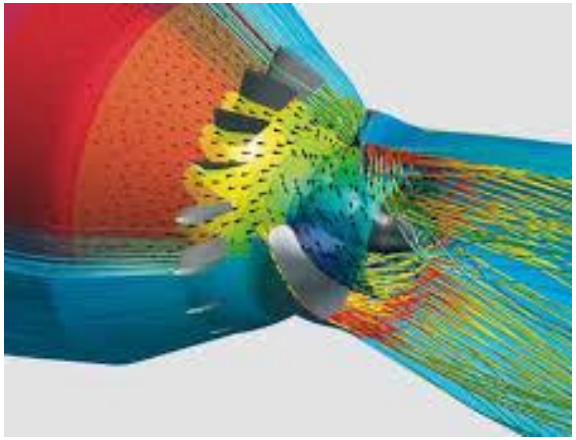

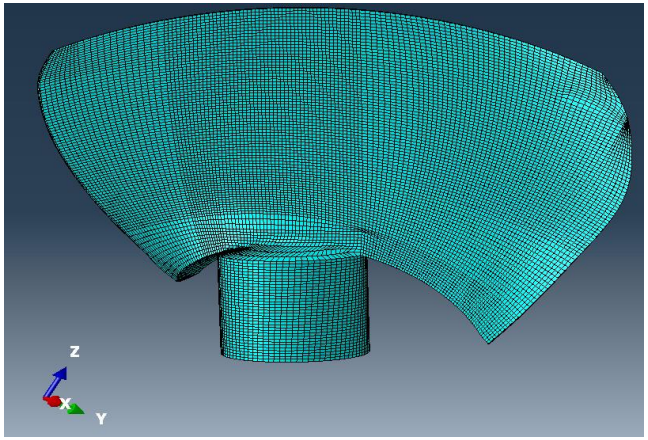

The Design and Development of a Composite Hydropower Turbine Runner

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Project Overview

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

The Design and Development of a Composite Hydropower Turbine Runner:

- Composite materials have the potential to be a reliable and economic alternative to traditional runner and flow guide materials.
- However, composite materials have yet to gain acceptance in traditional hydro-turbine applications.
- Design methodologies and standards have not been established.
- Long-term reliability, erosion performance, maintenance and repair procedures need to be validated .

Partners:

- Penn State Applied Research Laboratory (ARL): Hydrodynamic Testing and Design
- Tribologix, Inc: Specialized Coatings and Wear Testing
- Sandia National Laboratories: Coatings and Materials
- Voith Hydro: Hydroturbine industry leaders

Next Generation Hydropower (HydroNEXT)

Optimization

- Optimize technical, environmental, and water-use efficiency of existing fleet
- Collect and disseminate data on new and existing assets
- Facilitate interagency collaboration to increase regulatory process efficiency
- Identify revenue streams for ancillary services

Growth

- **Lower costs of hydropower components and civil works**
- **Increase power train efficiency for low-head, variable flow applications**
- **Facilitate mechanisms for testing and advancing new hydropower systems and components**
- Reduce costs and deployment timelines of new PSH plants
- Prepare the incoming hydropower workforce

Sustainability

- Design new hydropower systems that minimize or avoid environmental impacts
- Support development of new fish passage technologies and approaches
- Develop technologies, tools, and strategies to evaluate and address environmental impacts
- Increase resilience to climate change

Next Generation Hydropower (HydroNEXT)

Growth

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The Impact

- Improved fatigue resistance and lower maintenance cost over system lifetime
- Composite materials can become a viable option for runners, vanes, and secondary structure
- Lower system mass can impact installation and maintenance costs
- Composites can be an advantage for smaller variable flow systems
- Develop material and validation baseline for composite materials and structures
- Provide a runner design and composite design methodology that can be used industry wide.

