	Status	Contractor	Location	Workforce	POC
Letterkenny Munition Center	GOGO	USG Operated	Chambersburg, PA	GS & WG	LTC Dennis Williams; Mr. Ed Goetz; Mr. Ed Averill
Holston AAP*	GOCO	BAE Systems Inc	Kingsport, TN	Contractor & Limited GS	LTC Scott Carpenter
Lake City AAP	GOCO	Olin-Winchester	Independence, MO	Contractor & Limited G.S.	Mr. William "Doug" Dillon
Radford AAP	GOCO	BAE Systems Inc	Radford, VA	Contractor & Limited GS	LTC Anthony Kazor
Scranton AAP	GOCO	GD – OTS	Scranton, PA	Contractor & Limited G.S.	Mr. Rich Hansen
Armtec*	COCO	Armtec	East Camden AR	Company Workforce	Mr. Ben Nutt
Fiocchi of America	Commercial	Fiocchi of America	Ozark, MO & Little Rock, AR	Company Workforce	Mr. Jared Smith & Mr. Tim Caldwell
Sierra Bullets	Commercial	Sierra Bullets	Sedalia, MO	Company Workforce	Mr. Matt Ohlson

* = Denotes virtual visit/speaker

Abbreviations:
AAP = Army Ammunition Plant
COCO = Contractor Owned/Contractor Operated
GOCO = Government Owned/Contractor Operated
GOGO = Government Owned/Government Operated

Other Sites Visited				
Facility	**Status**	**Location**	**POC**	**Visit Purpose**
Aberdeen Proving Ground	Military Installation	Aberdeen, MD	Ms. Chrissie McClung	Tour Testing center for multiple munitions and weapon systems

Dahlgren	Military Installation	Dahlgren, VA	Ms. Erin Snipes	Tour to gain an understanding of naval capabilities development, particularly with munitions (i.e., missiles)
Eagle Pincher	Commercial Company		Mr. Paul Cheathem	Batteries for rocket motors/ejection seats
GD-OTS Joplin	Defense Contractor	Carthage, MO	Mr. Trent Bogar	Briefings/tour on Demil process
*GD-OTS Red Lion	Defense Contractor	Red Lion, PA	POC: (virtual)	Learning about 105MM tank round, 120MM tactical tank round, and 120MM training round
JNLEA-Quantico	Military Installation	Quantico, VA	Col Wendell Leimbach, USMC	Briefings on intermediate force capabilities
MELD Manufacturing	Commercial Company	Radford, VA	Ms. Nanci Hardwick	Additive manufacturing
Norwegian-US Defense Industry Cooperation (NAMMO)	Commercial Company/ International Partner	Arlington, VA (the U.S. Hub)	Mr. Einar Gustafson Ms. Chloe Freiburg	Ammo/Ordnance for U.S. & NATO partners; International Support for the U.S. Defense and Munitions Industrial Base
New River Energetics	Commercial Company	Radford, VA	Mr. Matt Ridgley	Small munitions manufacturing
Whiteman AFB	Military Installation	Knobknoster, MO	Whiteman AFB Protocol Office	Strategic nuclear mission; conventional weapons loading and storage

* = Denoted virtual visit/speaker

Industry Study Virtual Speakers (In Order of Appearance)	
Col JasonRusco, USAF, Program Manager, Direct Attack Division	Munitions Acquisition Process
Mr. Charles Kelly, Office of the Secretary of Defense	OSD Munitions Requirements
Dr. Christine Michienzi, Office of the Secretary of Defense	OSD Industrial Policy
LTC Brett Carey, Defense Threat Reduction Agency (DTRA)	Understanding Energetics and Propellants
Mr. Matt Zimmerman, Joint Program Executive Office (JPEO) for Armaments and Ammunition	Joint Munitions Oversight/Process
CAPT Schorn, Joint Program Executive Office (JPEO) for Joint Bombs	Munitions Acquisition Process
Mr. Nate Hawley, Joint Munitions Command (JMC)	Joint Munitions Oversight/Process

Col Guy Spencer, USAF, Senior Material Leader, Munitions Sustainment Division	USAF Life Cycle Munitions Command
Lt Col Gregory Voth, USAF, Air Force Life Cycle Liasion for JPEO-Armaments and Ammunition	Munitions Acquisition Process
Mr. Joe Buzett, General Dynamics	R&D/Innovation, new technologies, and loitering munitions
Mr. Brian Lindamood, Radford AAP	Propellant Manufacturing
Mr. Matt Ridgley, New River Energetics	Commercial Powder
Ms. Elizabeth Griffin, House Armed Services Committee (HASC)	Modernization of the Conventional Ammunition Production Industrial Base
Ms. Amy O'Donnell, Indian Head Naval Arsenal	Explosives Disposal
Dr. Jason Morrison, Southern Arkansas University	Education and Supporting the Defense Industrial Base
Mr. Bruce Webb, Nammo Defense Systems	Munitions Innovation
LTC Jason Bohannon, Program Executive Office for Soldiers	Next Generation Squad Weapon (NGSW)
Col (ret) Andrew "Tippy" Knoedler, Defense Advanced Research Projects Agency (DARPA)	Hypersonic Propulsion
Ms. Katie Hartman, General Dynamics – Ordnance and Tactical Systems	Private Sector Supply Chain
Mr. Mark Signorelli, BAE Systems Inc	Private Sector Perspective
Mr. Morten Brandtzaeg, Nammo	Industry Perspective and Foreign Military Sales
Brig Gen Neri Horoviz, Israeli Defense Force	Israeli Foreign Military Sales and Strategic Relationships
Mr. David Rogers, NAVSEA, Picatinny Arsenal	Packaging, Handling, Shipping, and Transport (PHST) of Munitions
LTG L. Neil Thurgood, Director, Army Rapid Capabilities & Critical Technologies Office (RCCTO)	Rapid Acquisition for Hypersonics, Directed Energy, and Space; Emerging Technologies

C. Acknowledgments

The past 15-months have brought unique challenges to our collective lives, including our time at the Eisenhower School for National Security and Resource Strategy, National Defense University. Our experience may not have been that of years past, but it was not short on immersive experiences into a vital cornerstone of our greater Defense Industrial Base. Not only did these experiences foster a deeper, more strategic understanding of the criticality of the Munitions Industrial Base, but it fostered a new appreciation for the expertise and dedication of the men and women, ensuring the U.S.'s ability to "fight tonight."

We want to offer our most heartfelt thanks to our instructors, COL Ned Krafchick, USA, Lt Col Douglas "Lucky" Luccio, USMC, and Mr. Peter Duffy of the U.S. Agency for International Development, for their tireless efforts in ensuring the execution of our course of study was nothing short of first-class. Despite the challenging circumstances of the COVID-19 pandemic and the virtual learning environment, they delivered an experience that was second to none. Our appreciation for your dedication to our academic and professional experiences is boundless.

We would also like to acknowledge all the speakers, hosts, and tour guides (both virtual and in-person) who took time out of their busy schedules to speak to our seminar. Your expertise, perspectives, and, most importantly, your passion for supporting the Munitions Industrial Base was palpable in every encounter. Your continued support and dedication to the Munitions Industry Study from year to year has been key in making students past, present, and future more agile strategic thinkers and leaders. We appreciate you more than you know!

To our family and friends, thank you for continuing to be a touchstone during this past year. Our gratitude for your support of our service and careers can never be fully expressed.

Finally, and most importantly, we would like to thank the men and women of the Munitions Industrial Base. Your dedication to ensuring our ability to support and defend our nation's interests, both at home and abroad, is beyond vital to our continued success as the world's premiere superpower. Thank you will never be enough.

- The Members of the Munitions Industrial Base Industry Study

II. Executive Summary

The Munitions Industrial Base (MIB) is one of the oldest industries within the larger U.S. Defense Industrial Base (DIB). Since 1775, the MIB has supported the U.S. military's ability to support and defend our nation's national security interests both at home and abroad. At its peak, historical surges supported a multitude of global engagements, up and through today's Global War on Terror. However, today's MIB footprint is only 20% than that of the 1940s and 50s. The necessity of evolution, waxing and waning demand signals, shrinking defense budgets, and various other reasons have all shaped the current landscape of today's domestic MIB. As we explore, develop, plan for present and future conflicts, the MIB will continue to be a critical cornerstone of the greater DIB. As we conclude operations in Iraq and Afghanistan, we must consider the context of two paradigms. First, what is the "right size" for the greater MIB to sustain steady-state productions in peacetime while maintaining surge capacity? Second, how do we effectively shape the future of our MIB to meet the demands of both state and non-state actors, particularly as it relates to a Great Power Competition/peer adversaries, such as China and Russia?

Today's MIB strategic environment is dynamic and unique, similar to other areas within the DIB. The MIB faces many similar challenges especially concerning the availability of materials, rare earth elements, recruiting and retention of human capital, the state of the infrastructure, and single/sole-source supply chain vulnerabilities. The MIB presents a mix of Government Owned-Government-Operated (GOGOs) and Government-Owned-Contractor-Operated (GOCOs). Each structure brings its strengths and challenges as it relates to production and any potential surge capacity. Infrastructure modernization, government spending, and the appetite for long-term investment on the part of defense contractors remain at the forefront of the conversation in improving efficiency within MIB. Many installations continue to operate within World War II-era facilities, many of whom also rely on legacy equipment/technology to supplant surge any future surge capacity.

Additionally, determining steady-state production vis-a-vis dynamic demand signals remains a challenge within the strategic environment of the MIB. Such complexities make it particularly difficult for defense contractors and their sub-contractors to balance their support of the MIB/DIB while considering profit share and stakeholder interests. Challenges with human capital recruitment, retention, and engagement remain prolific throughout the MIB, significantly impacting the ability to meet current demand, as well as the ability for many locations to surge. The ability to recruit qualified, skilled labor and STEM professionals and provide competitive compensation remain just some of the articulated challenges by those working within the MIB.

Supply chain resiliency within the MIB presents similar concerns when compared to other areas of the DIB. With several single/sole-source chokepoints embedded within the MIB, vulnerabilities are rampant, not only related to our ability to surge but also to support steady-state production. The prolific sub-contractor base, while critical, bring to bear a multitude of concerns both in terms of overall visibility and their ability to continue to support the demands of the DoD/survive in times of leaner defense spending. Single/sole-source materials procurement adds another layer of complexity in the broader supply chain discussion. With a significant portion of raw materials, especially rare earth elements (REEs), coming from China, the U.S. could find itself facing a crisis of unfathomable proportions, not only as it relates to our ability to produce munitions but to support other every day, non-defense related industries. Finding and funding the means to mature domestic sources of mining and production will be

essential in moving the evolution of the MIB forward.

We provide a nuanced analysis of critical issues affecting the MIB and the greater DIB throughout this report and propose policy recommendations. Moreover, some of these policy recommendations have utility across the greater defense industrial base, creating a cohesive way to meet current and future national security challenges.

III. Introduction

The munitions industry is one of the oldest known to the U.S. defense industrial base. Since 1775 and the founding of the first Continental Army Depot Arsenal in Carlisle, Pennsylvania[1], the art and science of crafting our nation's munitions has remained a cornerstone in our greater defense schema. World Wars I and II ushered in historical surges in industrial capacity to meet the demands of multiple theaters, peaking at over 80 production sites at the height of the conflicts and beyond into the Korean and Vietnam eras.[2] Today, a mere 16 sites comprise the government's munitions industrial base (MIB). The current footprint answered our nation's call over the last 20-years of conflict in Iraq and Afghanistan, ensuring the readiness and lethality of the joint warfighter. However, as these operations reach their conclusions, we must consider the context of two competing paradigms. First, what is the "right size" for the greater munitions industrial complex to sustain steady-state productions in peacetime while maintaining surge capacity? Second, how do we effectively shape the future of this MIB to meet the demands of both state and non-state actors, particularly within the context of a Great Power Competition/peer adversaries, such as China and Russia?

The following work represents the capstone of a joint service collective of professional officers and dedicated government civilians, providing an analysis of the U.S. MIB. Through critical analysis of the greater strategic landscape, we propose policy recommendations to meet both current and future demands by both the U.S. and allies/partner nations. Limitations to this experience include both time and those related to the current COVID-19 pandemic. The forthcoming commentary is rooted in the students' experience/observations/analysis. It does not necessarily reflect the official policy or position of the National Defense University or the Department of Defense.

IV. Strategic Environment

The U.S. MIB strategic environment is dynamic and unique, facing many challenges, particularly related to the availability of materials, human capital, state of the infrastructure, and single/sole-source supply chain vulnerabilities. As of 2020, there are approximately 16 active sites within the Joint Munitions Command (JMC) supporting the MIB, with an even balance existing between Government Owned-Government Operated (GOGOs) and Government Owned-Contractor Operated (GOCOs).[3] However, GOCOs handle the preponderance of physical munitions production compared to GOGOs, which largely address maintenance, storage, and demilitarization. Of those entities operating as GOCOs, most are contracted with one of the "Big 6" defense contractors (i.e., Lockheed-Martin, Boeing, General Dynamics, Northrup-Grumman, BAE Systems, and Raytheon), with few exceptions. While not completely devoid of private sector support, given the unique and highly defense-focused nature of the MIB, relatively few Contractor-Owned-Contractor-Operated (COCOs) are represented within the greater enterprise, particularly those that are not already counted among the "Big 6." The COCOs that are active participants (especially the smaller, non- "Big 6" cohort) operate within very niche markets (i.e., snipper bullets, batteries, energetic devices, smaller caliber ammunition, additive manufacturing, etc.)[4]

The MIB remains dominated by a few concentrated prime defense contractors, primarily due to the specialized nature and demands of the industrial base. As the Department of Defense (DoD) is almost always the sole buyer, a monopsony exists, with limited opportunities to expand product lines into the broader commercial market. The DoD as an exclusive buyer is a double-

edged sword; on one side, you have a guaranteed customer entering into potentially long-term production contracts. On the other, those few are at the mercy of the dynamics of strategic defense priorities and subsequent investments/spending, particularly during times of relative peace. Therefore, entry into this industry may require a substantial up-front investment, as well as an appetite for assuming financial risk. Additionally, as domestic demand ebbs, global demand has been steadily increasing, presenting new opportunities for foreign military and direct sales to our allies and partners.[5] However, existing regulations such as the U.S. Arms Export Control Act (AECA) and the International Traffic in Arms Regulations (ITAR) make it exceedingly difficult to leverage these opportunities, despite 2018 updates to existing policies.[6,7]

The existing infrastructure of the MIB is of particular concern. In a 2020 report to Congress on industrial capabilities, the DoD acknowledged the need for major modernization efforts to achieve capability and capacity for both current and future demands.[8] Some locales operate out of World War II-era facilities, with surge capacity dependent on "warming-up"[9] legacy equipment/technology. Advances in technology are evident throughout the MIB, especially with precision-guided missiles (PGMs), but consistency is lacking. As we observed during our field study, some production areas continue to rely on a 70-year-old hands-on methodology because it either remains the "gold standard"; or the current physical infrastructure (and the cost of modernization) does not support newer, more efficient technology. In recent comments to both Congress and public conferences, Dr. Bruce Jette, the former head of Acquisitions for the Army, emphasizes the critical need for modernization. He states, "we've kind of come to the end of the rope with respect to modernization of those facilities….people who were killed at the facilities doing exactly what they were supposed to do; following procedures that had been 'modernized,' yet we still had catastrophic events."[10] The alarm, without question, is being rung.

A resource debate exists between the government and the contractors to modernize physical infrastructure. From the government's perspective, contractors should invest in physical infrastructure modernization because it directly supports production requirements stipulated in their contracts. The impression from the contractor's perspective would be one of ownership; the government owns the facility and therefore should pay for most of the physical modernization, with some financial offset from the contractors where it directly relates to production. Naturally, the impetus for such contractor-led investments continues to be framed within the context of contractual obligations (as written in the contract), investor demands, and proximity to the end of their contract with the government.

Steady-state production rates and surge capacity also present unique challenges within the MIB. In the aforementioned 2020 congressional report, the DoD acknowledges the complexities of maintaining a consistent demand signal for steady-state production and its impact on the industry at large.[11] It is unclear whether the DoD has a clear picture regarding the true surge capacity across the industrial space and an appreciation for the calculus of time for mobilization.[12] Where other industries may offset a decrease in demand from the DoD with commercial production, few such opportunities exist within the MIB. This has led to an incongruence between U.S. strategic priorities and those of the suppliers within the industry. The availability of workers within the manufacturing industry presents human capital challenges during steady-state and surge operations for the MIB. For example, as of April 20, 2021, a review of various public job websites found over 80 jobs available within the energetics industry in East Camden, Arkansas. A 2018 Deloitte study on U.S. manufacturing projects approximately 2.2 million job vacancies between now and 2028, creating a significant gap in competition for

workers.[13] Throughout the field research, attracting qualified personnel throughout various skill levels (technical through more STEM-heavy roles) was a trend of prime and sub-prime vendor H.R. reps. The remote locations of production sites, competitive compensation, turnover/retention, and lifestyle choices that impact one's ability to pass a background check (i.e., failed drug tests, prior legal issues) are just a few of the articulated reasons for these challenges.[14] In terms of competitive compensation, we noted that wages were wages barely above (or sometimes below) other, less dangerous jobs that did not require background checks and physicals.[15] Most sites cited viable workforce candidate availability as a predominant driver impacting their steady-state and surge capacities. For example, one site visit revealed that their utilization rate was only roughly 70% of their actual production capacity despite both DoD and commercial demand. The main reason: not enough qualified workers, a trend noted across our visits.[16] In site visits to both GOGOs and GOCOs, manufacturing workforce shortages impacted production and surge capacity.

The MIB strategic environment also faces supply chain resiliency, sourcing of materials, and single/sole-source production chokepoints challenges. Further, reliance on a plethora of sub-tier contractors by the prime vendors is also an area of potential vulnerability. Many of these sub-tier contractors are the single/sole source for component production and material source procurement. This creates concerns not only for the general scope of oversight but for the viability of some of these contractors within the greater industrial base. In essence, if demand decreases within the MIB, what are the second and third-order effects on these sub-contractors? Can they survive the leaner years or begin to divest themselves from the industry?

In terms of materials procurement, a significant portion of the raw materials required for munitions manufacturing, with few exceptions (i.e., steel, batteries, etc.), comes from sole sources outside of the U.S., most concerning being China. At present, China controls 80% of the mining and processing of the world's rare earth elements (REEs.[17] As many of these REEs are critical to munitions production, reliance on China as a node in the larger supply chain creates a potentially harmful impact on our national security. Not surprisingly, the Chinese are analyzing the impact on U.S. defense contractors and their ability to produce munitions if they limit their exports of REEs or use them as leverage in ongoing trade wars.[18,19] Efforts to mature domestic sources of mining and production are currently being evaluated. Still, they are not prepared to handle a surge in demand due to deliberate export limitations.[20] Current U.S. policies and environmental regulations have all but subsidized the offshoring of REEs, and "reshoring" will be both costly and lengthy. However, when one considers the cost of conflict with China, failure to pursue domestic efforts would be fatal.

V. Stakeholder Interests

There are several significant stakeholders within the MIB, each with complementary and competing interests. Government stakeholders include the DoD, the services, Joint Munitions Command (JMC), Army Material Command (AMC), Joint Program Executive Officers (JPEOs), acquisitions professionals, and the Combatant Commands (COCOMS). Other stakeholders include the "Big 6" of U.S. defense contractors (BAE Systems Inc, Boeing, General Dynamics, Lockheed Martin, Northrup Grumman, and Raytheon) and the multitude of sub-tier contractors, as well as a few other smaller, prime defense contractors; and our NATO allies/partners. On the surface, all can agree on the common goal of sustaining partnerships that both strengthen and project U.S. national security. The DoD's primary interest will continue to be ensuring the readiness, lethality, and capacity of the warfighters to defend our nation both at home and

abroad. It is naïve to assume that stakeholder interests, especially for defense contractors, are purely patriotic. They are still large corporations who answer to their investors and have economic interests outside of the defense sector. The motivation of profit and the ability to invest that profit within a more diversified portfolio of interests will continue to be the primary goal of these companies.[21]

Service parochialism will also continue to impact stakeholder interests internal to the DoD, especially within the MIB. The realities of budgetary/fiscal constraints, fights to control nascent and emerging mission sets, will continue to shape the demands on the MIB. Competing priorities within the services (i.e., long-range precision munitions for the Army; the Air Force replenishing its PGM stockpiles and the fate of platforms like the A-10; and the Navy's interest in its own long-range, precision strike capabilities) will bring both opportunities and challenges to the MIB.[22,23,24]Applying these realities to future policy will be essential.

VI. Porter's Diamond Model

Michael Porter's Diamond Model (officially titled the "Theory of National Competitive Advantage of Industries")[25] offers a framework for assessing the relative competitive advantage of national or regional industry (See Addendum I). Despite significant differences between the MIB (largely defense-only) and traditional industry, the model lends insights for creating a robust and resilient MIB. The model consists of four interrelated and mutually effective corners of a diamond: factor conditions, related and supporting industries, demand conditions, and strategy and rivalry.

Factor Conditions

Diamond Model: Here, the model refers to the natural and created conditions that shape a national industry's relative competitiveness and strength. Natural factors include a nation's geography, natural resources, and population. Created factors include everything that has developed from the natural resources such as infrastructure (i.e., roads, rails, ports, etc.) and human capital/skilled labor force, academia/research centers, systems of government, banking and capital structures, and partnerships and alliances. Essentially, factor conditions refer to the broad context within which an industry operates in a given country.

MIB: The U.S. provides several beneficial factor conditions for the MIB. These factors include diverse and plentiful natural resources, a broad labor force, renowned research, technology centers, a well-developed logistics infrastructure, and a relatively stable system of systems—government structures (including a relatively high proportion of defense spending), banking, and capital markets, and commerce. However, recent trends indicate a steady reduction in federal spending on research and development, along with a lack of critical STEM skills and knowledge in the overall workforce. The MIB would benefit from a renewed focus and investment in those two key areas.

Related & Supporting Industries

Diamond Model: This area of the diamond refers to industries or subsegments that directly support the primary industry (either upstream or downstream) through supply lines or indirectly through mutually beneficial relationships. The former relates to suppliers and component manufacturers, while the latter refers to different industries whose activities benefit

the industry in question. The stronger and more competitive these related and supporting industries are on an international scale, the better they can strengthen a core industry.

MIB: Thousands of companies comprise the diverse MIB ecosystem. Supporting industries range from raw materials producers, subcomponent manufacturers to logistics providers. Specifically, concerning the modernization and evolution of the MIB, a few key industries may play critical supporting roles, notably robotics, additive manufacturing, and digital engineering. These industries are uniquely positioned to facilitate an overdue upgrade to antiquated machinery and processes in the MIB. Such investments and would bolster the MIB and add both capacity and flexibility while realigning human resourcing.

Demand Conditions

Diamond Model: The domestic demand for goods or services within a market will influence several aspects and decisions for the firms in an industry. A clear, steady domestic demand encourages investment within an industry and fosters competition from new firms. With a solid domestic demand, the industry can then grow to be competitive internationally in new markets.

MIB: The U.S. MIB is unique in this corner of the model. Except for small-caliber ammunition, the entire industry is defense-only, and as such, the universe of buyers consists of a single entity: the U.S. government. U.S. defense firms export munitions to partner nations, but only with the express permission of the monopsony buyer. Sales only occur after lengthy coordination to ensure compliance with regulatory requirements (i.e., International Traffic in Arms Regulations [ITAR] and the Arms Export Control Act [AECA]), involving multiple federal agencies. Furthermore, the unpredictable demand signal for munitions within DoD fails to create a steady and reliable course within the MIB. Various factors, including military operations, geopolitical events, economic conditions, appropriations friction, and last-minute budget reallocations, the year-to-year procurement demand for munitions can ebb and flow with substantial swings. This unpredictability adds risk for firms and discourages longer-term investments in capital improvements, research and development (R&D), or human capital. Implementing a mechanism to smooth the demand signal year-to-year would reduce the i.firms' risk to revenues and encourage investments.

Strategy & Rivalry

Diamond Model: Competition and rivalry within an industry shape firms' strategy, including their investment decisions. A healthy degree of competition encourages firms to continue investments in R&D to improve products and processes, creating more innovative offerings and overall improved performance. This also facilitates a greater competitive advantage internationally. On the contrary, a lack of competition can discourage risk and investments that may create improvements or innovation for better products and services.

MIB: A decade of consolidation has narrowed the field of prime defense firms to the "Big 6". Within the MIB, each subsegment (i.e., air-to-air missiles, bombs, artillery shells, etc.) consists of only two of these major primes. Essentially, the MIB is an oligopoly, and each subsegment is in a duopoly, far short of a competitive industry. High barriers to entry will prevent smaller firms from becoming new major primes, especially because these primes tend to acquire smaller, niche firms for vertical integration. Other aspects of the diamond have created a strong, competitive, and advanced MIB that secures export contracts to dozens of partner

nations. Other countries look to the U.S. and our MIB for the highest performing and most complex munitions for their platforms, with few other competitors from which to choose.

VII.Strengths, Weaknesses, Opportunities, and Threats (SWOT) Analysis

The MIB is a well-established industry within the larger defense industrial base. In peace, the MIB has met or exceeded the demand to support the warfighter.[26] It has proven its flexibility in evolving production, adapting to technological advances in munitions while maintaining proficiency in more traditional production lines (i.e., various calibers of ammunition).

Weaknesses:

The MIB is highly dependent on U.S./DoD investment for its long-term viability. Because of the defense-centric nature of the MIB, few opportunities exist for commercial offsets to support production lines in times of decreased demand from the DoD. Additionally, current U.S. policies and heavily bureaucratic procedures hinder foreign military sales. The MIB is dominated by the "Big 6" of U.S. defense contractors, creating substantial barriers to entry for smaller firms wishing to enter into the marketplace. These smaller companies are often bought up/out by the "Big 6" under vertical integration efforts.

Opportunities:

The U.S./DoD needs to pursue opportunities that facilitate foreign military sales to our allies and partner nations. Not only does this strengthen these crucial relationships, but it also improves interoperability in a joint environment. The MIB needs to leverage opportunities to facilitate commercial sales, where appropriate. Support for commercial sales would provide additional avenues for profit, but it would go far in maintaining certain product lines, particularly when the DoD demand is low. Opportunities also exist to examine areas where the U.S. can support/restore domestic processing and production of certain REEs critical to the MIB.

Threats:

The most critical threat in the MIB is the aging infrastructure across the enterprise. Lack of infrastructure modernization continues to hamper production capacity and the implementation of newer technologies to improve safety and efficiency. Availability of skilled and unskilled workers impacts steady-state operations and limits surge capacity at remote locations.

Single/sole source issues, both in material procurement and production, continue to plague the MIB. Of particular concern are the REEs/scarce materials and the MIB's reliance on China as a sole source for these critical elements. Engaging in opportunities to decrease/eliminate such dependencies will be an essential path forward in mitigating this threat.

VIII. Policy Recommendations

The following sections will provide a more detailed discussion of five areas critical to ensuring the agility, lethality, and longevity of the MIB and providing policy recommendations. We will address concerns regarding the modernization of the MIB (critical

infrastructure, resourcing, and market dynamics), material procurement, particularly foreign adversaries, innovation, human capital, and, finally, other areas for consideration.

A. Modernization

Critical Infrastructure

Introduction:

The MIB (GOGOs and GOCOs) has faced significant modernization challenges with facilities and supporting infrastructure. Much of the MIB remains preserved from its World War II mobilization. Challenges stem from the lack of strategic funding sources, which poses a significant risk to mission readiness. The vulnerabilities identified that threaten our force's ability to project power are antiquated production lines, energy, water distribution, cybersecurity, and rail systems conveyance capabilities.

Issue:

The MIB remains outdated, with a significant need to modernize facilities and infrastructure to reduce the risk posed by single-source water and power distribution, antiquated equipment/facilities, and threats of cyber-attacks. These functions are crucial to the manufacturing and distribution of the commodities that support the defense of this nation. The negligence and disrepair within the infrastructure of the MIB may be the risk that costs us the next conflict due to the inability to support the mission appropriately.[27,28]

Discussion:

First, the deterioration of the MIB has been in a steady decline since World War II. Only recently, during a working session on March 25, 2021, has Army Material Command proposed a remedy plan to modernize the MIB. This plan primarily focuses on that sustains "the artisan workforce, maintains pace with the Army's modernization of weapon systems, and enables surge capacity for large scale combat operations."[29] Commanders will also be encouraged to consider climate change and energy efficiencies and physical and cybersecurity and protections.[30] These assertions are an example of not prioritizing critical support and operations that MIB needs to sustain enduring activities.

Second, the critical infrastructure supporting the MIB is expensive to upgrade and maintain. For example, during a 2005 Base Realignment and Closure (BRAC) review, the full replacement value of Scranton Army Ammunition Plant (SCAAP) was estimated at $98.4 million. [31] Over the last 20 years, SCAAP has received approximately $117 million in Production Based Support (PBS) funding, with contractor(s) contribution of around $52 million since 1993, all for modernization. Furthermore, SCAAP has not received any PBS funding since fiscal year (F.Y.) 15 over concerns of potential placement back onto the BRAC list, which at present has not occurred.[32] [33]Considering the impact of inflation on the full replacement value and lags in modernization efforts, the gap between the full replacement value and existing funding continues to grow.

Another example comes with the privatization of utility systems at Aberdeen Proving Grounds (APG). The cost for electricity, wastewater, and water were $498 million, with a

monthly reoccurring cost of $1.8 million. APG also privatized their natural gas infrastructure at the cost of the monthly tariff rate. All new modernization projects will require coordination with existing cybersecurity requirements to ensure that they are authorized to operate on the DoD network, with associated costs at approximately $250 thousand for the initial and $80 thousand for the 3-year reauthorization. [34]

Third, the transportation conveyance mechanisms of materials and goods to and from the MIB need upgrading and modernization. Rail systems, airfields, and tractor-trailer accessibility must get brought into the 21st century due to the volatility of their cargo. For instance, three phases of rail operations modernization at Letterkenny will cost approximately $23.6 million.[35]

Recommendations:

Policy Recommendation #1: The Department of the Army (DA) must enforce existing policy to report energy and water distribution systems and cybersecurity requirements. Substantial policy and guidance exist for data collection. This data is analyzed and compiled to prioritize funding for missions meeting critical requirements. Accuracy and lack of information have plagued senior leaders for many years. Hold reporting commanders accountable for lack of data or inconsistent reporting on all vital functions supporting the MIB.

Policy Recommendation #2: The DA must make modernization projects higher prioritization for MILCON, third party, and alternative financing.
Prioritize all resourcing opportunities for the MIB by criticality to the mission. The DA must leverage existing installation assessment data to identify vulnerabilities to mission readiness. The DA will convene a 3-star (or equivalent) board to determine funding allocation for modernization projects.

Resourcing

Issue:

The Munition Industrial Base strategic funding measures of the GOGO and GOCOs have impacted the modernization and readiness of the forces.

Discussion:

The MIB comprises three different models to meet the DoD's needs for defense support: the GOGO, the GOCO, and some COCOs. AMC is currently in charge of the GOGOs and GOCO's across the country, with funding falling to the Assistant Secretary of the Army for Acquisition, Logistics, and Technology (ASA [ALT]). Funding for GOGOs is primarily through Army Working Capital Funds (AWCF). The AWCF is self-financing and is heavily dependent upon the customers purchasing from the AWCF. The customers (i.e., all military services) largely receive appropriated funds and control how they execute those dollars.

There are a few ways for a GOGO to modernize and improve infrastructure by using operating funds for less than $250K. First would be capital investments of depreciable property, plant, equipment, or software worth over $250K. Second, use Military Construction (MILCON) for construction projects over $1 million. Third, use the Facilities Sustainment, Restoration, and Modernization (SRM) program (formerly Real Property Maintenance), which provides funds to keep facilities in working order (i.e., day-to-day maintenance requirements).[36]

The government share of funding for GOCOs is through Procurement of Ammunition, Army (PAA) funding. This is synonymous with PBS funding. The primary goal of this funding is to provide GOCOs with the modernization of facilities and equipment. Any other infrastructure investment is at the leisure of the contractor and their appetite for such, especially as it relates to the language within the existing contract Both GOGOs and GOCOs have significant challenges in resourcing and modernization. To be competitive and remain a world hegemony, the Army and, to an extent JMC, must establish a new approach to fortifying the MIB.

Recommendations:

Policy Recommendation #1: The DA must establish a policy to fund the MIB through separate appropriations. Much like Arlington National Cemetery (ANC) appropriations, the MIB must have a new funding appropriation created for support. The ANC is considered irreplaceable, unique, and essential to the existence of the DoD, and the MIB is no different. The Army would remain as the executive agent for the DoD. Congress separately will allocate funding for operations, modernization, improvements, and revitalization.

Policy Recommendation #2: An Army-appointed Executive Director (SES-3) to lead the MIB who reports directly to the Secretary of the Army. The organizational structure for this new leadership model would reflect that of the Arlington National Cemetery. Depending on the type of facility, each GOGO and GOCO will have a Superintendent/Commander/GS-15/O6 with an acquisition, logistics, or science/research background. This new position will allow functional commands (i.e., AMC, ASA(ALT), and Army Futures Command) to focus on the portion of the Great Power Competition. The JMC, the Single Manager for Conventional Ammunition (SMCA), and the Combat Capabilities Development Command (CCDC)-Armaments Center will provide their functional inputs to the Executive Director regarding the MIB. It streamlines the funding priorities and processes, aligns overall strategy, and focuses on the MIB to address infrastructure, modernization, and readiness.

Market Dynamics

Introduction:

The munitions market suffers from a few flaws, all of which can be addressed with government intervention. Almost all products within the market are for defense/government use only. Therefore, it is not a "pure" market per se. Government intervention for the sake of national defense interests is appropriate. The market suffers from a lack of competition due to over-consolidation, high barriers to entry, and aggravated by uneven demand signals.

Issue 1:

The uneven demand signal for the munitions market disincentives investment and innovation from firms within the industry and further raises contract pricing.

Discussion:

The munitions market is entirely defense-only, except for the production and sales of small-caliber ammunition (.50 cal and lower) for law enforcement and some commercial use. As a result, demand comes from a limited universe of buyers and places several constraints on demand. In the greater U.S. munitions market, the DoD is the primary buyer, with the government controlling exportability vis-a-vie various policies/regulations (i.e., ITAR, EAR, AECA). Furthermore, munitions tend to be a perennial "bill-payer," with funding often slashed to pay for other line items. In essence, munitions are considered "nice to have" equipment. Additionally, with an uneven demand signal from year to year (for example, 25,000 JDAM in FY20 then 10,000 in the FY21 budget)[37], firms are wary of investing too heavily in capital projects or improvements, fearing curtailed or even nil procurement funding the following year. This phenomenon of cash flow uncertainty has also disincentivized independent research and development (IRAD) for innovation.

