A Pathway for Maritime Innovation in Hampton Roads:

Recommendations based on an Assessment of High-Level Situational Scan of Hampton Roads Maritime Innovation Opportunities

November 2021 Launch

TECONOMY PARTNERS LLC

The "Story Line" for Hampton Roads Maritime Innovation Pathway

The analysis that follows sets out a pathway for maritime innovation in Hampton Roads that builds upon regional advantages and market-related innovation opportunities while addressing the region's challenges.

Hampton Roads Regional Advantages

- **Hampton Roads stands out in the unique combination of significant maritime-related customers** involved with the Navy's largest shipbuilding and repair complex, a large commercial port and related TDL activities, an emerging offshore-wind energy industry cluster and coastal resilience demands by government, industry and residents
- **The region is home to a wide range of existing and planned testing, demonstration and scale-up activities for maritime innovation solutions** that leverages Hampton Roads physical attributes, infrastructure and breadth of maritime activities
- **Complementing the region's testing and demonstration capabilities is a growing emphasis on applied research in key emerging technology areas** by ODU, SBIR defense companies, large defense primes, NASA Langley and Port of Virginia, and JLab supercomputing capabilities

Market Opportunities & HR Positioning in Maritime Innovation

- **The leading maritime activities found in Hampton Roads represent a $34 billion growing U.S. market increasingly dependent upon innovations that adopt advanced technologies**
  - *"Our thesis is that Bluetech is where cleantech and food & agtech was 10+ years ago, where those are now $10b+/year startup investment markets"* Boston's SeaAhead Initiative
- Key crosscutting maritime emerging technology applications that Hampton Roads is positioned to advance include: **autonomous systems, digital transformation, cybersecurity and advanced manufacturing**

Hampton Roads Regional Innovation Challenges

- **Disconnect of large maritime-related customers in Hampton Roads with the region's technology companies and broader innovation ecosystem**
- **Lacking a comprehensive and systematic approach to translating Hampton Roads activities in testing, demonstration and scale-up into rooting maritime innovation companies in the region**
- **Broader regional gaps in pre-seed funding, hands-on entrepreneurial management assistance and follow-on seed funding also found with maritime startups**

Pathway Initiatives for Advancing Hampton Roads Maritime Innovation

- **Become a national hub in integrated autonomous systems across aerial, surface ad undersea platforms linked to digital transformation** that solves market needs by Navy, offshore wind energy operations and maintenance and Port-related activities
- **Establish a leading Maritime Small Business Innovation Collaborative that creates a focus on maritime/bluetech start-up activity and leverages best practices associated with SBIR program** in "connecting to primes," providing wrap-around services and ensuring access to growth capital
- **Advance a DoD center of excellence in shipbuilding and sustainment technologies** leveraging mission engineering for integration of advanced technologies
- **Create a sustainable home and brand for maritime innovation building on the OpenSeas effort in partnership with 757 Collab to advance a "whole community" focus on maritime innovation** involving networking, mentoring, open innovation partnerships, venture acceleration services and national events

High Level Assessment of Maritime Markets and Innovation Drivers

Overview of Selected Maritime Market Trends

- **The leading maritime activities found in Hampton Roads represent significant and growing market opportunities totaling over $34 billion in the U.S. and average growth expected above 5% annually**

Market Size and Expected Growth Rates

Defense Shipbuilding, Sustainment & Unmanned Systems

$23.6 billion market in 2020 for U.S. Navy shipbuilding and repair

- 81% for new Navy shipbuilding and 19% for Navy ship repair and maintenance
- 3.8% growth expected in Naval Outlays expected over 2021-2025 (before Biden budget)

$4 billion market in 2018 for Defense Unmanned Autonomous Systems

- 9.8% compounded annual return projected over 2018-2023

Port Operations

- $2.8 billion market in 2020 for U.S. Port and Harbor Operations
  - 3.5% annual increase expected through 2025

Offshore Wind Energy

- Expected to grow in U.S. from 30 mega-watts to 23 giga-watts over the next decade
  - 76% compounded annual growth rate
- Turbine manufacturing – the largest cost of construction – will grow from $2.6 billion in 2018 to $5.2 billion in 2024
  - 11.6% compounded annual growth rate

Coastal Resilience Services

- $1.76 billion market in 2018 for U.S. climate adaption and resilience
  - 15.6% average annual growth projected from 2018-2020
- Key segments:
  - $1.1b in 2018 for climate change adaptation & resilience services
  - $410m in 2018 for climate adaptation equipment and systems
  - $330m in 2018 for disaster services

Cross-Cutting Maritime Innovation Technologies for Hampton Roads

Markets / Technologies	Defense Shipbuilding, Sustainment & Unmanned Systems	Port Operations and Logistics	Offshore Wind Energy	Coastal Resilience Services
Autonomous Systems	Core capability involving integration across aerial, surface and underwater platforms	Surface vehicles Core operational capability for monitoring port activities	Role in planning, operations and maintenance	Role in monitoring and surveillance
Digital Transformation	Emerging activity involving digital twins with real time, continuous data	Core to improved operations and logistics management	Key value in predictive maintenance	Planning and decision tools
Cybersecurity	Digital systems; Trusted electronics; Cyber-physical systems security	Digital systems; Cyber-physical systems security	Cyber-physical systems security	System to systems security
Advanced Manufacturing	Advanced materials for structures and batteries, including additive manufacturing; Digital shipbuilding	Advanced robotics	Advanced turbines; Improved platforms	Resilience engineering for coastal built environment