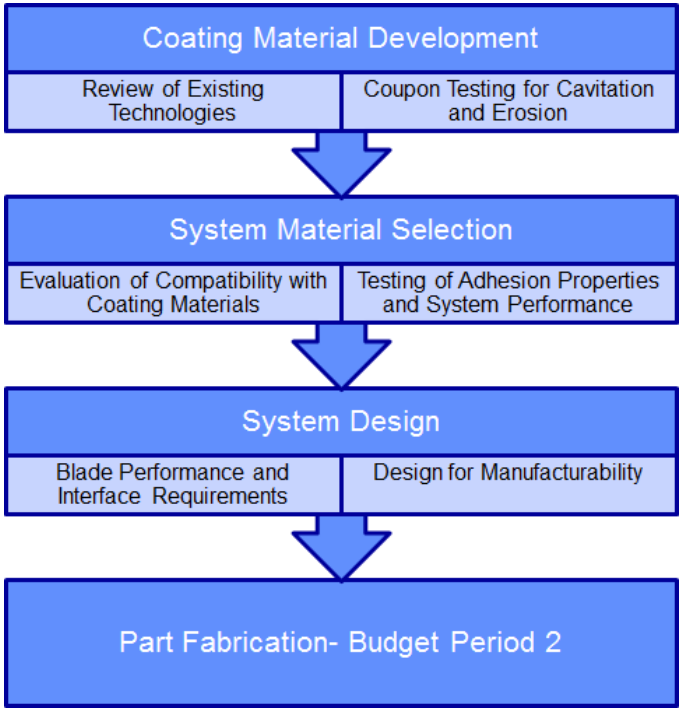
Technical Approach

Technical approach:

- Requirements Capture, Design and Analysis
- Component-level testing
- System-level testing.

Key issues:

- Developing a material system (substrate and coating) that can survive the marine and erosion environment
- Developing a design and manufacturing approach that is scalable and has a competitive life cycle cost.

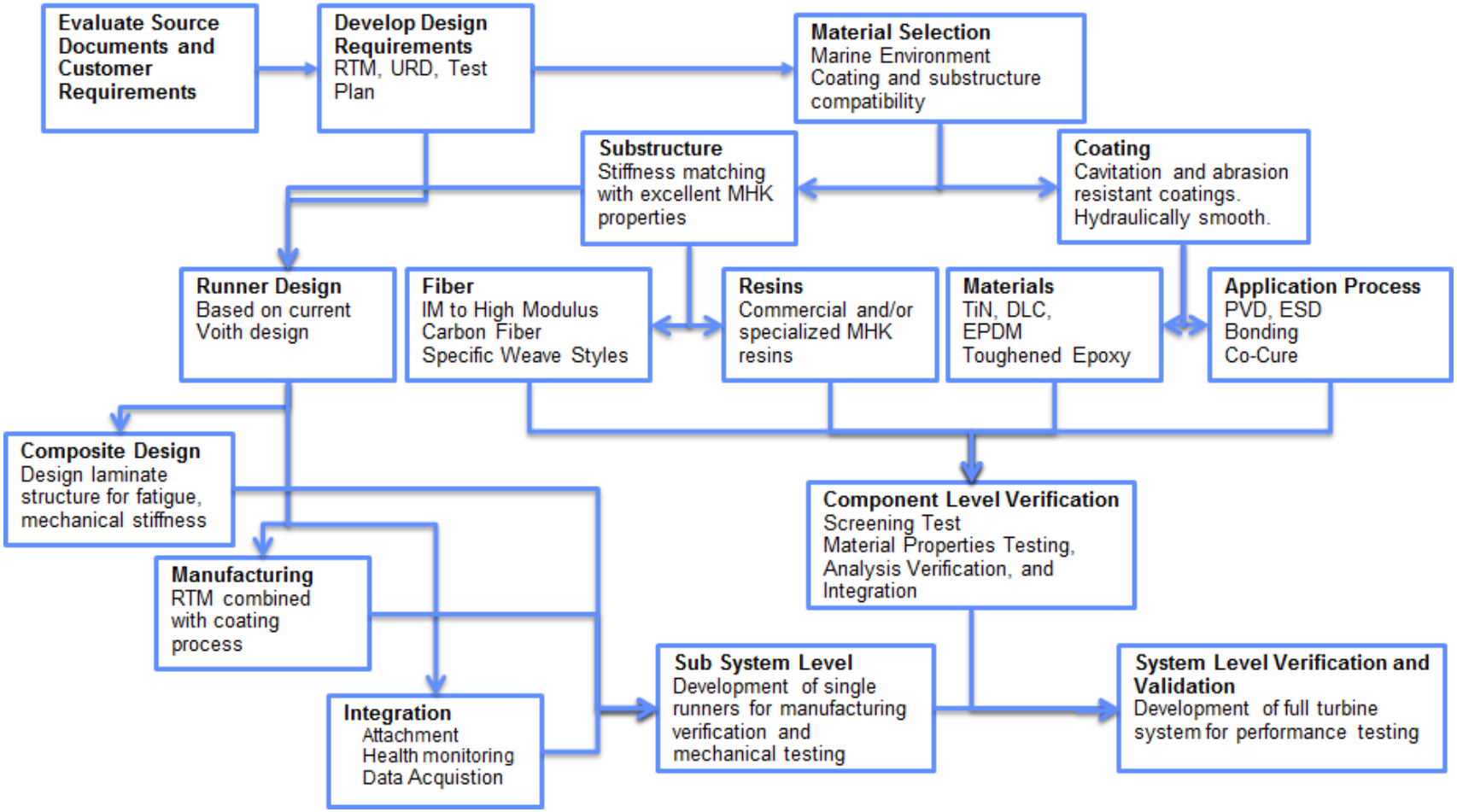


Unique aspects of approach:

- Novel composite coating processes are being investigated with large-scale manufacturing in mind.
- Coating and composite combination will be validated through a series of screening and evaluation tests.
- Nearly full scale (75%) system testing will be performed.

Technical Approach

- Building Block Approach: Component, Subsystem, System
- Couple Design and Analysis with Testing



Accomplishments and Progress

- The relevant customer and industry requirements have been identified and documented in an Resin Transfer Molding (RTM).
- Composite material candidates were surveyed and down-selected based on performance and process compatibility.
- An extensive literature survey on coating methods was completed.
- Candidate coating materials and processes were selected.
- Material coupons have been fabricated and coating evaluation is in process.
- Runner geometry has been scaled using computational fluid dynamics (CFD) analysis and the runner concept design is underway.

Project Plan & Schedule

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

- Original initiation date: July 01, 2016
- Planned completion date: June 30, 2017 (Budget Period 1)

			Quarters after Contract Award	1			2			3			4		
			Months after Contract Award	1	2	3	4	5	6	7	8	9	10	11	12
	WBS	***Tasks and Milestones***													
Budget Period 1		Project Management													
	1.1.1	Requirements Management													
	1.1.1.1	System Level Requirements Definition													
	1.1.1.2	Subsystem Level Requirements Definition													
	1.1.1.3	Verification Approach Development													
	1.1.2	Materials Assessment and Coating Development													
	1.1.2.1	Coating Screening and Evaluation													
	1.1.2.2	Coupon Development and Fabrication													
	1.1.2.3	Coupon Testing & Documentation													
	1.1.3	Turbine Runner Design													
	1.1.3.1	Composite Concept Design													
	1.2.3.2	Composite Runner Detailed Design													
	1.1.4	Manufacturing Readiness													
	1.1.4.1	Manufacturing Readiness													

- Verification Test Plans completion timed with testing activity
- Go/No-Go decision points for FY17

Project Budget

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Budget History					
FY2014		FY2015		FY2016	
DOE	Cost-share	DOE	Cost-share	DOE	Cost-share
				$81.587k	$29.658k

Budget Period	EERE $/%	FFRDC $/%	Cost Share	Total Estimate
1	$306.884k/64.7%	$50k/10.5%	$117.891k/24.8%	$474.775k
2	$643.116k/72.37%	$0/0%	$245.538k/27.63%	$888.654k
Total	$950k/69.7%	$50k/3.7%	$363.429k/26.6%	$1,363.429k

FFRDC - Federally Funded Research and Development Centers

- There are no variances from the planned budget.
- System Requirements Review was completed on time, panel fabrication was completed ahead of schedule and material testing is tracking to plan.
- Including ARL's anticipated billing (~$50K), the program has spent 44% and contributed 41% of the cost share.
- No other funding sources are being used.

Research Integration & Collaboration

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Partners, Subcontractors, and Collaborators:

- Voith Hydro Inc.: Stuart Coulson, Jason Foust
- Sandia National Laboratory: Dr. Bernadette A. Hernandez-Sanchez, Dr. Nicolas Argibay
- Tribologix, Inc.: Dr. Andras (Andy) Korenyi-Both
- Penn State ARL: Dr. Nicholas Jaffa, Dr. Arnie Fontaine, Mr. Bill Straka

Communications and Technology Transfer: Since the project is only in the second quarter of the first year, no technology transfer has occurred outside of the project partners. It is anticipated that materials and test data will be communicated once complete.

Next Steps and Future Research

FY17/Current research: The main objective for FY17 is to complete the coating cavitation testing, down select the material system and finalize composite runner design. Milestones include the concept design review and Go/No-Go review. Budget Period 2 will initiate tooling fabrication and prototype runner manufacturing.

Proposed future research:

- Field testing a runner system would provide the necessary long term operational data required for qualification
- Design, manufacture, and test a low-head, variable flow application.