Recommendations:

Policy Recommendation #1: A "smoothing function" for demand would help incentivize capital investment and IRAD. One option is multi-year funding, which would require Congressional support and may not be politically palatable. Another option is either legislative or internal regulatory or policy guidance for smoothing the demand. For example, set a 20% limit for declining orders, which would prevent such aggravated demand swings as in the JDAM example above. With a 20% limit, the FY21 budget would account for at least 20,000 JDAM. While this would decrease overall budget flexibility, it would add resiliency and flexibility to the MIB and insulate production lines for surge capacity.

Issue 2:

The DIB, specifically the munitions market, lacks sufficient competitiveness to effectively garner optimal output for the U.S. government as its primary customer.

Discussion:

The DIB currently consists of only six major prime vendors: Boeing, Lockheed Martin, Raytheon, Northrop Grumman, General Dynamics, and BAE. The first five of those companies represent the consolidation of 75 various companies since 1980. Within the munitions market, each submarket (i.e., air-to-air missiles, gravity bombs, small caliber ammunition, etc.) is only serviced by two major prime vendors. In coordination with DoD, the Department of Justice (DoJ) has not been able to ensure sufficient competition among defense firms, especially within the defense-only portions of the subsegments of the munitions market.[38] There are two primary counterarguments to consider. First is the idea that the market is self-correcting. The current landscape results from the "natural market forces" of consolidation from decades of mergers and acquisitions, and therefore, efficient. Second, the DoJ has the authority and responsibility to review any proposed mergers and acquisitions before executing. However, since the DoJ has allowed for the current situation, the merger practices of the large defense contractors may be viewed as "okay." For example, the DoJ allowed the merger between Raytheon and United Technologies after divesting certain business segments. On the surface, this appears beneficial, but it is more of a reallocation of assets from Raytheon to BAE.[39]

Recommendations:

Policy Recommendation #2: DoD, in conjunction with DoJ and Commerce, should initiate a study into the competitiveness of the defense munitions market. Based on these findings, the U.S. government should incentivize increased competition with development and production contracts. In parallel, DoJ should file suit against firms who demonstrate monopolistic market power in the various munitions market areas.

Issue 3:

The nature of development and procurement contracts further aggravates the over-consolidated MIB base and erects very high barriers to entry. Vendors who win production contracts tend to enjoy a monopoly of a market subsegment for decades, with the cash flow to go with it.[40]

Discussion:

For defense systems (to include munitions), typically, the competition is conducted within the development phase. Then once a vendor is selected, that firm (the which owns the data rights) tends to be the only firm that produces the goods for the life cycle of the weapon/munition, in our experience.[41] This monopolistic market power ensures a relatively steady cash flow for a year or even decades, though demand changes year-to-year (see Issue 1). This phenomenon disincentivizes competition or innovation IRAD within a life cycle for a weapon/munition, resulting in a suboptimal munitions industrial base for DoD.

Recommendations:

Policy Recommendation #3: DoD should assess which programs warrant purchasing the data rights on behalf of the U.S. Government. When DoD owns the data rights, production for a weapon/munition can be competed at various points along the life cycle, reenergizing competition and improving performance and even cost. The firm that develops the product and receives the first few production lots will still secure revenues. They will then have the opportunity to compete for follow-on production. However, with this model, other firms who do not possess the capital or risk tolerance for IRAD, but have the production capabilities can still compete for production contracts down the line.

B. Materials Procurement

Foreign Adversarial Dependence

Issue:

The MIB supply chain remains critically dependent on foreign adversaries, particularly China and Russia, for several rare earth elements (REEs) or other scarce materials. In particular, supply chain resilience in Antimony and tungsten, must be addressed for the long-term health of the MIB. Tungsten is a key component in circuit boards and dense projectiles, and Antimony

Sulfide is in primers and copper bullets.[42] Great Power adversaries dominate both markets, and national stockpiles are significantly depleted, as documented in U.S. Geological Survey commodity profiles.[43] In both cases, domestic capacity is virtually nil, despite mineral availability within the United States.

Discussion:

Foreign adversarial supply chain dependence remains a strategic risk to the MIB. James Kennedy, a former member of the China Initiative, clearly articulates this point, "Rare earths are actually a hegemonic trigger. If the United States gets into a conflict, China is supplying the majority of the upscale weapons." Furthermore, "China can determine the outcome of the conflict, and that could result in a hegemonic shift."[44] Current and pending policies remain disjointed and exploratory and do not mitigate strategic risk. Relying on an adversary for munitions materiel is both a supply chain issue and a critical national security concern.

The U.S. capacity for utilizing its resources is lagging in its industrial needs for commerce and national defense based on findings from James Kennedy, a former member of the China Initiative.[45] A specific policy is required to expand steady-state capacity regarding mining and production capacity and secure domestic mineral needs, and act as an enabler for further expansion as part of a mobilization scenario. Domestic capacity is critical for steady-state economic functions and maintaining the infrastructure and skills needed to rapidly expand domestic production to support mobilization needs.

The United States must expedite efforts to increase domestic mining and processing capacity. There are no large- or medium-scale tungsten mines active in North America, despite a wealth of confirmed claims. The 2020 USGS Antimony Report clarified that there is only one active but limited processing site within the United States capable of extracting Antimony from stibnite ore.[46]

Recommendations:

Policy Recommendation #1: Increase Domestic Capacity and Mobilization Readiness for MIB Critical Minerals. Moving forward, the U.S. government needs to develop policy measures that specifically target domestic mining and processing capabilities. This should include Defense Production Act (DPA) loans and loan guarantees, coupled with tax benefits and grants similar to the incentives for mines outlined within the Onshoring Rare Earths Act. Policy measures are also required to incentivize buying power from the U.S. & allied producing mines. Early entry and stable purchasing power from the DOD, DIB, and the commercial sector will create predictability within the market and further mitigate the vulnerability.

The MIB is critically dependent on multiple elements explicitly defined within the 2018 Department of Interior Critical Minerals List. The following policy recommendations focus on two critical minerals, tungsten and Antimony sulfide, but the recommendations must be expanded to address mining, refining, processing, and recycling shortfalls throughout the MIB.

Tungsten

Issue:

With multiple tungsten mines in Russia and China nearing their lifespans, limited expansion should be made to restore domestic capacity.[47] A domestic source should be utilized to provide a stable, secure supply source to key industry and defense partners, while securing the necessary domestic required experience and talent to expand mining capacity to support national mobilization.

Recommendations:

Department of Energy (DoE) and U.S. Department of Commerce (DoC): Secure government funding for loans and commercial investors to underwrite small-scale restoration of Tungsten mining and production in the U.S. This will expand existing capacity and begin to decrease reliance on foreign sources.

DOC, DIB Members, and DoD: Coordination with defense industry partners and commercial businesses to secure long-term supply contracts and customer demand for U.S. tungsten operations. This will assist in developing a steadier demand signal and encouraging more long-term investment.

Defense National Stockpile Center (DNSC)/ Defense Logistics Agency (DLA): Both groups should pursue the purchase of tungsten to increase demand on domestic suppliers and restore stockpile levels while ensuring sustained demand for domestic tungsten for suppliers.

Antimony Sulfide

*Issue***:**

The U.S. needs to pursue efforts to recover Antimony from secondary sources in the copper industry. Given that 20 percent of domestic Antimony comes from mining wastes and other recycling processes, this proposal leverages existing capabilities.[48]With the waste generated from conventional mining methods, a modest capacity exists to extract Antimony and other REEs. Other sources include end-of-life electronics and coal ash waste.[49] Engagement with the mining and environmental industries will be crucial in exploring these secondary sources.[50]

Additionally, efforts to accelerate research and development for antimony sulfide and REEs in the domestic market are essential.[51] In recent years, research and development into mining have seen a marked decline in government funding. Further funding is required to restore competitiveness to the U.S., and project emphasis should be placed on particularly well-positioned areas to transition to the commercial market.

Recommendations:

Environmental Protection Agency (EPA): Pursue policies to encourage reclamation of Antimony and REE waste from mining and processing when deposits are at levels sufficient for economically advantageous secondary extraction.

DoE and U.S. Copper Alliance: Advocate for the government to secure loans and investors to expand the processing of secondary wastes for Antimony, as well as other REEs.

United States Congress: Expand current and pending policies, including Senate Resolution 3694, to address enhanced refining, processing, and recycling.[52]

Policy Recommendation #2: Secure increased funding for DoE research and development portfolio, explicitly targeting REE and scarce materials. Global research on working to improve

recycling techniques to reclaim rare earth elements from electronic waste is ongoing. Tackling rare earth recycling requires building effective electronic waste collection systems, with responsibilities for producers and consumers. Recycling would allow for the reclamation of many other valuable elements aside from rare earths. Academia can further develop the rare earth sciences in recovery from secondary resources such as existing waste from other mines. The U.S. Department of Energy awarded $20 million to a group of researchers at Duke University and the University of Kentucky to extract rare earth from coal ash.

DoE: The DoE should advocate for continued and accelerated research for economically sustainable extraction methods for REE from waste materials, specifically from metal mining/production, coal mining, and ash disposal sectors. Emphasis should be placed on advancing technology and economically sustainable processes, which can rapidly transition to commercial operations. Further, the DoE should expand the existing REE research and development portfolio to include scarce materials such as Antimony.

Academia and Research Universities: The U.S. government needs to seek opportunities to partner with academia in developing the rare earth sciences, specifically in recovery processes that leverage secondary resources such as existing waste from other mines.

C. Human Capital

Issue:

Shortfalls in the manufacturing industry workforce present human capital challenges within the MIB when recruiting and retaining workers for steady-state and surge.

Discussion:

The MIB has skilled and unskilled labor challenges. Over the past six months, a regular topic of discussion with senior leaders involved in the MIB is shortfalls in Science, Technology, Engineering, and Mathematics (STEM) educated personnel. Many leaders referenced the annual defense industrial base report to Congress, which regularly highlights STEM hiring challenges. In this year's report, the DoD Office of Industry Policy's Fiscal Year 2020 *Industrial Capabilities Report to Congress*, focus shifted to labor force departures from the Missiles and Munitions sector.[53] The departure of skilled technical workers (labor force) leaves a gap within the industry that is hard to recover from when American society promotes four-year college/universities as the only viable post-secondary education option to be successful.[54]

Besides STEM requirements for research and development, the certifications earned at technical schools and two-year degrees from community colleges are a much larger concern for surge capacity in the MIB. Surge capacity within the MIB requires a manufacturing workforce, not engineers and other STEM graduates. When discussing the ability to surge their workforces, most of the MIB facility leaders said it was the skilled and unskilled workforce required for daily operations, most of which received their training through on-the-job training.[55] In contrast, others (i.e., welders) attended technical schools or community colleges. The lack of education opportunities and job security disparities within the MIB depends largely on geographic location and type of facility.

For example, the GOCO in Radford, Virginia, a town of only 18,249 people with the closest regional airport being 45 minutes away[56], is in an area most would consider a remote

location. The limited government staff positions provide consistency, but the "surge and gap" nature of munitions production leaves the contract employees with less stability. The conflict-dependent, cyclical nature of munitions creates unstable demand and, it appears, insecure job prospects. As a result, the labor force looks elsewhere for job security. While remote locations certainly limit the labor pool, multiple munitions plant managers indicated that job applicants were not the problem; the real challenge was finding viable candidates.[57] Without action, the U.S. is facing an increased risk that the MIB will not be able to surge enough to meet the munitions requirements of a large-scale conflict.

Recommendations:

To address the human capital shortfalls caused by limited education opportunities and the remote locations of MIB production, the U.S. Government must institute a workforce education and training pipeline and update its remote location compensation options. Community college and technical schools are critical for the manufacturing industry. To grow the workforce base required in the MIB, DoD should support the 'College Promise for All' campaign, a policy aimed at developing "... America's Talent Pipeline by Increasing Access to Education, Training, and Credentialing."[58] This framework offers subsidized post-secondary education to young Americans, providing an opportunity to them to continue their education and contribute to society within the burden of education debt. The program has three primary goals: "Increase post-secondary access and attainment; Improve college affordability and reduce student debt; and Build a sustainable pipeline of skilled workers for the future."[59]

Education and Training: To expand the MIB workforce, the DoD should sponsor 250 'College Promise for All' type program positions that focus on skills required in the MIB. The estimated cost to support 250 candidates is $1 million the first year and $2 million each subsequent year.[60] DoD-sponsored graduates would serve (with full pay and benefits) within the MIB for at least two years with the option to stay longer, a great way to provide education and gain the human capital required for surge operations. Separately, for those positions that do not require education or certifications, the USG should fund a 4-6-week training program for the manufacturing industry, familiarizing potential employees with munition manufacturing concepts and safety requirements before going to a pre-determined MIB location to finalize on-the-job training (OJT). Like the education sponsorship program, the training program would incur a two-year commitment to work within the MIB.[61] (OPR: USD P&R, Army G1, JMC, & CPAC) (Funding: Use funds allocated to STEM programs, December 2020 Funding Opportunity Announcement (FOA) for STEM).

Relocation: Training the workforce is only part of the equation for incentivizing Americans to move to remote locations and work in potentially dangerous conditions where job security might be an issue. To better recruit new employees to government-owned facilities (GOGOs and GOCOs), DoD should pay relocation expenses for all employees willing to move to the remote location. While the plants often pay competitive wages for the area, they may not pay enough to justify a relocation for prospective employees. This is particularly true when looking for highly skilled workers. For government employees, the Army could advertise the positions with relocation incentives. For contractor employees, the Army could create a reimbursable line item on the GOCO contracts to attract talent to difficult areas. (OPR: Army G1, JMC, & CPAC) (Funding: Add to the Program Manager's bill for products purchased at government-owned facilities).

D. Innovation

Introduction:

The production of advanced munitions is the foundation for the Department of Defense (DoD), providing lethality worldwide. However, developing innovative munitions has not received significant attention and subsequent funding to outpace our adversaries. Two examples of emerging technologies, additive manufacturing, and hypersonic weapons, could provide a game-changing technology to keep the United States ahead of its adversaries, necessitating significant policy action. Additionally, the overall munitions market has inherent structural constructs that limit innovation, and this section provides a recommendation to overcome the barriers. Support for munitions innovation is critical for the United States to keep its military advantages over adversaries and ensure the DoD is at the forefront of military power.

Hypersonic Weapons

Issue:

Russia, China, and the United States are in a deploy hypersonic weapons arms race.[62] Unlike more predictable ballistic trajectories, the exceptional speed, altitude, and maneuverability of hypersonic weapons pose a major strategic challenge for which the U.S. does not currently have a solution.[63] With recent fielding and media attention on Russia and China's hypersonic missiles, it appears that the U.S. is behind its adversaries and has an urgent need for a strategic plan to play catch-up.

Discussion:

First, the DoD lacks codified mission requirements for hypersonic weapons or long-term funding plans.[64] Despite multiple programs over $3 billion in contracts, none of them are programs of record still attempting to identify the most viable overarching weapon system concept. As technologies mature, the DoD will need to develop and evaluate clear mission sets for hypersonic weapons and consider a cost analysis of alternatives to these mission sets.

Second, hypersonic weapons could negatively impact strategic stability due to their short time-of-flight and unpredictable flight path, increasing the risk of miscalculation or unintended escalation in the event of a conflict, especially with countries like Russia and China with nuclear and conventional capabilities. A recent study suggested that there is little advantage to upgrading the existing U.S. nuclear arsenal to include hypersonic delivery systems. Their benefits in speed, range, and accuracy are on the margins, and the resources required may be better spent elsewhere.[65] The DoD will need to invest more towards defensive countermeasures as well as deference through Mutually Assured Destruction.

Lastly, the DoD will face challenges in the great powers arms race and the proliferation of hypersonic weapons in adversarial countries that can be harmful to the security environment. Russia and China may have a strategic advantage over the U.S., not only to invest in offensive and defensive hypersonic weapons for themselves, but to proliferate these weapons to countries hostile to the U.S., including Iran and North Korea. This will further complicate strategic arms control, the equation of the poles of power, or the peaceful resolution of crises. The possession

of hypersonic missile construction technology may be equivalent to the possession of the nuclear weapon unless measures are taken to limit access to it.

Recommendations:

Policy Recommendation #1: The DoD should prioritize funding for both offensive hypersonic weapons and defense systems. The rising trend of DoD hypersonic budget technology has focused on over 15 times offensive systems than defensive countermeasures. The U.S. needs to ramp up its investment in defensive capabilities. Furthermore, the DoD should identify and formulate clear mission sets, providing strategic guidance as to what the U.S. wants and needs to do with hypersonic capabilities, which will drive strategic resourcing decisions, rather than merely responding to aggressions made by Russia and China.

Policy Recommendation# 2: The U.S. must address hypersonic weapons capabilities as part of the strategic arms control effort. The current New START Treaty, recently extended to 2026, does not cover weapons that operate on a ballistic trajectory for less than 50% of their flight.[66] Hypersonic glide vehicles and hypersonic cruise missiles, therefore, do not fall under such treaties. Furthermore, China, a rapidly growing nuclear power with hypersonic capabilities, is not in any arms control agreement. As many analysts have proposed, the U.S. must consider negotiating a new international arms control agreement that would institute a moratorium or ban on hypersonic weapon testing to prevent a potential arms race and preserve strategic stability.

Policy Recommendation #3: The U.S. should leverage the private sector and NATO allies. Future hypersonic platform development will likely come from NATO members' existing air and missile defense communities and major industry partners. The U.S. should connect smaller, innovative companies and academic institutions within the allies and partner nations to harness hypersonic technology over the next decade. NATO should play a larger role in coordinating functions for its member countries across the disparate projects and supporting testing efforts. Furthermore, partnering with U.S. companies, for example, in the commercial laser telecommunications industry that already plans to distribute thousands of satellites capable of secure and fast data transfer, will be a significant cost saving for the DoD.

Additive Manufacturing

Issue:

The MIB has not incorporated technological advances into the design, manufacturing, and production of munitions. For example, additive manufacturing (AM) is widely used in several industries, contrasting with the limited utilization within the MIB. [67]There several areas where the MIB can incorporate additive manufacturing to improve overall efficiency.

Discussion:

Additive manufacturing can be a game-changing technology for the Department of Defense (DoD) and the Munitions Industrial Base. Additive manufacturing allows for novel designs of munitions with applications ranging from the case and shell design, internal control systems, and energetic materials. The methods used in AM would improve the effectiveness and lethality of modern munitions. Additive manufacturing of munitions can provide several advantages to the DoD, including using a broader range of materials, cost efficiency, ease supply

chain issues, increased precision and accuracy, and increased automation in the manufacturing process. The U.S. must ensure this critical technology area is supported by increasing research and development funds and supporting the growing consortium of industry and academic institutions driving research in additive manufacturing of munitions. This support is critical for the U.S. to keep its military advantages over adversaries and ensure the DoD is at the forefront of munitions technology and manufacturing.

Recommendations

The United States government can ensure the development of advanced technology for additive manufacturing of munitions materials by enacting targeted policies to enhance the long-term viability and promote innovation.

Policy Recommendation #1: Support the development of scientific knowledge and innovation in additive manufacturing of munitions. Appoint the Office of the Under Secretary of Defense for Research and Engineering (OSD/R&E) the lead for this task. OSD/R&E would add additive manufacturing of munitions to their current list of modernization priorities along with other key technology areas such as hypersonic, artificial intelligence, and autonomy.[68] They would also establish a DoD-wide, mission-focused roadmap to chart the path in delivering the technical capabilities needed. Further, OSD/R&E would assess the range of activities in the technical area, lead independent technical analyses, and conduct outreach activities in this area.[69] The above recommendation would use existing OSD/R&E funding and resources.

Policy Recommendation #2: Increase research and development funding for additive manufacturing of munitions and include funds to build up the R&D infrastructure (testing equipment, facilities). Appoint the Army Futures Command as the lead for this recommendation. The Combat Capabilities Development Command (DEVCOM), a subordinate organization under Army Futures Command, would execute this task. Further, DEVCOM will develop an R&D strategy to advance additive manufacturing technology of munitions and energetic materials. This strategy will include facility and testing needs.

Market Factors Effect on Innovation

Issue:

The nature of development and procurement contracts further aggravates the over-consolidated MIB and erects very high barriers to entry. Vendors who win a production contract tend to enjoy a monopoly of a subsegment of the market for decades, with the cash flow to go with it.

Discussion:

For defense systems (to include munitions), the competition occurs within the development phase. Then once a vendor is selected, that firm (which owns the data rights) tends to be the only firm that produces the goods for the life cycle of the weapon/munition. This monopolistic market power ensures a relatively steady cash flow for a year or even decades, though demand changes year-to-year (see Issue 1). This phenomenon disincentivizes competition or innovation IRAD within a life cycle for a weapon/munition, resulting in a suboptimal munitions industrial base for DoD.

Recommendations:

Policy Recommendation #1: DoD should carefully assess current and upcoming programs to determine which one warrants purchasing the data rights on behalf of the U.S. Government. When the DoD owns the data rights and production for a weapon/munition, contractors can compete at various points along the life cycle, reenergize competition, and improve performance and even cost. The firm that develops the product and is awarded the first few lots of production will still be rewarded for the efforts and investment and will then have the opportunity to compete for follow-on production. With this model, though, other firms who do not possess the capital or risk tolerance for IRAD and development but do have the production capabilities can still compete for production contracts down the line.

E. Other Areas for Consideration

Air-to-Air-Missiles

Issue:

Air-to-air missiles are tactical weapons, but the capabilities of Air-to-Air Missiles (AAMs) have strategic consequences. After all, without air superiority, present-day conflicts are at an extreme disadvantage. Therefore, it is essential to have the most competent Beyond-Visual-Range AAMs. For decades, the AIM-120 has been the golden standard for AAMs. This standard has resulted in relatively little innovation taking place. As a result, America is losing its competitive advantage on air-to-air-missiles.

Discussion:

Most domestic market conditions for AAMs within the United States are well developed.[70] However, the domestic rivalry is not very competitive since Raytheon is dominating the AAM market. The surge capacity for AAMs is too small if the situation devolved from near-peer competition became a near-peer conflict. For Allies and partners, this capacity is even lower[71,72], as are their current stocks in AAMs. Knowing that the number of American aircraft decreases, Allies can help in obtaining Air Superiority. To achieve this objective, it is essential that the Allies also have competent AAMs. Providing allies with the latest U.S. AAMs is risky. It can have severe, long-term consequences as the information about performance remain secret. The utilization of these missiles in a conflict that the United States does not support would be undesirable.

Recommendations:

Policy Recommendation #1: The United States will develop a unique AAM capability that is not shared with allies or only with very close and long-lasting allies.
In addition, affiliation is sought with existing programs of allies to jointly (further) develop another weapon. This way, the United States can maintain its industrial capacity and help allies maintain air superiority while monitoring technological developments. No matter how successful the Aim-120 has proven to be in the past, it would no longer be the only option.[73,74]Furthermore, U.S. producers have more competition when developing, building, and

maintaining AAM. When necessary, surge capacity is available in more than one geographic location. Of course, this cooperation with allies and partners will lead to a situation in which allies take over a small part of the current U.S. industry.

IX. Conclusion

The issues faced by the MIB are significant and complex. Infrastructure across the MIB is largely unchanged since World War II, necessitating critical investment in modernization to meet both steady-state demand and surge capacity. However, lack of stable, long-term funding has hindered the MIB's ability to modernize, adding to an existing lag in essential upgrades. The DoD and all other interested stakeholders must prioritize long-term financing of infrastructure modernization to ensure the MIB's ability to meet current and future demand.

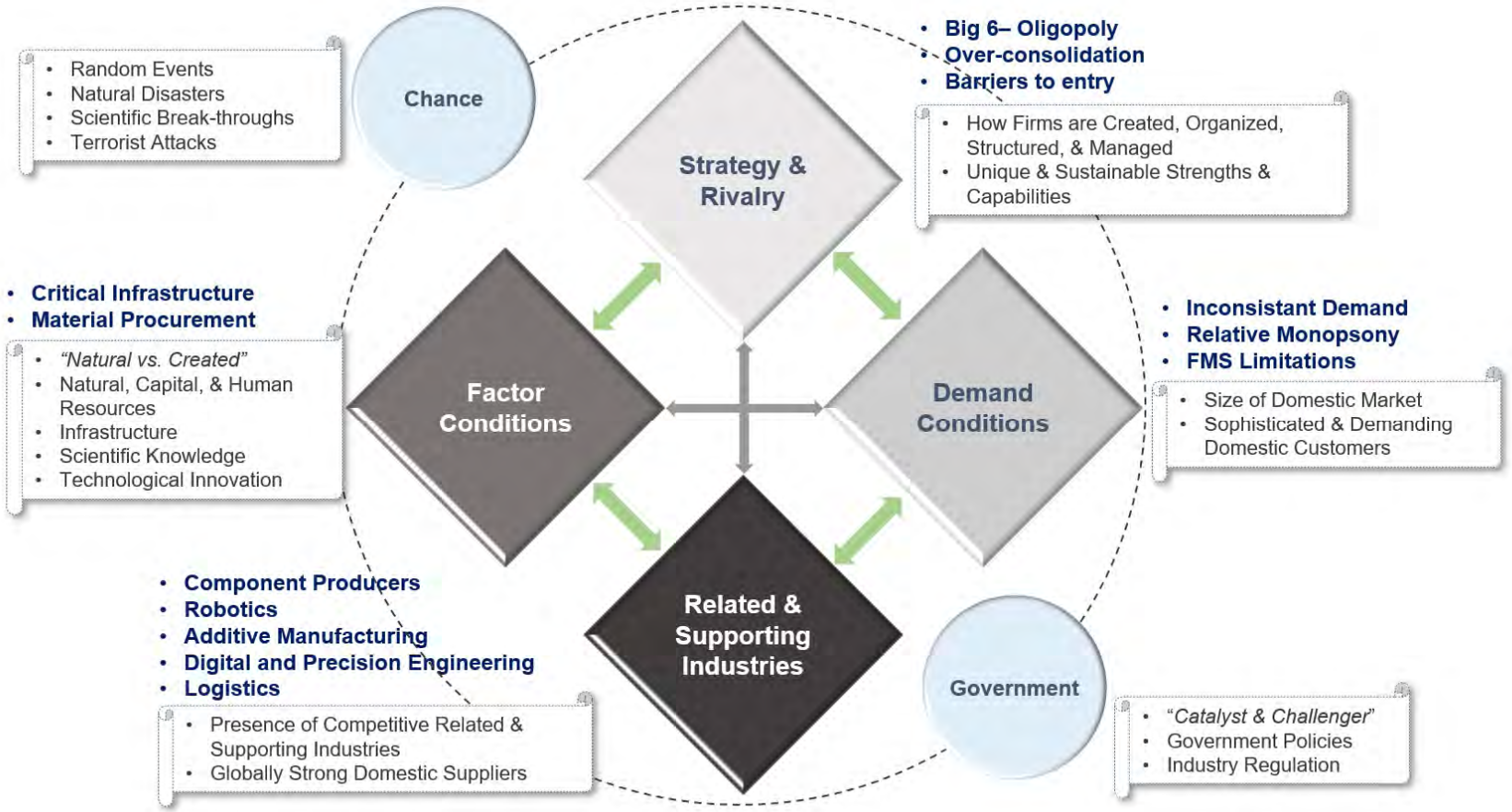
Recruiting and retaining viable workforce candidates continue to present human capital challenges within the MIB. Those within the industry need to facilitate a pathway to provide competitive compensation, educational opportunities, and recruitment/retention incentives, especially in remote locations, which are necessary to maintain steady-state and surge capacities.

Supply chain resiliency within the MIB is largely dependent on several single/sole source nodes of material procurement, many of which are outside of the U.S. Investing in domestic sources of REEs and other scarce materials is critical to decreasing U.S. dependency on foreign sourcing, particularly when those sources are more adversary than ally (i.e., China and Russia). Interested stakeholders within the MIB need to invest in domestic sources of such materials while partnering with environmental stakeholders to ensure stable source procurement.

The analyses and recommendations we have presented in this submission are a small sampling of issues we have captured during our study. We hope that we have provided a cohesive way forward in meeting the current and future national security challenges in preparing, sustaining, and modernizing the U.S. MIB in considering our recommendations regarding these critical areas.

X. Addenda

Addenda I: Porter's Diamond Model



End Notes

[1] Joint Munitions Command, *The Joint Munitions Command-A Concise History*. No Date Available. Retrieved from https://www.jmc.army.mil/Historian/JMCHistory.aspx (accessed on May 12th, 2021).
[2] Joint Munitions Command. *History of the Ammunition Industrial Base.* December 2010.
[3] Joint Munitions Command. *History of the Ammunition Industrial Base.* December 2010.
[4] Referencing student notes from site visits to MELD Manufacturing, Eagle Pincher, Sierra Bullets and Fiocchi; April 2021 Field Study.
[5] MarketWatch. *Ammunition Market Growth 2021, Global Industry Demand, Share, Top Players, Industry Size, Futrue Growth by 2025.* Press Release, April 8th, 2021. Retrieved from https://www.marketwatch.com/press-release/ammunition-market-growth-2021-global-industry-demand-share-top-players-industry-size-future-growth-by-2025-2021-04-08?dist=bigcharts&tesla=y (accessed on April 27th, 2021).
[6] Defense Security Cooperation Agency. *Foreign Military Sales FAQ.* Date unavailable. Retrieved from https://www.dsca.mil/foreign-military-sales-faq (accessed on April 27th, 2021).
[7] Briefing on Updated Conventional Arms Transfer Policy and Unmanned Aerial Systems (UAS) Export Policy, Special Briefing, Tina S. Kaidanow, Principal Deputy Assistant Secretary, Bureau of Political-Military Affairs, U.S. State Department, April 19, 2018.
[8] The Office of the Secrtary of Defense Acquistion Strategy. *Fiscal Year 2020 Industrial Capabilities: Report to Congress*. Retrieved from https://media.defense.gov/2021/Jan/14/2002565311/-1/-1/0/FY20-INDUSTRIAL-CAPABILITIES-REPORT.PDF (accessed on April 27th, 2021).Specifically, see pages 85-87.
[9] Based on information relayed by plant manager during field study site visit, April 2021.
[10] Freedberg, S. *Army Ammo Plants at "The End of the Rope': Jette.* Breakingdefense.com, October 13th, 2020. Retrieved from https://breakingdefense.com/2020/10/army-ammo-plants-at-the-end-of-the-rope-jette/ (accessed on April 28th, 2021).
[11] The Office of the Secrtary of Defense Acquistion Strategy. *Fiscal Year 2020 Industrial Capabilities: Report to Congress*. Specifically, see pages 85-87.
[12] Kelly, J., Lago, D., & Thomason, J. *Strengthening Industrial Base Decision-Making for Precision-Guided Munitions.* War on the Rocks, August 11th, 2020. Retrieved from https://warontherocks.com/2020/08/strengthening-industrial-base-decision-making-for-precision-guided-munitions/ (accessed on April 28th, 2021).
[13] Deloitte Insights. *2018 Deloitte skills gap and future of work in manufacturing study* (2018): 1-16. Accessed April 17, 2021. https://www2.deloitte.com/content/dam/insights/us/articles/4736_2018-Deloitte-skills-gap-FoW-manufacturing/DI_2018-Deloitte-skills-gap-FoW-manufacturing-study.pdf.
[14] Synopsis of human capital challenges articulated at multiple sites from student field experiences, April 2021.
[15] Synopsis of human capital challenges articulated at multiple sites from student field experiences, April 2021.
[16] Synopsis of human capital challenges articulated at multiple sites from student field experiences, April 2021.
[17] Tegler, E. *The U.S. is Trying to Secure Rare Earth Elements for National Security. That Goes Beyond Simple Investment.* Forbes Magazine, February 26th, 2021. Retrieved from https://www.forbes.com/sites/erictegler/2021/02/26/the-us-is-trying-to-secure-rare-earth-elements-for-national-security-that-goes-beyond-simple-investment/?sh=fe5727d5c536 (accessed on April 28th, 2021).
[18] Sedgman, P & Jing, Li. *China Eyes Rare Earth Export Curbs for U.S. Defense, FT Says.* Bloomberg News, February 16th, 2021. Retrieved from https://www.bloomberg.com/news/articles/2021-02-16/china-eyes-rare-earth-export-curbs-for-u-s-defense-sector-ft-kl7l9uxb (accessed on April 28th, 2021).
[19] Reuters. *U.S. Dependence on China's Rare Earth: Trade War Vulnerability.* June 27th, 2019. Retrieved from https://www.reuters.com/article/us-usa-trade-china-rareearth-explainer/u-s-dependence-on-chinas-rare-earth-trade-war-vulnerability-idUSKCN1TS3AQ. (Accessed on May 12th, 2021).
[20] Sedgman, P & Jing, Li. *China Eyes Rare Earth Export Curbs for U.S. Defense, FT Says.* Bloomberg News, February 16th, 2021. Retrieved from https://www.bloomberg.com/news/articles/2021-02-16/china-eyes-rare-earth-export-curbs-for-u-s-defense-sector-ft-kl7l9uxb (accessed on April 28th, 2021).
[21] The Office of the Secretary of Defense Acquisition Strategy. *Fiscal Year 2020 Industrial Capabilities: Report to Congress*. Specifically, see pages 85-87.
[22] Judson, J. *US Army Solidifying Plan for Long-Range Precision Munitions for Future Vertical Lift.* Defense News, October 15th, 2019. Retrieved from https://www.defensenews.com/digital-show-dailies/ausa/2019/10/15/us-army-solidifying-plan-for-long-range-precision-munitions-for-future-vertical-lift/ (accessed on April 28th, 2021).

