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Predicting and Minimizing Industrial Base Risks on Emerging Technologies

2022 ICEAA Professional Development & Training Workshop

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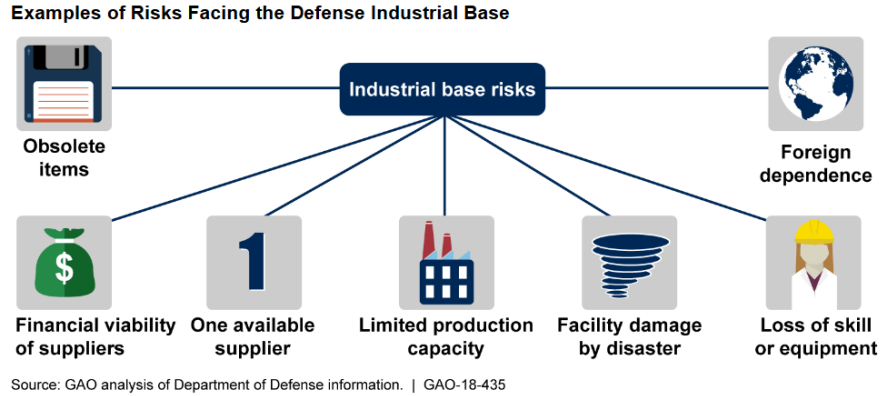
Agenda

- Objective & Approach
- Industrial Base Risks
- Risk Identification Framework
- Framework Example: Hypersonics
- Conclusions
- Potential Uses

Objective and Approach

- Objective:
  - Develop a methodology to predict how industrial base constraints will impact programmatic schedule and cost on emerging technologies and minimize overall risk
  - Apply standard cost estimating techniques (Analogy, Risk & Uncertainty, Economic Analysis)
- Technology Timeframe: Focus on when the technology is being transitioned from *government* led experiments to *industry* led development as part of an Acquisition Program
- Case Study:
  - Focus on emerging technology of Hypersonic Missiles
  - Leverage JHU/APL SMEs
  - Methodology of identifying risks early in the development phase can be leveraged for other emerging technologies

Industrial Base Analysis



- GAO definition of US Defense Industrial Base – Combination of people, technology, institutions, technological know-how, and facilities used to ***design, develop***, manufacture, and maintain the weapons needed to meet US national security objectives
- Document Review
  - 2018 GAO Industrial Base Report (GAO-18-435)
  - 2018 SecDef Report: Assessing and Strengthening the Manufacturing and Defense Industrial Base and the Supply Chain Resiliency of the United States
  - GAO Technology Assessment Guide
- Strategic Technology Protection & Exploitation (STP&E) Technology and Manufacturing Industrial Base (TMIB) directorate under OUSD(R&E)
  - Focused on DoD Manufacturing technology evaluation (ManTech Program)
  - Assess health and risks of emerging technology industrial base; develop long term strategies
- Office of Industrial Policy under OUSD(A&S)
  - Policies for maintenance of the US defense industrial base
  - Anticipate and close gaps in manufacturing capabilities for defense systems
- Individual Program Offices and Military departments responsible for identifying risks within their own areas
- DCMA's Industrial Analysis Group
  - Used by program offices to conduct industrial base assessments
  - Have information on 70% of DoD's major defense acquisition programs: sub-tier suppliers, unique capabilities, minimum monthly production rates

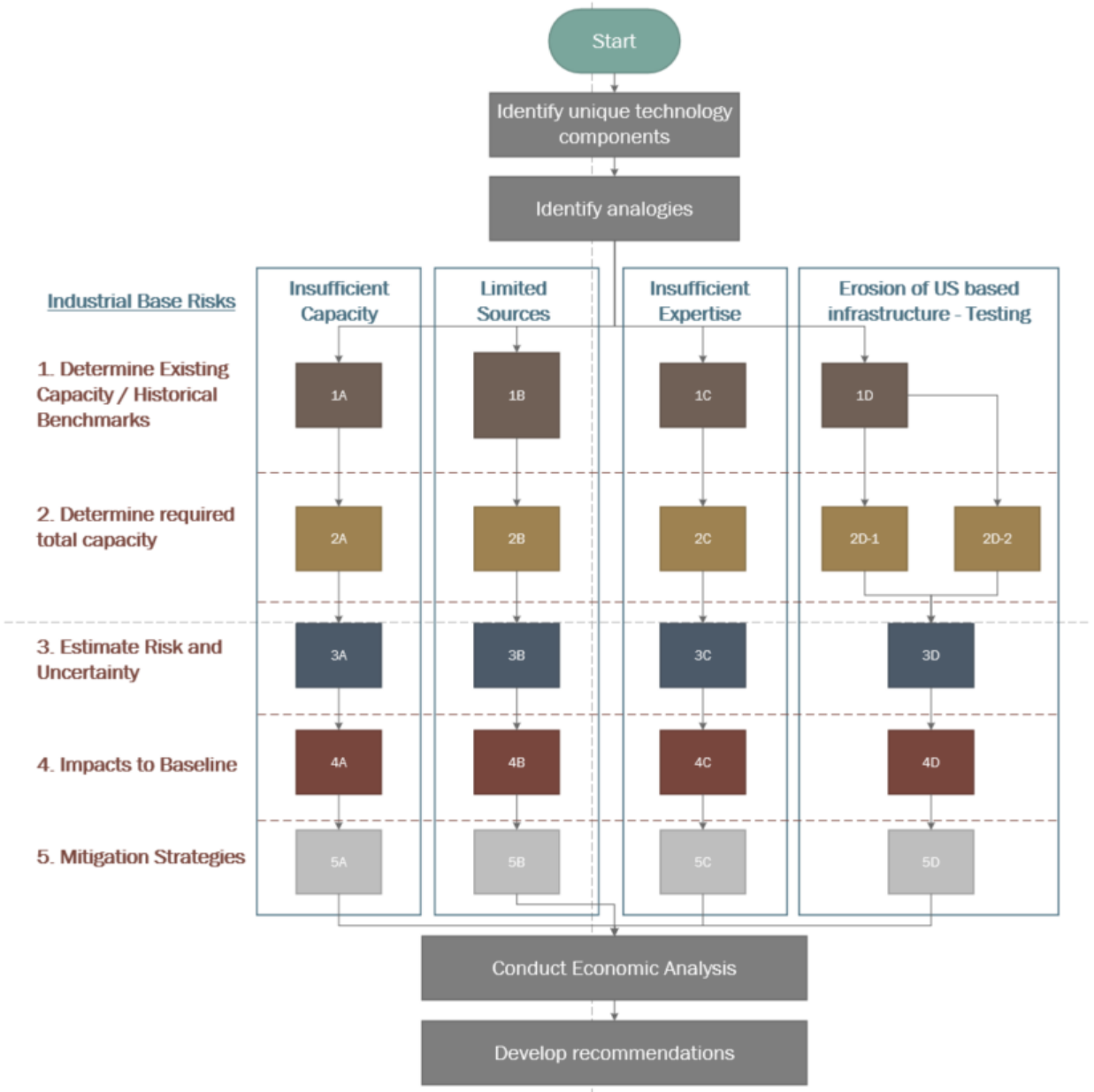
DoD mechanisms to address industrial base issues are focused on Production and Sustainment