See Appendix slide for more details on innovation drivers for each market

High Level Situational Assessment of Hampton Roads in Maritime Innovation

Situational Assessment: Strengths in Maritime-Related Innovation

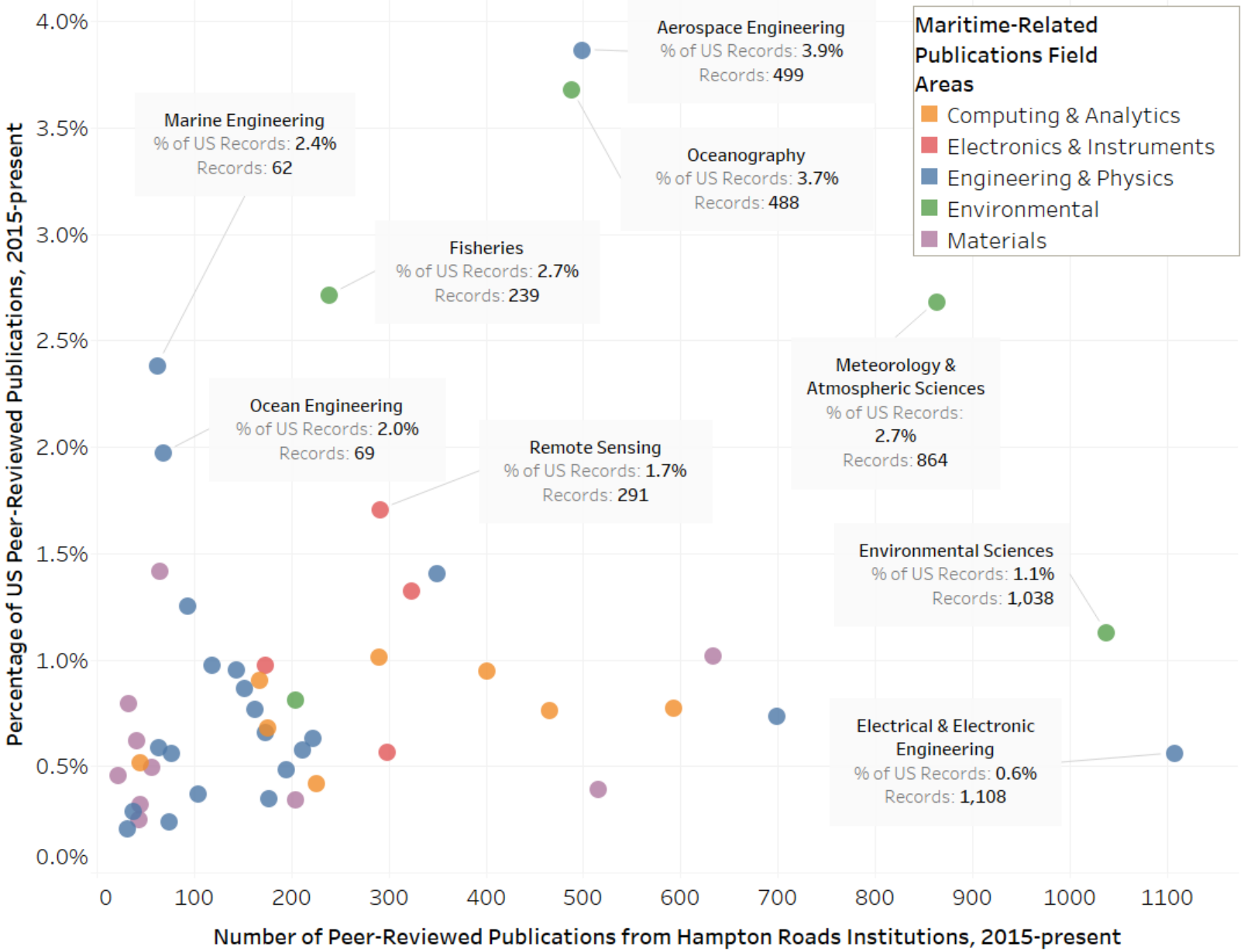
- **The Hampton Roads region stands out in the scale and breadth of its ongoing maritime operations**
  - Unique in having the largest Navy shipyard with a robust defense shipbuilding and repair industry, a large commercial port with its related intermodal transportation, distribution and logistics industry complex and a growing focus on offshore wind energy
  - This mix of maritime industry activities not only stands as the region's leading industry cluster, but it offers a significant base of potential customers for innovations in a broad range of maritime markets
- **The region offers ongoing and strong potential for future opportunities in testing, demonstrating and scaling up maritime innovation solutions**
  - Leverage physical attributes, infrastructure and breadth of maritime activities (i.e. deep and wide channels, no air restrictions to the sea, almost immediate access to the open ocean, port and Navy shipyard facilities, and multi-modal transportation)
  - Ongoing testing, demonstrating and scaling activities underway:
    - NASA Langley's CERTAIN* test range for Urban and Advanced Air Mobility (CERTAIN)
    - RISE engagement of innovation companies working in coastal resilience and climate adaptation
    - ODU's research offshore wind turbines testbed -- one of two offshore energy research lease sites in the U.S.
- **Regional emphasis on applied research for advancing maritime solutions**
  - Active base of publications in more focused maritime-related fields
  - ODU applied research activities are found in port-related cybersecurity, off-shore wind energy, maritime logistics, coastal resilience, autonomous systems, robotics/digital manufacturing and Navy mission engineering
  - NASA Langley efforts in urban and advanced air mobility with support from the National Institute of Aerospace as well as its applied sciences program for prediction of worldwide energy resources (POWER) using meteorological and solar data sets
  - Port of Virginia a national leader in port automation and innovations with ongoing innovation grants from U.S. Department of Transportation in truck reservation systems and autonomous vehicle pilot enabled by 5G network
  - Defense prime contractor efforts in applied research and applications for additive manufacturing, robotics and integrated digital shipbuilding
  - Active base of SBIR companies advancing technology solutions for U.S. DoD, NASA, NOAA and DoT
- **Growing efforts in entrepreneurial development for maritime innovation**
  - NIA's REaKTOR Unmanned Systems Accelerator
  - RISE
  - OpenSeas Technology Innovation Hub advancing a lean startup assistance effort tailored as a "continuous process" and not a start-stop approach of working with cohorts