[23] Tirpak, J. *USAF Rebuilds Precision Munition Stockpiles.* Air Force Magazine, April 1st, 2020. Retrieved from https://www.airforcemag.com/article/usaf-rebuilds-precision-munition-stockpiles/ (accessed on April 28th, 2021).
[24] NAVAIR. *Precision Strike Weapons*. No date available. Retrieved from https://www.navair.navy.mil/precision-strike-weapons (accessed on April 28th, 2021).
[25] Expert Program Management. *Porter Diamond Model (1990)*. No date available. Retrieved from https://expertprogrammanagement.com/2018/04/porter-diamond-model/ (accessed on April 28th, 2021).
[26] Stout, Wesley. *Bullets by the Billion.*Chrysler Corporation, 1946. Specifically, see page 12.
[27] Synopsis of infrastructure challenges articulated at multiple sites from student field experiences, April 2021.
[28] Haraburda, S. *Conventional Munitions Industrial Base.* The Land Warfare Papers, No 113, August, 2017. Retrieved from https://www.ausa.org/sites/default/files/publications/LWP-113-Conventional-Munitions-Industrial-Base.pdf. Specifically see page 15. (Accessed on May 12th, 2021).
[29] Hanson, Kim, *New Strategy Paves ay for Industrial Base Modernization*, Army, 26 March 2021, https://www.army.mil/article/244677/new_strategy_paves_way_for_industrial_base_modernization
[30] Hanson, Kim, *New Strategy Paves ay for Industrial Base Modernization*, Army, 26 March 2021, https://www.army.mil/article/244677/new_strategy_paves_way_for_industrial_base_modernization
[31] BRAC-2005-DCN: 9490: Scranton Army Ammunition Plant. Retrieved from https://digital.library.unt.edu/ark:/67531/metadc21729/m2/1/high_res_d/BRAC-2005_09490.pdf (Accessed on May 13th, 2021).
[32] Costs/information provided during site visit to Scranton Army Ammunition Plant (SCAAP), April 2021.
[33] Current EPA listings of BRAC closures by state; note SCAAP is not listed for Pennsylvania; current as of May 2021. Retrieved from Base Realignment and Closure (BRAC) Sites by State | Cleanups at Federal Facilities | US EPA (Accessed on May 13th, 2021).
[34] Costs provided during Aberdeen Proving Ground site visit, April 12th, 2021.
[35] Cost provided during Letterkenny site visit, February 2021.
[36] DAPAM 700-16
[37] Defense Budgets for FY2020 and FY2021. Retrieved from https://www.defense.gov/Newsroom/Releases/Release/Article/2079489/dod-releases-fiscal-year-2021-budget-proposal/ and https://www.saffm.hq.af.mil/Portals/84/documents/FY20/PROCUREMENT/FY20_PB_3011_Ammo.pdf?ver=2019-03-18-152806-073
[38] Edwards, J. *Jerry McGinn: Federal Government Should Maintain "Steady as She Goes' Approach for Defense M&A Policy*. Govcon.com. March 31st, 2021. Retrieved from: https://www.govconwire.com/2021/03/jerry-mcginn-federal-government-should-maintain-steady-as-she-goes-approach-for-defense-mand (Accessed on May 13th, 2021).
[39] Cordell, C. *Raytheon Completes Merger with United Technologies.* April 3rd, 2020. Retrieved from https://www.bizjournals.com/washington/news/2020/04/03/raytheon-completes-merger-with-united-technologies.html (Accessed on May 13th, 2021).
[40] Comments are based on conversations with our AQ/CONS professionals, as well as observations of DoD programs.
[41] Comments are based on conversations with our AQ/CONS professionals, as well as observations of DoD programs.
[42] Royal Society of Chemistry. *Tungsten and Antimony Sulfide Uses*. May 2021. Retrieved from https://www.rsc.org/periodic-table/element/51/antimony; and https://www.rsc.org/periodic-table/element/74/tungsten. (Accessed on May 13th, 2021).
[43] Butterman, W.C., *Mineral Commodity Profiles: Antimony*, U.S. Department of the Interior, U.S. Geological Survey, Accessed 29 March 2021, 31, https://pubs.usgs.gov/of/2003/of03-019/of03-019.pdf

[44] Kennedy, James, *How China Could Shut Down America's Defenses*, Foreign Policy, 11 June 2019, https://foreignpolicy.com/2019/06/11/how-china-could-shut-down-americas-defenses-rare-earth/
[45] Kennedy, James, *How China Could Shut Down America's Defenses*, Foreign Policy, 11 June 2019, https://foreignpolicy.com/2019/06/11/how-china-could-shut-down-americas-defenses-rare-earth/
[46] Klochko, Kateryna, *Antimony 2020 Report*, U.S. Geological Survey, Mineral Commodity Summary, January 2021, https://pubs.usgs.gov/periodicals/mcs2021/mcs2021-antimony.pdf

[47] ”Tungsten producers may hae to look at new markets-report," mining.com, accessed 24 April 2021. https://www.mining.com/as-tungsten-demand-remains-low-producers-may-have-to-look-at-new-markets-report/
[48] Dupont, David, et al. ”Antimony Recovery from End-of-Life Products and Industrial Process Residues: A Critical Review,” The Minerals, Metals, & Materials Society, 08 February 2016. Page 84.
Barragan, Jose Angel, et al., ”Copper and Antimony Recovery fro Electronic Waste by Hydrometallurgical and Electrochemical Techniques,” ACS Omega Journal. Pages 12355-12356.

[49] ”Rare Earth Elements,” 2019 Portfolio. Document, National Energy Technology Laboratory. U.S. Department of Energy. Pages 4-6.
[50] Gaffney, Austin,”Can Harvesting Rare Earth Elements Solve the Coal Ash Crisis?” Sierra Club, 23 February, 2021. https://www.sierraclub.org/sierra/2021-2-march-april/feature/can-harvesting-rare-earth-elements-solve-coal-ash-crisis
[51] Based on student interview with companies within the mining community, April 11th, 2021.
[52] United States Government, U.S. Congress, *S. 3694 ORE ACT*, Accessed 29 March 2021, https://www.congress.gov/bill/116th-congress/senate-bill/3694/text?q=%7B%22search%22%3A%5B%22Onshoring+Rare+Earths+Act+of+2020%22%5D%7D&r=1&s=3
[53] Department of Defense, *Fiscal Year 2020 Industrial Capabilities: Report to Congress* (Washington, DC: Department of Defense, 2021), 86. https://www.businessdefense.gov/Portals/51/USA002573-20%20ICR_2020_Web.pdf?ver=o3D76uGwxcg0n0Yxvd5k-Q%3d%3d.
[54] “Industrial Capabilities Report to Congress: 2020 Annual Report,” *Office of the Secretary of Defense, Acquisition & Sustainment, Industrial Policy* (January 2021). Accessed April 17, 2021). https://media.defense.gov/2021/Jan/14/2002565311/-1/-1/0/FY20-INDUSTRIAL-CAPABILITIES-REPORT.PDF.
[55] Synopsis of human capital challenges articulated at multiple sites from student field experiences, April 2021.
[56] Census information for Radford, Virginia. Retrieved from https://www.census.gov/quickfacts/radfordcityvirginiacounty (Accessed on May 13th, 2021).
[57] Several munitions plants, both government and contractor-operated, identified finding ***viable*** applicants as a major problem. Issues ranging from mechanical aptitude, criminal background checks, ability pass a drug test (ATF requirement), and failed physicals disqualify most applicants during the hiring process.
[58] Marth Kanter, Rosye Blancas Cloud, and Danielle Lazarowitz. “College Promise for All Policy Framework,” *College Promise.org* (April 16, 2021). Accessed April 20, 2021. https://www.collegepromise.org/cpfa.
[59] Marth Kanter, Rosye Blancas Cloud, and Danielle Lazarowitz. “College Promise for All Policy Framework,” *College Promise.org* (April 16, 2021): 5. Accessed April 20, 2021. https://www.collegepromise.org/cpfa.
[60] According to the college promise proposal, a 2-year school costs $3770. So, even if the DoD sponsors 250 people per year, it is still only about $1M for the first year and $2M per year after that. The cost estimate excludes relocation to a government-owned factory at the completion of the program.
[61] General Dynamics Ordnance and Tactical Systems (GD-OTS) of Red Lion, Pennsylvania is currently developing a program that follows this model.
[62] American Foreign Policy Council, “Strategic Primer: Hypersonic Weapons,” vol. 6, 2019
[63] Speier, Richard H., George Nacouzi, Carrie Lee, and Richard M. Moore, “Hypersonic Missile Nonproliferation: Hindering the Spread of a New Type of Weapon,” *Rand Corporation*, 2017, 8. https://www.rand.org/pubs/research_reports/RR2137.html (accessed April 18, 2021).
[64] Richard M. Harrison, “Welcome to the Hypersonic Arms Race,” *The National Interest*, January 19, 2019, https://nationalinterest.org/blog/buzz/welcome-hypersonic-arms-race-42002.
[65] Nathan Terry and Paige Cone, “Hypersonic Technology: An Evolution in Nuclear Weapons?” *Strategic Studies Quarterly*, 2020, pp. 74-99.
[66] Kelly Sayler, *Hypersonic Weapons: Background and Issues for Congress*, CRS Report No. R45811 (Washington, DC: Congrssional Research Service, 2020), https://fas.org/sgp/crs/weapons/R45811.pdf.
[67] James Wejsa, "ARDEC Energetics at Joint Armaments Conference."
Joint Defense Manufacturing Council, “Department of Defense Additive Manufacturing Strategy,” January 2021.
[68] https://www.cto.mil/modernization-priorities/
[69] https://www.cto.mil/modernization-priorities/

[70] "The Market for Air-to-Air Missiles 2021-2030," accessed April 26, 2021, https://www.forecastinternational.com/fistore/pdf_sample.cfm?FISSYS_RECNO=88&title=The-Market-for-Air-To-Air-Missiles.
[71] Information from student who is NATO SME
[72] Tirpak, John. *Munitions Production Surge Planned for at Least Five Years.* Air Force Magazine, February 22nd, 2018. Retrieved from https://www.airforcemag.com/Munitions-Production-Surge-Planned-for-At-Least-Five-Years/ (accessed on May 17th, 2021).
[73] Sameer Joshi, "How China Is Fast Catching up with the West in the Race for Air-to-Air Missile Superiority," accessed April 27, 2021, https://theprint.in/defence/how-china-is-fast-catching-up-with-the-west-in-the-race-for-air-to-air-missile-superiority/597206/.
[74] Douglas Barrie, "Will America's Next Long-Range Air-to-Air Missile Match Up to China's?," Defense One, accessed April 13, 2021, https://www.defenseone.com/ideas/2019/10/will-americas-next-long-range-air-air-missile-match-chinas/160771/.

BAE FIRM BRIEF
APRIL 2020

AGENDA

- Firm Profile
- Research and Development
- Firm Strategy
- Market Reviews
- Financials
- Challenges
- U.S. Government Strategy
- Human Capital

FIRM PROFILE

Main: US and UK

NATO (aligned) Allies (Swe/Ger/Neth)

Saudi Arabia, Australia

Japan, Korea, Brazil

85,000 Employees, over 30 Countries

History

BRITISH AEROSPACE

HAWKER SIDDELEY

Marconi

VSEL

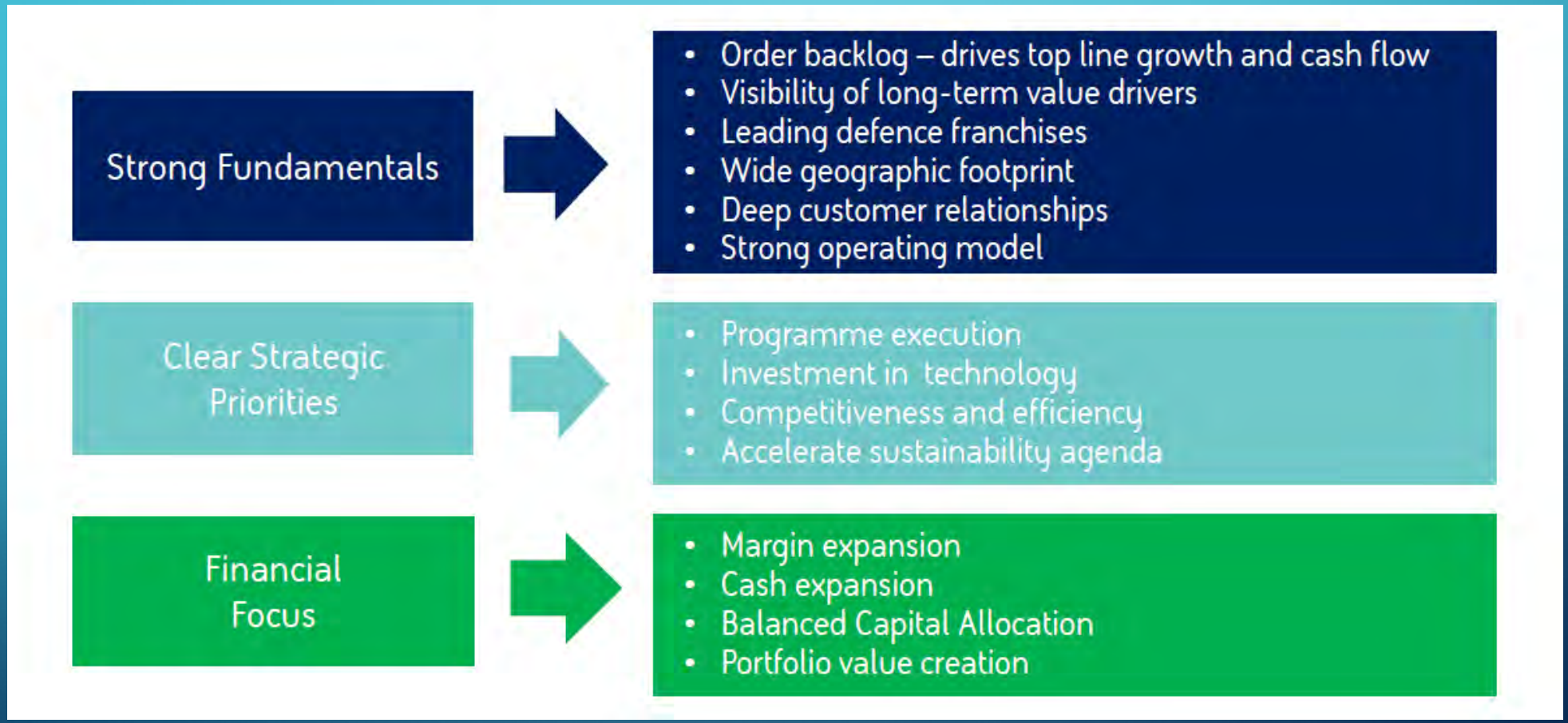
United Defense

CHANGING THE FUTURE OF DEFENSE™

MBDA

MISSILE SYSTEMS

FIRM STRATEGY



FIRM STRATEGY

Value creating operating model

Our operating model and domain incumbency is a strength and creates barriers to entry

Efficient R&D model – customer, self and collaboration funded

CAPEX self and customer funded – franchise specific

Advance Payments

Strong operating model – Negative working capital

Heightened Capex and process investment in recent years

+

Programmes ramping

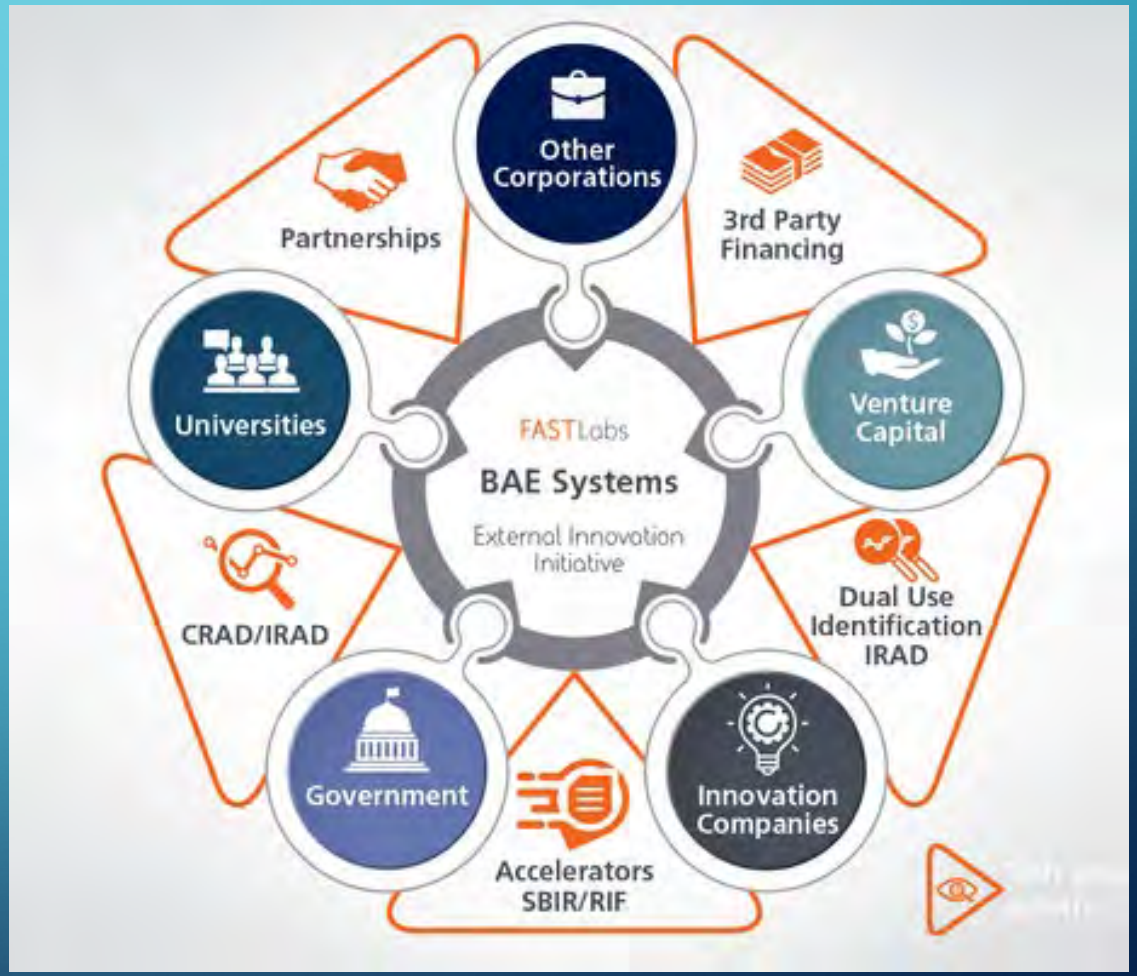
→

Operational leverage and margin expansion

Drive higher ROCE

RESEARCH AND DEVELOPMENT

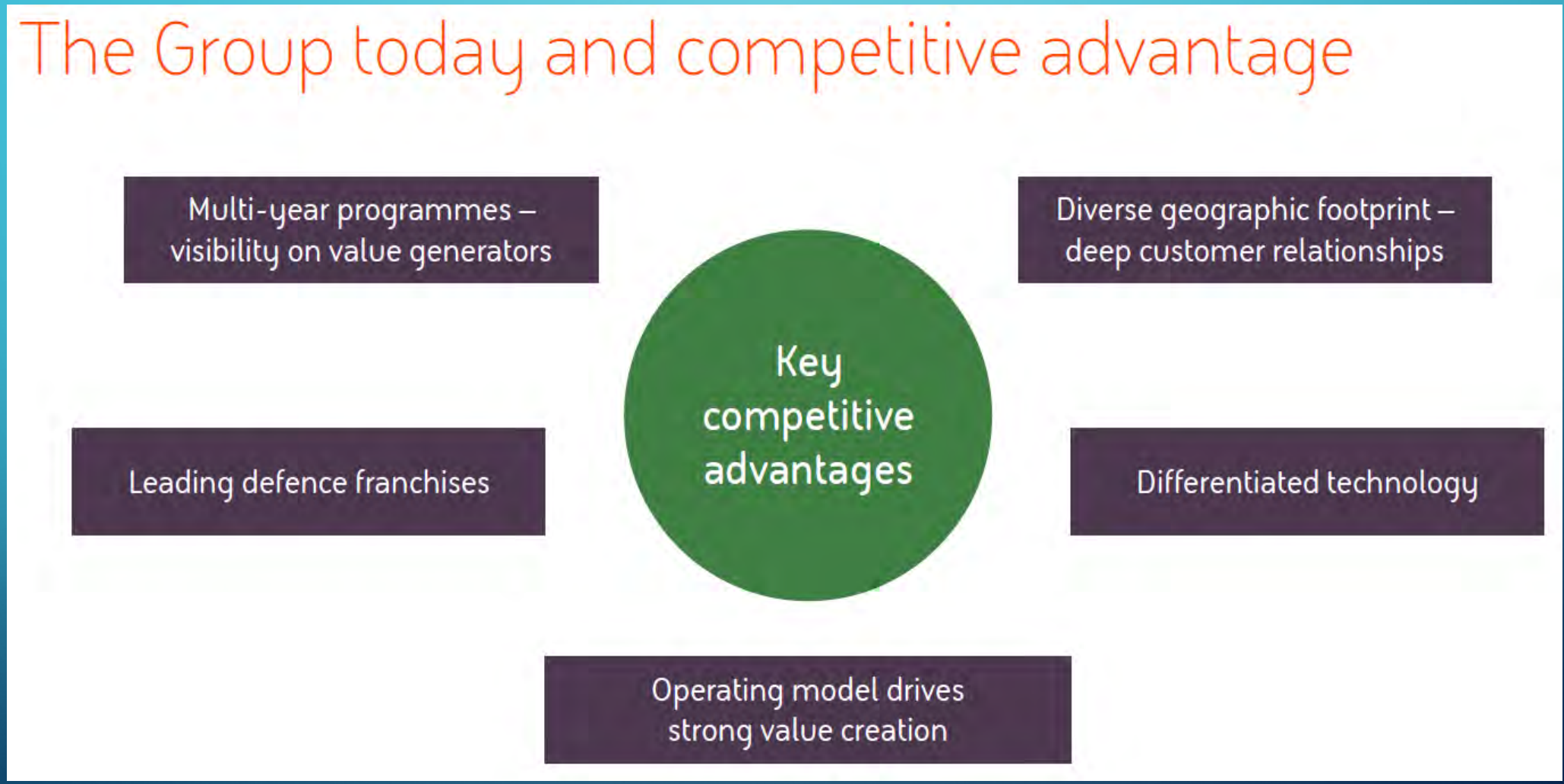
- Overall Budget £1.5bn
  - 2020 funding from DARPA
  - Own Budget £237m
- Change = Market Access into specific areas of market
- Focus on:
  - R&D with potential for business returns
  - Increased efficiency to reduce costs and remain competitive
  - Diversity of defense portfolio, and capability offerings to customers



OFFERINGS

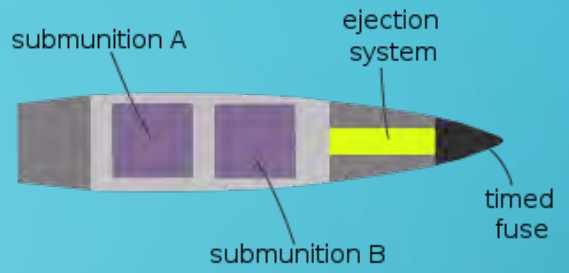
- Access
- Compatibility
- Support

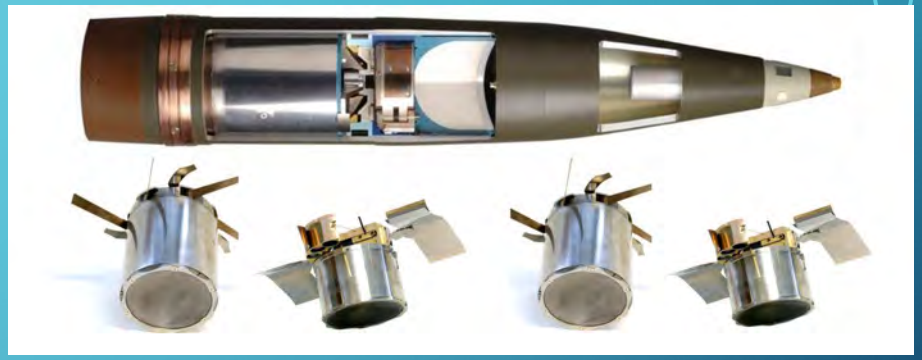
The Group today and competitive advantage

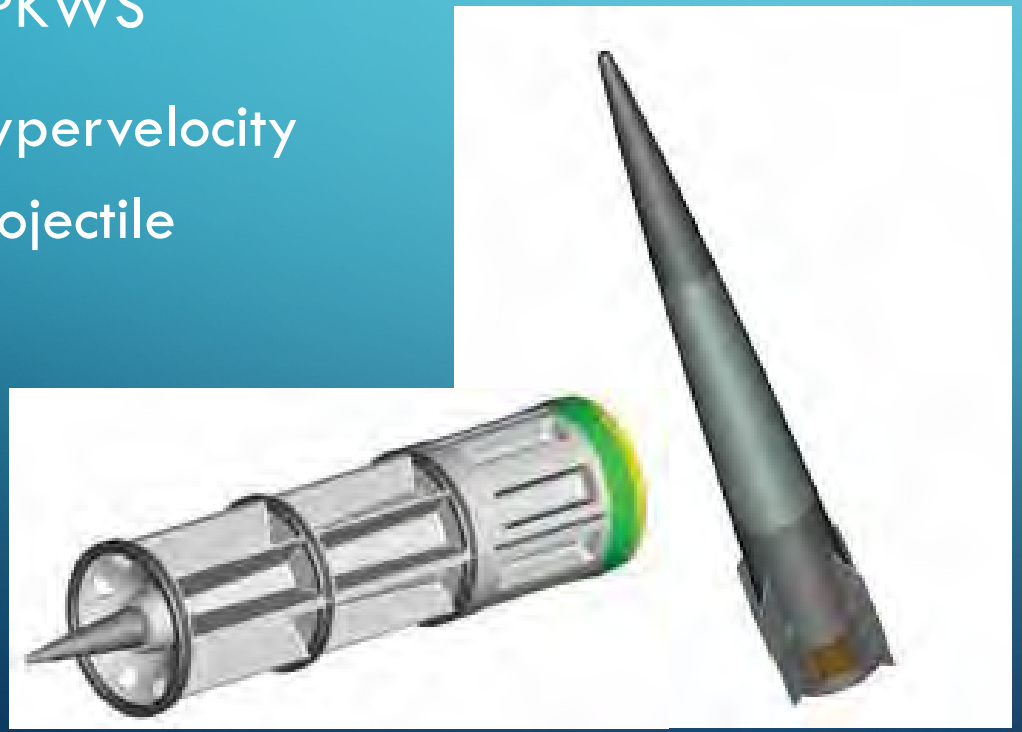


EXAMPLES OF INNOVATION

- BONUS Munition
- APKWS
- Hypervelocity Projectile







HOW VALUE IS CREATED

- Not NEW system—adds on to existing weapons systems with little/no modifications
  - Cheap, unique capabilities
  - Extends the service life of existing platforms
- Accessibility to allies with limited budgets
- GPC Implications
  - Increase Coalition capabilities, lethality
  - Stronger coalition, means a stronger USA/UK
  - Distributed manufacturing/surge capabilities

BAE Systems to Supply 9999 Additional APKWS II to Nigeria and Netherlands

Our Bureau 11:34 AM, February 7, 2019 3151

LAND WARFARE, NETWORKS / CYBER

New Army Cannon Doubles Range; Ramjet Ammo May Be Next

BAE will deliver the first 18 ERCA vehicles by 2023 – but the Army is already working on further upgrades.

Jordan To Buy BAE's APKWS Laser-Guided Rockets

Our Bureau 02:43 PM, May 8, 2014 5420

MSPO 2020: BAE Systems to Support Polish Krab Howitzers Export

10 września 2020, 10:57

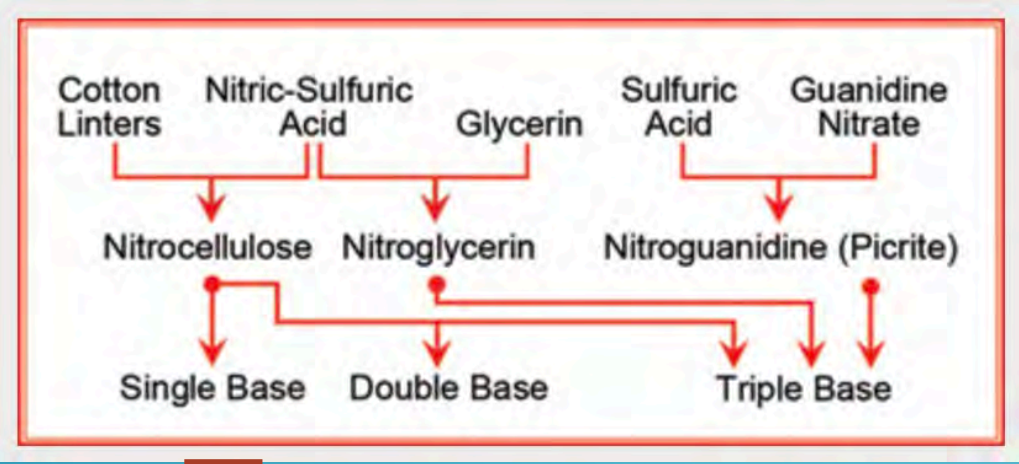
BAE ORGANIZATION

- Future Tech
- Electronics
- Cyber
- Land
    - Munitions/Energetics
- Sea
- Services

Reporting Segments

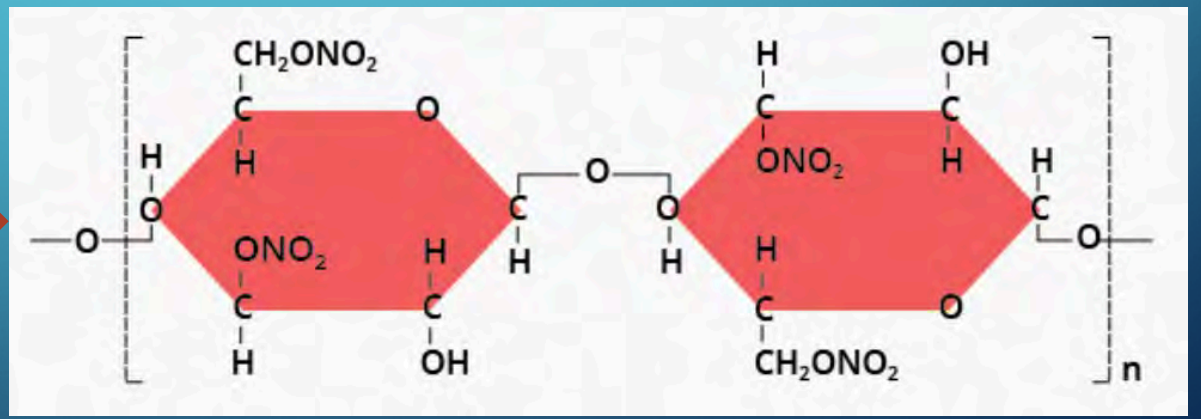
- Electronic Systems
- Cyber and Intelligence
- Platforms and Services
- Air
- Maritime
- Headquarters

PROPELLANTS



Nitrocellulose w/Nitrogen Content:

- 10.7-12.2% - Ink & Lacquers
- 12.6-13.4% - Propellants & Dynamite



MARKET ANALYSIS - PROPELLANTS

OLIGOPOLY

FIREWORKS by Grucci

COMPETITIVE SPECTRUM

MORE COMPETITION ← LESS COMPETITION

Perfect Competition | Monopolistic Competition | Monopoly

LESS CONCENTRATION → MORE CONCENTRATION

MARKET CHARACTERISTICS

- Unique/single category good
- Limited dual-use market
- Universe of Sellers
- Universe of Buyers
- Rules

EPA

BUREAU OF ALCOHOL, TOBACCO, FIREARMS AND EXPLOSIVES 1972

PORTER'S FIVE FORCES - PROPELLANTS

Low

Regulation

Threats of New Entrants

Low

Bargaining Power of Suppliers

Medium

Rivalry

Medium

Bargaining Power of Buyers

Low

BAE Systems Inc Contract Extension

Threat of Substitute Products

Medium

UNITED STEELWORKERS USW

MUDENICHEMIE INTERNATIONAL BV

RHEINMETALL NITROCHEMIE

MANUCO

MS

IPI ISLAND PYROCHEMICAL INDUSTRIES

SAE

DOW

GJ CHEMICAL

Alchemix A nitro Company

STRATEGY - PROPELLANTS

Bargaining Power of Suppliers – Medium

- Constant Communication with United Steelworks Local 8-495
- "Lead a Responsible Life" and Leadership Development Programs
- Partner with DASD-Industry Policy on Supply Chain Management

Threat of Substitute Products – Medium

- Complete new Nitrocellulose plant
- Participate in Research and Development (Internal Funds)

Rivalry – Medium

- Creditable Partner with USG

Bargaining Power of Buyers – Low

- Purchase from International Market

STRATEGIC GAME BOARD - PROPELLANTS

Where to compete	Same Game	New Game
Across-the-board	Emulate market leader's functional approach, strengths	Rewrite industry rules to exploit a unique, industry-wide advantage
Selective	Re-segment the market to create a niche	Create and pursue a unique advantage

How to compete

Innovation

Modernization

PRECISION GUIDED MUNITIONS-KITS

MARKET ANALYSIS – PRECISION GUIDED MUNITIONS-KITS

MAKING DUMB BOMBS SMART AGAIN

MARKET CHARACTERISTICS

- Unique/single category good
- Limited single-use market
- Market of Buyers US, Canda, Mexico, U.K., see next page for full list
- Market of Sellars
- Rules

MARKET STRUCTURES

MORE COMPETITION ← LESS COMPETITION

Perfect Competition | Monopolistic Competition | Monopoly

LESS CONCENTRATION → MORE CONCENTRATION

PORTER'S FIVE FORCES - PRECISION GUIDED MUNITIONS-KITS

Rivals

- Boeing

U.S.
Canada
Mexico
U.K.
Germany
France
Italy

Russia
China
India
South Korea
Brazil
Argentina
Saudi Arabia
Iran

STRATEGY – PGM-KITS

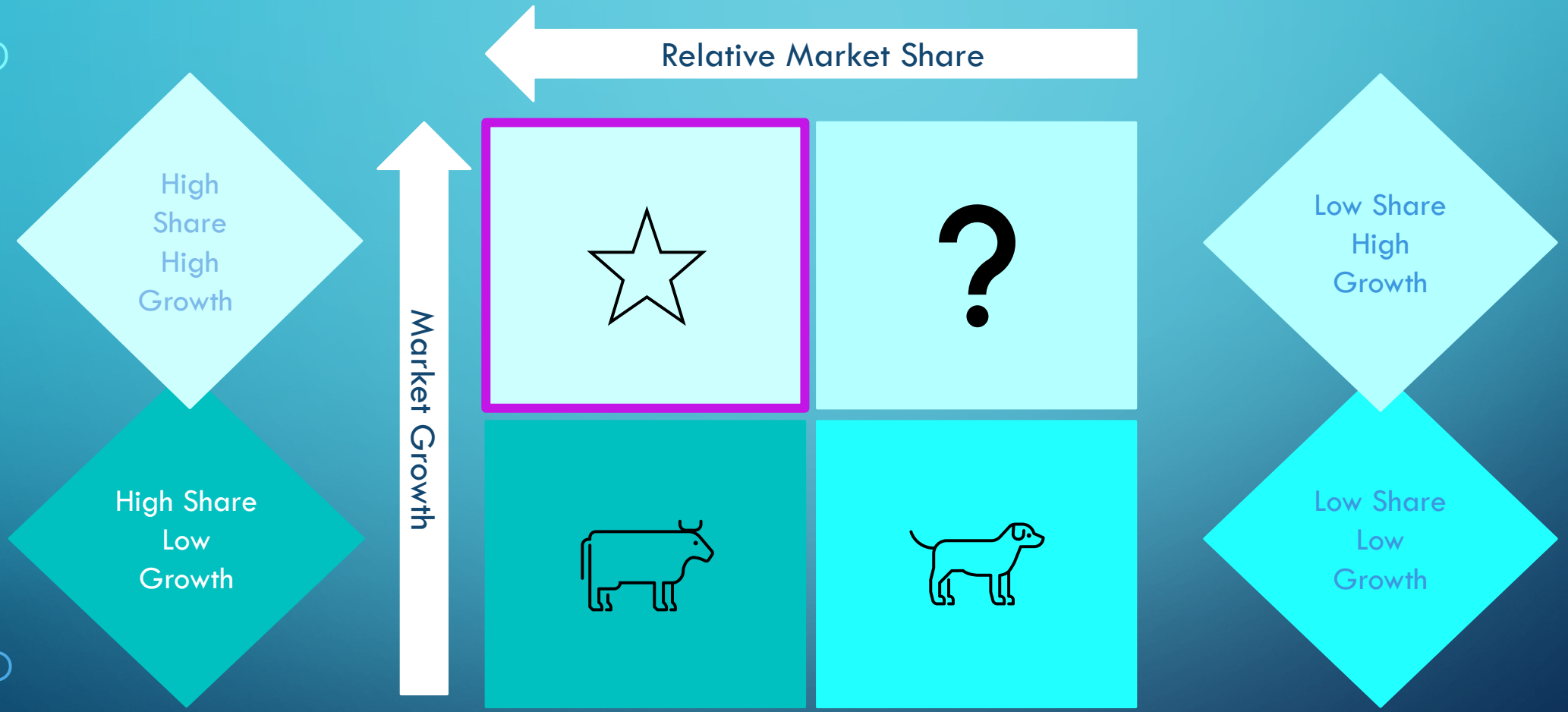
Threat of Entrants to Market – High

- Growing Market projected to be 47.5B in 2025
- Increase due to precise target capability (reduces loss of life and infrastructure)
- Understand growing markets and competition from India, China and Australia
- Geopolitical conflicts between nations increasing