Industrial Base Risks during System Development

Risk	Definition
Insufficient Capacity	Capacity is unavailable in required quantities or time due equipment or personnel limitations
Limited Sources	Only one supplier is able and/or qualified to provide the required capability
Insufficient Expertise	Industry is unable to hire or retain U.S. workers with the necessary skill sets
Erosion of U.S. based infrastructure	Loss of specialized capital equipment needed to integrate, manufacture, **test**, or maintain capability
Product security	Lack of cyber and physical protection results in eroding integrity, confidence, and competitive advantage
Supplier Financial Fragility	A specific supplier is financially challenged
Foreign Dependency	Domestic industry does not produce the product, or does not produce it in sufficient quantities
Diminishing manufacturing sources & material shortages (DMSMS)	Product of material obsolescence resulting from decline in relevant suppliers
Fragile Market	Structurally poor industry economics; potentially approaching domestic extinction
Emergencies or Disasters	Natural or man-made disasters that could disrupt operations (Ex: Pandemic)

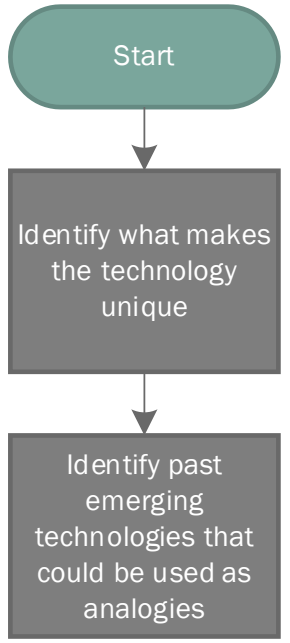
Smaller subset of risks are relevant to Development programs

Risk Identification Framework



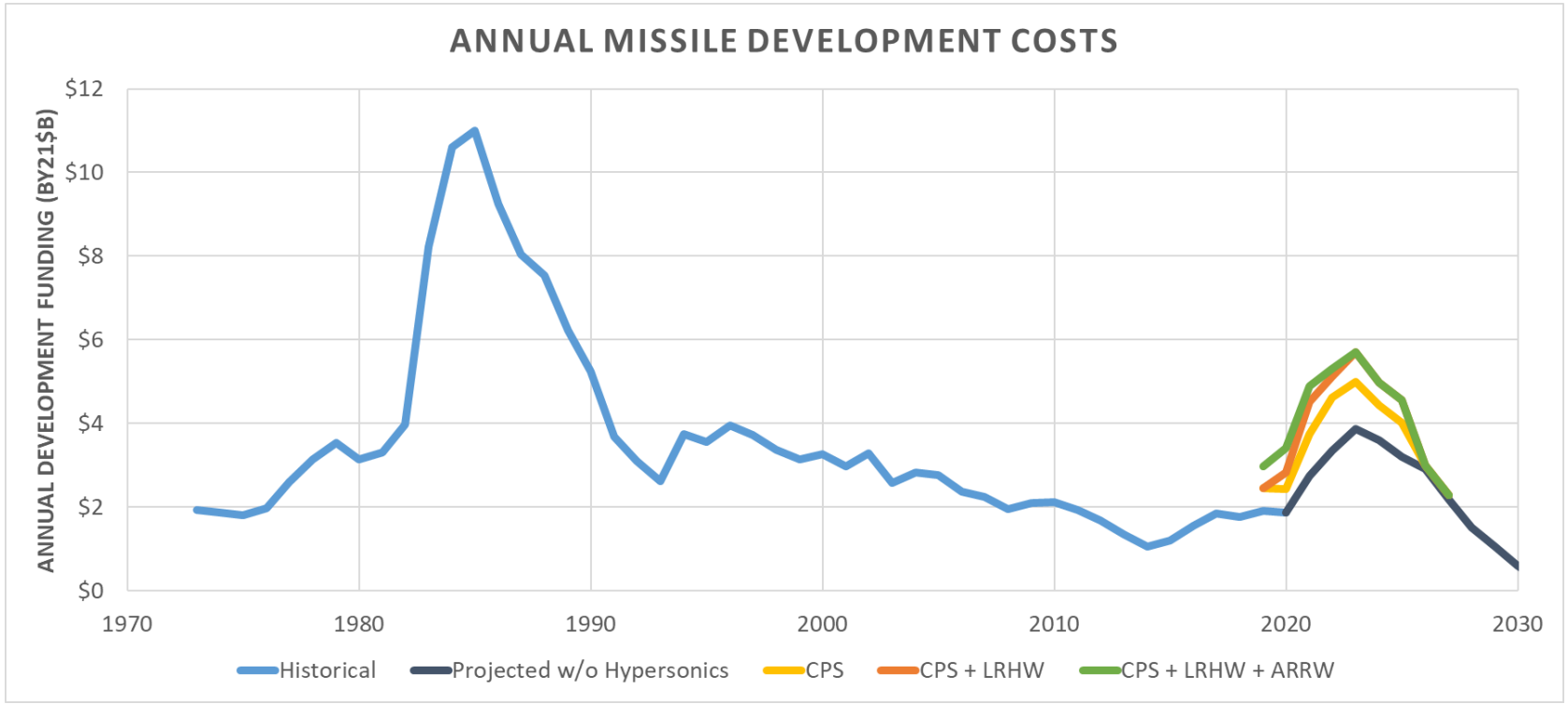
Risk Identification Framework – Hypersonic Use Case