* CERTAIN stands for City Environment for Range Testing of Autonomous Integrated Navigation and is a instrumented UAS test range across the NASA Langley campus fully integrated into NASA Langley's autonomy research activities

Quantitative Scan of Hampton Roads Innovation Activity

Publications in maritime-related research fields reveals an active and diversified base of research activities in maritime-related fields (>20 publications), but generally low share of the total U.S. activity

- ***Hampton Roads specializations are reasonably high in more niche marine sciences disciplines as well as aerospace engineering***



Quantitative Scan of Hampton Roads Innovation Activity

Patent Activities:

- Few patent innovations being invented in Hampton Roads in maritime-related innovation areas:
  - Some patenting activity present in leading technology classes aligned with innovation drivers but few clear linkages to potential marine industry applications

Leading Patent Technology Class	Patent Apps, 2015-present	Patent Awards, 2015-present	Key Companies Involved
Cyber security	18	18	Amazon, Neustar, Inc., Apple
Data management	15	16	Capital One, BoA
Database archit. & storage	9	12	Oracle
Image recognition/ detection	5	15	Huntington Ingalls
Air traffic control systems	4	14	NASA, SmartSky
Networked applications	5	11	Capital One

Venture Capital:

- Few companies in Hampton Roads in leading areas of maritime innovation receiving any venture financing – pre-seed, angel investor, seed or formal VC investments
  - **DroneUp** – Walmart strategic investment; previous $8m raised, CIT and Charlottesville Angels -- drone flight services provider, including flight services, data analysis, drone program development, regulatory consulting, training, equipment, and Part 107 drone delivery
  - **SVT Robotics** -- $5.5m raised, 757 Accelerate, Plug & Play Tech Center, Cowboy Ventures, Ludlow Ventures, NRV, Dynamo Ventures, Schematic Ventures – warehouse automation software for enterprise robot technology deployment
  - **Psionic** -- $4.4m raised, 757 Angels, Ridgeline, CIT + SBIR– LIDAR technology developer for precision navigation
  - **NanTrak** -- $2.3m raised, 757 Angels – intelligent tracking systems for defense and law enforcement
  - **Ario** -- $2m raised, 757 Accelerate/Angels, NRV, Plug & Play Tech Center, CIT + SBIR – augmented reality for knowledge sharing and training of front-line workers in manufacturing
  - **Advanced Aircraft** -- $0.75m raised, CIT and Charlottesville Angels – unmanned aerial systems involving vertical takeoff and landing
  - **Netarus** -- $0.3m raised, The Launch Place + Angel Investor – applies wireless, video, software and sensor technology to create hardware and software systems for heavy lift of containers and other industry applications to improve safety and productivity; SBIR grant

SBIR Funded Companies:

- 26 companies received 44 SBIR awards across DoD, DHS, NASA, NOAA and DOT since 2016

Agency	Phase 1	Phase 2	Total
Navy	8	8	16
Air Force	8	6	14
NASA	10	1	11
NOAA		1	1
DHS	1		1
DoT	1		1

- Leading companies with 3 or more SBIRs include:
  - **Bihrle Applied Research, Inc.** (5 SBIR awards) – an aeronautical **R&D company** specializing in the development of flight-representative software math models
  - **Analytical Mechanics Associates, Inc.** (4) – Engineering services linking engineering and mathematics capabilities with the latest in information technology and visualization to build innovative solutions.
  - **G2 Ops, Inc.** (4) – Cybersecurity, Engineering and Strategic IT solutions provider
  - **Spatial Integrated Systems** (3) – Division involved in unmanned surface vessel (USV) solutions – recently acquired by Huntington Ingalls

Situational Assessment: Highlights of Hampton Roads Assets in Maritime-Related Innovation Drivers

Autonomous Systems

NASA Langley is key driver of innovation and applications in autonomous systems – has evolved from autonomy incubator to mature testbed environment with CERTAIN*

Success of NIA's REaKTOR Unmanned Systems Accelerator – 32 companies assisted, 52 jobs created and $4 m in revenue generated

Base of autonomous companies in region – i.e. DroneUp, Longbow, Psionic

Huntington Ingalls development of an unmanned systems center of excellence 20-acre campus in Hampton Roads

ODU's leadership of Virginia Institute for Spaceflight and Autonomy and applied research in applications for drones and autonomous systems