Threat of Substitute Products – High

- Invest in research and development
- Eliminate supply chain vulnerabilities
- Expand production capabilities
- Size and weight variety
- Invest in emerging technologies

BOSTON MODEL - PRECISION GUIDED MUNITIONS-KITS

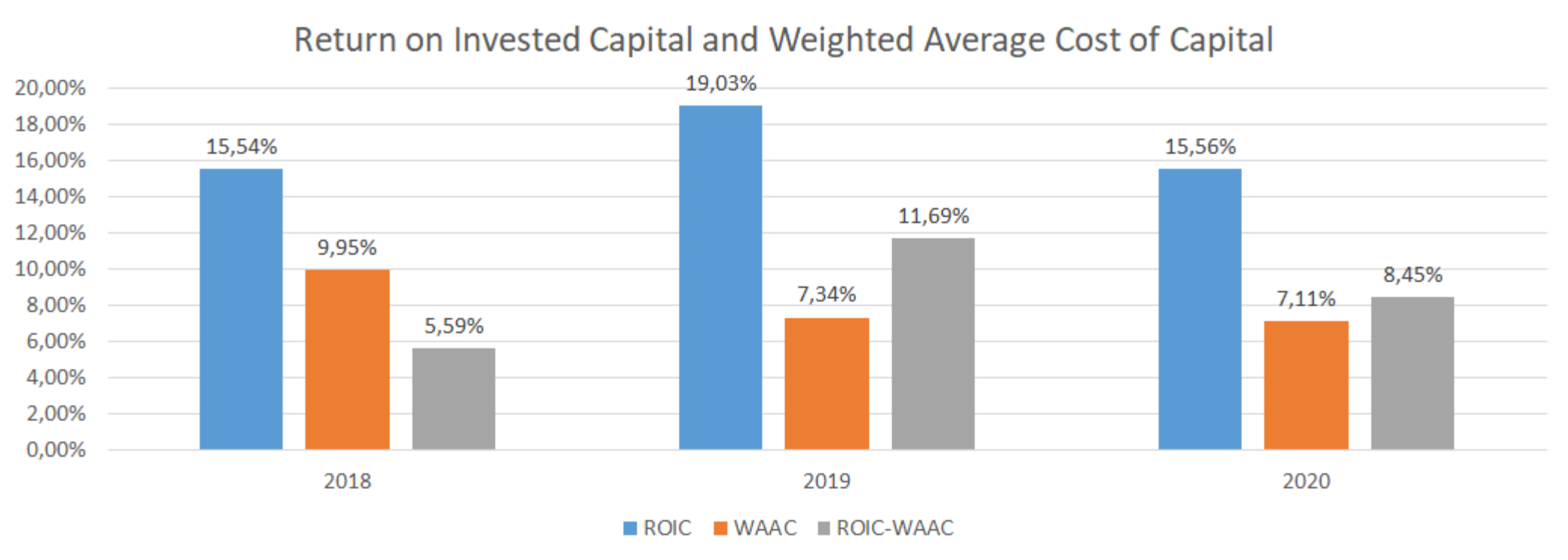


FINANCIALS – RISKS

- Liquidity risk (Current Ratio = 1.01) ---- Not too good >1.2
  - Assets: £M 9,406
  - Liabilities: £M 9,383

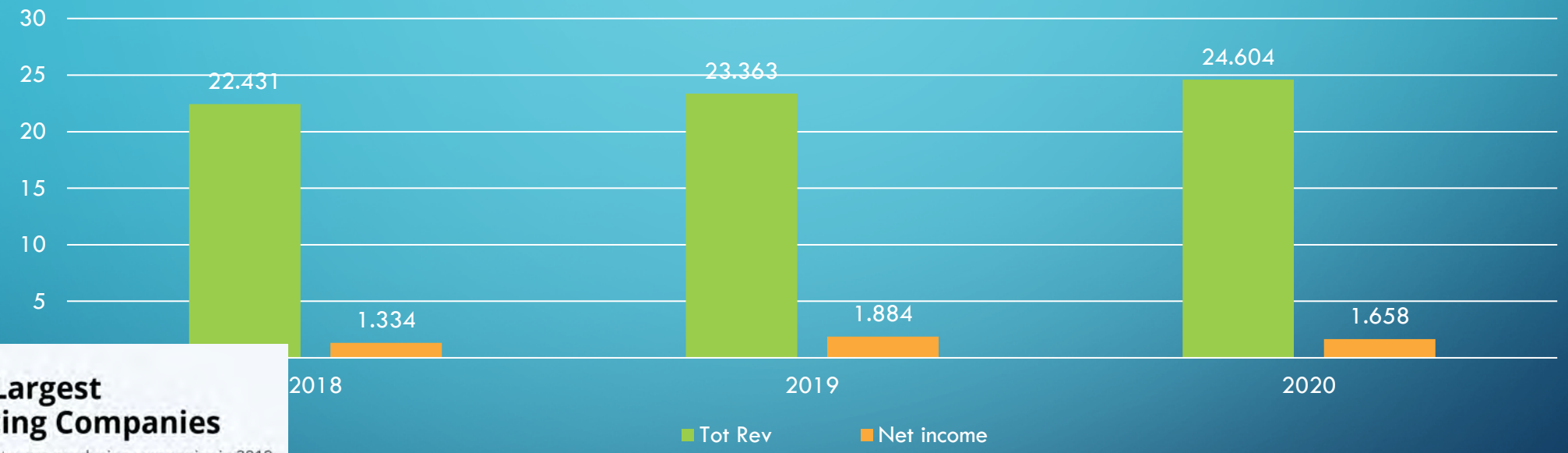
- Solvency risk (Long-Term-Debt-to-Equity Ratio = 0.80) ---- Good <2
  - Non-current liabilities : £M 13,226
  - Equity shareholders £M 1,299
  - Non-current assets £M 18,124

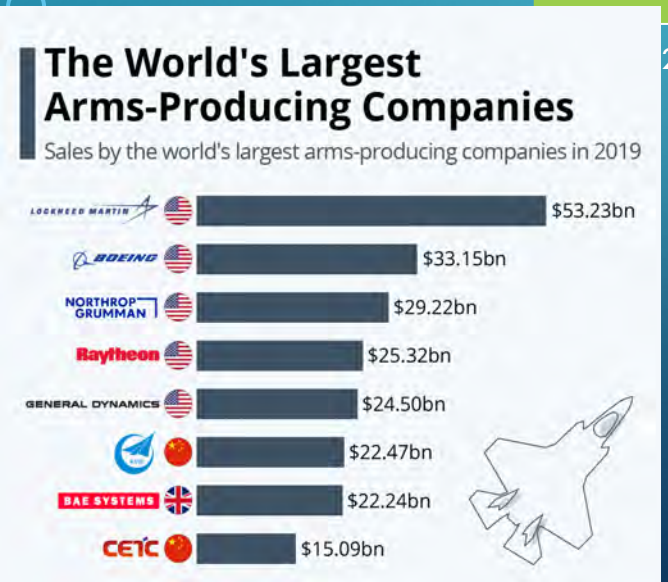
FINANCIALS - VALUES



FINANCIALS -2

100	Estonia	30,468
101	Cambodia	26,316
102	*Macau (China)*[n 7]	26,348
103	El Salvador	24,784
104	Senegal	24,409
105	Honduras	23,984

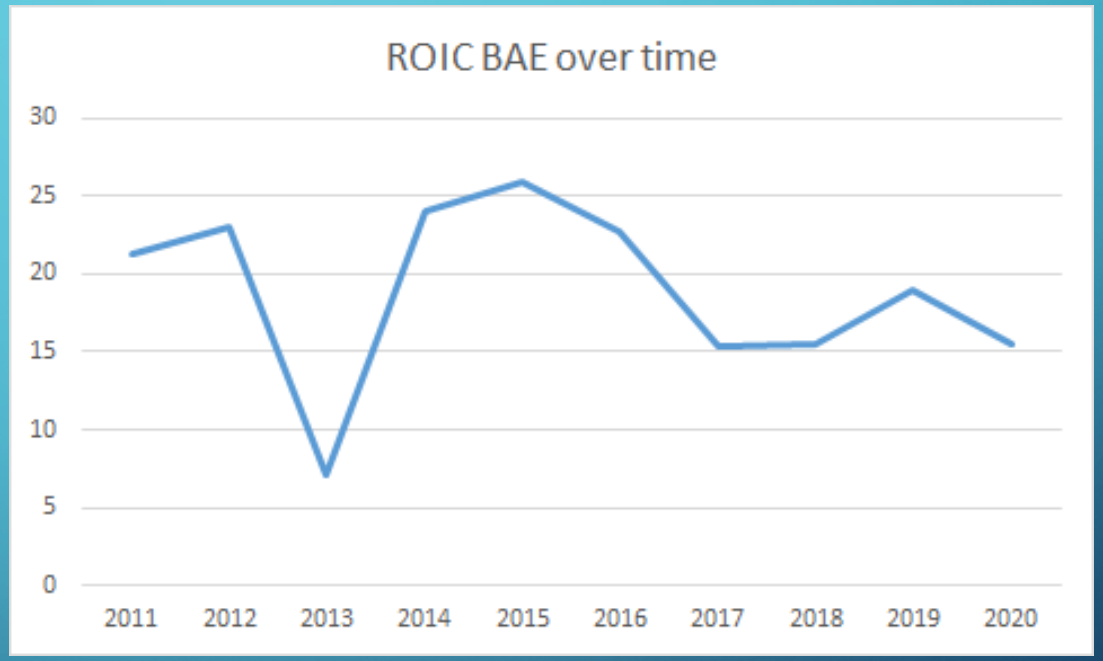




HOW GOOD IS BAE?

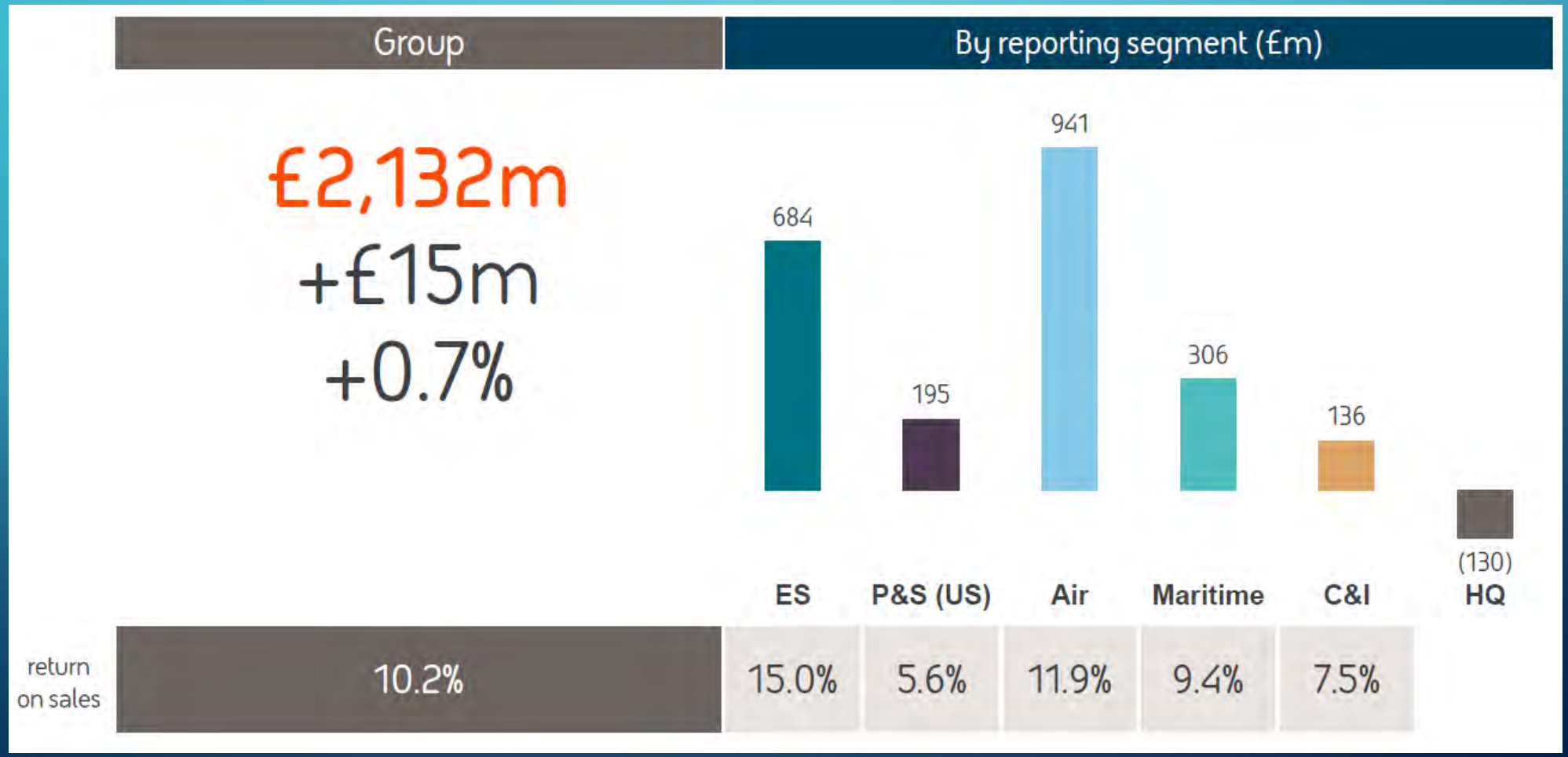
Figure 18. Top 20 aerospace and defense companies by 2016 return on invested capital

Rank	Company	%
1.	QinetiQ	50.2%
2.	MTU Aero Engines	38.9%
3.	Fuji Aerospace	36.9%
4.	BWX Technologies, Inc.	33.4%
5.	Safran	30.5%
6.	Huntington Ingalls Industries	28.5%
7.	Lockheed Martin	26.7%
8.	Thales	26.6%
9.	BAE Systems	25.8%
10.	Northrop Grumman	23.6%
11.	Airbus Group	22.1%
12.	Spirit AeroSystems	20.8%
13.	Rockwell Collins	20.1%
14.	B/E Aerospace	18.7%
15.	Honeywell Aerospace	18.5%
16.	General Dynamics	18.1%
17.	Raytheon	17.5%
18.	Parker Hannifin Aerospace	17.3%
19.	Amphenol	16.8%
20.	Singapore Technologies (ST) Engineering Ltd.	16.7%



2020 EBITA – BUSINESS UNITS

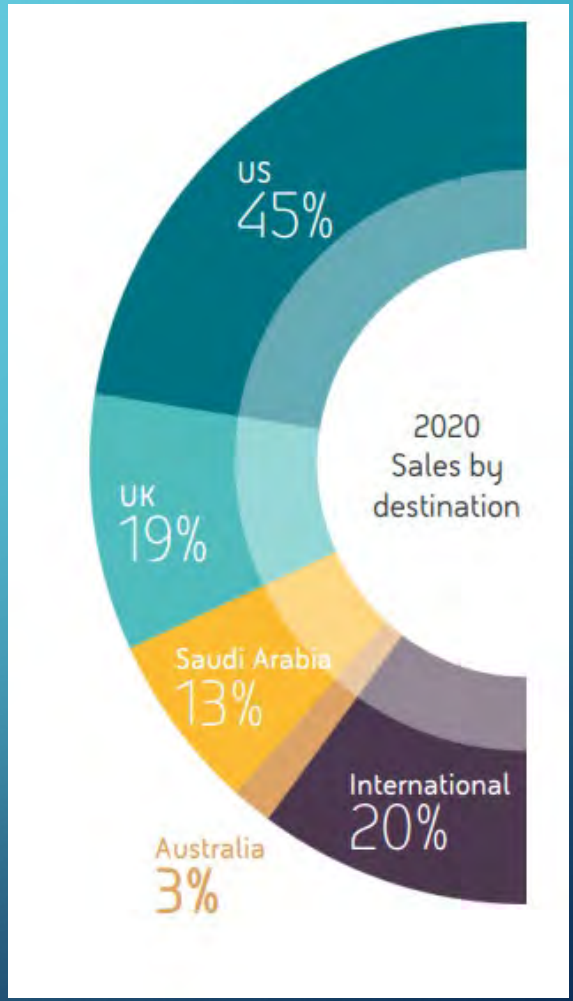
(EARNINGS BEFORE DEDUCTION OF INTEREST, TAX AND AMORTISATION)



COMPARISON WITH OTHERS (-20%, + 30%)

FIRM STRATEGY

- Very broad portfolio, no real choices
  - Misses Space
- Small geographic area (South America, Africa)
- Ethics (Tax paying Australia)



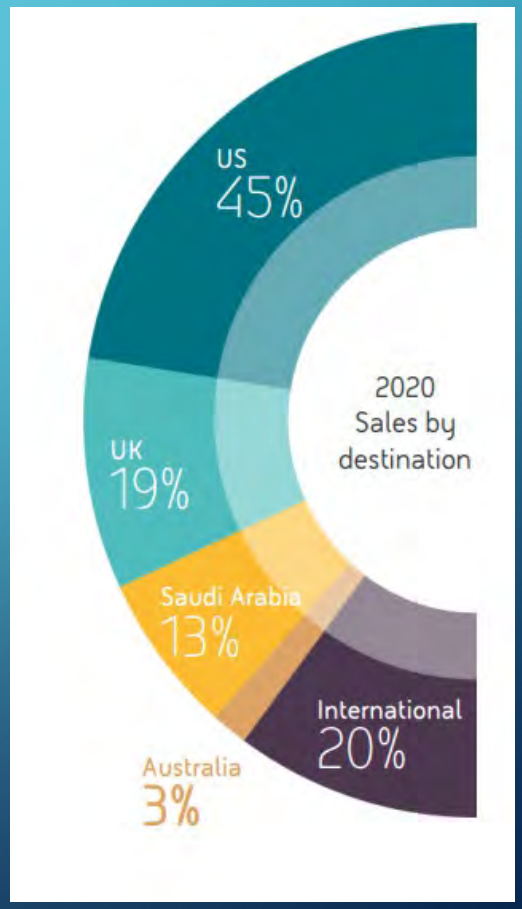
CHALLENGE 1: DEPENDENCY ON SAUDI-ARABIA

WSJ NEWS EXCLUSIVE | NATIONAL SECURITY

Biden Re-Examining U.S. Arms Sales to Saudi Arabia, U.A.E.

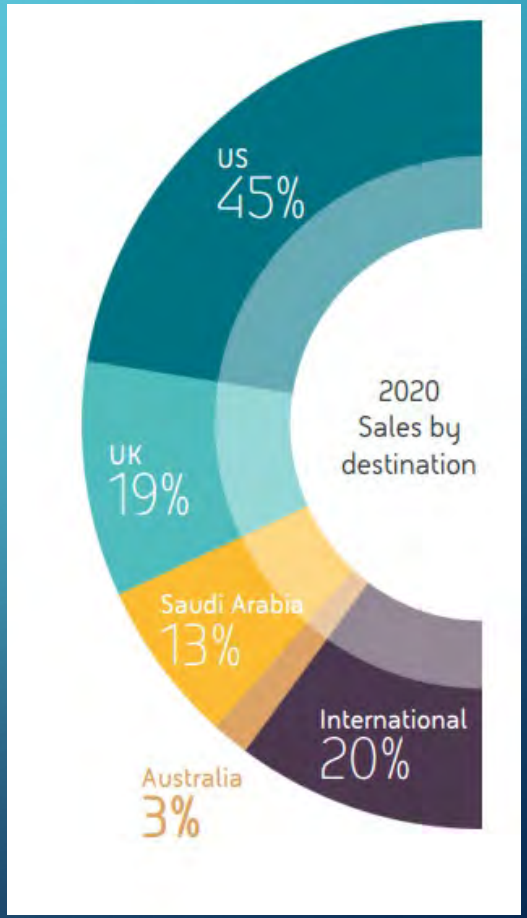
New administration is reviewing weapons transactions earlier approved by Trump

The administration of President Biden, pictured Wednesday, wants to ensure that U.S. weapons aren't used in the Saudi-led military campaign in Yemen.



CHALLENGE 2: BREXIT

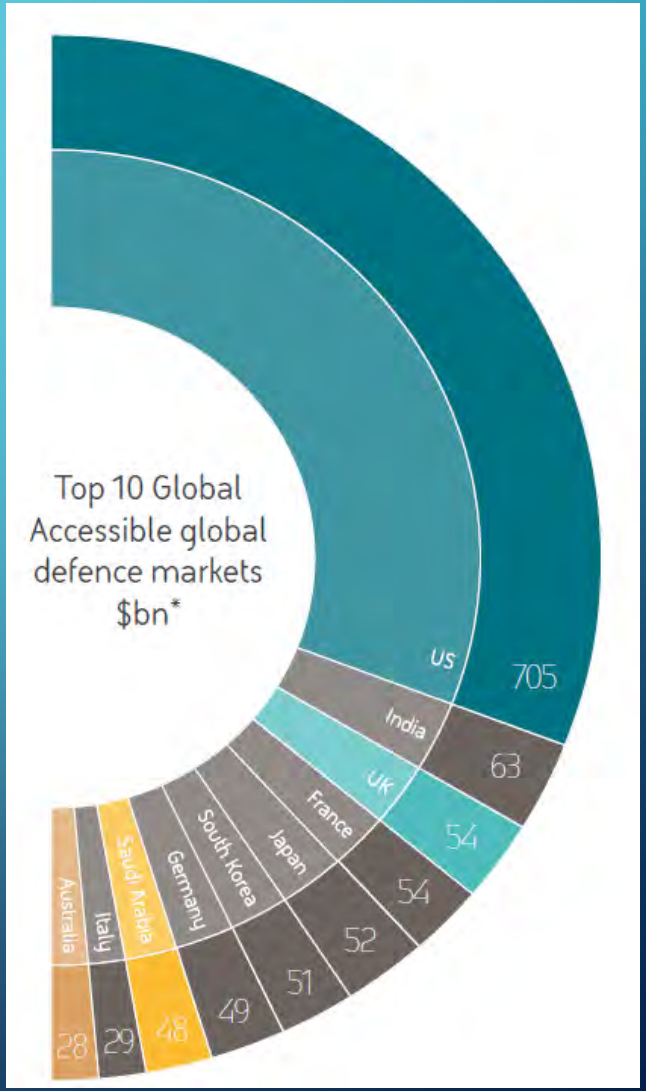
- Not the biggest market for BAE
  - Little direct trade with countries in the EU
- Use US – EU relation, not UK-EU relation
- More room-to-maneuver for UK-companies
  - Lobby: The business is Britain's biggest manufacturing employer
  - Taxation deals
- Long term effects in consortiums



CHALLENGE 3 – EXCHANGE RATES (POUND-DOLLAR: 15 %)

U.S. GOVERNMENT STRATEGY

- Use Brexit and US-UK trade negotiations
- Use buying power as 'super customer'
- Use and exploit the more stringent “Buy American Act”
- BAE can be used in relation with the UK (GPC)
- Use BAE to target QUAD-countries for GPC



HUMAN CAPITAL

Issue: Talent Pool in the Defense Industry

Strategy:

- Education Partnerships – NTIB Nations
- Trade Schools
- Internships
- Messaging / Job Fairs – US & UK

Source of Top 10 Lists	Number of NTIB Schools in Top 10
QS World University Rankings	6
US News & Global Report	3
Times Higher Education	8
Academic Influence	10

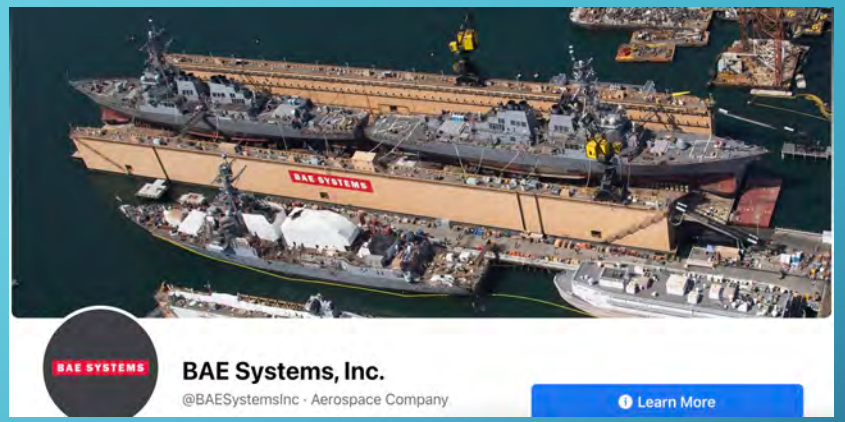
FOCUS

KICKSTART SCHEME

MADE SMARTER

QUESTIONS/COMMENTS

Bonus: BAE's footprint in social media...



General Dynamics Firm Brief

Industry Analysis– Academic Year 20/21

Sarah Abel, Jung Ormerod, Leon "Slim" Rogers, Matt Western

Industry Analysis (ES6206)
Professor Peter Duffy

Eisenhower School

April 2, 2021

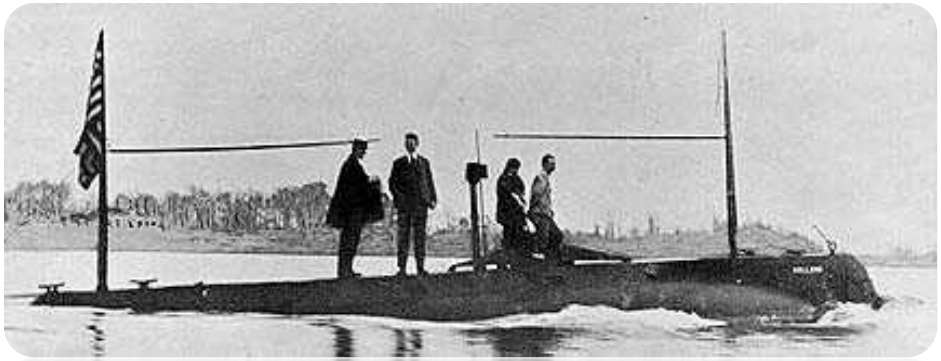
NATIONAL DEFENSE UNIVERSITY
Washington, D.C.

Agenda

- **Introduction**
  - History
  - Firm Profile (Sector, Location, Size)
  - SWOT Analysis
  - Financial Analysis
- **Market Analysis**
  - Small Caliber
  - Artillery
- **Risks / Challenges**
  - Approach to Industry Change
  - Supply Chain Vulnerabilities
  - Human Capital
  - Peer Competitors
- **Conclusion**
  - Innovation
  - Values
  - Great Power Competition
  - Recommendation for Policy Improvements

History

- Originally founded in 1899 by Isaac Rice and known as the ***Electric Boat Company***
  - Known for making *USS Holland* (SS-1) the first modern, commissioned submarine for the US Navy
  - **WWI:** All things submarines (85)/ tactical surface craft (722) for USN
  - **WWII:** Built another 74 submarines 400 PT boats; ranked 77th among US corporations in terms of value of military production contracts
  - **1952:** Re-organized under the name of ***General Dynamics Corporation***, and was led by John Jay Hopkins
  - **1950s to Present**: product portfolio includes tanks, munitions (rockets/missiles), submarines, warships, fighters and electronic systems to all DoD services



https://en.wikipedia.org/wiki/USS_Holland_(SS-1)

Four Main Sectors

Aerospace:

Gulfstream & Jet Aviation

Combat Systems:

GD Dynamics European Land Systems, GD Land Systems, **General Dynamics Ordnance and Tactical Systems**

Marine Systems:

Bath Iron Works, Electric Boat, NASSCO

Technologies:

GD Information Technology, GD Mission Systems

https://www.gd.com/

At a Glance

- **By the Numbers (Corporation Level):**
  - 100K employees globally

Financial details

Financial performance (USD million)

	2015	2016	2017	2018	2019
Revenue	31,781	30,561	30,973	36,193	39,350
Gross profit	4,178	3,656	4,077	4,085	4,202
Net profit	2,965	2,572	2,912	3,358	3,484
Order book backlog (funded)	66,100	51,783	52,031	55,826	57,530

Revenue by business area (USD million)

	2015	2016	2017	2018	2019
Aerospace	8,851	7,815	8,129	8,455	9,801
Combat Systems	5,640	5,530	5,949	6,241	7,007
Information Systems and Technology	8,965	9,144	8,891	8,269	8,422
Marine Systems	8,013	8,072	8,004	8,502	9,183

Overall

Today: 5th largest U.S. defense contractor & 6th largest worldwide

#92 among Fortune 500 companies

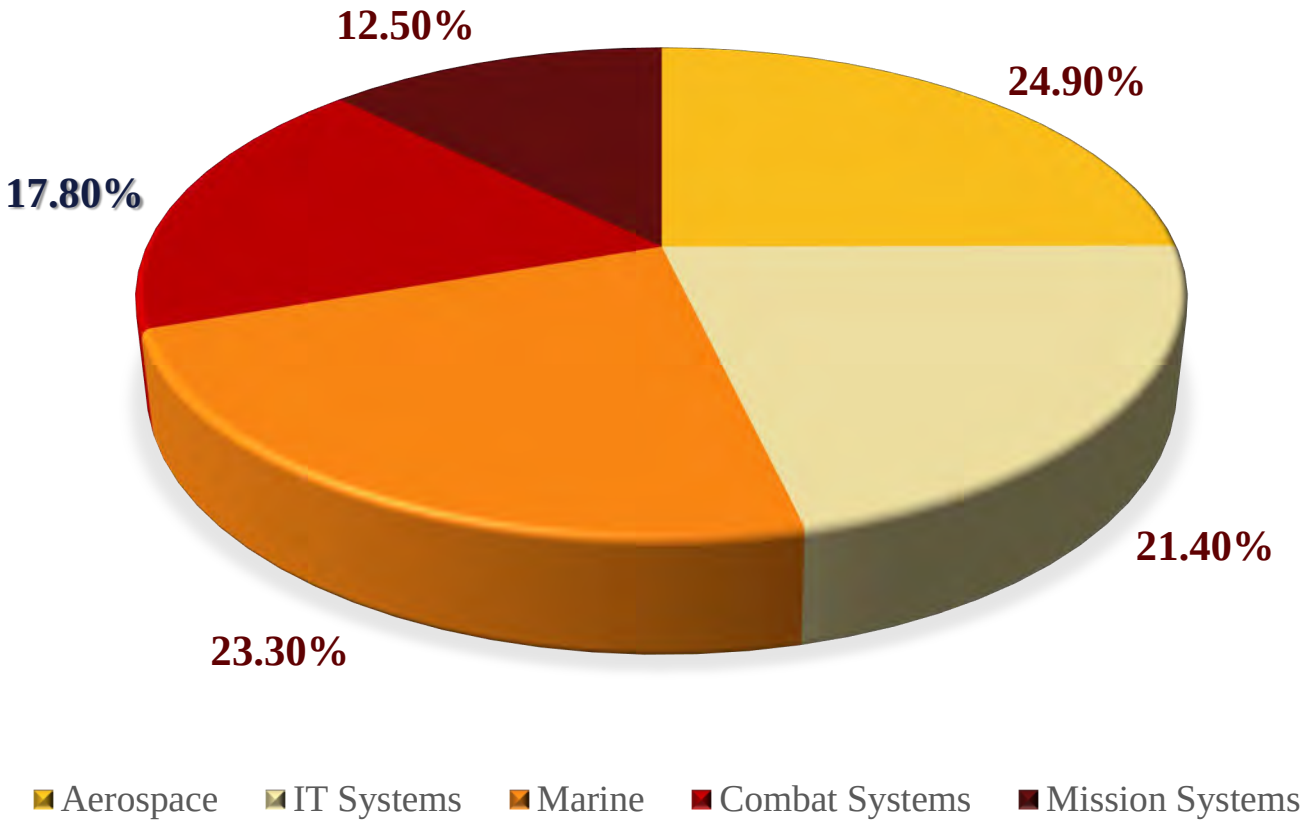
2018: 16.85% increase
2019: 8.72% increase

2020: 6.32% ***decrease****

Trends in revenue loss in 2015/16 were similar to other defense contractors as a result of decreased defense