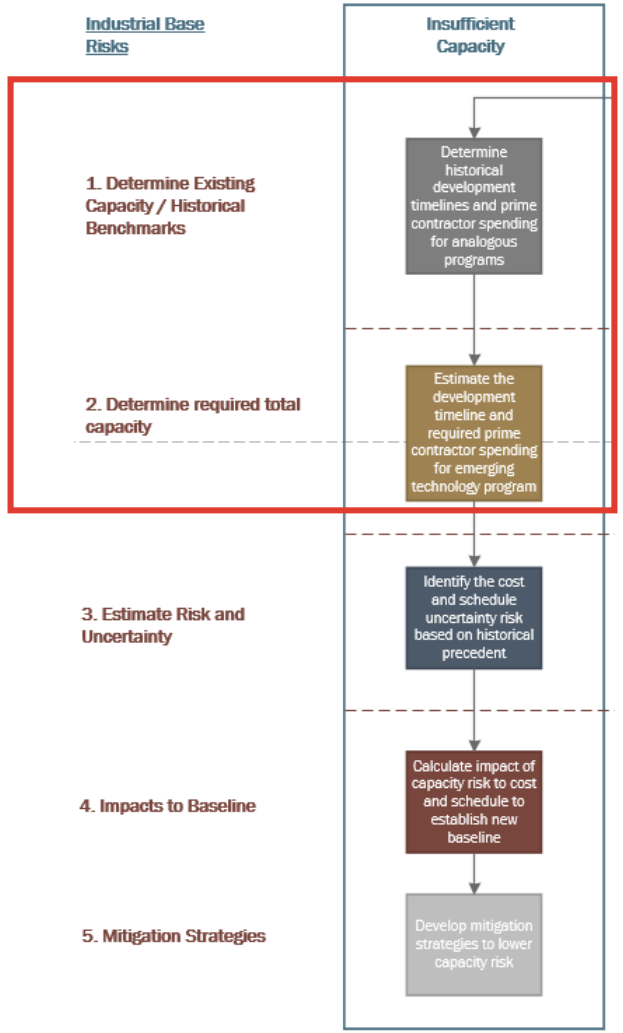
- Identify what makes the technology unique
  - Interviewed APL SMEs to identify
  - Two types of hypersonic missiles: **Glide Vehicles**, Cruise Missiles (Scramjets)
  - Advanced materials used for Thermal Protection Systems
  - Advanced control hardware
- Identify past emerging technologies that could be used as analogies
  - Advanced Materials
    - Ballistic Missile Reentry systems (Trident, Minuteman)
    - Airframe Composites (F-18)
    - Stealth (F-117)
  - Advanced Controls
    - Ballistic Missile Post Boost Control Systems (Trident, Minuteman)
    - Cruise Missiles (Tomahawk)
  - Missile Systems



Identifying historical, analogous programs provides data points that can be analyzed

Insufficient Capacity – Historical & Required Capacity





1. Determine Historical Development Timelines and Prime Contractor Spending for Analogous Programs

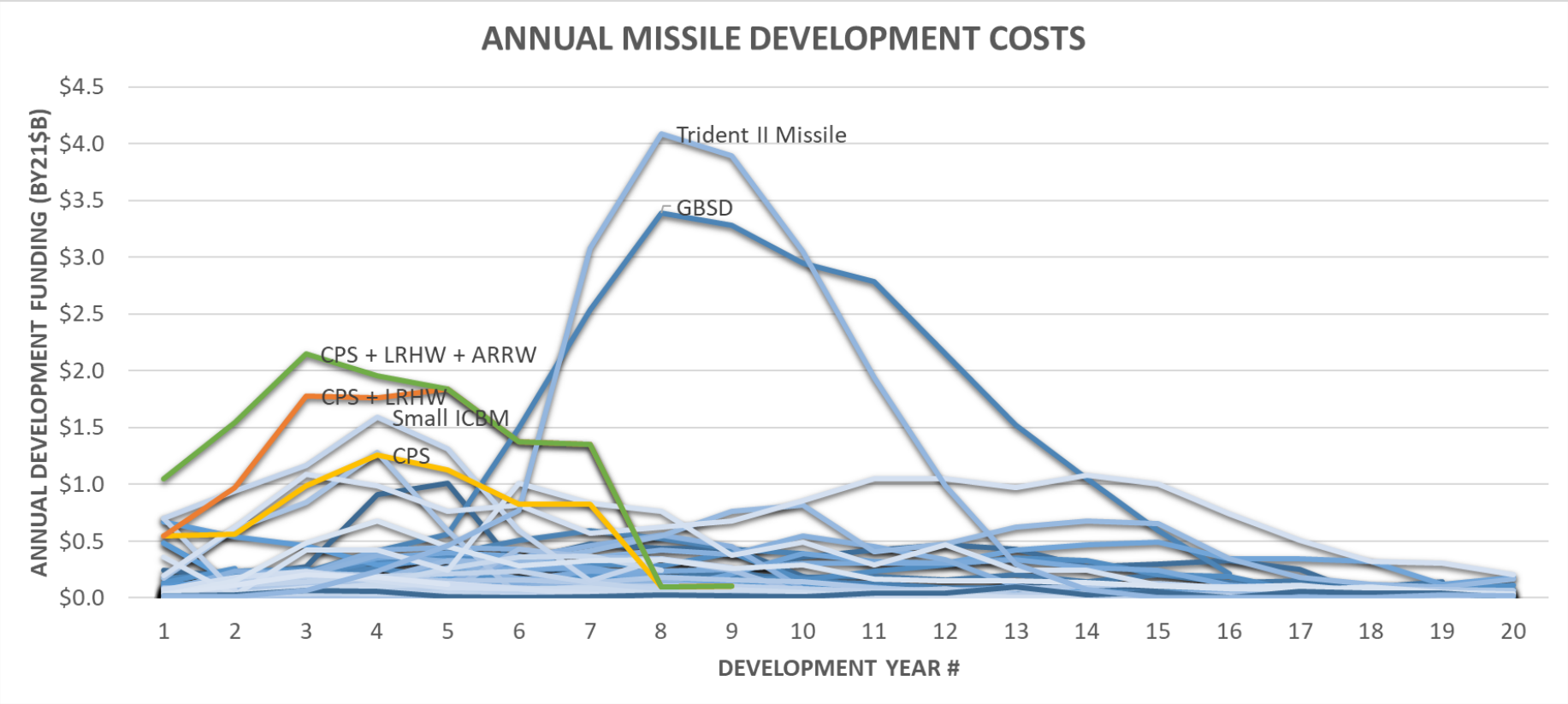
- Data Source: DTIC
  - Selected Acquisition Reports (SAR) Funding Appropriations
  - Development timelines with annual funding for missile programs since 1973 (~90)
- Prime Contractor infrastructure and expertise has likely declined highlighting insufficient capacity