Cybersecurity

ODU capabilities:

- VMASC – applied research
- New School of Cybersecurity – fast growing degree program

Coastal Virginia Center for Cyber Innovation – regional node for Commonwealth Cyber Initiative

Base of regional technology companies

Port of Virginia advancing new cybersecurity solutions with ODU

Digital Transformation

VMASC capabilities in model-based systems engineering, data sciences/analytics/fusion

Port of Virginia leading efforts in automation

Emerging efforts in shipbuilding and repair by defense contractors

Base of regional technology companies

Pending establishment of new supercomputer centers at Jlabs focused on real-time

Advanced Manufacturing

NASA Langley research capabilities in structures and materials, including light alloys, high performance polymers, metal printing, large scale composites and wind tunnel

NIA basic research in advanced materials, such as nanomaterials, but not applications oriented

ODU efforts in mechatronics, robotics and digital manufacturing

Defense contractor activities in use of additive manufacturing and robotics

* CERTAIN stands for City Environment for Range Testing of Autonomous Integrated Navigation and is a instrumented UAS test range across the NASA Langley campus fully integrated into NASA Langley's autonomy research activities

Situational Assessment: Weaknesses and Gaps in Maritime-Related Innovation

- **Large maritime anchoring organizations in Hampton Roads are primarily consumers and integrators of innovation and not drivers**
- **Disconnect of large maritime anchoring organizations in Hampton Roads with the region's technology companies and broader innovation ecosystem**
  - Access and engagement with large maritime organizations as the "voice of the customer" to drive ideation and customer discovery is not taking place – unlike what is happening in healthcare with Sentara but not across major primes, Port, shipping companies, etc.
  - An exception may be in resilience with work of RISE to engage local communities on needs for solutions to coastal flooding, real-time decision tools, etc
  - Weak connections between region's DoD SBIR companies and large defense contractors and other large maritime organizations in the region – region not translating SBIRs into procurement for DoD tech companies, while Port innovations largely involving outside regional vendor solutions and not strong engagement with region's tech community
  - Lack of collaborative culture across large maritime entities to advance innovation
  - Region missing strong connections to Navy research labs – i.e. ONR's Naval Research Lab and Warfare Research Centers -- in areas related to key shipbuilding technologies, sustainment, autonomous systems, etc.
- **Not a systematic approach to translating Hampton Roads efforts in testing, demonstration and scale-up into rooting maritime innovation companies in the region**
  - Needs identified for follow-on venture financing – broader weakness within region's entrepreneurial ecosystem
  - Additional co-location spaces that meet needs of maritime innovation companies
- **Few companies in Hampton Roads in leading areas of maritime innovation receiving any venture financing –** pre-seed, angel investor, seed or formal VC investments
- **Broader regional gaps in venture capital funding and entrepreneurial management talent**
  - Gap in systematic sources of pre-seed funding – exceptions are SBIR funding and RISE's Catalytic Funding
  - Follow-on venture capital funding beyond Angel Investors … starting with Seed Funding through Series A and Follow-on Financing
  - Concerns about lack of serial entrepreneurs and need for hands-on entrepreneurial management assistance (lots of subject domain experts, mentors and advisors)

See Appendix slide on Headwinds associated with each market segment

Situational Assessment: Threats

- **Future defense spending levels and priorities**
- **Current Navy contracting for surface shipbuilding and repair creates disincentive for innovation**
  - In past, Navy used Multi-Ship, Multi-Option cost plus contracting to enable contractors to bid on sustainment for a class of Navy ship on a multi-year basis – proved to be too expensive for Navy
  - Shifted to a ship-by-ship approach using fixed price – no incentive for contractors to invest in new capacities or innovations since uncertainty in being awarded future contracts
  - Seek a new direction to combine Multi-Ship, Multi-Option but with fixed price, along with a small business set-aside requirement
- **Other regions of the nation are actively advancing maritime innovation**
  - Southeast New England Defense Industry Association – Pro-active defense cluster networking organization and Undersea Technology Innovation Collaborative
  - SeaAhead in Boston – Multi-prong entrepreneurial development initiative connected to broader innovation ecosystem
  - Washington Maritime Blue Initiative – Comprehensive strategy with an active innovation accelerator program

Recommended Pathway Initiatives:

- A National Hub in Integrated Autonomous Systems
- A Maritime Small Business Innovation Collaborative
- A DoD Center of Excellence in Ship-building and Sustainment Technologies
- A Sustainable Home and Brand for Maritime Innovation

Recommended Pathway Initiative: Become A National Hub in Integrated Autonomous Systems

Competitive focus is on Hampton Roads ability to offer testing and demonstration, combined with applied research strengths, across aerial, surface and underwater platforms linked with digital transformation

- Link with Data Transformation to enable applications in addressing Navy's Unmanned Campaign Framework, preventive maintenance for off-shore wind and Navy sustainment, and new tools for Coastal Resilience
- **Key Testing and Demonstration Activities**: NASA Langley CERTAIN, Fort Monroe (Longbow's Center for Unmanned Systems Research & Technology), Wallops, HHI Unmanned Center of Excellence Campus, ODU/VISA, etc.
- **Applied Research Strengths**: NASA Langley Autonomous Research; NIA Autonomous Research group; HHI Autonomous Vessel Software Development group; ODU/VISA/VMASC

<u>Activities to Consider</u>:

- VISA leads establishment of a national integrated autonomous systems translational research and testing center at Wallops - to identify, develop, test, and commercialize solutions in partnership with industry, the Navy, other universities, and Open Seas; combines modeling and simulation, data analytics, and cybersecurity

Recommended Pathway Initiative: Establish a Leading Maritime Small Business Innovation Collaborative

Build upon the base of SBIR companies to foster an open innovation/collaboration SBIR-Prime partnership approach with focused growth-oriented services for SBIR companies

- 26 companies in Hampton Roads received 44 SBIR awards across DoD, DHS, NASA, NOAA and DOT since 2016
- Weak connections between region's DoD SBIR companies and large defense contractors and other large maritime organizations in the region – region not translating SBIRs into procurement for DoD tech companies, while Port innovations largely involving outside regional vendor solutions and not strong engagement with region's tech community
- SBIR development is a key component of new Mid-Atlantic NavalX initiative collaborating with 757

More broadly focus on maritime/bluetech start-up activity in Hampton Roads enhancing the efforts of OpenSeas and 757 Collab

- Leverage region's assets in having large maritime customers, testing/demo/scale-up facilities and subject matter expertise with an enhanced and targeted entrepreneurial development infrastructure for maritime

Activities to Consider:

- **Learn from best practices associated with SBIR program** in "connecting to primes," providing wrap-around services and ensuring access to growth capital
  - Example of past efforts by Connecticut's Small Business Innovation Program – strong outreach to large defense primes, matchmaking based on small tech company capabilities, and pilot funding for "Partner with a Prime"; model from "Plug and Play" with maritime, Port and, OSW customers
  - ODU Initiates development and leads a regional "Open Seas Innovation Hub" to leverage SBIR funding and partnership approach; align with 757 Collab, RISE, and others; and offer co-located space; would serve as one of the first ODU Maritime Consortium initiatives
- **Create maritime-focused accelerators and hands-on venture development organization**
  - Engage Port, Dominion Energy, shipping companies, large defense contractors as the "voice of the customer" and for first customer opportunities
  - Focus on customer needs discovery, mentoring and First Customer type programs
  - Example of Plug & Play Technology Center that provides assistance to large companies on how to collaborate with startups and translate into real business opportunities – operates "themed" accelerators across U.S. and global regions; Des Moines Global Insurance Accelerator (https://www.globalinsuranceaccelerator.com/); recent National Geospatial-Intelligence Agency Geospatial Accelerator with Capital Innovators in St. Louis (https://capitalinnovators.com/nga-accelerator-program)
  - Venture development organizations providing hands-on entrepreneurial management assistance to launch new startups: Dartmouth's Celdara Medical (https://celdaramedical.com/about/); VIC Technology Venture Development (https://victech.com/business-model/)

Recommended Pathway Initiative: Advance a DoD Center of Excellence in Ship-building and Sustainment Technologies

Focus on advanced manufacturing applications and digital transformation efforts for the U.S. Navy:

- Address weak connections among regional defense complex with ONR and Warfare Center R&D on sustainment technologies
- Help bridge current "problematic" dynamics of Navy waiting on industry for sustainment innovation while defense contractors defer to Navy direction in contract requirements
- Leverage the existing relationship of ODU and NSWC Dalghren that spans applications of modeling and simulation, data analytics, AI/ML and mission engineering.* This includes participation in NSWC Dahlgren's Naval Surface Technology Innovation Consortium and active engagement with NSWC Dahlgren's Dam Neck facility in Virginia Beach.
- Engage newly-opened Mid-Atlantic Tech Bridge capabilities and partnerships.
- Engage applied research and technology deployment efforts by major primes and their supply chain around additive manufacturing, robotics, digital shipbuilding and other advanced manufacturing technologies.

<u>Activities to Consider</u>:

- Scale-up and formalize ODU's relationship with NSWC Dahlgren to advance a University-Industry Collaboration Center to Accelerate Technology to the Navy Fleet. Requires a contract vehicle with a high budget authorization, such as through a Partnership Intermediary Agreement or Indefinite Delivery/Indefinite Quantity contract.
- Example:
  - Wright Brothers Institute in Dayton, Ohio – uses a Partnership Intermediary Agreement for "Aerospace Collaboration and Technology Transfer" and provides a range of activities and services advancing innovation, collaboration and commercialization related to defense technology needs involving defense contractors and AFRL. Received $11.3 million in government contract funding in 2018.

* DOD Mission Engineering Guide defines mission engineering as "the deliberate planning, analyzing, organizing, and integrating of current and emerging operational and system capabilities to achieve desired warfighting mission effects."