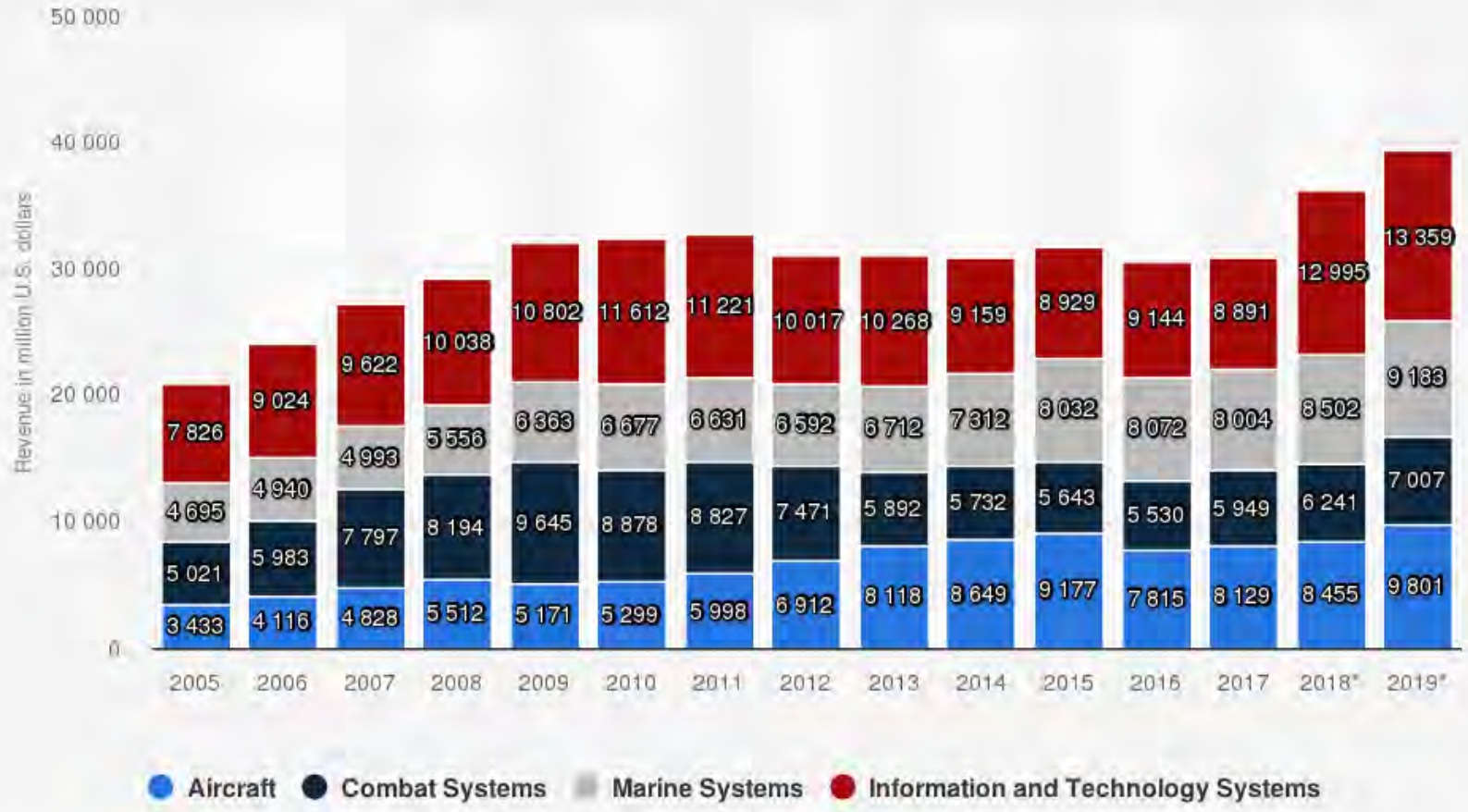
https://customer-janes-com.nduezproxy.idm.oclc.org/Janes/Display/JWDI0395-JWDI

Revenue % by Sector



Revenue from 2005 to 2019

Revenue of the defense technology supplier General Dynamics from 2005 to 2019, by product group (in million U.S. dollars)



Source
General Dynamics
© Statista 2020

Additional Information:
Worldwide; 2005 to 2019

Revenue by Geography (USD million)

	2015	2016	2017	2018	2019
United States	23,257	23,431	23,519	28,578	31,982
Other North America	1,080	691	915	755	852
Europe	2,485	2,355	2,558	2,772	2,808
Asia/Pacific	1,678	1,914	2,011	2,252	1,670
Africa/Middle East	2,508	2,668	1,655	1,565	1,739
South America	461	294	315	271	299

2017 – 2020 Five Major Acquisitions

- **Oct 2020:** Medico Industries Manufacturing Division (metal parts – large calibre projectiles)
- **Nov 2018:** FWW Fahrzeugwerk GmbH – Maintenance/Service for German Army and to be merged into GD European Land Systems
  - Undisclosed acquisition figure
- **April 2018**: Hawker Pacific – Australian aerospace company acquired by Jet Aviation for $250M
  - **Company was previously and largely owned by a Chinese company**
  - Maintenance/service of aircraft out of Australia, several locations across Asia and Dubai
- **Feb 2018: CSRA – Government IT Services**
  - **$9.6 billion cash/debt deal**
  - **Expected to become 2nd largest federal government IT contracting company**
- **May 2017:** Electronics and Communications Division of Advatech Pacific
  - Secure comm equipment for military/national security

Ordnance Tactical Systems (OTS) Portfolio

- Accounts for around 13.3% of the market share for munitions
- 2nd only to Northrop-Grumman who holds 14% of the market share

Source: GD Industry Perspective, 11 February 2021

Ordnance Tactical Systems (OTS) Locations

Source: GD Industry Perspective, 11 February 2021

SWOT Analysis

S

- Support from parent company
- Strong/reliable customer base with DoD buyers
- Diverse product portfolio

W

- Limited customer base outside of LE/military
- Limited opportunities to capitalize on emerging opportunities internationally

O

- Strategic Initiatives
- Positive forecasts for global ammunition markets
  - Increasing global demand
  - 45% missiles/rockets
  - 22.3% artillery
  - 14.8 small caliber

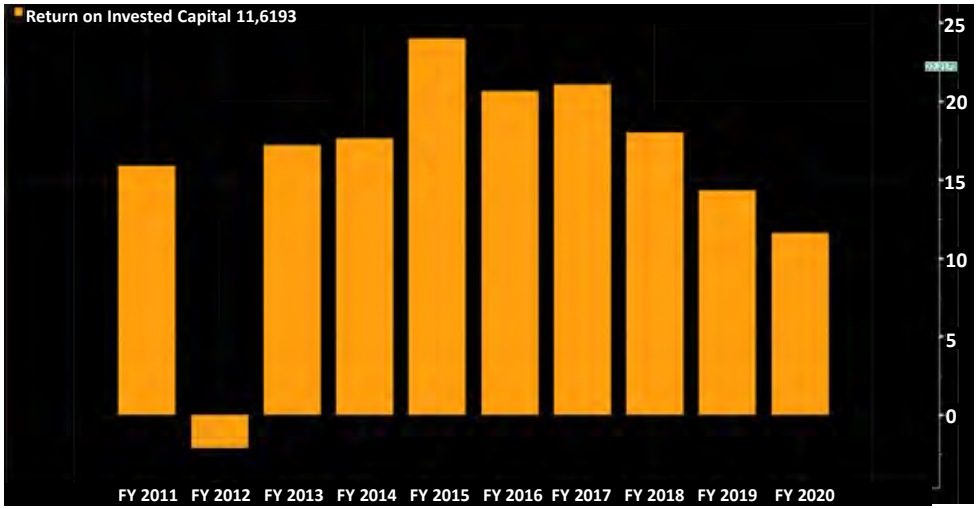
T

- Rapid changes in technology
- Multitude of regulation at all levels of government
- Government contracting process
- Supply chain resiliency

https://advantage-marketline-com.nduezproxy.idm.oclc.org/Company/Profile/general-dynamics-ordnance-and-tactical-systems?companyprofile

Financial Analysis

- **Return on Invested Capital (ROIC): 11.6193%**
- **Weighted Average Cost of Capital (WACC): 7.24%**
- **Total Revenue: $37,900,000,000 (2020)**
  - **Weapons Systems, Armament, and Munitions: $1,991,000,000**
  - IT Services: $7,892,000,000
  - Nuclear Powered Submarines: $6,938,000,000
  - Aircraft Manufacturing: $6,115,000,000
  - C4ISR Solutions: $4,756,000,000
  - Military Vehicles: $4,687,000,000
  - Surface Ships: $2,055,000,000
  - Aircraft Services: $1,960,000,000
  - Repair/Services: $986,000,000
  - Engineering: $545,000,000
- **Debt to Equity Ratio: .92**



Source: Bloomberg, Accessed 30 March 2021

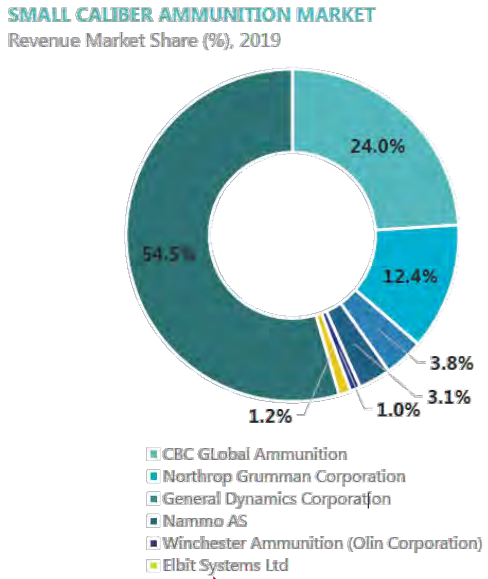
Market Strategy

Small Caliber Market

- Global Small Caliber Market
  - Relatively unique category of goods
  - Valued at $5.09 billion in 2019, Est. $6.5 billion by 2025 at 5.42% CAGR
  - EU expected to reach CAGR of .43% by 2025
  - Dual use (40% civilian and 60% military)
  - Civilian demand expected to reach CAGR of 5.6% by 2025

- GD Portfolio: 5.56 mm and .50 caliber[1]

- Market Structure: **Oligopoly**
- Major Players: CBC (24%), NG (12.4%), **GD (3.8%)**
- Competitive Spectrum:



1. M1037 Frangible Short-Range Training Ammunition, .50 Caliber RRA 12.7mm Ball and Tracer ammunition, .50 Caliber Sniper Elite

Small Caliber – Porter's Five Forces Analysis

- Number and size of suppliers: high
- Uniqueness of product: low
- GD's ability to substitute: high
- Switching cost: low

Bargaining Power of Suppliers

- **Number of customers: moderate**
- Size of each order: high
- Competitors differences: low
- **Price sensitivity: low**
- Buyer's ability to substitute: high
- Buyer's info availability: medium
- Switching costs: low

Bargaining Power of Buyers

- **Number of competitors: high**
- **Quality differences: low**
- Industry concentration: high
- Industry growth: medium
- Brand loyalty: medium
- Barriers to exit: low
- Switching costs: low

Rivalry Among Existing Competitors

Threat of Substitute Products or Services

- Number of available substitutes: low
- Buyer propensity to substitute: low
- Price performance of substitute: low
- Perceived product differentiation: low
- Switching costs: medium

Threat of New Entrants

- Barriers to entry: high
- Economies of scale: high
- Brand loyalty: high
- Capital requirements: high
- Cumulative experience: high
- Government policies: high
- Access to distribution channels
- Switching costs: medium

Small Caliber – Strategic Game Board

Strategy to build defenses against the competitive forces

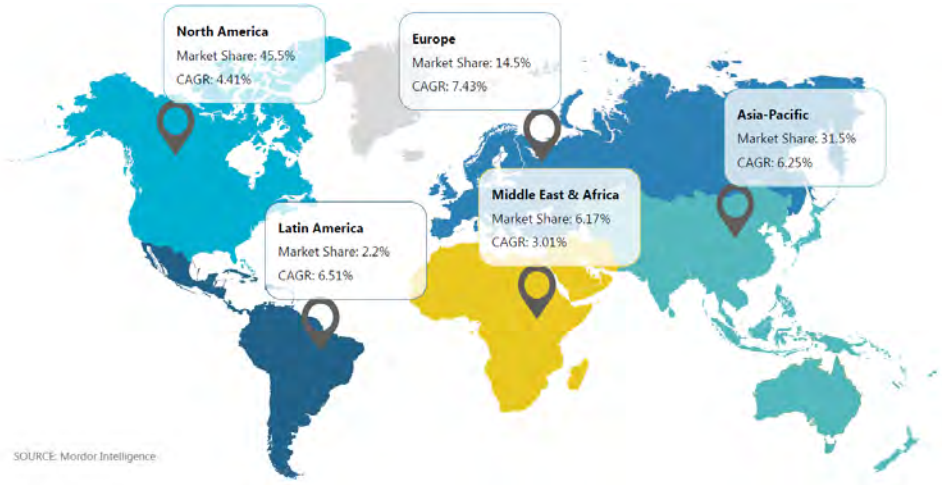
Where to Compete	*How to Compete*	
	Same Game (Traditional Rules)	**New Game (Rewritten Rules)**
Entire Market	Emulate market leader's functional approach, strengths	Rewrite industry rules to exploit a unique, industry-wide advantage
Niche Market	Resegment the market to create a niche	Create and pursue a unique advantage

Competitors Rivalry

- Market diversification
- Product differentiation
- Lower cost thru process improvement and efficiency

Buyers Power

- Market expansion
- Increase FMS and exports
- Civilian market



General Dynamics OTS was selected for submission of 43 NGSW automatic rifles and 53 NGSW rifles, along with 845,000 rounds of 6.8mm ammunition for evaluation by the military. The guns and ammunition will replace the existing M4A1 carbine and M249 squad automatic weapons for close-combat with military adoption aimed for 2023.

SEP 2019

Artillery Munition Market

- Global Artillery Market
  - Unique category of goods: armor-piercing shells, high-explosive (HE) shells, non-lethal shells, and *guided shells*
  - Valued at $7.51 billion in 2019, Est. $9.58 billion by 2025 at 5.16% CAGR

- GD Portfolio
  - 105mm and 155mm caliber: 155mm M107 HE projectile, M795 HE, M549A1 HE-Rocket Assisted Projectile, MR103 Training Ammunition, and SMArt 155 Sensor Fuzed Munition for 155mm Cannon Artillery
  - Exclusively for the defense sector, primarily for the U.S. military and NATO partner nations

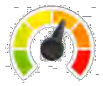
- Market Structure: **Oligopoly**
- Major Players: BAE (14.4%), GD (13.3), NG (9.5)
- Competitive Spectrum:

- One buyer and small sellers
- Information asymmetries
- Similar but slightly differentiated products
- Small but real barriers to entry
- Downward sloping demand curve for firm
- Firm produces at less than most efficient level

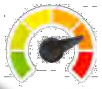
Perfect Competition — **Monopolistic Competition** — **Monopoly**

Artillery Market – Porter's Five Forces Analysis

- **Number and size of suppliers: low**
- **Uniqueness of product: high**
- GD's ability to substitute: low
- Switching cost: low
- **Price sensitivity: medium to high**



Bargaining Power of Suppliers



Bargaining Power of Buyers

- **Number of customers: low (Monopsony Power)**
- Size of each order: high
- Competitors differences: low
- Price sensitivity: low
- Buyer's ability to substitute: high
- Buyer's info availability: medium
- **Switching costs: medium to high**

- Number of competitors: high
- **Quality differences: low**
- **Industry concentration: high**
- Industry growth: medium
- Brand loyalty: low
- **Barriers to exit: high**
- Switching costs: medium

Rivalry Among Existing Competitors

Threat of Substitute Products or Services

Threat of New Entrants

- Number of available substitutes: low
- Buyer propensity to substitute: low
- Price performance of substitute: low
- Perceived product differentiation: low
- Switching costs: high

- Barriers to entry: high
- Economies of scale: high
- Brand loyalty: high
- Capital requirements: high
- Cumulative experience: high
- Government policies: high
- Access to distribution channels
- Switching costs: medium

Artillery Market – Strategic Game Board

Strategy to build defenses against the competitive forces

Competitors Rivalry

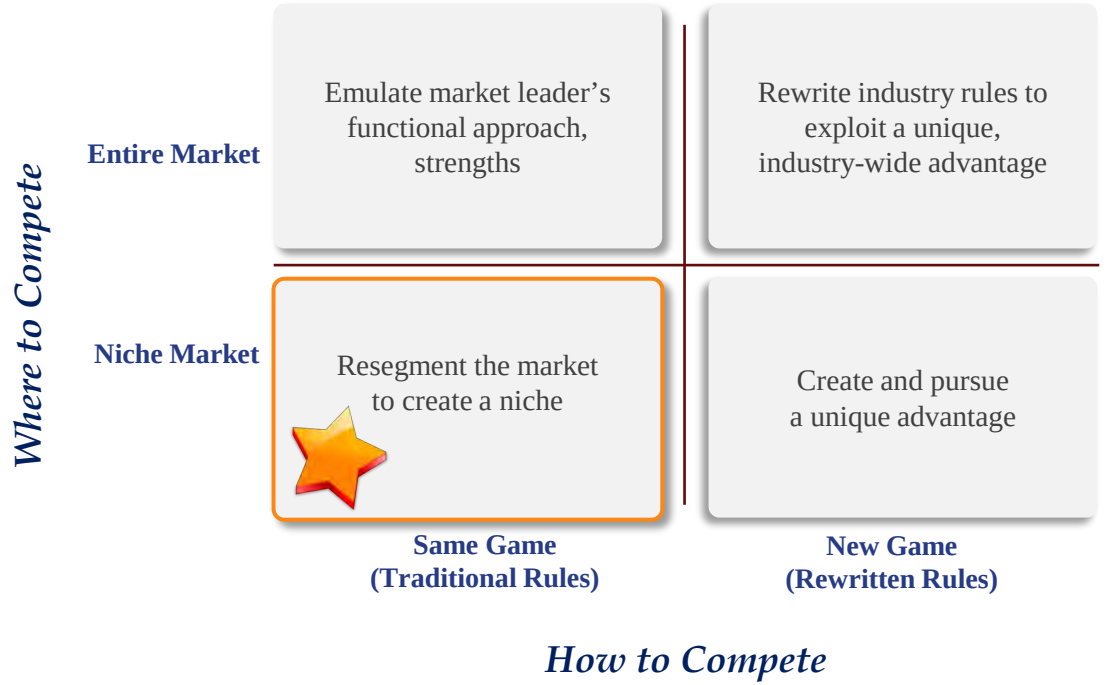
- Market diversification (e.g. IT sector)
- R&D, IP protection
- Long term contracts

Buyers Power

- Market expansion
- Increase FMS
- Brand loyalty (performance & reliability)

Suppliers Power

- Substitute material
- Global partnership
- Strategic reserve



January 27, 2021 | Publication: Euclid - News

United States : General Dynamics Awarded $695 Million U.S. Army Europe Contract for Enterprise Mission Information Technology Services

General Dynamics Information Technology (GDIT), a business unit of General Dynamics, announced it has

November 05, 2020 | Publication: Euclid - News

United States : General Dynamics Awarded $4.4 Billion Department of Defense Enterprise Cloud Contract

General Dynamics Information Technology (GDIT), a business unit of General Dynamics (NYSE:GD), announced it was awarded the Defense Enterprise Office

November 05, 2020 | Publication: Euclid - News

United States : General Dynamics awarded $761 million GSA contract for U.S. Southern Command cyber modernization

General Dynamics Information Technology (GDIT), a business unit of General Dynamics, announced it has been awarded the Southern Commands (SOUTHCOM) Cyber Information Technology Enterprise Services

August 26, 2020 | Publication: MediaCorp NewsAsia

General Dynamics unit wins US$870 million contract from Spain

NEW YORK: General Dynamics Corp said on Tuesday (Aug 24) its joint venture along with Spanish defense contractor Santa Barbara Sistemas had won a contract worth US$870 million for wheeled combat vehicles from the Spanish Ministry of Defense. The deal, a part of a

Boston Matrix Analysis

Annual real rate of market growth (%)

HIGH

"Low Share – High Growth"

- Earnings: low, unstable, growing
- Cash flow: negative
- Strategy: analyze to determine likelihood of the business becoming a "star" or a "dog"

"High Share – High Growth"

- Earnings: high, stable, growing
- Cash flow: neutral
- Strategy: invest for growth

LOW

"Low Share – Low Growth"

- Earnings: low, unstable
- Cash flow: neutral or negative
- Strategy: divest

"High Share – Low Growth"

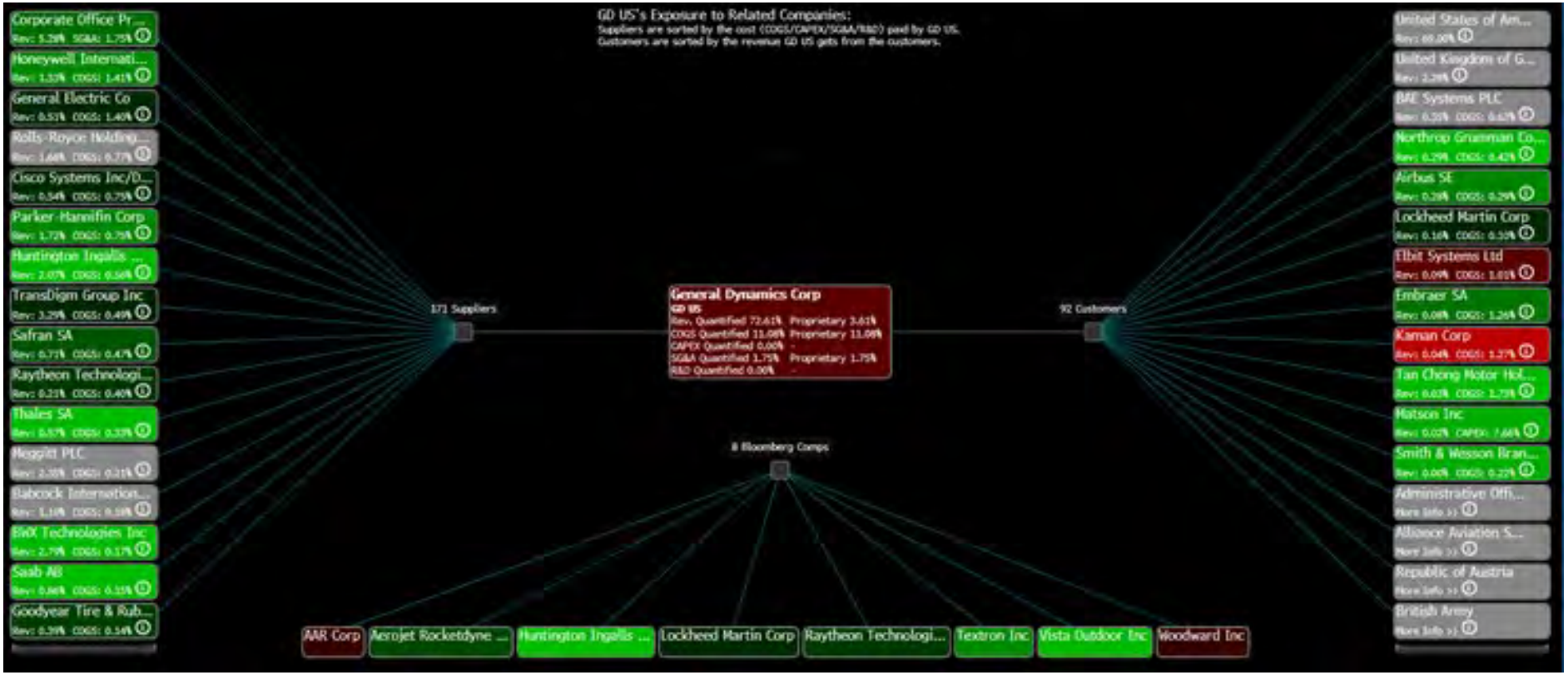
- Earnings: high, stable
- Cash flow: high, stable
- Strategy: milk

LOW — ***Relative market share*** — HIGH

Risks / Challenges

Supply Chain Vulnerabilities

- General Dynamics supply chain fragility and upstream impact
- Lack of vertical integration – reliance on thousands of suppliers
- Foreign dependency (rare earth materials)
- Backlog impacts operations



Source: Bloomberg, Accessed 30 March 2021

Human Capital Challenges

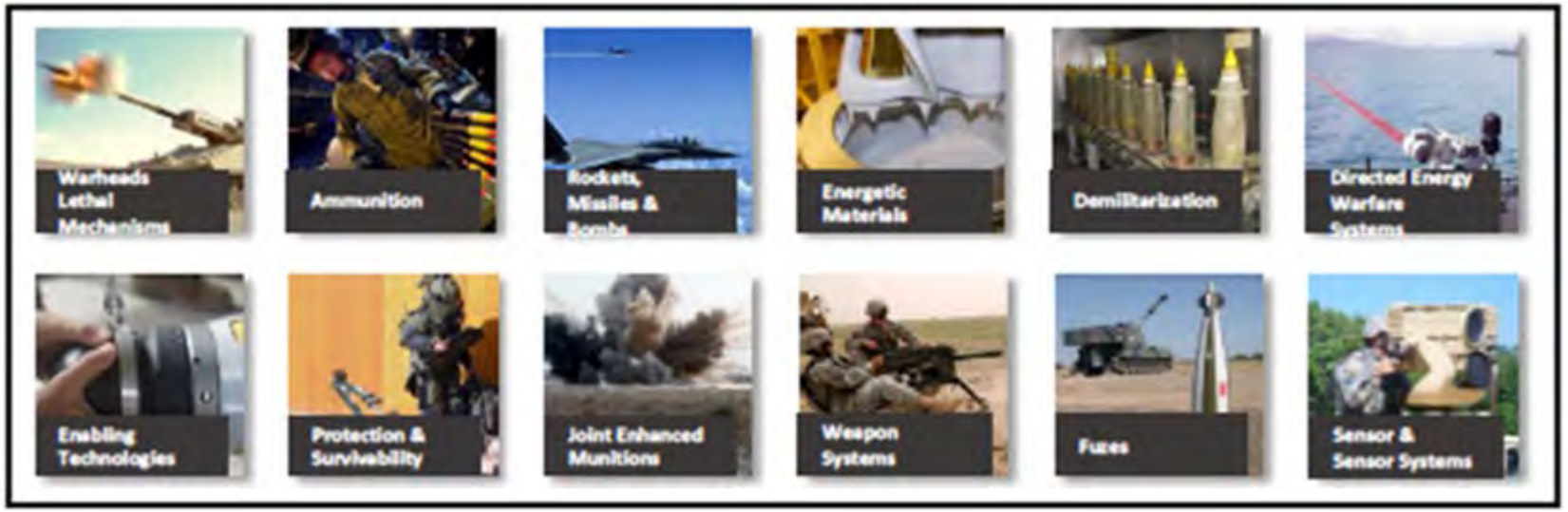
- **General Dynamics workforce**
  - Difficulty filling all skilled/technical positions (engineers, etc.)
  - Higer costs to recruit and retain personnel
  - Total employee reductions
  - Labor unions and worker representatives
  - Decentralization
  - Production capacity

Source: General Dynamics 10K

Source: GD Industry Perspective, 11 February 2021

Approach to Industry Change

- Postured to adapt to the evolving requirements of the U.S. Army (largest customer)
  - Close coordination with U.S. Army Futures Command (involvement with five cross-functional teams)
- Remain focused on "Everything in the kill chain"
- Focus on "affordability, innovation, and speed to market"
- Deliver increased "survivability, performance and lethality"
- Foster strategic relationships (DOTC, industry, academia, government)
- Continue to expand to the international market to deliver "tailored solutions"



Source: General Dynamics 10K

Source: GD Industry Perspective, 11 February 2021

Peer Competitors

Defense Market Competition			
	Name	Revenue	Employees
1	Raytheon	$97.8B	195,000
2	Lockheed Martin	$59.8B	110,000
3	Boeing	$58.2B	141,000
4	Northrop Grumman	$30.1B	97,000
5	BAE Systems	$27.4B	85,800
6	SAAB	$37.8B	17,800

- Domestically: General Dynamics competes against both large contractors and smaller businesses
- Internationally: GD competes against state-owned and private companies
- Team and subcontract with competitors

Source: Bloomberg, Accessed 30 March 2021

Source: General Dynamics 10K

Mobilization and Surge

- **Choke Points / Associated Challenges:**
  - **Human Capital:** Skilled personnel shortages
  - **Facilities:** Aging / antiquated facilities coupled with production equipment that requires downtime for preventive maintenance
  - **Materiel:** Reliance on foreign source (rare earths) and single source domestic suppliers

- **Recommendations to Private Industry:**
  - **Human Capital:** Increase shifts / transfer GD workforce
  - **Facilities:** Maximize Canadian production / modernize (robotics, etc.)
  - **Materiel:** Substitute materials / expedite distribution

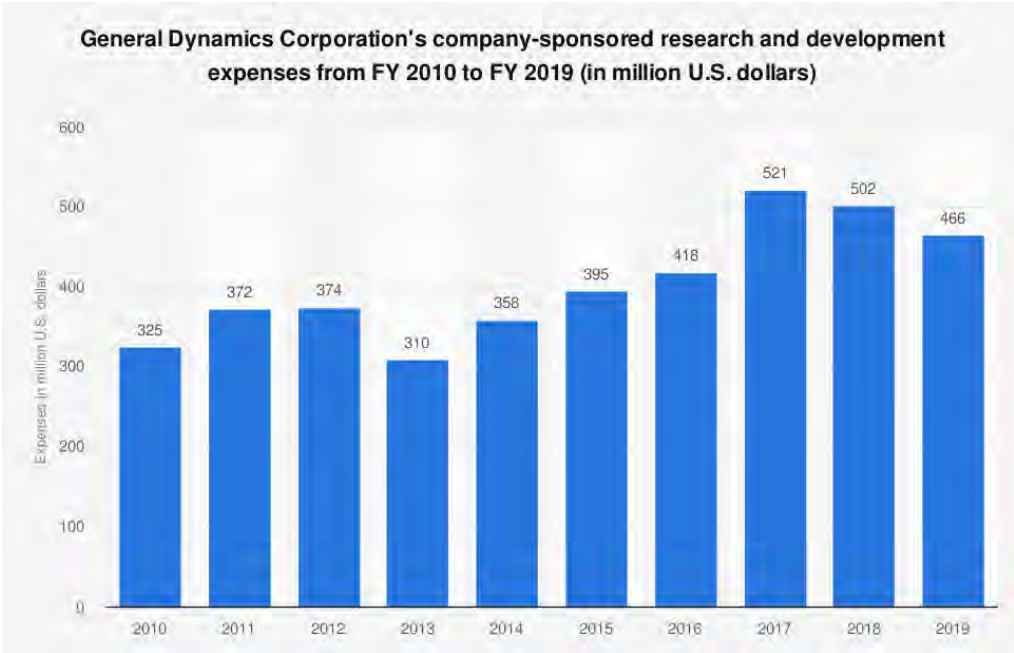
- **U.S. Government Policies:**
  - **Human Capital:** Loans/investment (overtime, hiring, etc.)
  - **Facilities:** Modify environmental policies
  - **Materiel:** Use of strategic stockpiles

Source: General Dynamics 10K

Conclusion

Innovation

- Teaming DARPA, Research Labs, and the Space Development Agency
  - Proliferated low Earth orbit capabilities – technology development, seeking opportunities to operationalize within Space Force
- Focused Areas
  - Combat Systems
  - Shipyards to improve execution and cost savings
  - Gulfstream with Technology and new product innovation



- In FY2019, General Dynamics spent US$466 million on R&D, which accounted for 1.2% of the company's revenue. Thus, strong focus on R&D enables product innovation, which helps the company to attain competitive edge over its peers in the marketplace.

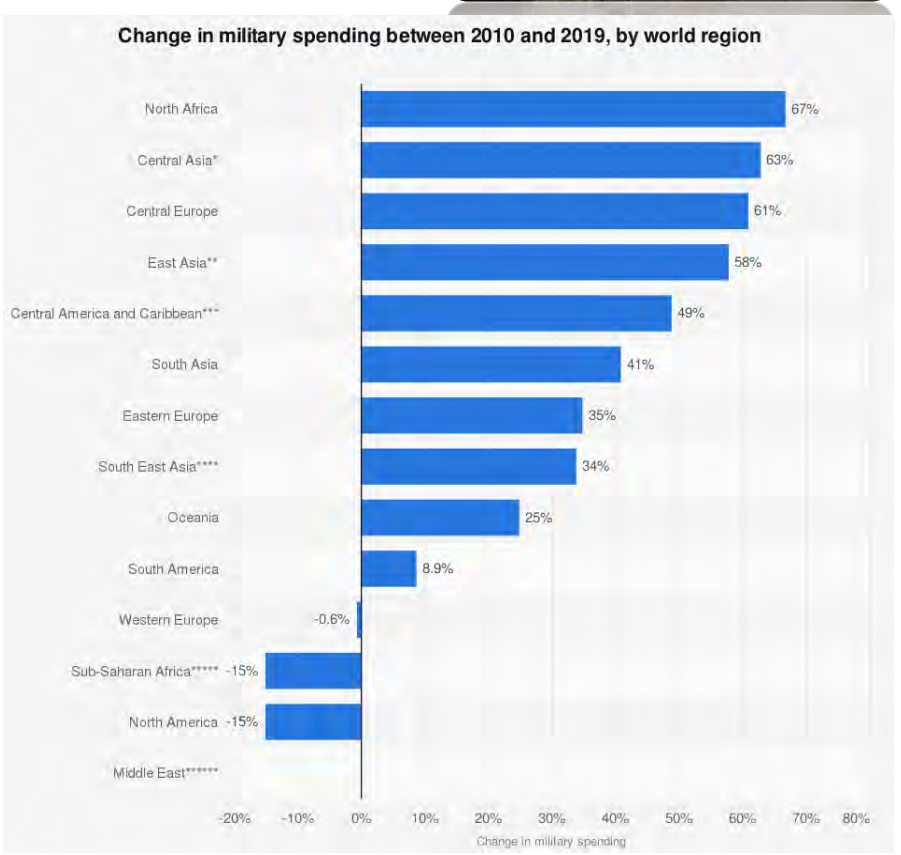
Is the Firm Creating Value?

Value

- Next-Generation ballistic missile submarine Columbia
  - Marine business expects its work in building submarines to drive hundreds of millions of dollars in annual revenue growth over the coming years
  - The company is expecting a $300 million increase in revenue in 2021, with a rough estimate of between $400-500 million of growth a year

Risks

- The government provides 65% of revenue, subject to disruption or delay
- Sales and operations outside of U.S.
- Opportunities
  - OTAs – Gov't contractors operate in a highly regulated environment



Is the Firm Creating Value?

WACC
7.24%

Debt to equity Ratio 0.92

ROIC – 11.6193%

Solvency – Long Term Debt to Equity – .22 in 2020, .21 in 2019, an increase indicates GD may becoming more dependent on debt to grow their business.

Liquidity – Current Ratio – 1.35 (Good Short-Term Financial Strength)

Risks

- Asset Growth : faster than revenue growth, builds asset at 12.8% a year, faster than its revenue growth rate of 7.8% over the past 5 years, it means that the company may be getting less efficient.
- Gross Margin % : Declined, gross margin has been in long term decline. The average rate of decline per year is -2.9%.
- Operating Margin % : Declined, operating margin has been in 5-year decline. The average rate of decline per year is -3.8%.
- Long-Term Debt : Issuing new debt, over the past 3 years, it issued USD 8.9 billion of debt. But overall, its debt level is acceptable.