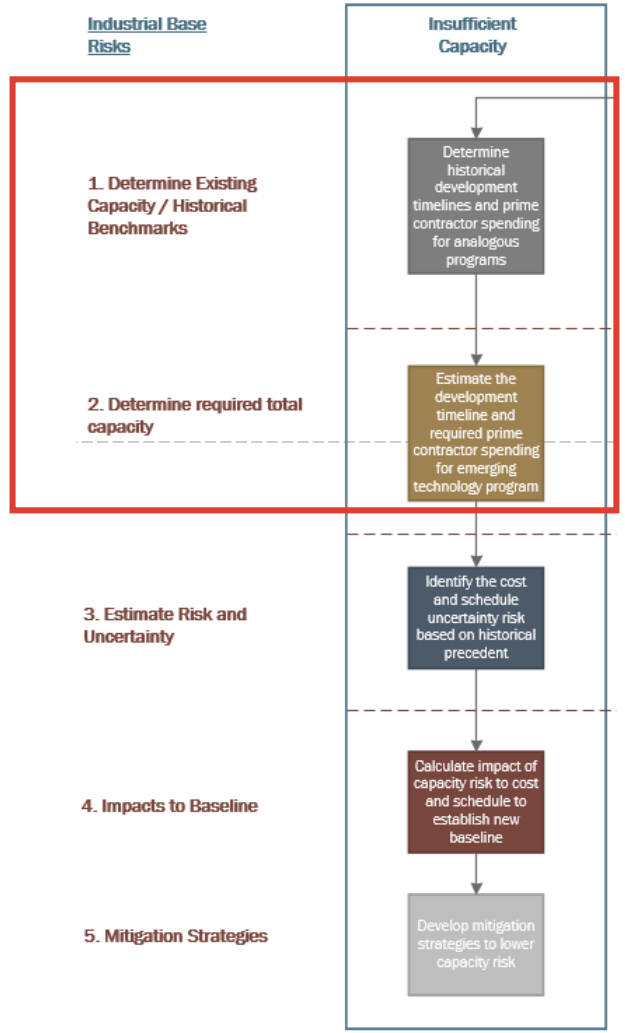
2. Estimate the development timeline and required prime contractor spending for the emerging technology program

- Data Source: FY21 President's Budget Submissions for Hypersonic Programs
- Hypersonic program budgets account for a significant short term increase