Recommended Pathway Initiative: Create a Sustainable Home and Brand for Maritime Innovation in Hampton Roads

Create a sustainable home and brand for maritime innovation to advance a "whole community" focus on maritime innovation

- Address customer-driven innovation gap in the region – where large maritime organizations in the region not serving as the "voice of the customer" to drive ideation and customer discovery and there not being a collaborative culture across large maritime entities to advance innovation
- Currently Hampton Roads growing innovation ecosystem is not connected to maritime opportunities and the threat is real from other regions of the nation that are actively advancing maritime innovation

Activities to Consider:

- **Support establishment of the proposed ODU Maritime Consortium to play a leadership role for innovation, research, and pathways for training and educating the innovation workforce of the future**
- **Build on the OpenSeas effort in partnership with 757 Collab to advance maritime innovation involving networking, mentoring, open innovation partnerships, and national events**
- **Clarify and confirm role of the Hampton Roads Maritime Collaborative for Growth & Innovation (HRMC) - Examples from other maritime regions:**
  - Southeast New England Defense Industry Association – Pro-active defense cluster networking organization and Undersea Technology Innovation Collaborative
  - SeaAhead in Boston – Multi-prong entrepreneurial development initiative connected to broader innovation ecosystem
  - Washington Maritime Blue Initiative – Comprehensive strategy with an active innovation accelerator program

Graphic Illustration of Story Line

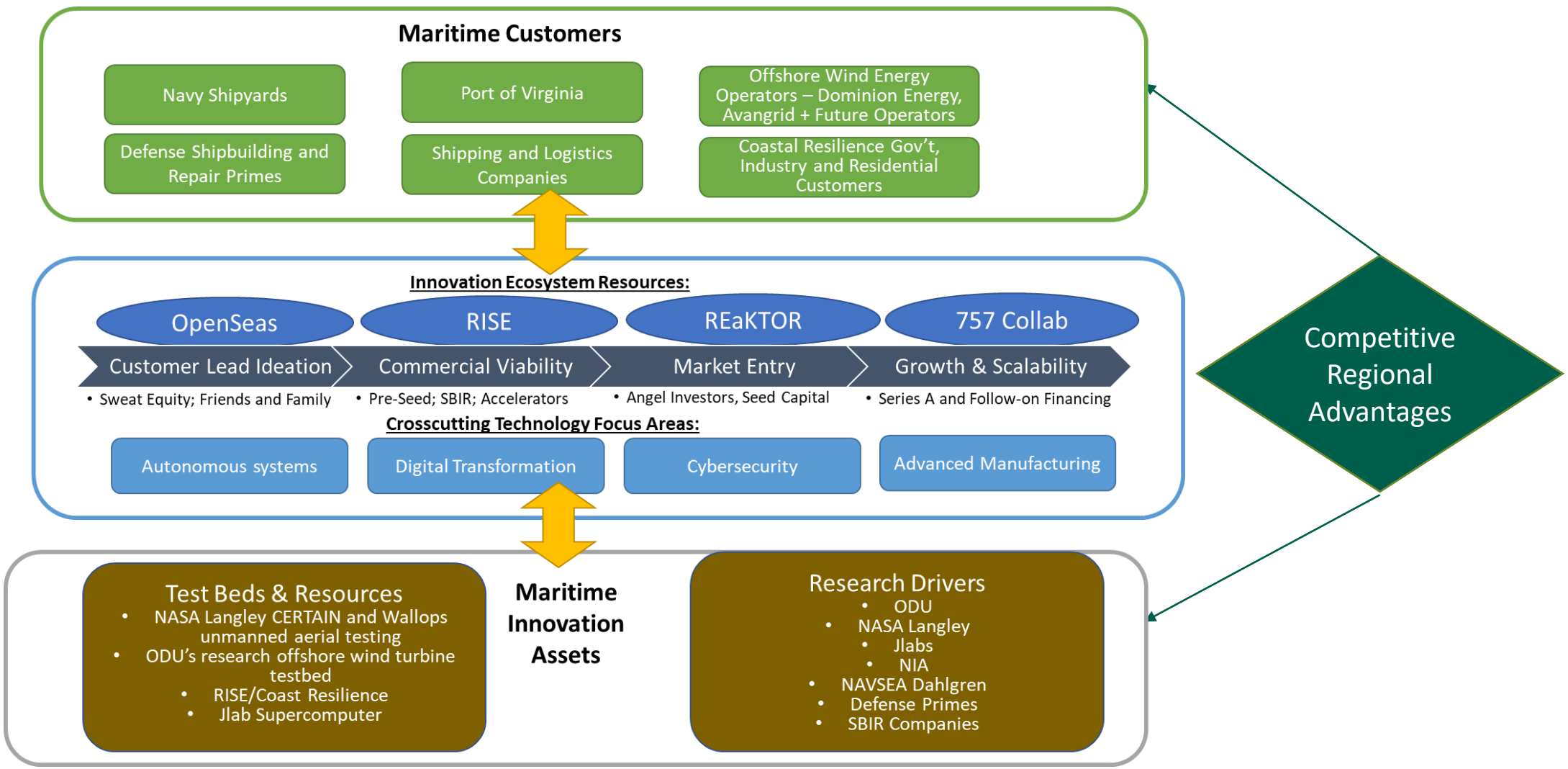
Pathway Initiatives:

A National Hub in Integrated Autonomous Systems

A Maritime Small Business Innovation Collaborative

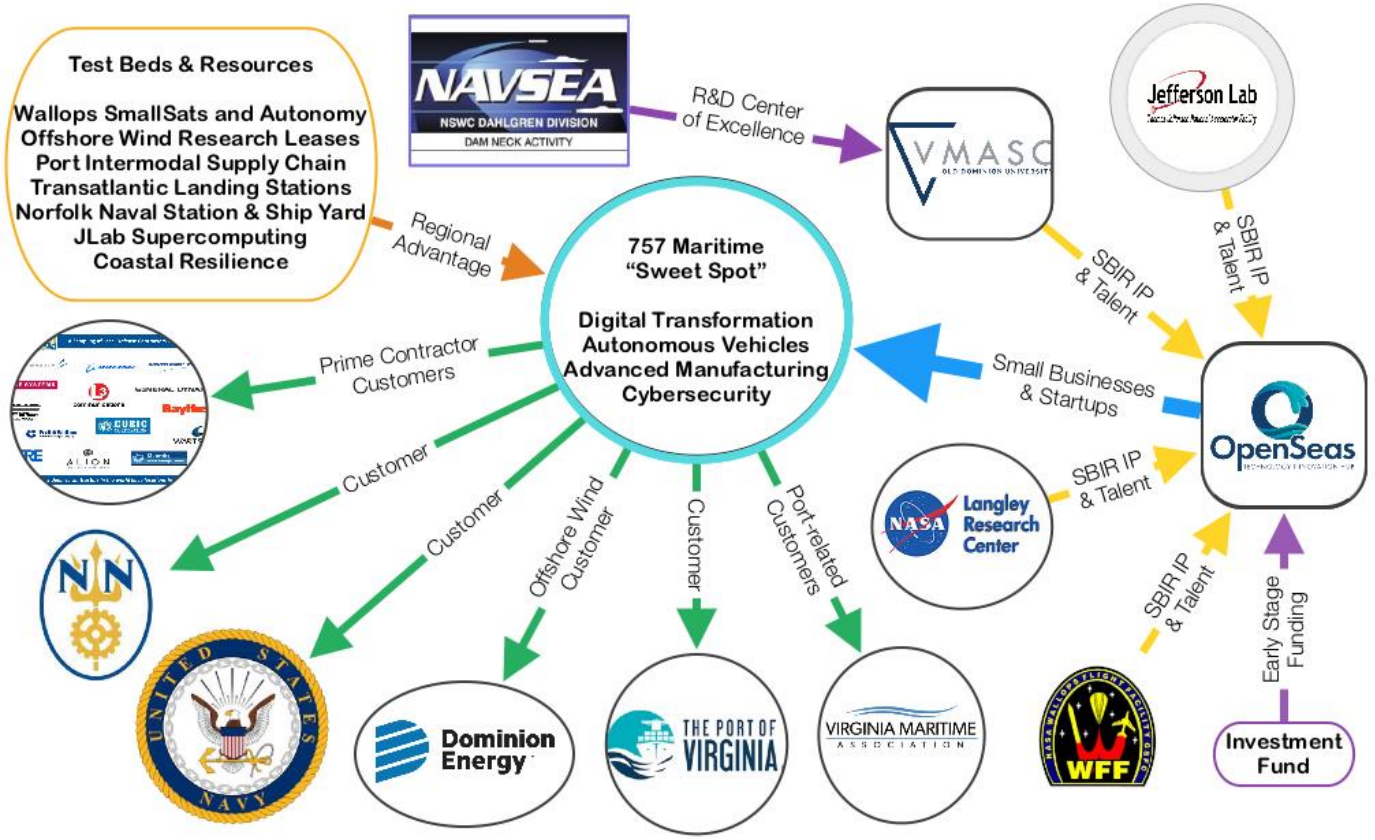
A DoD Center of Excellence in Ship-building and Sustainment Technologies

A Sustainable Home and Brand for Maritime Innovation



Integrated Approach to Hampton Road Maritime Innovation

Position Hampton Roads to be a national hub for Maritime Innovation, with a focus on advancing regional strengths in core technologies that are cross-cutting in all of the leading maritime activities in the region, while leveraging the region's strengths in the breadth of its leading maritime customers for innovation and its testing, demonstration and scale-up capabilities.



Innovating Tomorrow's Economic Landscape

TEConomy Partners is a global leader in research, analysis and strategy for innovation-based economic development. Today we're helping nations, states, regions, universities, and industries blueprint their future and translate knowledge into prosperity.

Appendix Slide: Sources of Information Used in Study

Market Studies Examined

- **Defense Shipbuilding, Sustainment & Unmanned Systems:**
  - IBISWorld, Ship Building in the US, September 2020
  - Congressional Research Service, Navy Force Structure and Shipbuilding Plans: Background and Issues for Congress, March 18, 2021
  - Rand, A Strategic Assessment of the Future of U.S. Navy Ship Maintenance, 2017
  - GAO, Navy Shipbuilding Report to the Senate Armed Services Committee, March 2020
  - Mallory Shelbourne, "Navy Using New Working Groups to Problem Solve Sustainment Issues," U.S. Naval Institute, September 21, 2020
  - BCC Research, Defense Robotics/Autonomous Systems, 2018
  - Department of the Navy, Unmanned Campaign Framework, March 2021
- **Port Operations and Logistics:**
  - IBISWorld, Port & Harbor Operations in the U.S.
  - Information from Port Technology.org website
  - Port activity from web articles by Ship Freight, Logistics Management, McKinsey and iContainers
- **Offshore Wind Energy:**
  - Global Wind Energy Council, Global Offshore Wind Report 2020
  - Mangum Economics, Opportunities for Developing the Offshore Wind Energy Industry in Hampton Roads, 2020
  - BCC Research, Global Markets for Offshore Wind Turbines, 2019
- **Coastal Resilience:**
  - Environmental Defense Fund, Coastal Resilience is Getting High-Tech, Blog, June 2018
  - Climate Change Business Journal, Climate Change Adaptation & Resilience Service Markets, 2019

Data Sources Analyzed:

- **Patents** – USPTO data from Clarivate Analytics Derwent Innovation patent analysis database, 2016-Present
- **Federal Small Business Innovation Grants** – SBA Database, 2016-Present
- **Venture Capital Funding** – PitchBook, 2016-Present
- **Publications** – Clarivate Analytics Web of Science database, 2016-Present

Interviews Conducted:

30 Interviews Conducted to Date

- **757 Angels/Accelerate**: Monique Adams and Evans McMillion
- **Ario**: Nate Fender
- **Christopher Newport University**: Willy Donaldson
- **Department of the Navy**: Sean Burke, Deputy Assistant Secretary for Sustainment and Steven Stancy, Director of Fleet Maritime Sustainment
- **Dominion Energy**: John Larson, Director of Public Policy and Economic Development; Adam Sledd, Dominion Energy Innovation
- **G2 Ops, Inc.**: Tracy Gregorio, CEO
- **Huntington Ingalls Technical Solutions –** Grant Hagan, VP for Business Operations
- **Jefferson Lab**: Stuart Henderson, Director
- **NASA Langley**: Danette Allen, Autonomous Systems; Christie Funk, Entrepreneurship; Harry Belvin, Adv Mfg
- **National Institute of Aerospace**: Doug Stanley, President and Executive Director
- **Newport News Shipbuilding Division of Huntington Ingalls Industries**: Don Hamadyk, Director of Innovation & Engineering Solutions and Terry Tyler, Director of R&D
- **NTELX**: Rob Quartel, Executive Chairman of the Board **City of Norfolk**: Chip Filer, City Manager (former ODU professor)
- **OpenSeas Technology Innovation Hub**: Jerry Cronin, Executive Director with Marty Kaszubowski, Executive Director, Institute for Innovation and Entrepreneurship
- **Port of Virginia**: Stephen Edwards, CEO and Executive Director; Joe Ruddy, Chief Innovation Officer; Rich Ceci, Senior Vice President of Technology and Projects; John Reinhart, former CEO
- **ODU**: Morris Foster, VPR; Eric Weisel, VMASC; George Hagerman, Jr., research scientist on offshore wind energy; Mileta Tomovic, Engineering Technology; Jessica Whitehead and Tom Allen, ICAR; Brian Payne and Michael Wu, Coastal Virginia Center for Cyber Innovation and School of Cybersecurity; Ricardo Ungo, Maritime & Supply Chain Management
- **RISE Resilience Innovations**: Paul Robinson
- **Virginia Economic Development Partnership:** Stephen Moret, CEO and President
- **Virginia Institute for Spaceflight and Autonomy**: Dave Bowles, Executive Director
- **Xodus Group**: Jeff Tingley, Senior Consultant
- **Zel Technologies, LLC.**: Jack Ezzell, CEO

Appendix Slide: Overview of Selected Maritime Market Innovation Drivers

- **The future growth of maritime markets found in Hampton Roads is increasingly dependent upon innovations to adopt advanced technologies that provide a competitive advantage and address specific challenges**

	Defense Shipbuilding, Sustainment & Unmanned Systems	Port Operations and Logistics	Offshore Wind Energy	Coastal Resilience Services
Technology Trends & Challenges	Sustainment of all-electric ships with integrated electronics and need for micro-miniature repair Battery development and maintenance Aluminum ship structures, involves new welding capacities Digital manufacturing – 3D + enhanced CNC Cybersecurity, including trusted electronics Digital transformation – including predictive maintenance, digital shipbuilding/digital twins Autonomy as a capacity and integration of platforms across aerial, surface and underwater	Automation using AI for self-aware systems 5G for deployment of automation and smart technologies Real-time, digitalization for port operations, electronic billing, and situational awareness using data analysis and visualization End-to-end supply chain management using AI, block chain and IoT Cybersecurity Cloud technologies Environmental sustainability	Increasing size of offshore wind turbines Floating offshore wind platforms Energy storage Unmanned inspections and preventive maintenance Improved extreme weather monitoring and prediction	Coastal resilience mapping, modeling and data visualization – including high-resolution modeling and decision-making under uncertainty Cloud computing and data management of large spatial and temporal environmental data Real-time, smart tools for monitoring and surveillance involving satellites, remote sensing and machine learning Improved extreme weather and flooding monitoring Resilience engineering for the built coastal environment

Appendix Slide: Specific Headwinds to Innovation for Maritime Markets in Hampton Roads

Defense Shipbuilding, Sustainment & Unmanned Systems

Stakeholders indicated that innovation-related supply chain (component mfgers, etc) largely outside of Hampton Roads

Weak connections among regional defense complex with ONR and Warfare Center R&D on sustainment technologies

Current "problematic" dynamics of Navy waiting on industry for sustainment innovation while defense contractors defer to Navy direction in contract requirements

Regional defense technology companies not connected to large defense primes in region

Port Operations and Logistics

While innovation actively pursued as a competitive advantage, typically seek outside vendor solutions for customer-driven innovation needs

Offshore Wind Energy

Not clear that regional innovation is necessary to attract construction and manufacturing related activities

- Innovations in turbine technology and platforms largely dominated by Europeans and this innovation "travels"

Potential for innovation in operations and maintenance, but years away

Coastal Resilience

Not many local entrepreneurs

Region is still fragmented in advancing large scale solutions and large maritime anchor organizations have shown intermittent interest