Great Power Competition

- GD to deliver prototype combat vehicles – Mobile Protected Firepower to provide long-range, direct-fire capability to infantry brigade combat teams.
- Anti-Jamming capabilities integrated into vehicles
- Improvements to M1 Abrams Tank – Sepv4 additions
- Interim maneuver Short-Range Air Defense Systems
- Leveraging Other Transactions – in Multi-Domain areas
  - Munitions
  - Ground Systems
  - Cyber
  - Space

Policies For Improvements

- Great Power Competition Strategy
- Mattis on Board of Directors
- Deregulations of Aerospace Markets
- Environmental Regulations to Allow for Greater Competition
  - Rare Earth Metals
- ITAR, Export Policies, Strategic Partnerships

Questions

References

- https://www.gd.com/about-gd/our-history#:~:text=Incorporated%20in%201952%2C%20General%20Dynamics%20is%20proud%20of,the%20Electric%20Boat%20Company%2C%20Canadair%20and%20several%20others. (GD – About)
- https://www.macrotrends.net/stocks/charts/GD/general-dynamics/revenue
- United States Securities and Exchange commission, Form 10-K, General Dynamics, For the Fiscal Year Ended 31 December 2019
- General Dynamics, Ordnance and Tactical Systems, Industry Perspective on Innovation and Technology Development, 11 February 2021
- Bloomberg Terminal, Accessed 30 March 2021

Northrop Grumman Corporation

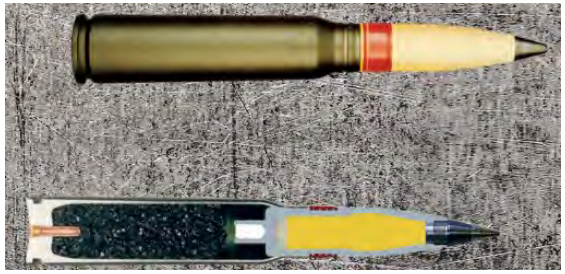
LTC Steve Cheadle

Col Mellami Lukumay

Lt Col Andy Peterson

Mr. Ben Phillips

Overview



- Company background
- Air-to-Ground missile market
- Medium-caliber ammunition market
- Northrop Grumman value proposition
- Recommendations

Background

- Originally formed in California in 1939 by Jack Northrop
  - Reincorporated in Delaware in 1985
- After the end of Cold War, it went on a series of acquisitions
  - They bought noteworthy companies such as: Grumman Aerospace, Westinghouse Electric Corporation and ORBITAL ATK Inc.
- It is well known for development of the ‘flying wing design’
- U.S. defense contractors and monopoly
- Major international cooperation defense acquisition

“When it comes to missile defense, no nation – and no system – can stand alone”

Background, cont.

Today

- Major American manufacturer specializing in defense and commercial aerospace, electronics and information–technology products and services

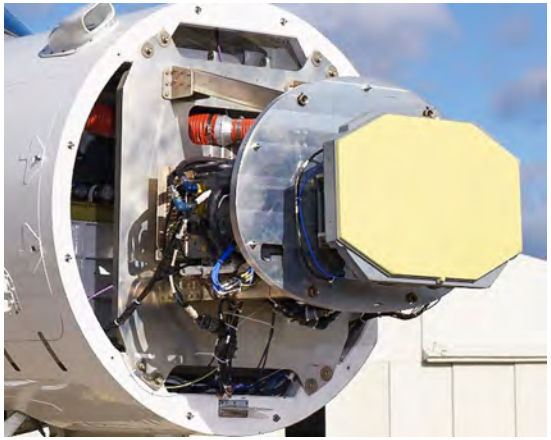
- Employs ~97,000 people

- Products: Military Aircraft, Unmanned aerial vehicles (UAVs), military vessels, missiles and missile defense systems, Autocannons, chain guns and munitions, satellites, space information electronic sensors and systems, rocket launch systems

Operating Sectors

Aeronautics Systems

Mission Systems



Space Systems

Defense Systems

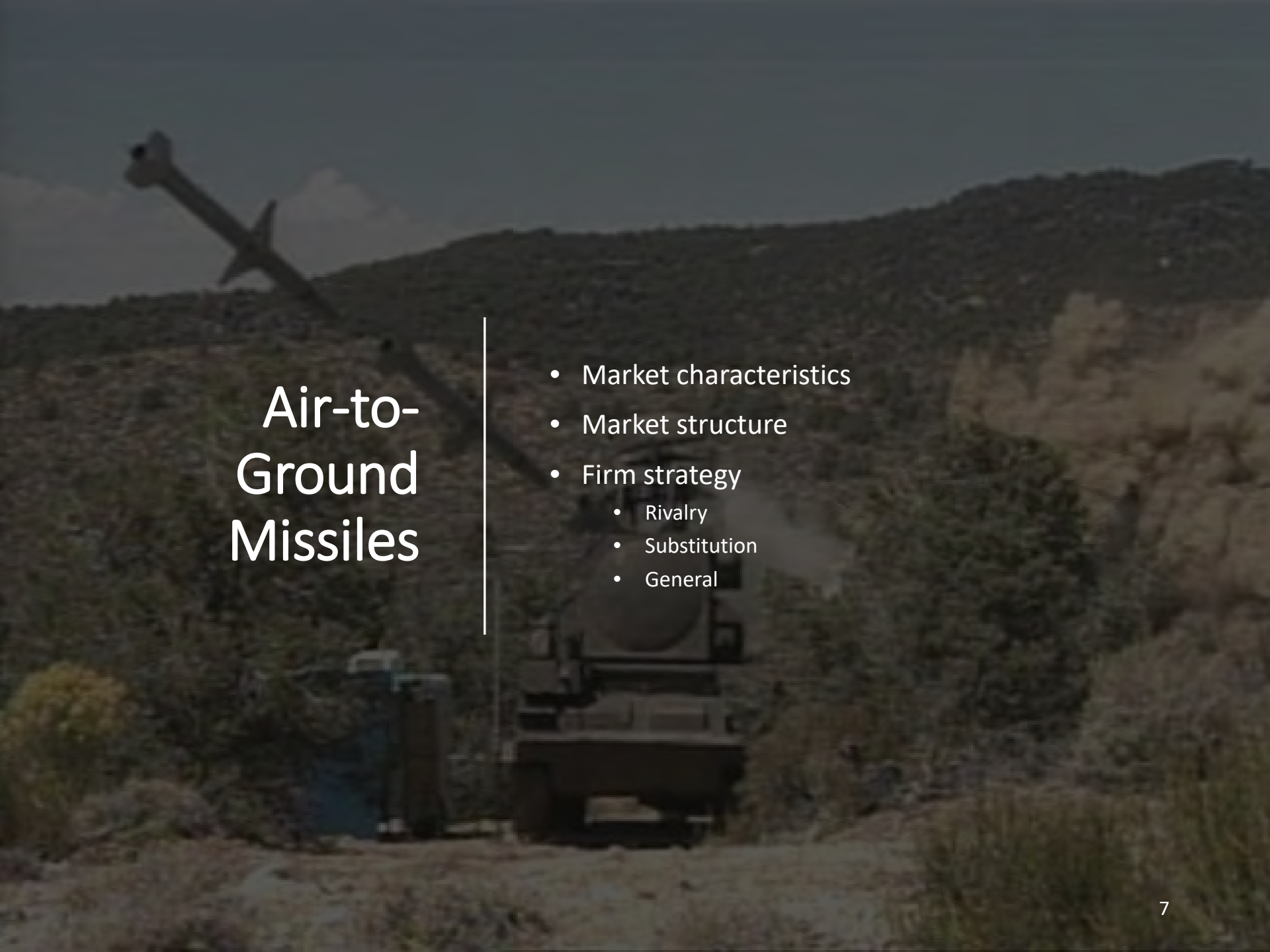
Company Value

- Revenue: $36.8 billion
- Operating Profit: $4.065 billion
- Net Profit: $3.189 billion
- Earnings per Share: $19.08
  - Peer competitor EPS
    - Raytheon: $-2.04
    - Lockheed Martin: $6.46
- WACC: 8.0%
- ROIC: 14.98%

- Debt-to-Equity Ratio: 3.2
  - Peer competitor Debt-to-Equity Ratio:
    - Raytheon .44
    - LM 2.02
- Current Ratio: 1.6
  - Peer competitor Current Ratio:
    - Raytheon 1.2
    - LM 1.39
- Long-Term Debt-to-Equity Ratio: 1.34
  - Peer competitor LT Debt-to-Equity Ratio:
    - Raytheon .43
    - LM 1.93

Mellami

"When it comes to missile defense, no nation – and no system – can stand alone"

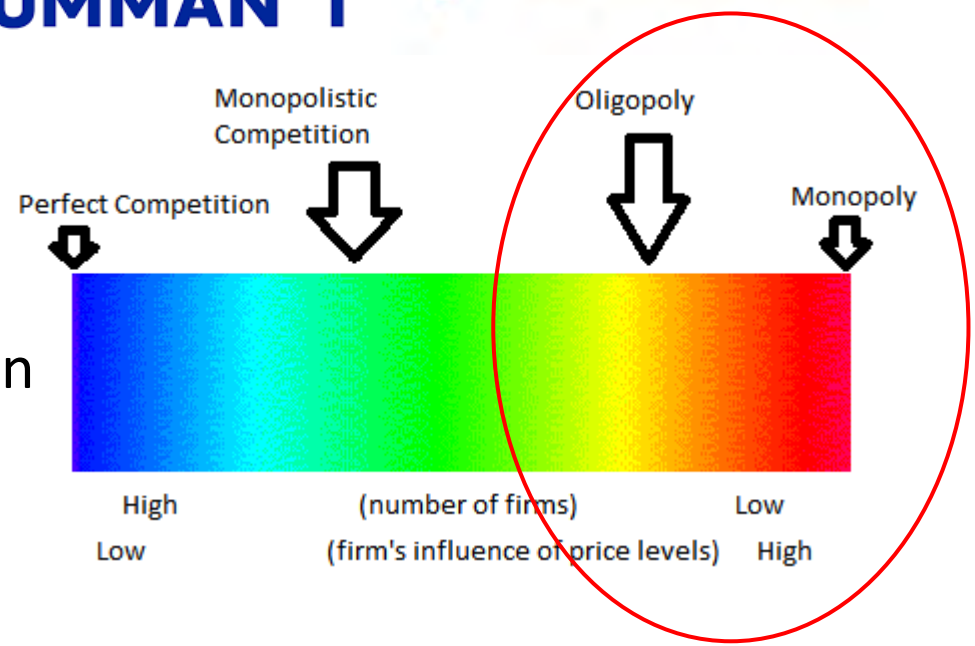


Air-to-Ground Missiles

- Market characteristics
- Market structure
- Firm strategy
  - Rivalry
  - Substitution
  - General

AGM Market

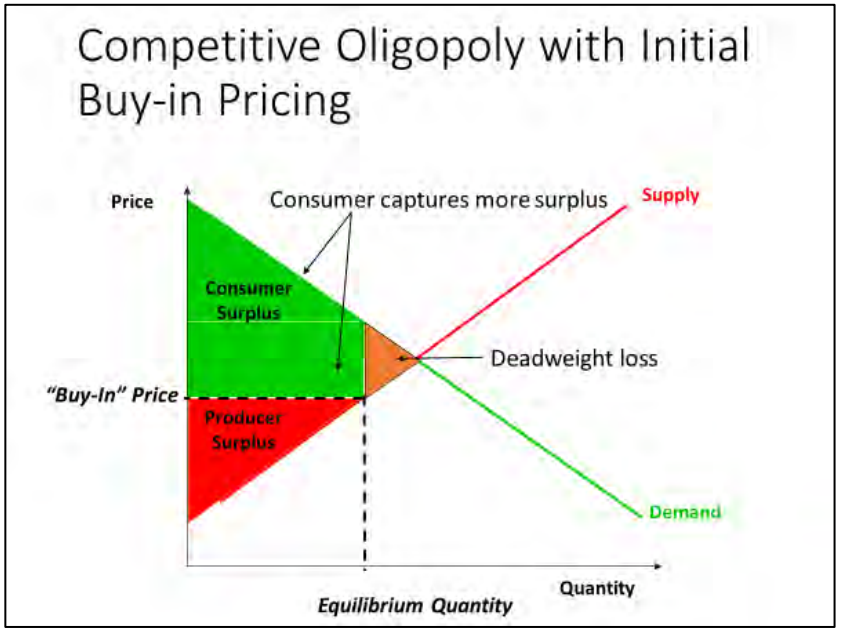
- Buyers
  - U.S. DoD
  - Foreign Military Sales
- Sellers
  - Lockheed Martin
  - Raytheon
  - Northrop Grumman
  - Boeing
- Environment
  - Oligopoly during competition
  - Monopoly

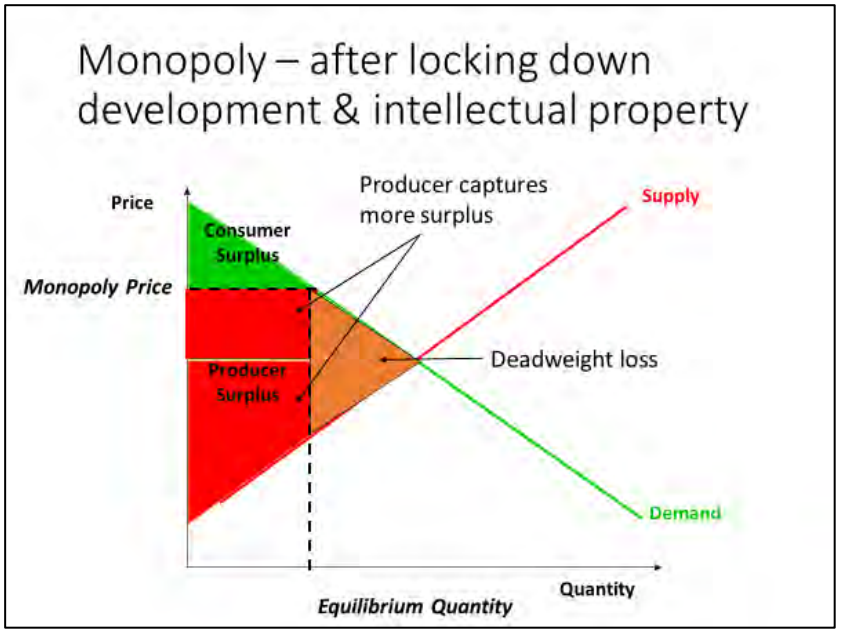


Andy

AGM Economics

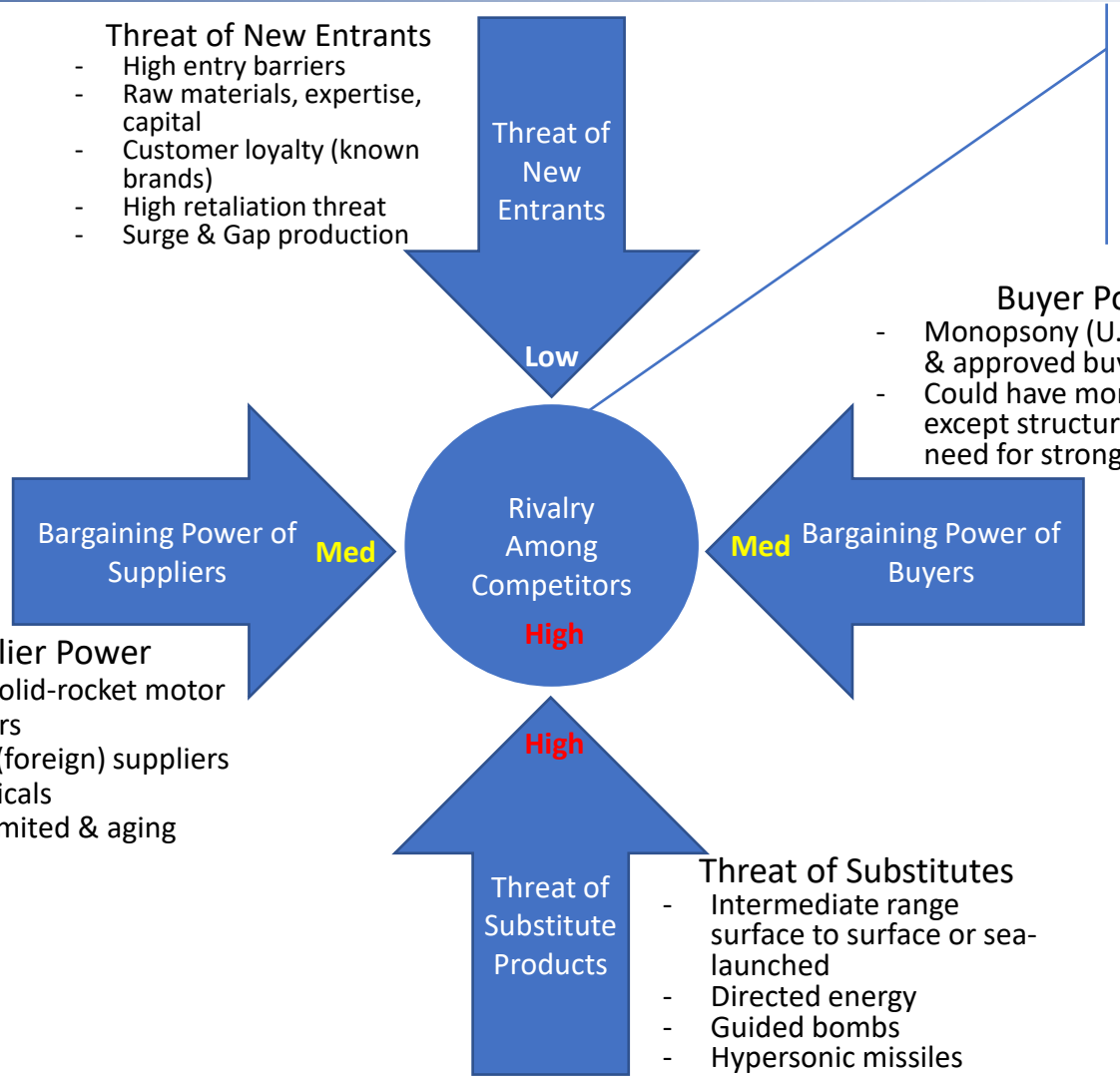
- Inefficient market





Andy

AGM Market Forces



Threat of New Entrants
- High entry barriers
- Raw materials, expertise, capital
- Customer loyalty (known brands)
- High retaliation threat
- Surge & Gap production

Competitive Rivalry
- Finite procurements that last decades
- NG is a new entrant
- Tempered by component reliance & specialization

Buyer Power
- Monopsony (U.S government & approved buyers)
- Could have more influence except structure/process and need for strong MIB

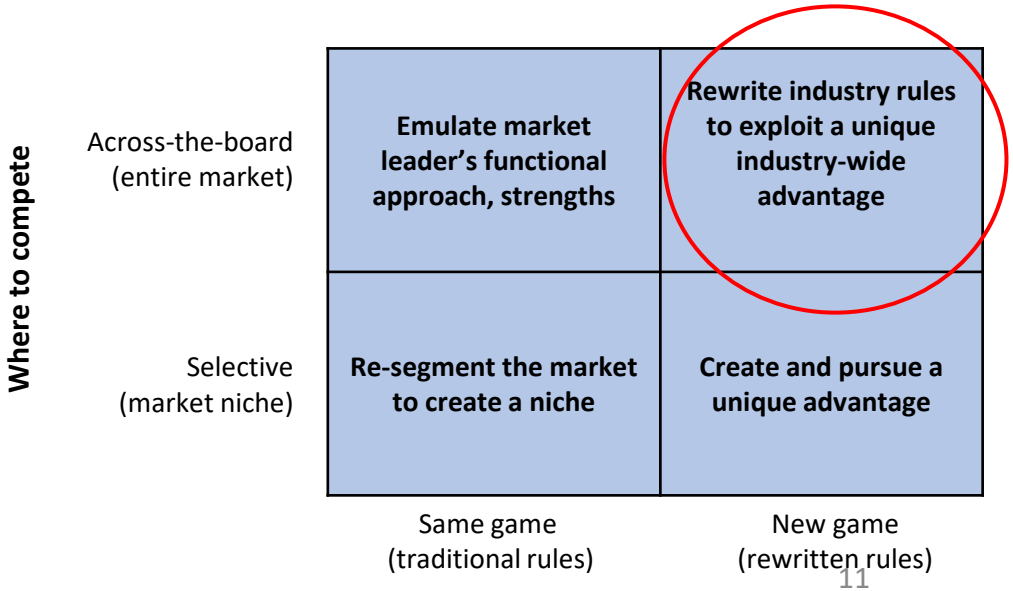
Supplier Power
- 2 large solid-rocket motor producers
- Limited (foreign) suppliers of chemicals
- Labor; limited & aging

Threat of Substitutes
- Intermediate range surface to surface or sea-launched
- Directed energy
- Guided bombs
- Hypersonic missiles

Andy

NG Strategy - Rivalry

- After Orbital ATK acquisition
  - Propulsion, fuzes, sensors, warheads, components
- Combined with strategic weapon EMD funded by the government
- Future competitor for missile systems



Andy

NG Strategy – Substitutes

- Innovation & Partnering
- Hypersonic missiles
  - Partnered with Raytheon to compete against Lockheed
  - Testing: Aerothermal Research and Testing facility
  - DARPA development contracts
- Counter hypersonic systems

Andy

NG Strategy – Mergers & Acquisitions

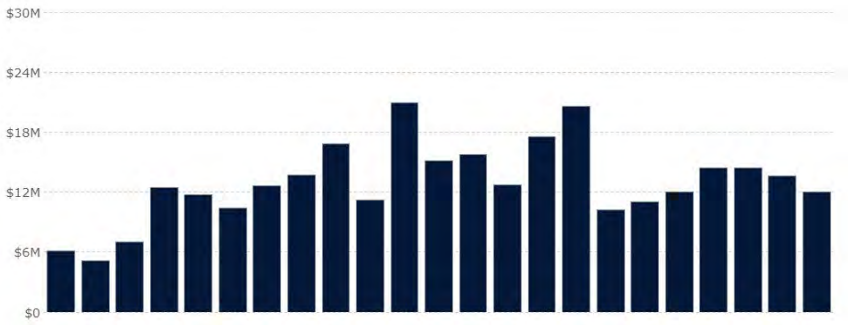
- Acquired Orbital ATK in 2018

- Future M&A after “strengthening balance sheet”

Andy

NG Strategy – Lobbying

- Political
  - $12M in lobbying expenditures for 2020
    - #14 / 5,568 firms/orgs
  - #3 major defense firm
    - Behind LM and Boeing



Northrop Grumman Annual Lobbying Totals

- Media
  - **"Northrop exec calls for more clarity, urgency on hypersonic defense system"**
  - **"Winning the hypersonic race is a national imperative"**

Andy

Medium Caliber Ammunition Market

NORTHROP GRUMMAN

- Northrop Grumman is a leading producer of a complete family of Med Caliber tactical and target practice ammunition
- Applications
  - Anti-armor, anti-material, anti-personnel, ground suppression, air defense and shipboard-defense

*Sky Viper 20mm Chain Gun

Bushmaster 30mm Chain Gun

30 X 173mm SUITE OF AMMUNITION

PGU-46
HIGH EXPLOSIVE INCINDIARY WITH INERT TRACER

PGU-15 TP
TARGET PRACTICE

PGU-13 HEI
HIGH EXPLOSIVE INDCENDIARY

MK310 PABM
PROGRAMMABLE AIR BURST MUNITION WITH TRACER

MK 266 HEI-T
MK238 HEI-T/SD
HIGH EXPLOSIVE INDCENDIARY WITH TRACER AND SELF-DESTRUCT

MK239 TP-T
TARGET PRACTICE WITH TRACER

M928 APFSDS-T
ARMOR PIERCING FIN-STABILIZED DISCARDING SABOT W/TRACER

Ben

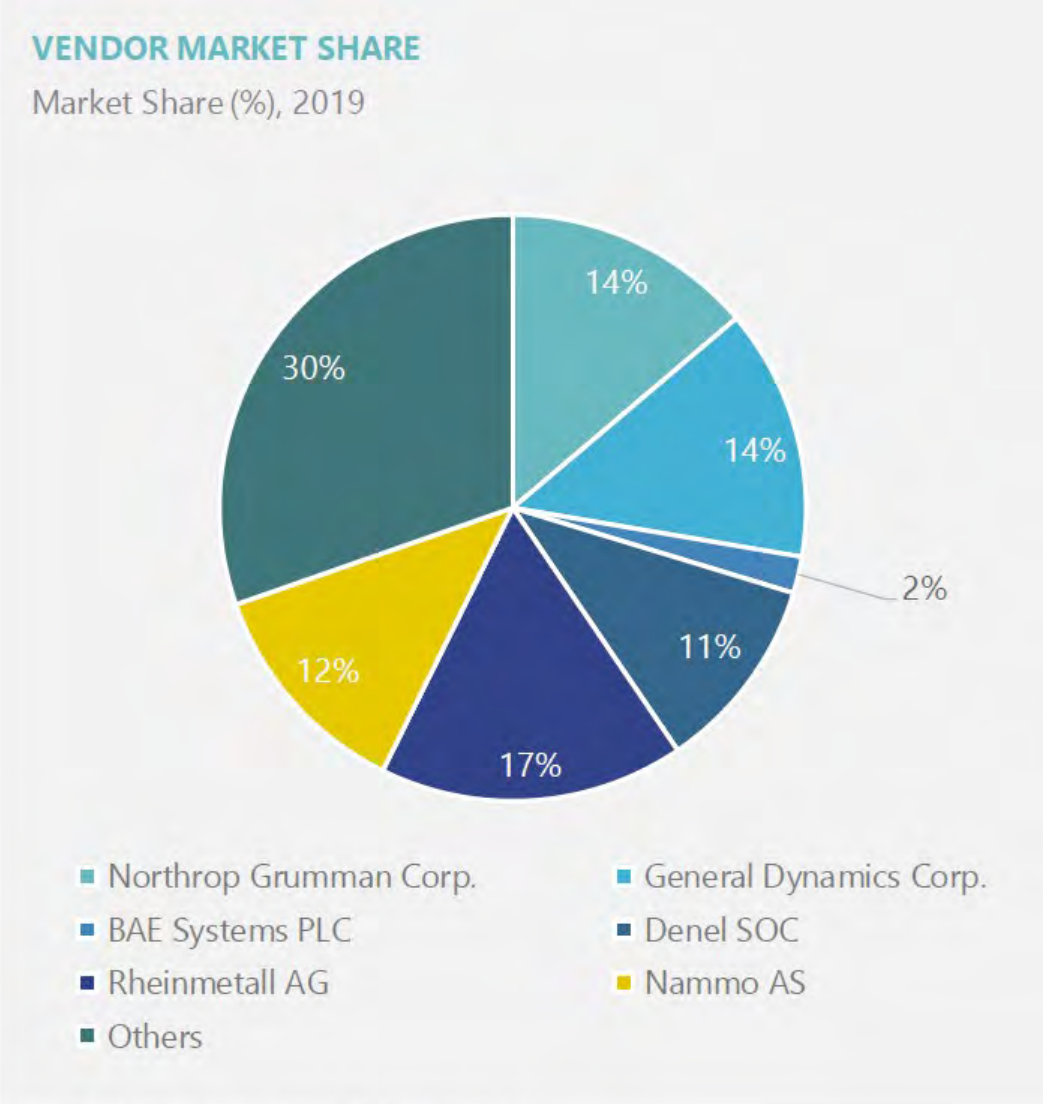
Med Cal Ammo Market

- Caliber size 20mm to 40mm
- 1.4B USD in 2025; CAGR 2.3%

- Asia-Pacific: 38%
- North America: 26%
- Europe: 19%

- 85% of NG sales are in the United States

- Drivers:
  - Increased Military Budgets
  - Upgrade Capabilities to Counter Emerging Threats



SOURCE: Mordor Intelligence, Company Data

Ben

Med Cal Ammo Market

- Buyers
  - U.S. DoD
  - Foreign Military
  - Limited Law Enforcement
- Sellers
  - BAE Systems
  - Rheinmetall
  - Northrop Grumman
  - General Dynamics
  - Denel
  - Nammo
- Market Structure
  - Oligopoly

NORTHROP GRUMMAN

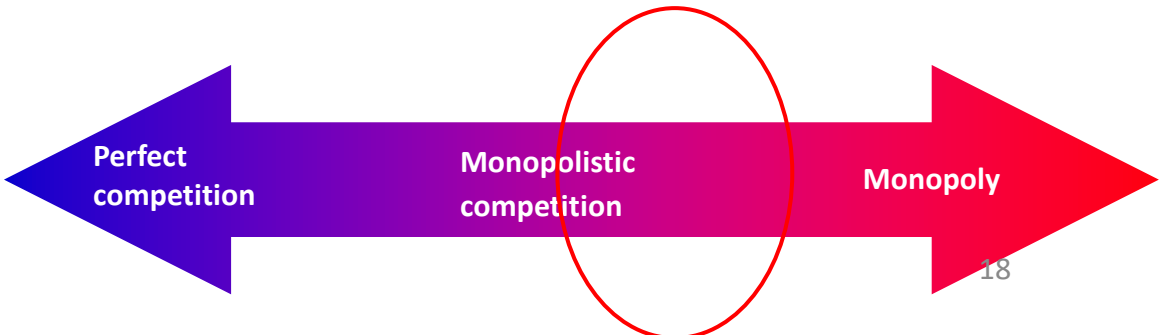
Nammo

DENEL

BAE SYSTEMS

RHEINMETALL

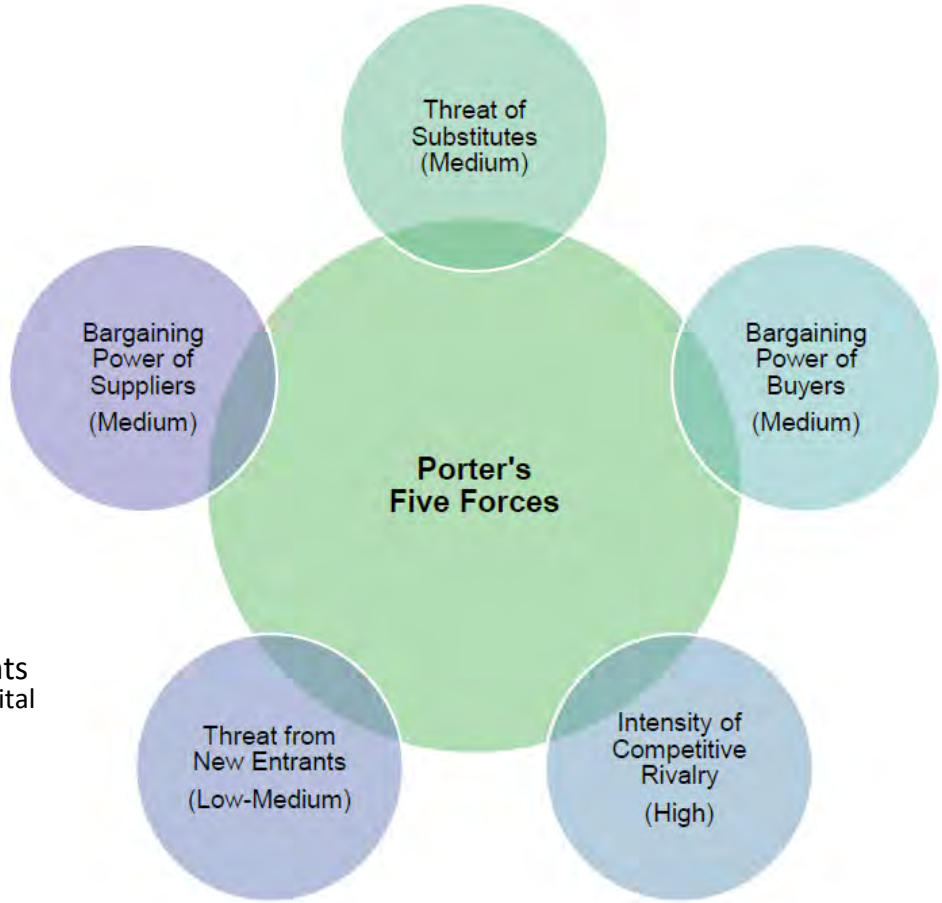
GENERAL DYNAMICS



Ben

Med Cal Ammo Market Forces

Threat of Substitutes
- Buyer's Propensity to Substitute
- Substitute Quality and Performance
- Alternative Technology



Supplier Power
- Product Differentiation
- Brand Identity
- Price Sensitivity

Buyer Power
- Buyer's Switching Cost
- Price Sensitivity
- Brand Identity

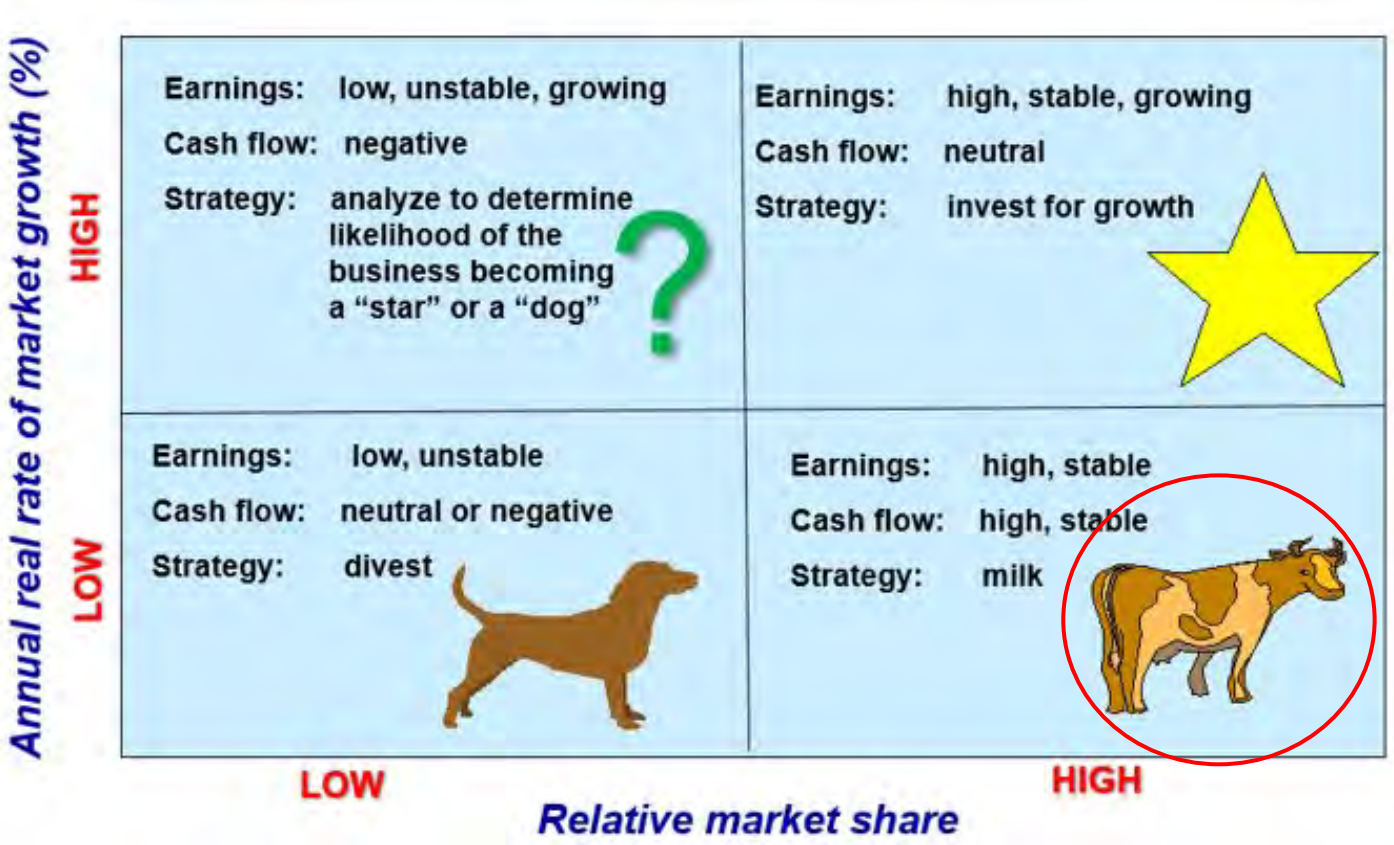
Threat of New Entrants
- High entry barriers, capital requirements
- Access to Distribution Channels
- Legal and Regulatory
- Brand Differentiation
- Product Differentiation