Missile development funding has been in decline for the last 30 years

Insufficient Capacity – Historical & Required Capacity

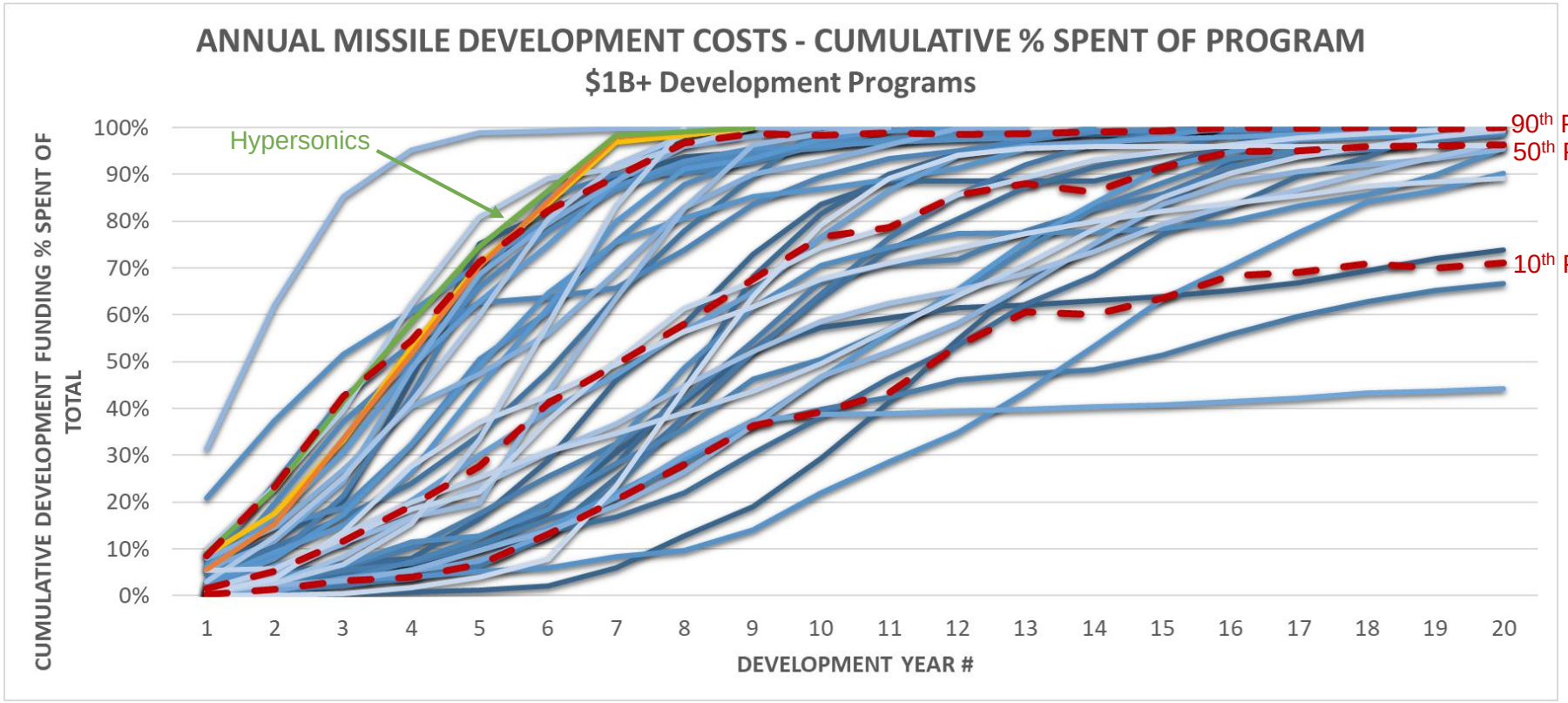


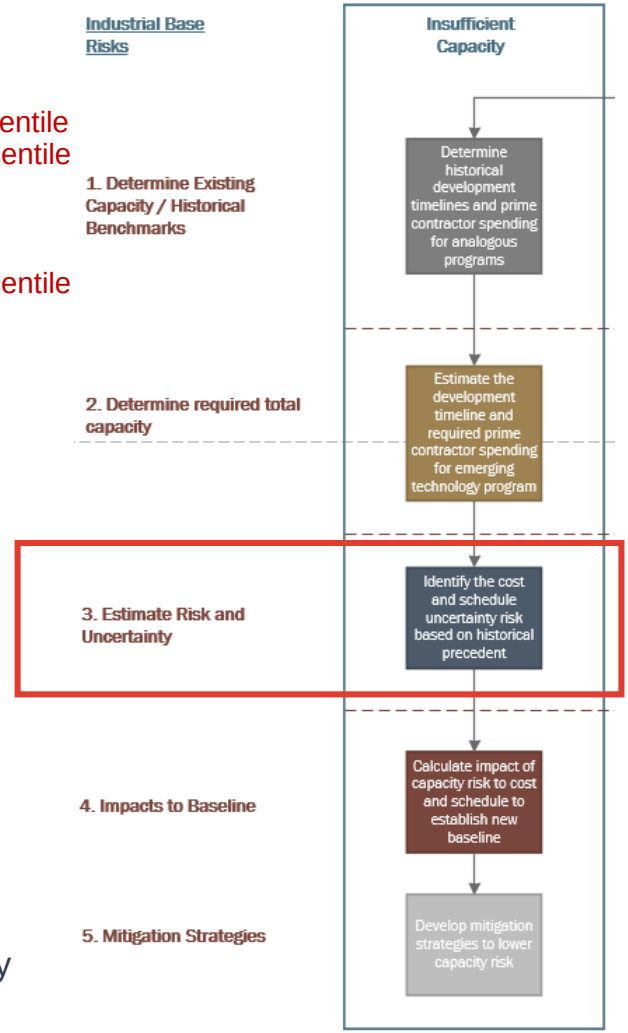


- CPS, LRHW, and ARRW hypersonic programs all being developed simultaneously by one lead system integrator
- Hypersonic programs are spending money quicker than any missile program historically
- Only Trident II has had higher peak spending but ramped up over 9 years

Hypersonic programs are planning to spend more money faster than any other missile program