Competitive Rivalry
- Number of Firms
- Exit Barriers
- Brand Identity
- Price Wars

Ben

Source: BIS Research Global Military Ammunition Market

NG Strategy – Growth Share Model



Annual Growth 2015-2020

2.3%

Profit Margin 2020

10.6%

Revenue Growth 2020

7.5%

NG Market Share: 14%

Ben

Med-Caliber Ammo Innovation

- Budget-$0.95B in R&D
  - SkyViper 20mm gun (Brand Identity)
  - Develop advanced high-precision medium-caliber ammunition (Product Differentiation)
    - Ex 30mm air-burst munition, developed in 2017
- Mergers & Acquisition
  - ATK
  - Apply similar strategy when novel ammo products are mature

Ben

Supply Chain Vulnerabilities

- Sequestration and Uncertainty of U.S. Government Spending
- Decline of US Manufacturing Base Capabilities and Capacity – Domestic Goods
- Shrinking Supply Chain / Sole source
- Availability and Pricing of Raw Materials and Components
- Adequate Visibility Into Lower Tier

Steve

NG Vulnerabilities Continue

- 84% of sales from US Government
- Nuclear Posture Review
  - B-21
  - GBSD
- Biden Administration Middle East FMS review
- BBB bond rating

Steve

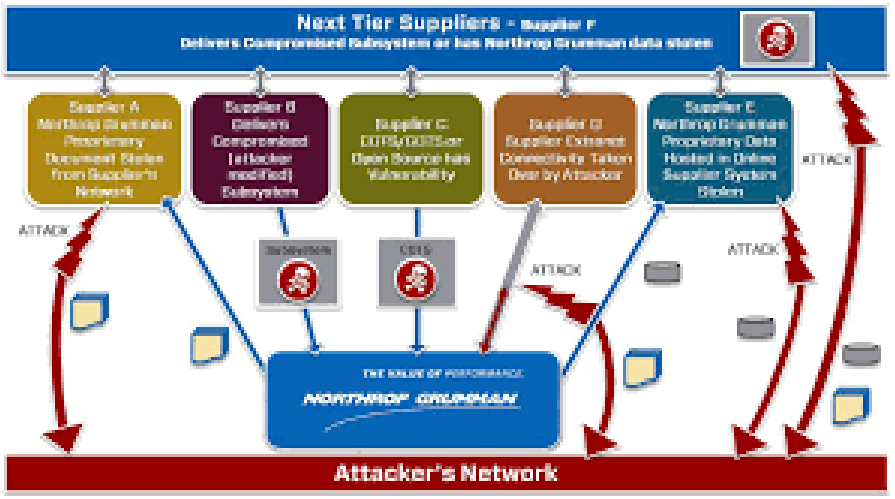
Human Capital Challenges

- Personnel Security Clearances Timing
- Diminishing U.S. STEM Graduates
- Attrition and Retention
- Wage War Within the Industry

Steve

Support of US National Security Needs

- Great Power Competition
  - Cyber Security
    - Data / Automation
- Surge
  - Reduction of Standard Hour Content of Product
    - Increase Automation
    - High-Volume Technology



Steve

Policy Recommendations

- Government procurement reform
  - Streamline Testing Guidelines to Speed Up Production Process
  - Expand Digital Engineering
  - Increase Award Fee use to incentivize contractor innovation
- Congress Commit to Inflation Adjustment Defense Spending Growth
- Continue Measures to Expedite Reform of Security Clearance Investigations
- DoD Improve Process for Assessing and Addressing Weak Points in its Supply Chains

Steve

Questions?


Raytheon Technologies

COL Alirio Aponte Sepulveda
LTC Elaine Bower
COL Jaroslav Jiru
Lt Col Nicholas Lofthouse

Overview

- Company Profile and History (Nick)
- Air-to-Air Missile Market Analysis (Elaine)
- Aircraft Engine Market Analysis (Jaroslav)
- Raytheon's Firm Strategy (Alirio)
- Financial Analysis and Supply Chain (Nick)
- Human Capital (Jaroslav)
- Surge and Mobilization Capacity (Alirio)
- Recommendations (Elaine & Jaroslav)
- Conclusions (Nick)

Raytheon Technologies

Company Profile

- 195,000 employees
- Four Business Segments
- Market Cap $118B (S&P 500)
- Historically a defense company

United Technologies

Raytheon

Collins Aerospace

Pratt & Whitney

Raytheon Technologies

Waltham, MA

Hartford, CT

Charlotte, NC

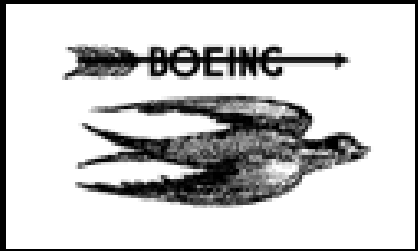
Arlington, VA

Tucson, AZ


Raytheon Technologies Locations
RTX US Factories
Distribution
Manufacturing
R&D

Firm History

Firm History



Firm History

RAYTHEON
"Excellence in Electronics"
RAYTHEON MANUFACTURING COMPANY

RAYTHEON COMPANY

QRS

The Beech Aircraft Company
WICHITA, KANSAS

ACME

HAWKER AIRCRAFT LTD

Amana

CHRYSLER CORPORATION

SUBMARINE SIGNAL COMPANY

ti

apelco

HUGHES ELECTRONICS

BOEING

UNITED AIRCRAFT & TRANSPORT CORPORATION

Sikorsky

UNITED AIR LINES

UAC UNITED AIRCRAFT CORPORATION

PRATT & WHITNEY

Sikorsky

CHANCE-VOUGHT CORPORATION
EAST HARTFORD CONNECTICUT

BOEING SEATTLE, U.S.A.

UNITED AIR LINES
COAST-TO-COAST

Raytheon

United Technologies

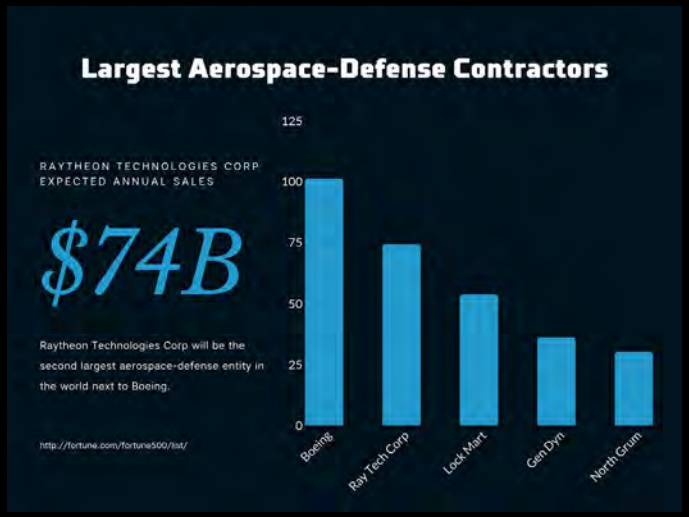
Raytheon Technologies

OTIS

GOODRICH

Carrier

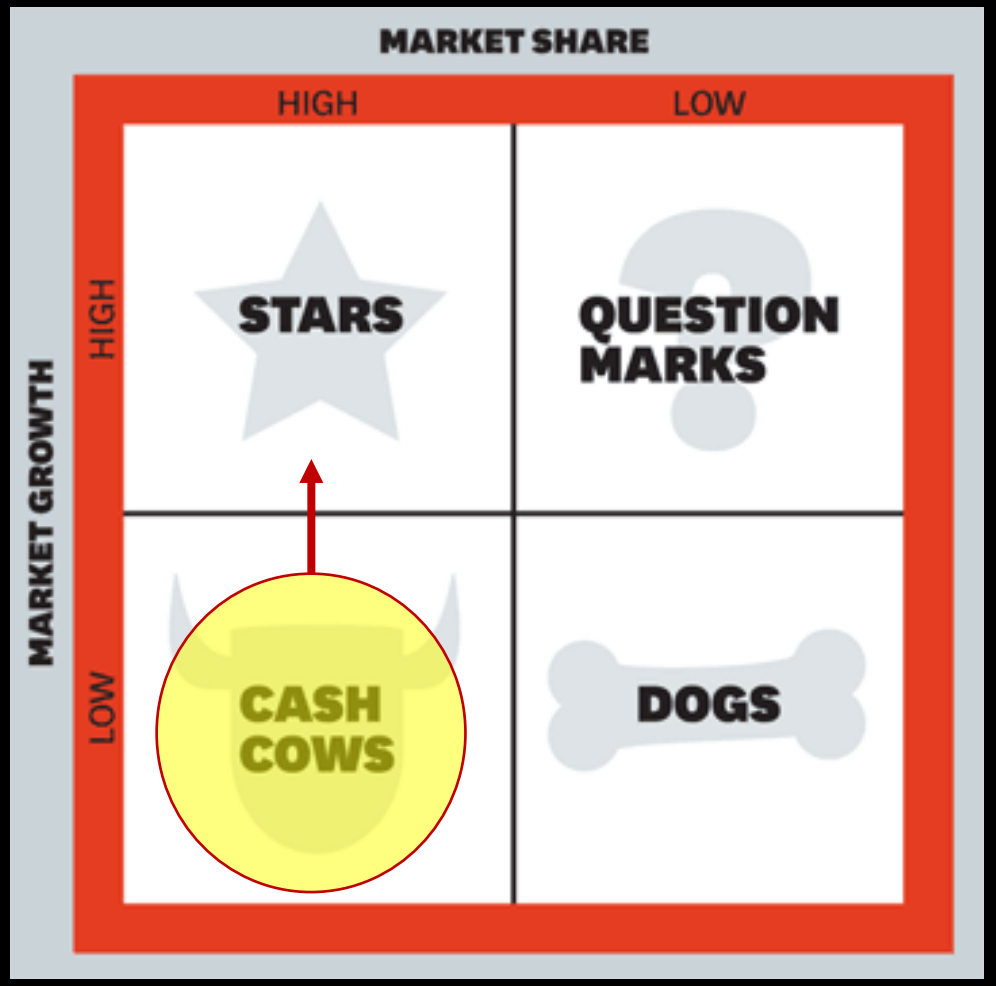
Rockwell Collins



Raytheon's Four Businesses

	Employees	Countries	Revenue
Collins Aerospace	68,000	46	$18B
100+ years in aerospace; 28,000 patents; 75% commercial/25% defense			
Pratt & Whitney	36,000	40	$17B
11,000 commercial/7,000 military engines in service			
Intelligence & Space	37,000	46	$10B
Support for air & space ISR, C2, PNT, cyber… all domains			
Missiles & Defense	30,000	28	$11.5B
Air, land, and sea missiles, radars, and support systems			

Raytheon's Markets– BCG Matrix



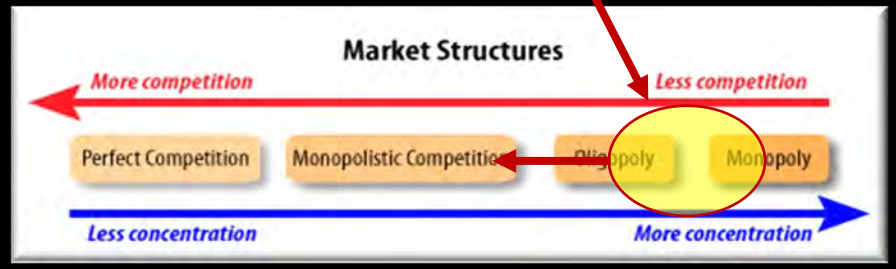
Raytheon operates in markets and competes in those segments with low, steady growth and sustainable cash flows, typically as a subcontractor to a prime.

Meanwhile, it also competes in subsegments where growth opportunities appear profitable and where Raytheon can earn even more market share.

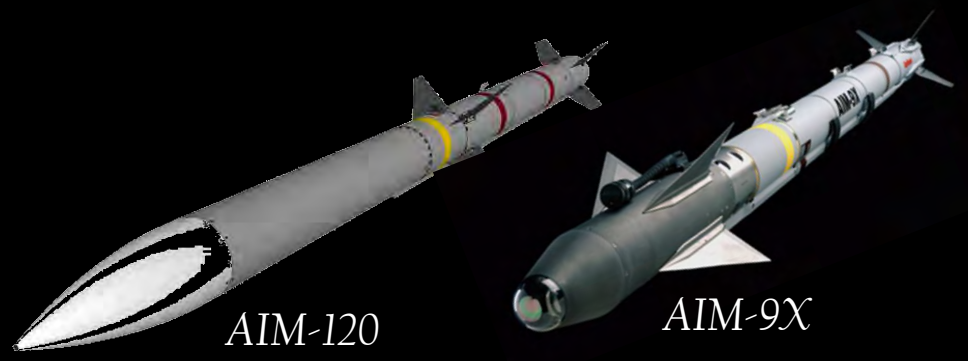
Air-to-Air Missile Market

Raytheon Technologies

- Subsegment of larger missile market
  - Raytheon is also dominant in surface missiles
- US Duopoly: *Lockheed contracted for AIM-260 development*
- Int'l Oligopoly: *MDBA/Rafael/Diehl*
- Raytheon Manufactures: *AIM-9 Sidewinder (IR) and AIM-120 Advanced Medium Range Air-to-Air Missile (AMRAAM) (radar-guided) families of missiles*
- Strategic Advantages: *Resource strengths, such as strong brand reputation, established customer space, and 745 patents*

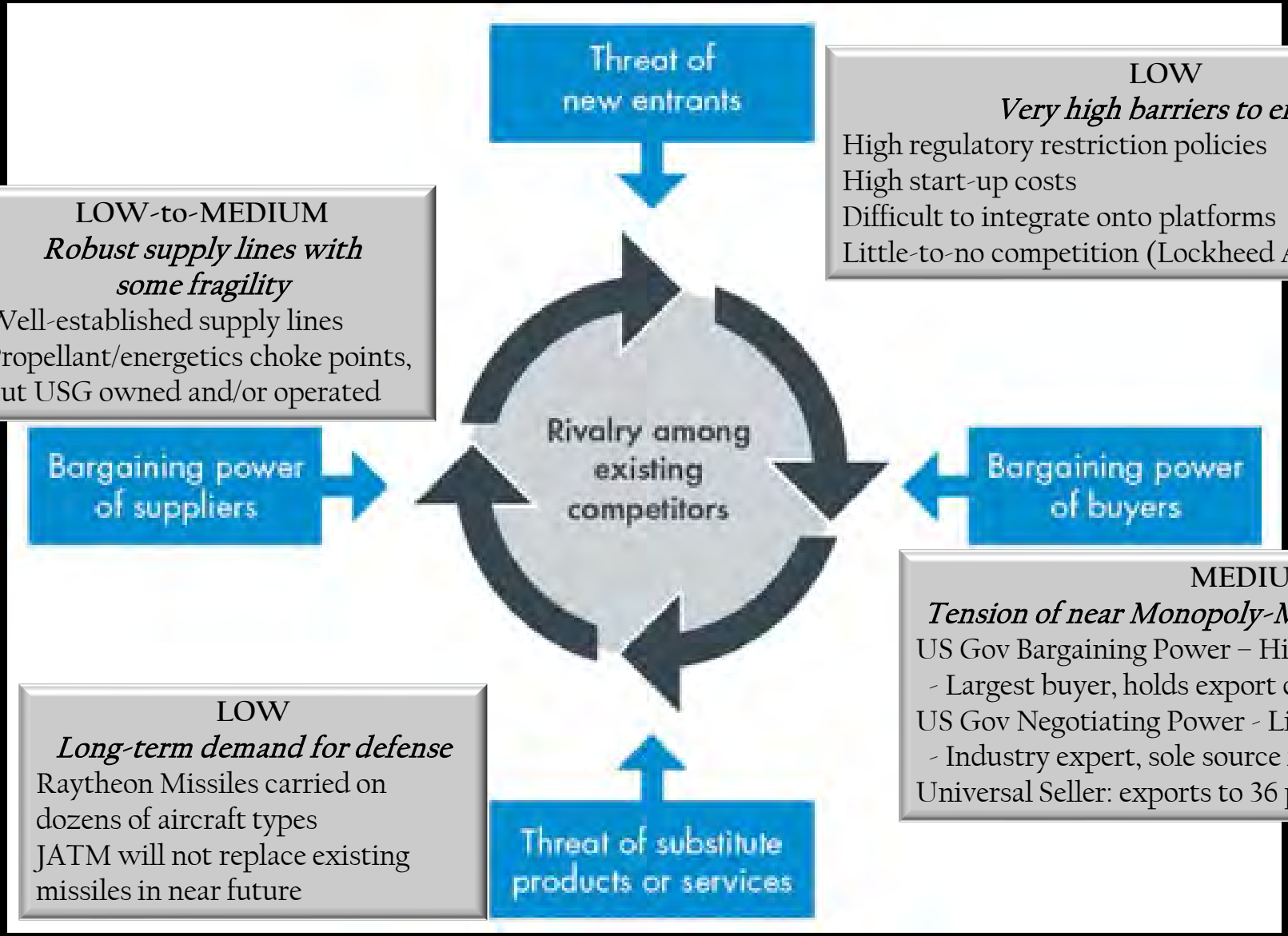


Raytheon Missiles & Defense



Air-to-Air Missile Market: Porter's Five Forces

Raytheon Technologies



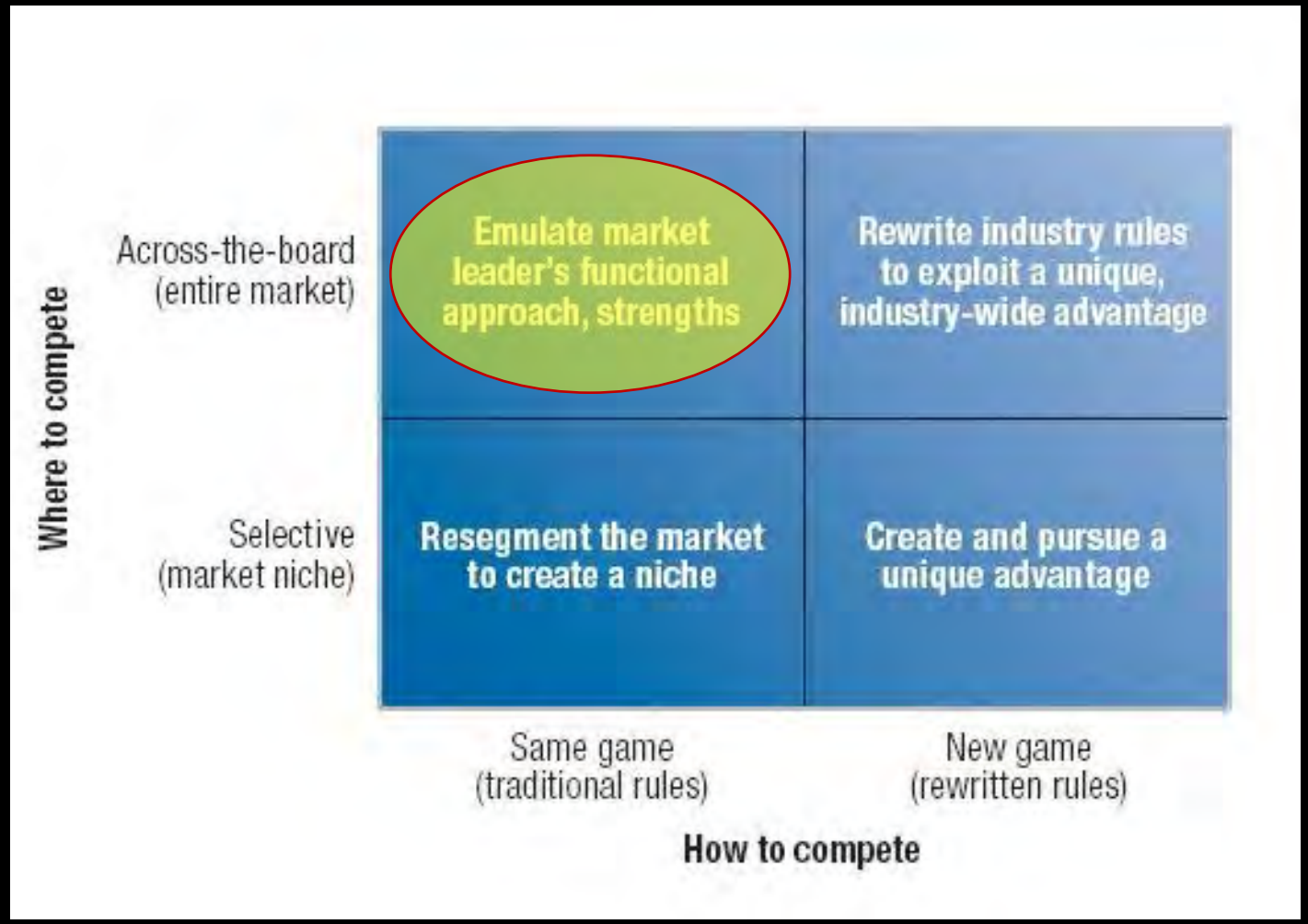
LOW
Very high barriers to entry
High regulatory restriction policies
High start-up costs
Difficult to integrate onto platforms
Little-to-no competition (Lockheed AIM-260 next?)

LOW-to-MEDIUM
Robust supply lines with some fragility
Well-established supply lines
Propellant/energetics choke points, but USG owned and/or operated

MEDIUM
Tension of near Monopoly-Monopsony relationship
US Gov Bargaining Power – High
- Largest buyer, holds export controls
US Gov Negotiating Power - Limited
- Industry expert, sole source for current inventory
Universal Seller: exports to 36 partner countries

LOW
Long-term demand for defense
Raytheon Missiles carried on dozens of aircraft types
JATM will not replace existing missiles in near future

Air-to-Air Missile Market: Strategic Gameboard

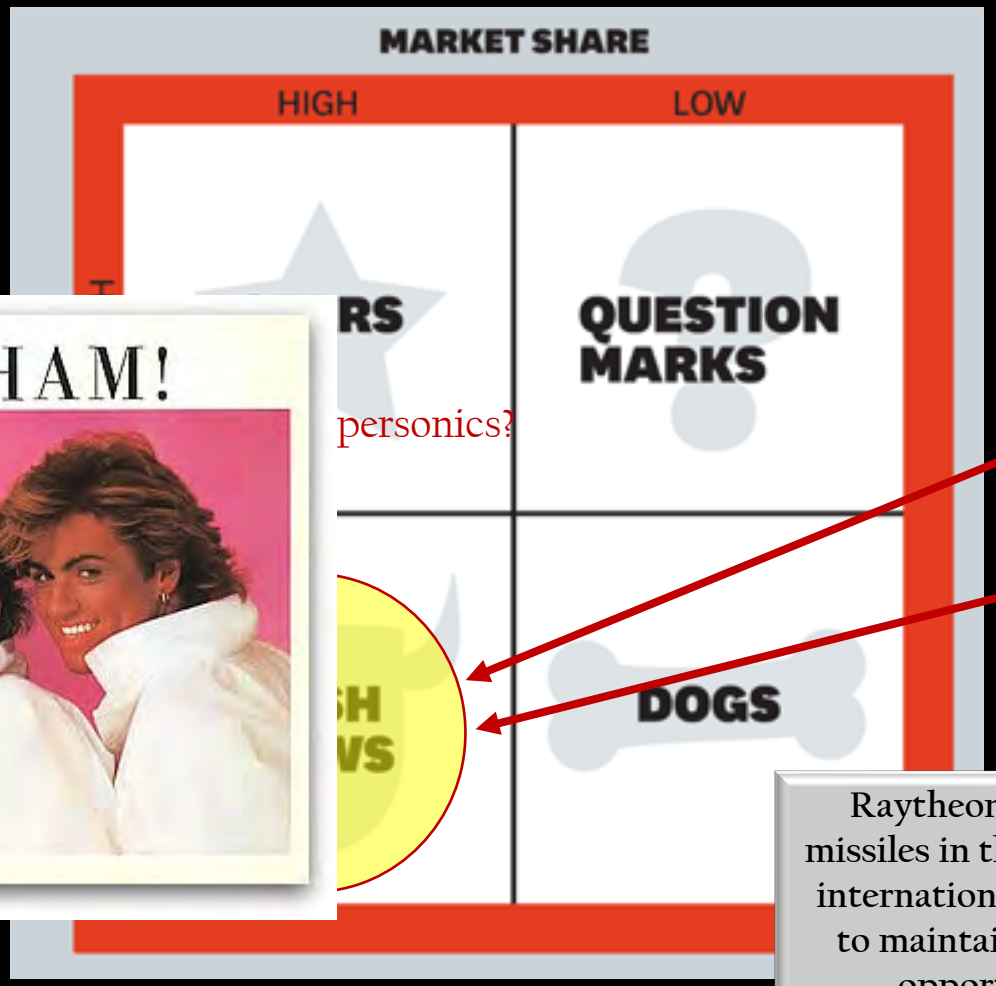


Raytheon Technologies

Raytheon is the market leader in the air-to-air missiles market, with very few competitors. They have historically been the front runner for both infrared (IR) and radar-seeking missiles, and will compete for JATM as well as hypersonics.

Air-to-Air Missile Market: BCG Growth Share Matrix

Raytheon Technologies



Raytheon is a near monopoly of current air-to-air missiles in the US market, and part of a small oligopoly internationally. They will compete for new programs to maintain high market share and look for growth opportunities with JATM and hypersonics.

Air-to-Air Missile Market: Raytheon's Strategy

- Continue support for current production
  - *AIM-9X and AIM-120 will be carried and used for decades to come*
  - *Positive, sustainable cash flows for value proposition*
- Leverage experience and expertise to compete in new segment areas
  - *Raytheon + Collins Aerospace (UTC) synergies*
  - *JATM, or an alternative next-generation missile; Hypersonics for air-to-air?*
  - *New, innovative solutions– kinetic or non-kinetic*
  - *Partner with USG agencies for R&D investments*

	United Technologies Competency	+	Raytheon Competency	=	Raytheon Technologies Customer Solution
Hypersonics / Future Missile Systems 	• High-temperature materials • Thermal and signature management • Advanced propulsion		• Vehicle integration expertise • Seekers and payloads • Advanced guidance and control		*Advanced high speed missiles and hypersonic weapons addressing survivability needs in highly contested environments*

Aircraft Engine Market

Raytheon Technologies

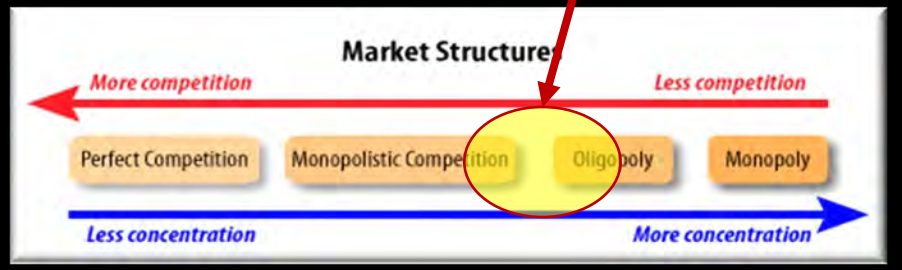
Portfolio

- Designs, manufactures, and supplies aircraft engines for the commercial, military, business jet and general aviation markets
- Support and sustainment services for life cycle of engines

Business market

- Commercial Engines, Military Engines, Business Aviation Engines, Regional Aviation Engines, General Aviation Engines, Auxiliary Power Units, and Helicopter Engines
- The company offers its products to aircraft manufacturers, aircraft leasing companies, airlines and other aircraft operators, and the US and foreign governments

PRATT & WHITNEY
DEPENDABLE ENGINES



P&W F135 engine, which powers the F-35 JSF

Aircraft Engine Market

Raytheon Technologies

Segments

Commercial Engines

- Passenger aircraft: Installed more than 13,000 large commercial engines
  - More than 25% of the world's mainline passenger fleet,
  - 63 engine types in service in 200 countries
- PW2000, GTF engine, PW4000-94, GP7200, V2500, JT8D, JT9D and others

Helicopter engines (turboshaft)

- PT6C, PW200, PW210, PT6T, and PT6B series

Business Aviation Engines (turbofan)

- PW800, PW600, and PW300

Regional aviation segment

- 3,500 PW100/PW150 turbofan engines across the globe.

Aircraft Engine Market

Raytheon Technologies

Military Engines

- Over 7,000 military engines to 34 armed forces
- Major engine manufacturer for military aircraft, along with GE
  - Includes F-15, F-16, F-22, F-35, B-52, B-21, C-17, EA-6, E-3, E-8, KC-135

Forbes

EDITORS' PICK | Feb 18, 2020, 01:06pm EST | 94,382 views

Why Pratt & Whitney's F135 Fighter Engine Will Be The Most Important Military Franchise Raytheon Technologies Owns

Loren Thompson Senior Contributor

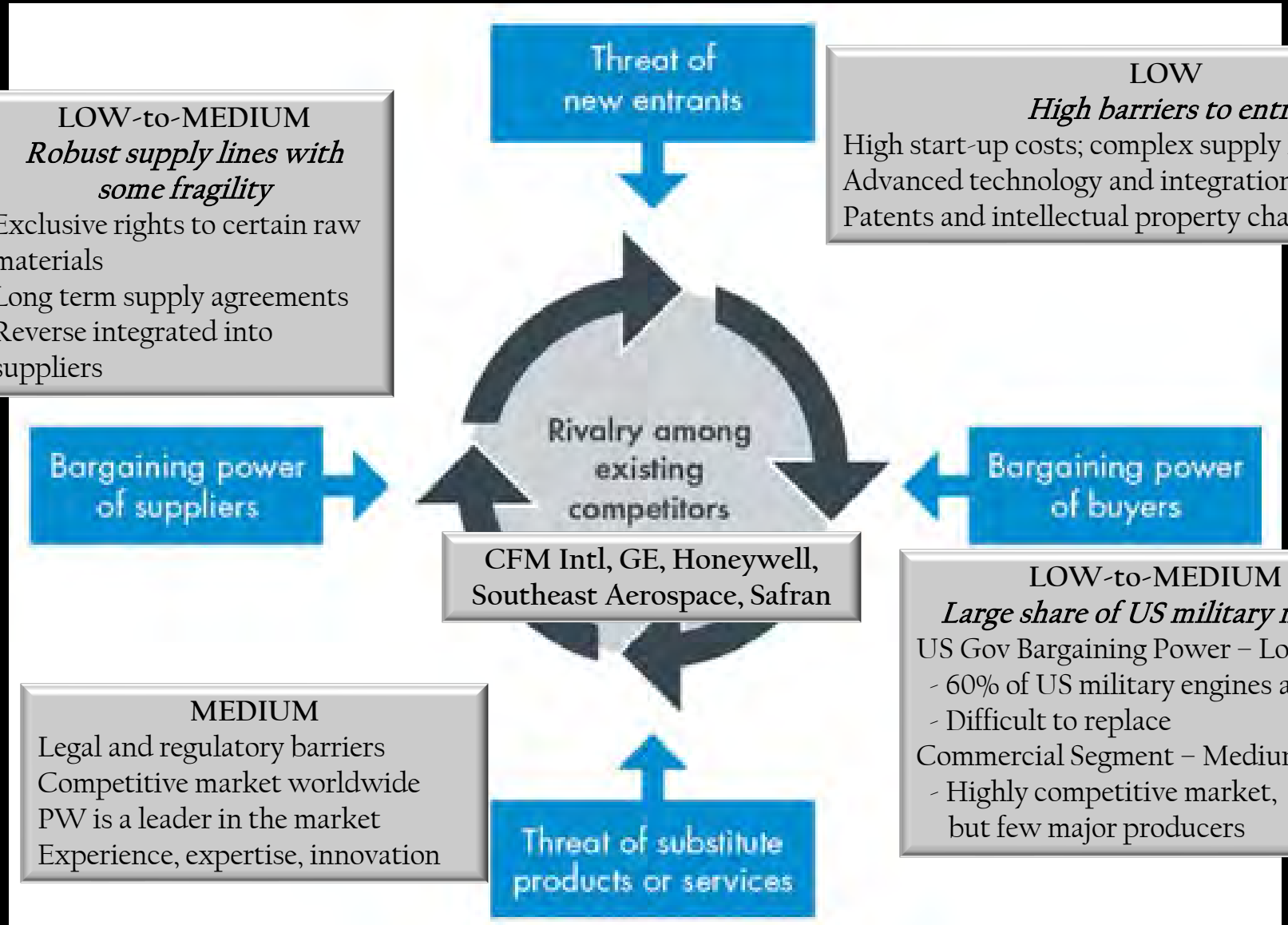
Aerospace & Defense

I write about national security, especially its business dimensions.

The F135 engine promises cash flow for half a century across 13 countries and a fleet of thousands of aircraft

Aircraft Engine Market: Porter's Five Forces

Raytheon Technologies



LOW-to-MEDIUM

Robust supply lines with some fragility

Exclusive rights to certain raw materials
Long term supply agreements
Reverse integrated into suppliers

LOW

High barriers to entry

High start-up costs; complex supply lines
Advanced technology and integration
Patents and intellectual property challenges

CFM Intl, GE, Honeywell, Southeast Aerospace, Safran

MEDIUM

Legal and regulatory barriers
Competitive market worldwide
PW is a leader in the market
Experience, expertise, innovation

LOW-to-MEDIUM

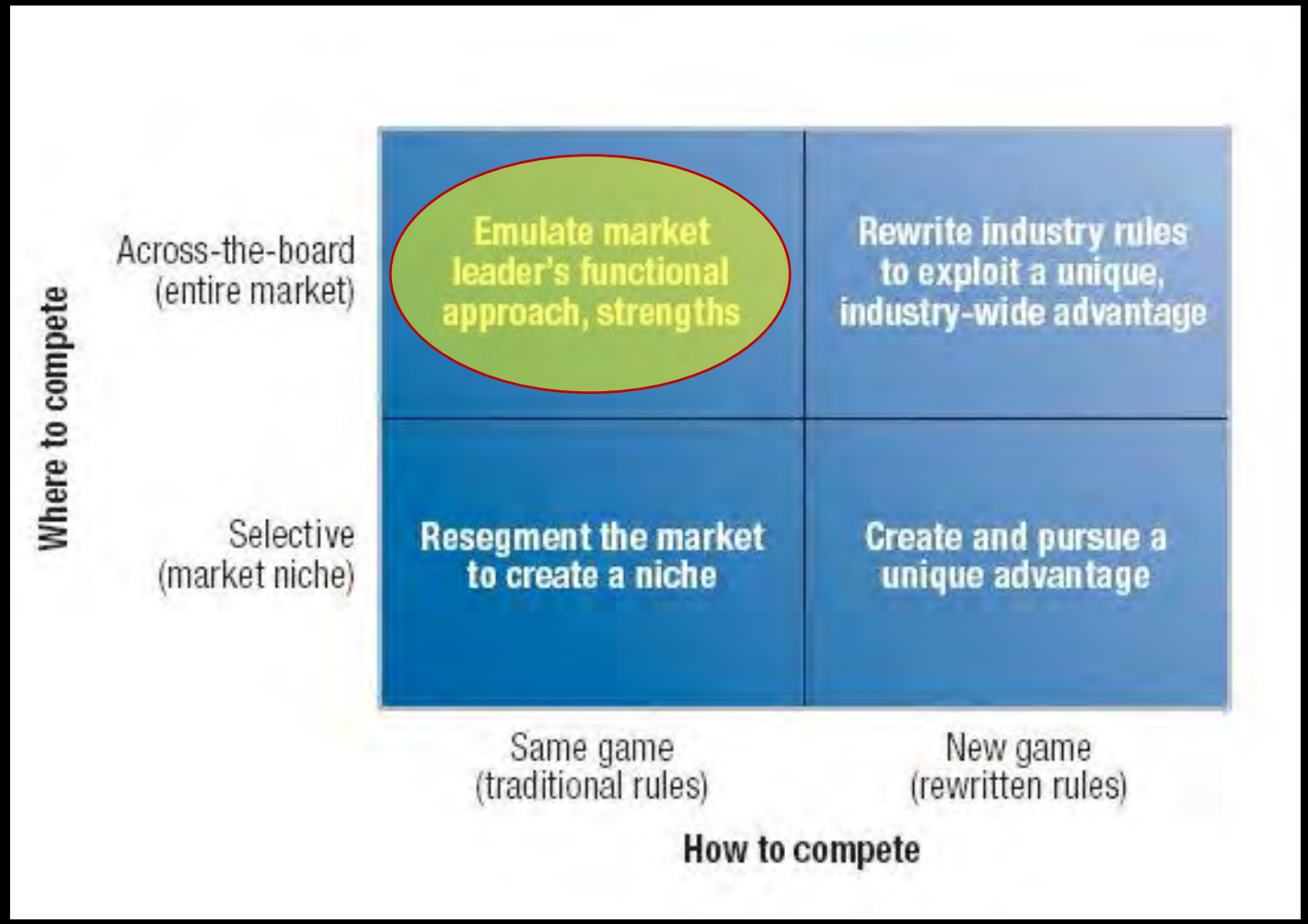
Large share of US military market

US Gov Bargaining Power – Low
- 60% of US military engines are PW;
- Difficult to replace

Commercial Segment – Medium
- Highly competitive market, but few major producers

Aircraft Engine Market: Strategic Gameboard

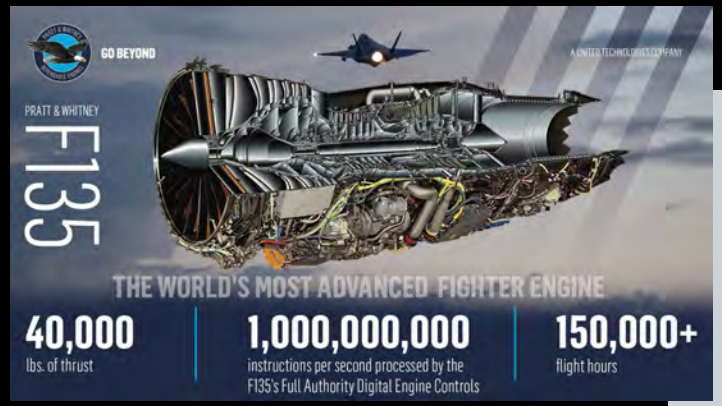
Raytheon Technologies

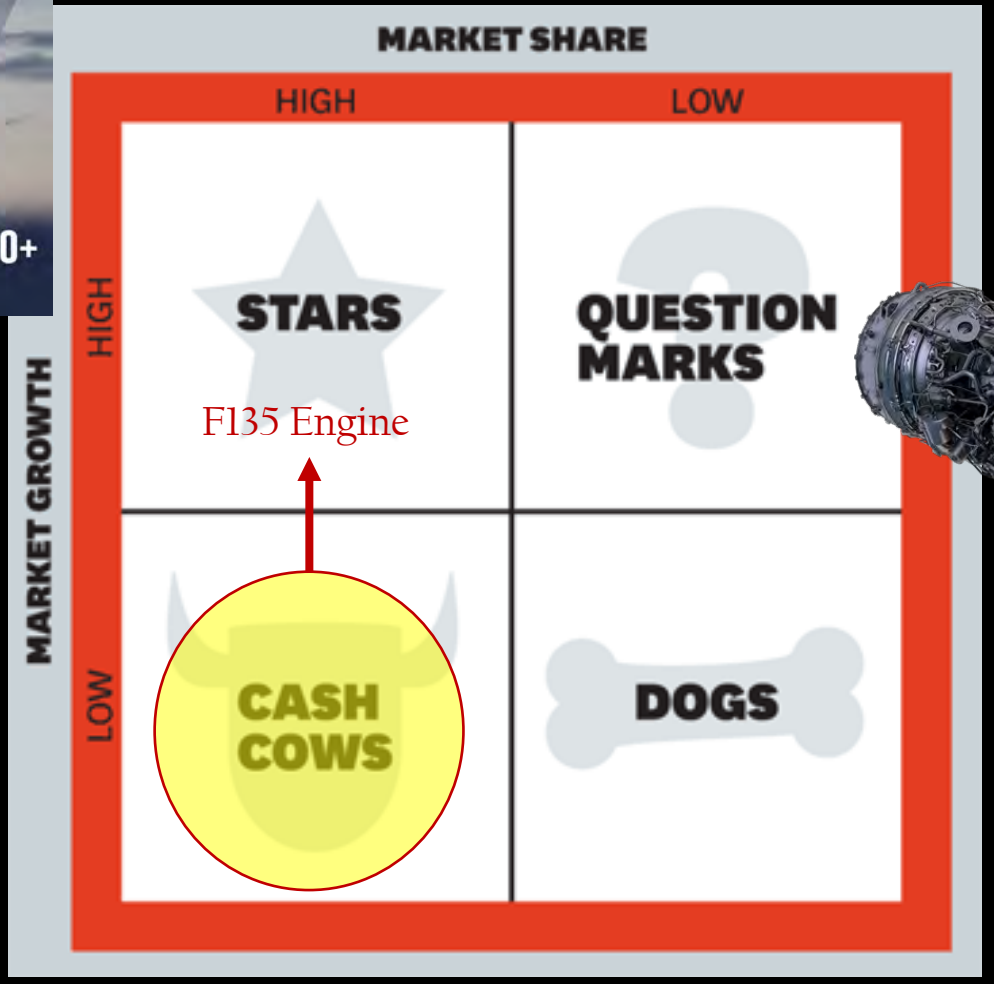


PRATT & WHITNEY
DEPENDABLE ENGINES

Pratt & Whitney provides 60% of US military aircraft engines and 25% of commercial aircraft engines globally. They compete in all major segments of the aircraft engine market, making the most of intersegment synergies and long-term cash flows.

Aircraft Engine Market: BCG Growth Share Matrix





Pratt & Whitney's broad market approach brings steady cash flows from diverse areas– commercial aviation, helicopter, turbofan, and military.

The F135 engine specifically reaches up to the "stars" quadrant, where PW enjoys monopolistic power across a growing subsegment of the market.

Raytheon Technologies

PRATT & WHITNEY DEPENDABLE ENGINES

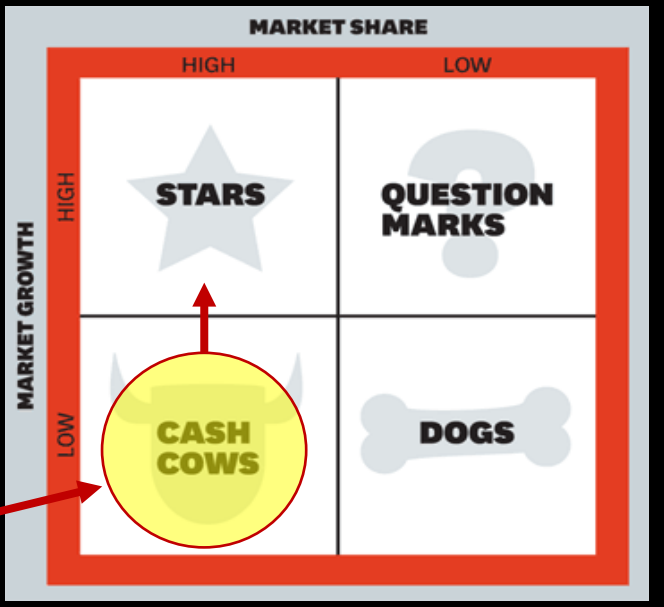
Aircraft Engine Market: Raytheon's Strategy (P&W)

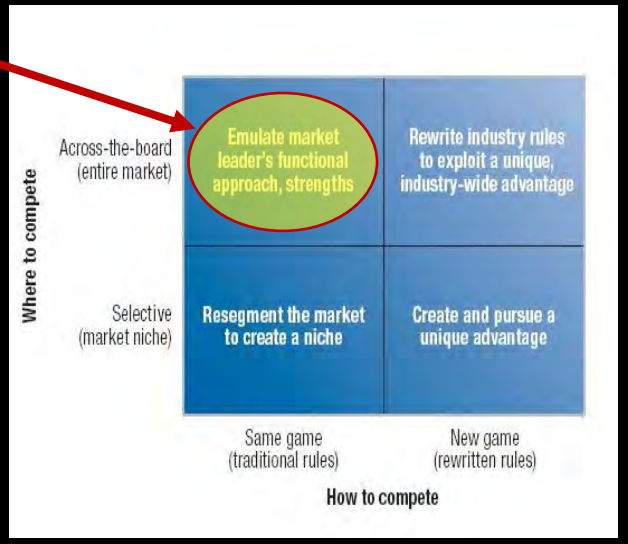
Pratt & Whitney Business Strategy focuses on

- Reworking business model and positioning as a solution provider to create improved value proposition for its customers
- Various products and offerings to provide holistic and end-to-end solutions
- Training and attract highly motivated, productive professionals. In this line, the strategy is to monitor adjusting remuneration systems by reinforcing human resources and pushing ahead with work style innovation.

Firm Strategy

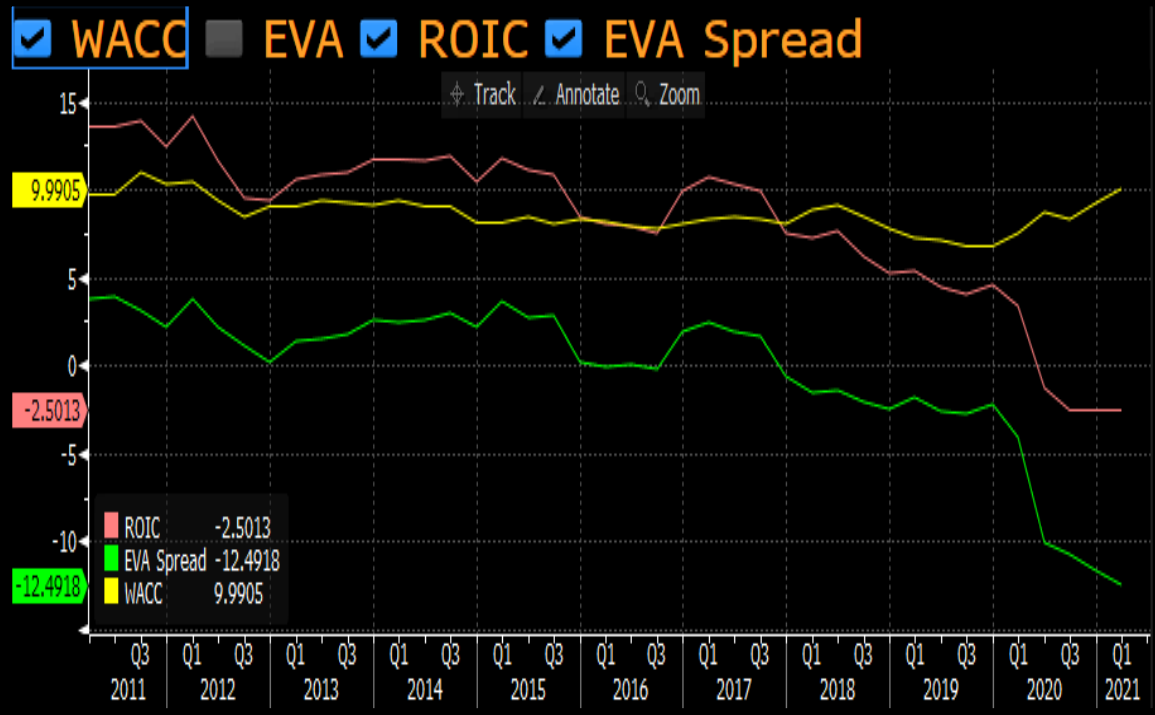
- Diversification
  - Defense and commercial contracts both domestic and international
  - Horizontal integration of multiple aviation industry leaders–
    Collins Aerospace and Pratt & Whitney
  - Risk mitigation through diversification of portfolios
  - Economies of scope; tangible & intangible resources
- Steady cash flows from existing programs
  - Adds resiliency across business cycles
  - Leverage experience and expertise to maintain and gain market share
  - Merger creates $1B in cost synergies annually
- Compete for next generation missile systems
  - Long Range Engagement Weapon
  - Hypersonics for various applications
  - AI
- Continue investments in growth areas
  - Air traffic control, PNT, sensors, etc.
  - Expand to civilian clients





Financial Analysis

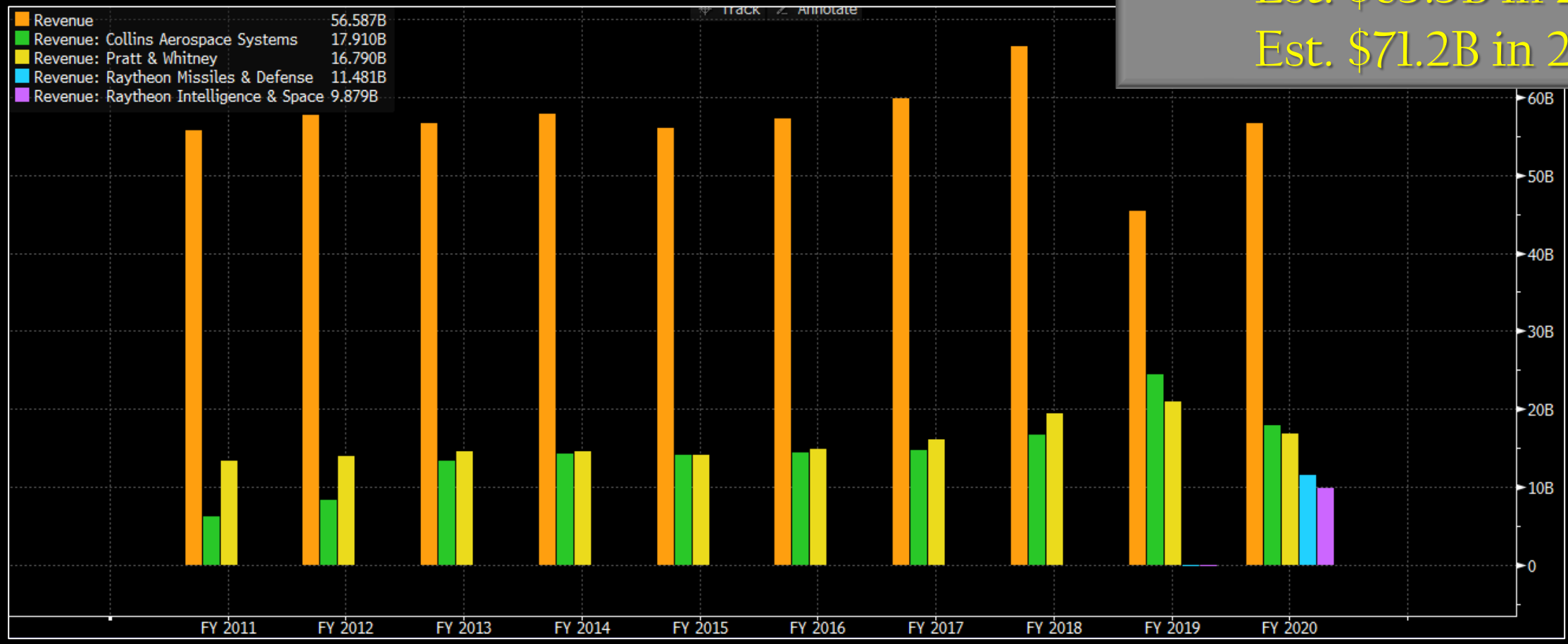
- Effects of the Raytheon merger and reduced sales in 2019-20 are still settling out
- Current ratio: 1.21
- LT Debt-to-Equity ratio: .44
- Economic Value Added?
  - 2020-2021 WACC 10% > ROIC -2%
  - Longer term, ROIC edges over WACC
  - Expected growth in revenues/ROIC



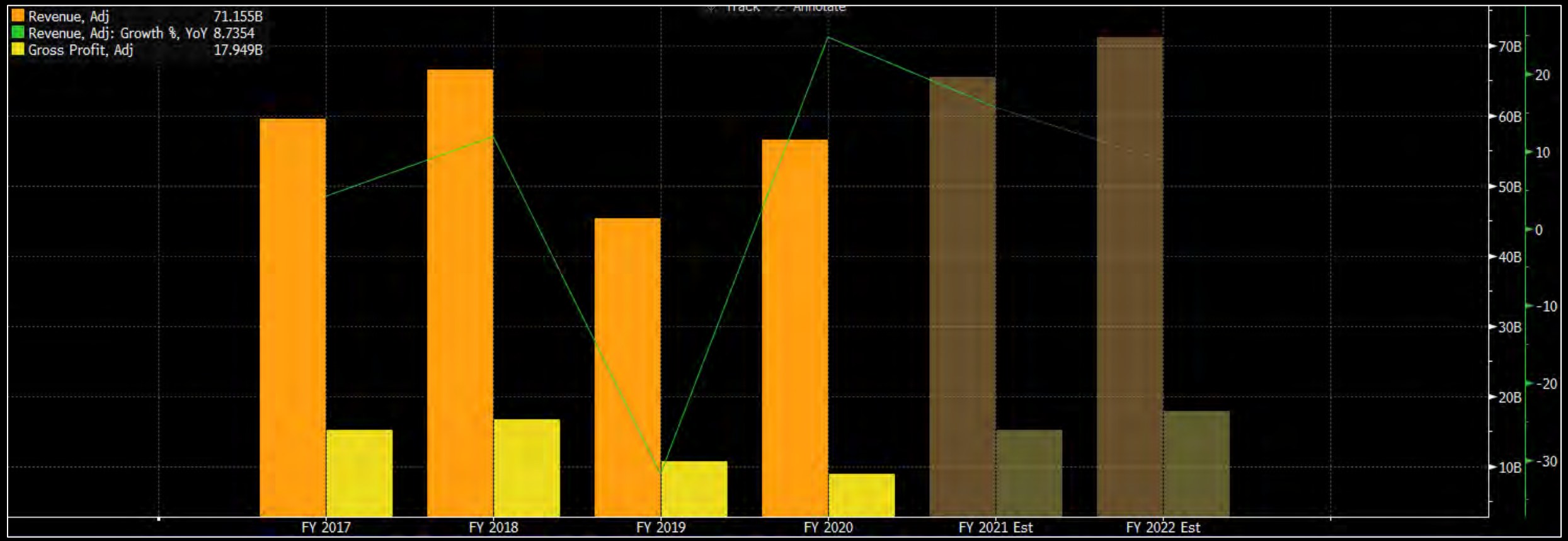
Financial Analysis

Raytheon Technologies

Revenues: $56.6B for 2020
Est. $65.5B in 2021
Est. $71.2B in 2022



Financial Analysis



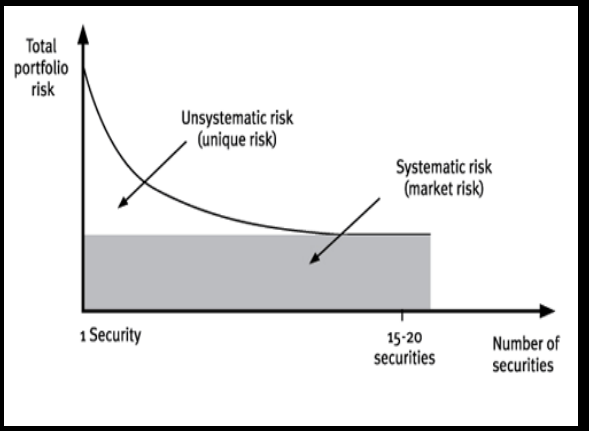
Expected to regain revenues and grow after merger integration is more complete and as sales pick up after COVID contraction

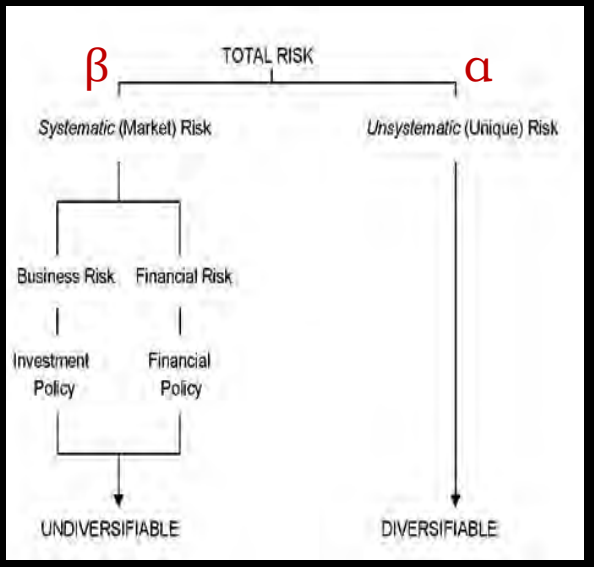
Financial Analysis

Raytheon Technologies

Longer Term Effects of Merger Are Unknown

+ Similar corporate strategies and cultures merging together
+ Complementary aerospace businesses– Collins + Raytheon
+ Internal capital funding structure may save money
- Merger transaction costs are high
- Integration and diversification synergies are difficult to fully realize
- Agency issues– separate businesses may compete rather than integrate
- Aviation industry is down and US defense budget is under pressure
? Will Pratt & Whitney still be a Raytheon business in 10 years?





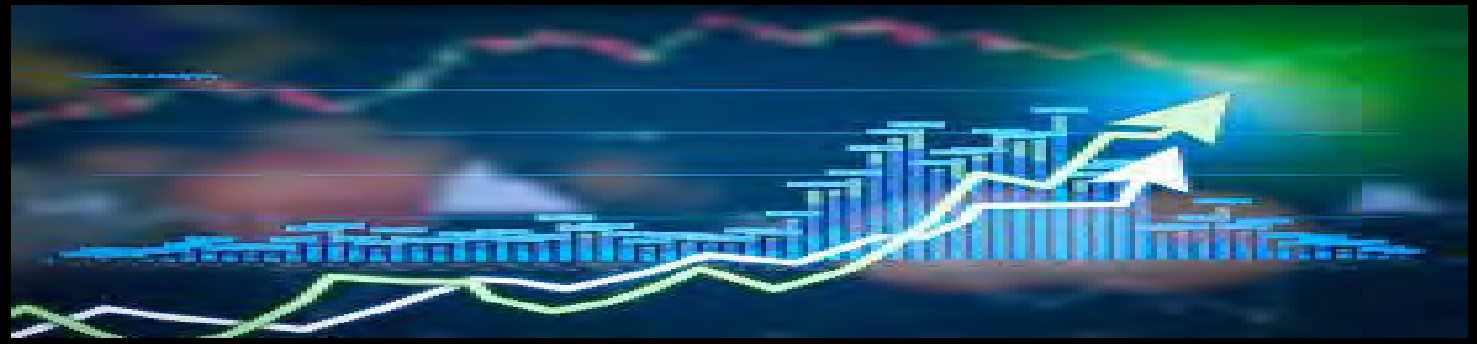
Financial Analysis

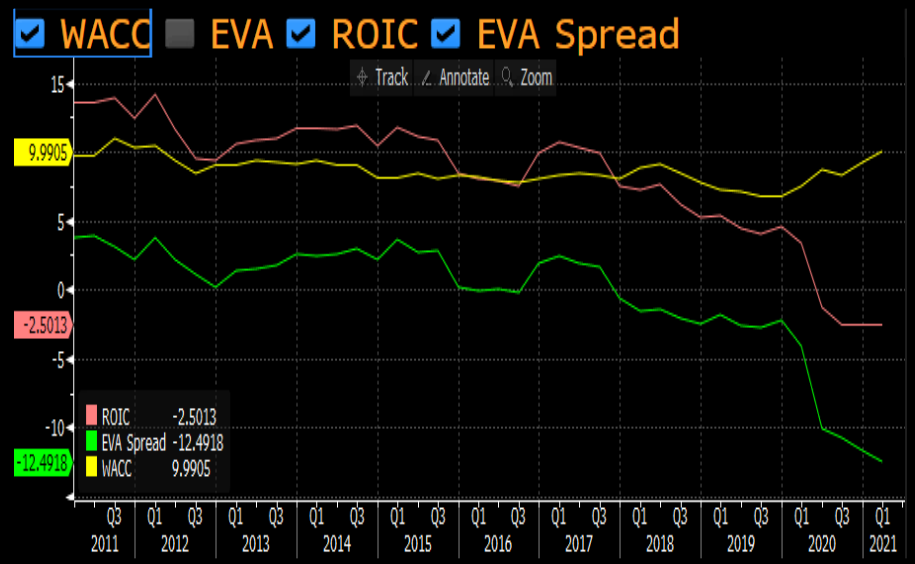
Raytheon Technologies

Does Raytheon create reasonable shareholder value?

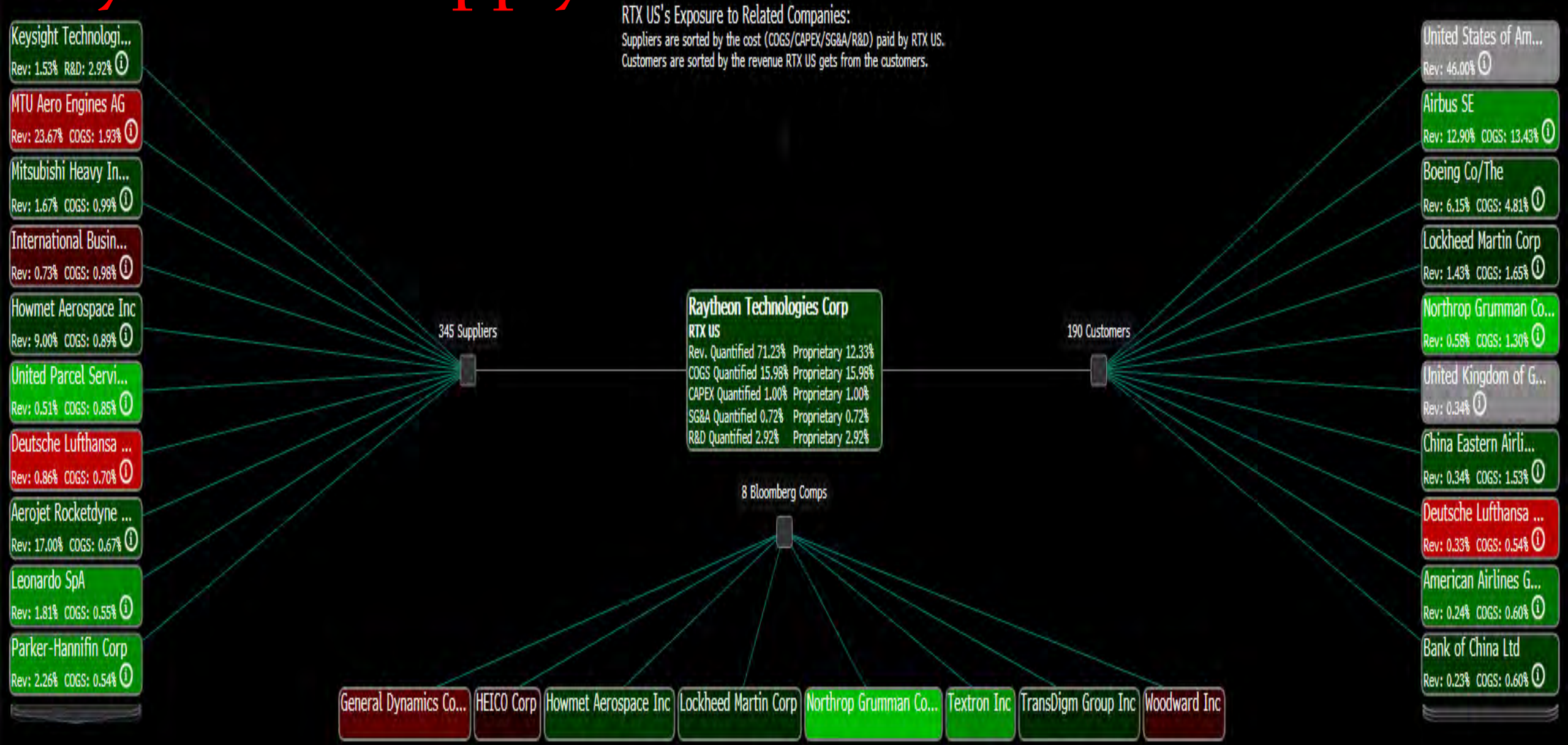
- Short term– No (ROIC ‹ WACC)
- Longer term– Maybe
  - Internal capital structure can decrease WACC
  - Future revenues expected to rebound

- With 100 years of success and the strength of the merger, Raytheon is well-positioned to offer shareholder value over time





Raytheon's Supply Chain



Human Capital Challenges

Raytheon Technologies

Three Pillars

1. Work Environment
   - Advance, diverse, equitable, inclusive
2. Skilled and Educated Workforce
   - Technical, engineering, science, and experience
3. Investment
   - Training, education, and development programs

Surge & Mobilization

Raytheon Technologies

- Actual vs potential output to increase production
- Develop and improve Cyber Security products -Military & civil
- Enhance Websense to strength Forcepoint
- 10.3% expected annual growth in defense segment
- 15% expected annual growth in civil segment
- Increase to 100% revenue in 2025
- Increase production efficiencies

Surge to 100%

- JIMPP coordinates the requirements with DoD
- Identify constraints to increase production in a crisis time caused by limited production capacity in war time defense systems
- Increased demands on a diminished sub tier, and extensive reliance on external suppliers
- Ability to get more defense systems in a hurry has considerable value when needed without exceeding six months or when DoD can take advantage of warning time

Mobilization to 300%

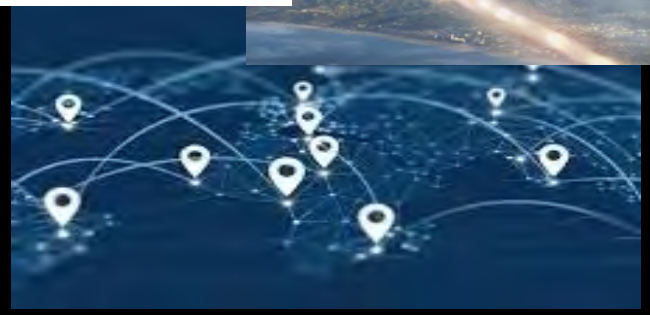
Recommendations for USG

Great Power Competition

- Partner with Raytheon and others to advance capabilities to offset China and Russia
  - Increase funding R&D for key capabilities and technologies–
    - Hypersonics, electronic warfare, GPS, comm
- Facilitate FMS/DCS for Raytheon businesses
  - Expand export markets for US-made goods to counterbalance PRC influence/market share– counter-BRI

Diversify Industry Base for Air-to-Air Missiles

- Wise to contract Lockheed-Martin to develop AIM-260
  - Breaks monopoly of Raytheon in air-to-air missiles
  - Recommend competing the production/sustainment after development
  - Or, dual-source production to add diversification and resilience
- Facilitate partnership between Raytheon and international base
  - Further diversify production and add resiliency to supply lines and human capital base



Recommendations for USG

Robust Supply Chains for Defense Goods

- Invoke DPA authorities to add diversification and prevent single-source suppliers
  - Mandate dual-source for key components and critical materials
- Continue to advance Trump administration's momentum for domestic resourcing– no reliance on PRC by 2023
  - Rare earth metals, critical elements (Ti, Co, Li, etc)

Human Capital Development

- Incentivize partnerships/internships with academia/research
- Promote international collaboration for next-generation technologies
  - NAMMO/MBDA/Rafael for hypersonics

Conclusions

Raytheon Technologies

- Centenarian Company With Market-Leading Businesses
  - *There are good reasons Raytheon has been around for 100 years*
- Steady, Sustainable, Balanced Business Model
  - *Defense + Commercial… US + International… Cash Cows + Reaching for Stars*
- Facing Similar Challenges to Other Defense Companies
  - *R&D funding, fragility in supply chains, generational human capital drain*


Raytheon Technologies

QUESTIONS?