Insufficient Capacity – Risk and Uncertainty



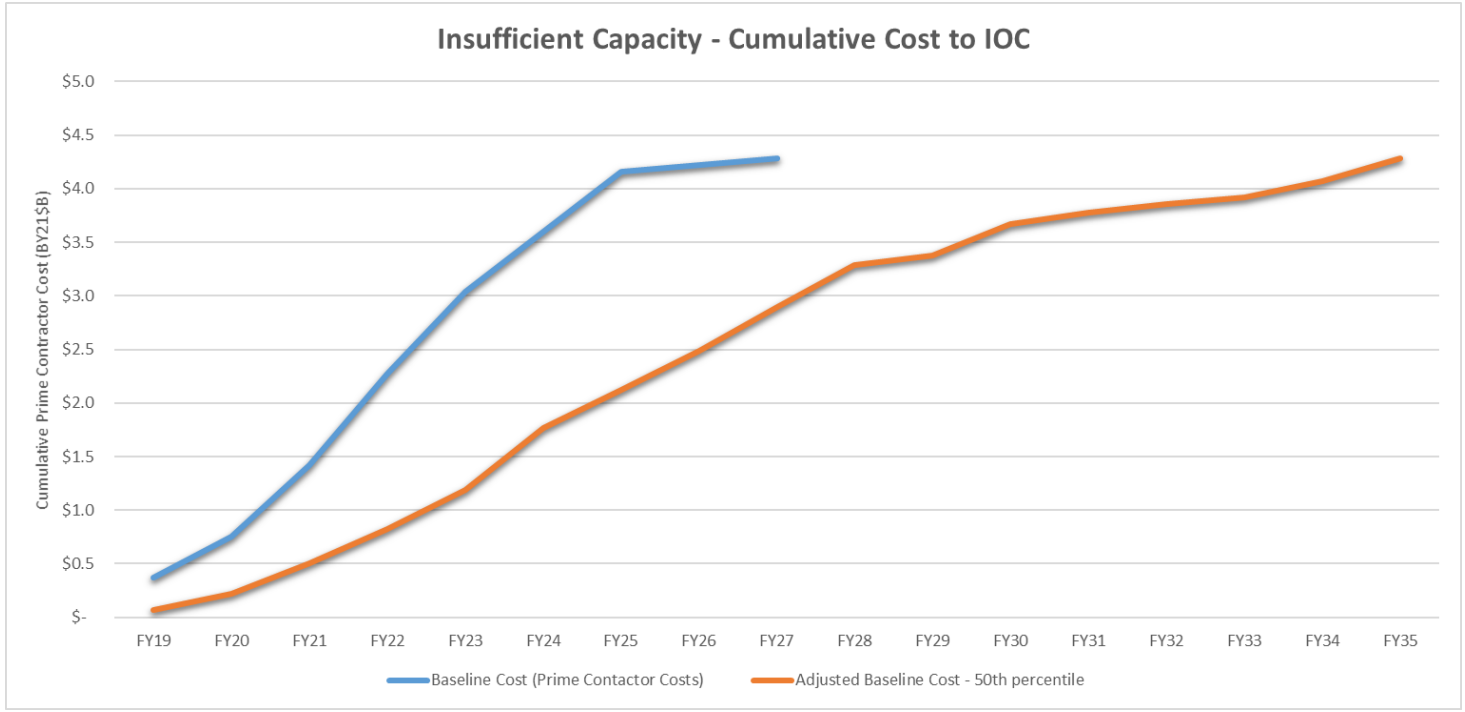


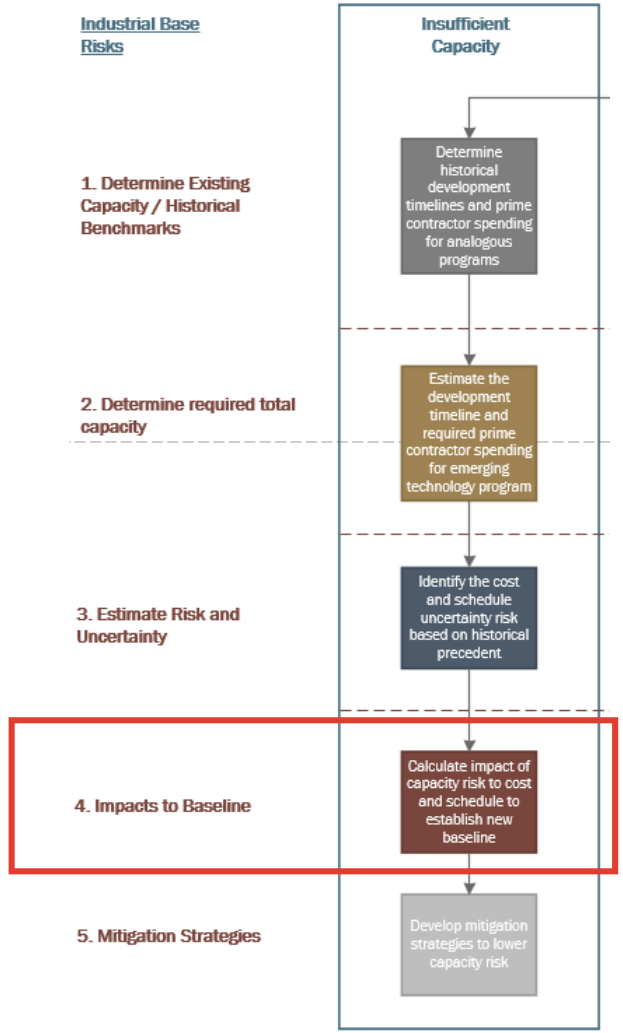
3. Identify the cost and schedule uncertainty risk based on historical precedent

- Normalizing the annual funding by the cumulative percentage spent over time allows for risk quantification
- Planned hypersonic missile program spending is at ~90th percentile (top red dotted line) which indicates very high risk

Hypersonic development is planned at a high level of risk

Insufficient Capacity – Impacts to Baseline





4. Calculate impact of Capacity Risk to cost and schedule to establish a new baseline

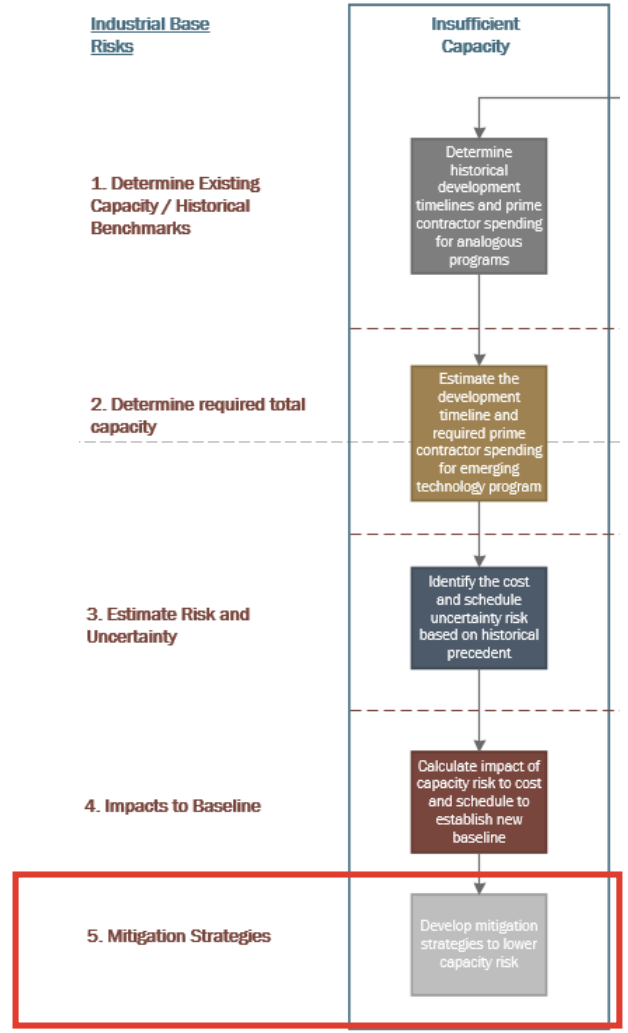
- Estimates reflect prime contractor costs only (~70%)
- Baseline plan has a 10% confidence and is adjusted to have a 50% confidence based on similar historical programs
- Adjusting the baseline delays the IOC by 8 years

Significant delay to IOC based on comparison to historical programs

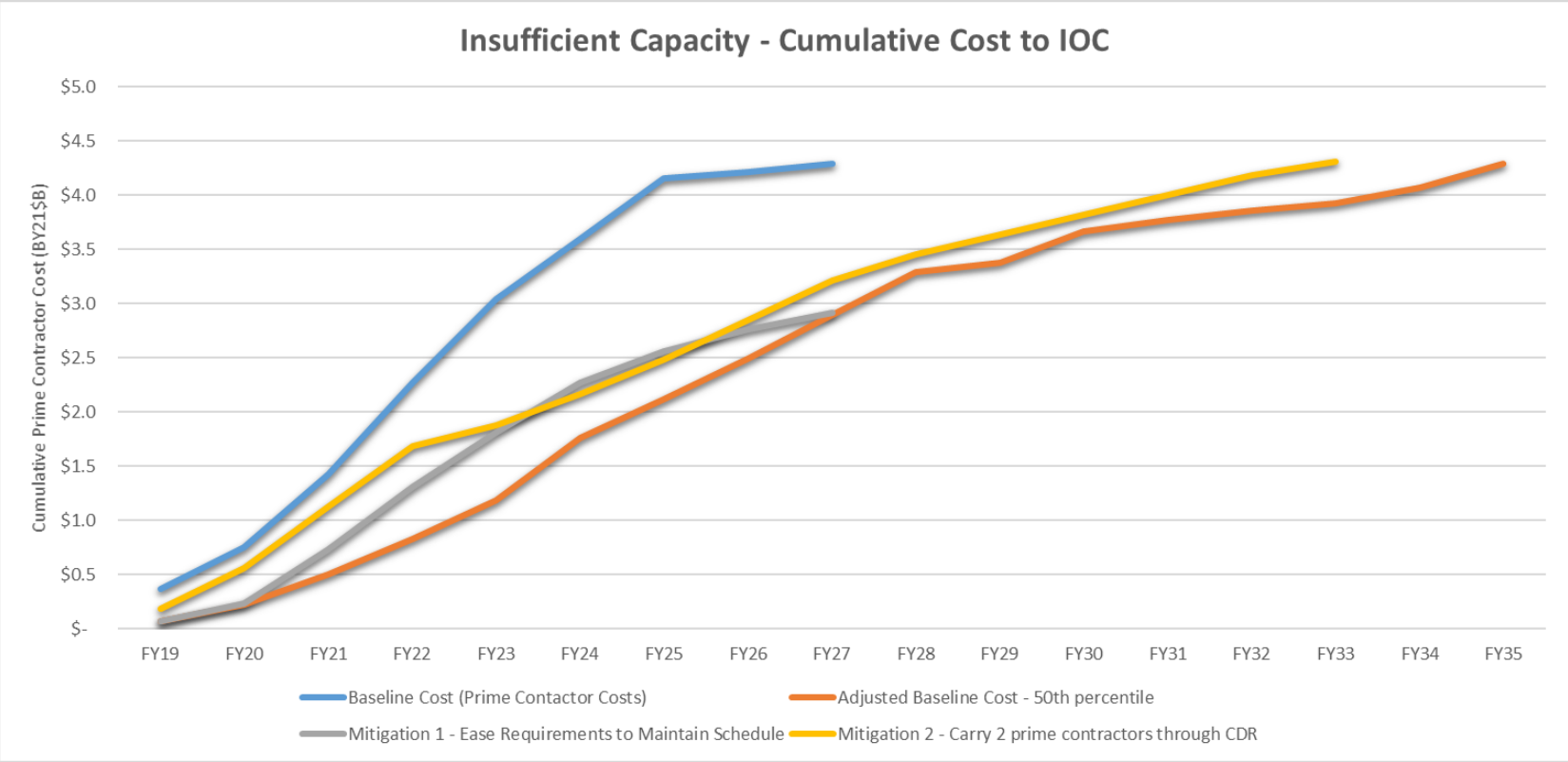
Insufficient Capacity – Mitigation Strategies

5. Develop mitigation strategies to lower capacity risk

- Mitigation Strategy 1 – Ease Requirements to Maintain Schedule
  - Description:
    - Reduce number of operational platforms
    - Maintain existing glide body design (no changes/upgrades)
  - Impact:
    - Significantly reduces the estimated non-recurring development cost
    - Decreases the number of tests due to a stable design and platform
    - Missile capability is reduced which may not fulfill Navy requirement
- Mitigation Strategy 2 – Carry 2 prime contractors through CDR
  - Description:
    - Contract multiple contractors through the Critical Design Review
    - No changes to the overall program requirements
  - Impact:
    - Reduction of risk as multiple primes are competing
    - Increased overall program cost but individual cost per prime is reduced
    - May increase the Insufficient Expertise risk



Insufficient Capacity – Mitigation Strategies



Alternative	Cost (BY21$M)		Schedule		Schedule Risk	
	Development Cost	Cost Increase	Years to IOC	Change	Confidence Level	Change
Baseline	$4,288		9		10%	
Adjusted Baseline	$4,288	$ -	17	+8	50%	+40%
Mitigation 1 - Ease Requirements to Maintain Schedule	$2,912	-$1,376	9	0	50%	+40%
Mitigation 2 - Carry 2 prime contractors through CDR	$4,310	+$23	15	+6	50%	+40%

Economic Analysis

Conduct Economic Analysis of Mitigation Strategies to determine impact on risk adjusted baseline

Industrial Base Risk	Alternative	Cost (BY21$M)		Schedule		Schedule Risk	
		Development Cost	Cost Increase	Years to IOC	Change	Confidence Level	Change
Insufficient Capacity	Baseline	$4,288		9		10%	
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	Mitigation 2 - Carry 2 prime contractors through CDR	$4,310	+$23	15	+6	50%	+40%
Limited Sources	Baseline	$31		7		2%	
	Adjusted Baseline	$30	-$1	10	+3	80%	+78%
	Mitigation 1 - Purchase oven to double capacity	$45	+$14	7	0	65%	+63%
	Mitigation 2 - Purchase 2 ovens to triple capacity	$56	+$25	6	-1	80%	+78%
	Mitigation 3 - Add a new supplier	$61	+$30	7	0	80%	+78%
Erosion of US Based Infrastructure - Testing	Baseline	$125		7		12%	
	Adjusted Baseline	$180	+$55	10	+3	50%	+38%
	Mitigation 1 - Create instrumented hypersonics flight corridor	$497	+$372	7	0	50%	+38%
	Mitigation 2 - Leverage efficiencies with Trident to share assets	$155	+$30	8	+1	50%	+38%

- Significant schedule risk exists in the baseline schedule
- Largest Programmatic Risk is associated with Insufficient Capacity as it has the greatest impact on schedule
- Targeted investments in industrial base risk areas can be made to decrease programmatic risk

Mitigation Recommendations

Develop recommendations of risk mitigation strategies based on ROI or other metrics

Industrial Base Risk	Alternative	Cost (BY21$M)		Schedule		Schedule Risk		Priority
		Development Cost	Cost Increase	Years to IOC	Change	Confidence Level	Change	
Insufficient Capacity	Baseline	$4,288		9		10%		
	Adjusted Baseline	$4,288	$ -	17	+8	50%	+40%	3
	Mitigation 1 - Ease Requirements to Maintain Schedule	$2,912	-$1,376	9	0	50%	+40%	1
	Mitigation 2 - Carry 2 prime contractors through CDR	$4,310	+$23	15	+6	50%	+40%	2
Limited Sources	Baseline	$31		7		2%		
	Adjusted Baseline	$30	-$1	10	+3	80%	+78%	4
	Mitigation 1 - Purchase oven to double capacity	$45	+$14	7	0	65%	+63%	2
	Mitigation 2 - Purchase 2 ovens to triple capacity	$56	+$25	6	-1	80%	+78%	1
	Mitigation 3 - Add a new supplier	$61	+$30	7	0	80%	+78%	3
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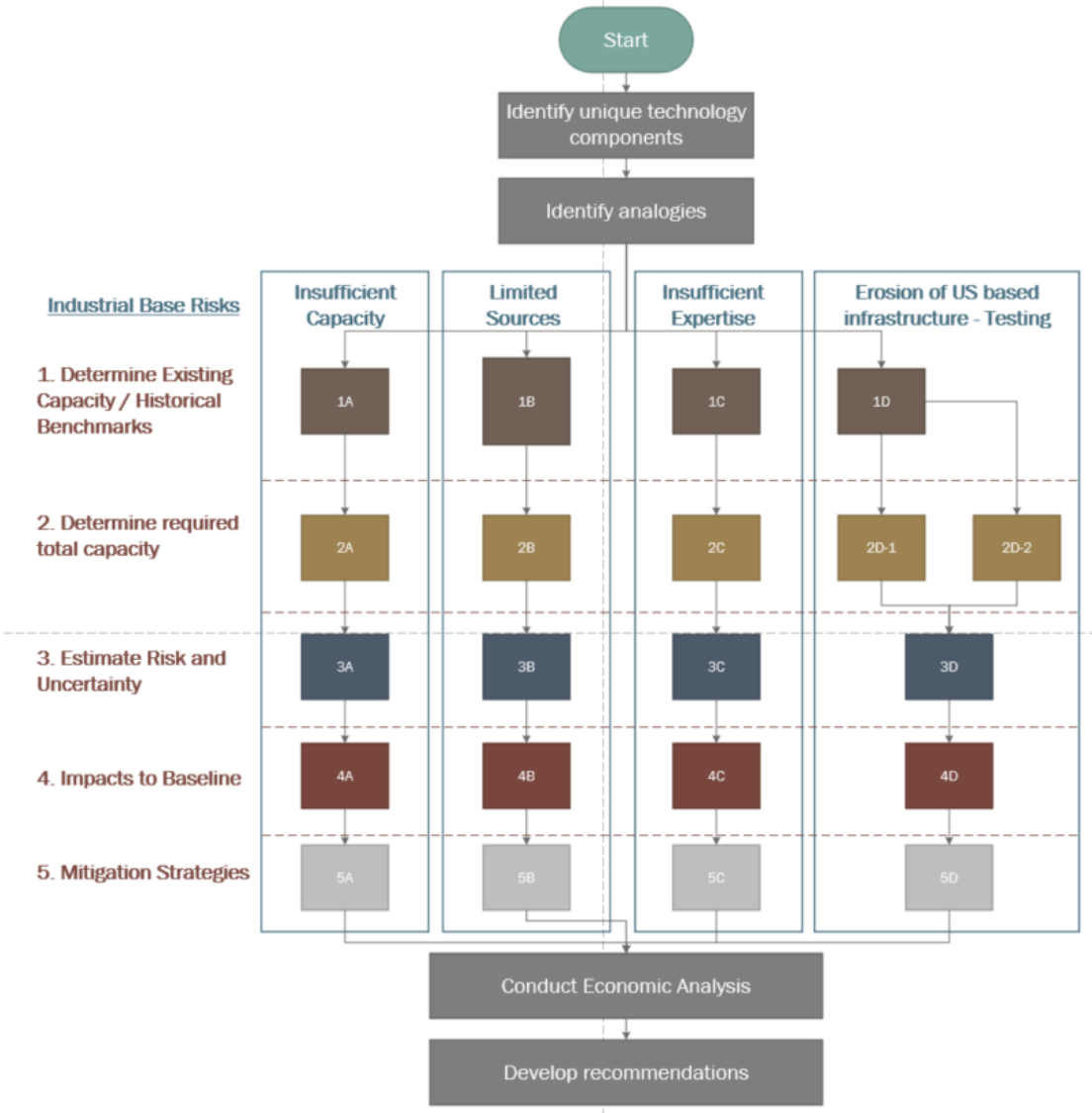
- Primary goal is to decrease development timeline with an increased level of confidence
- Mitigations by risk area were prioritized based on schedule return on investment
- Program budget would now be updated to include investments in these areas

Analysis Conclusions

- General
  - A lot of work is being done to examine the industrial base for emerging technologies but it is primarily reactionary to address issues that have already been encountered
  - Methodologies commonly used in Cost Estimating such as the use of analogies and Risk & Uncertainty analysis can be applied to quantify Industrial Base Risks
  - Early identification and quantification of risks and impacts is especially important to emerging technologies in order to allow time for investments in mitigation strategies
  - DoD Program Offices could use the framework and identified data sources to develop more comprehensive and defendable budgets
- Use Case
  - Industrial Base Risks identified for hypersonics have largely materialized to date
  - Investments in the Industrial Base need to be made in order have a successfully deployed capability
  - Impact of designating the program as a Rapid Prototyping Program (Section 804 Middle Tier Acquisition Program) compared to ACAT I (DoD Directive 5000.01) is largely unknown
  - Need to work directly with program to develop modeling assumptions
- Future Work
  - Additional analysis is required to link the impacts of the individual Industrial Base risks and the resulting mitigation strategies as they were viewed independently
  - Identify and quantify performance impacts of mitigation strategies
  - Expand the data sources that were analyzed for each risk type
  - Work with SMEs to develop additional mitigation strategies

Potential Uses for Framework

- Early identification of industrial base shortcomings for any new program to decrease risk
- Establishing more realistic early program budget estimates (schedule and funding)
- Prioritization of competing programs utilizing similar emerging technologies to decrease risk
- Methodology for justification of industrial base investments
- Identified data sources that have already proven useful on other projects



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