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## MHK Risk Management Framework

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MHK Risk Management Framework: The Development and application of a MHK Risk Management Framework can significantly reduce the risk of MHK at sea demonstrations and avoid the significant failures the MHK industry has been suffering.

The Challenge: Reduce MHK technology development and demonstration risk to increase growth of the sector.

During project: Achieve completeness of methodology.

After project: Acceptance by MHK community.

Partners: DOE subcontractors, DNV-GL (reviewed product), and many MHK stakeholders (provided feedback and input).

## Technology Maturity

- Test and demonstrate prototypes
- Develop cost-effective approaches for installation, grid integration, operations and maintenance
- Conduct R&D for innovative MHK systems & components
- Develop tools to optimize device and array performance and reliability
- **Develop and apply quantitative metrics to advance MHK technologies**

## Deployment Barriers

- Identify potential improvements to regulatory processes and requirements
- Support research focused on retiring or mitigating environmental risks and reducing costs
- Build awareness of MHK technologies
- Ensure MHK interests are considered in coastal and marine planning processes
- Evaluate deployment infrastructure needs and possible approaches to bridge gaps

## Market Development

- **Support project demonstrations to reduce risk and build investor confidence**
- Assess and communicate potential MHK market opportunities, including off-grid and non-electric
- Inform incentives and policy measures
- Develop, maintain, and communicate our national strategy
- Support development of standards
- Expand MHK technical and research community

## Crosscutting Approaches

- Enable access to testing facilities that help accelerate the pace of technology development
- Improve resource characterization to optimize technologies, reduce deployment risks, and identify promising markets
- Exchange of data information and expertise

## Technology Maturity

- Develop and apply quantitative metrics to advance MHK technologies

## Market Development

- Support project demonstrations to reduce risk and build investor confidence

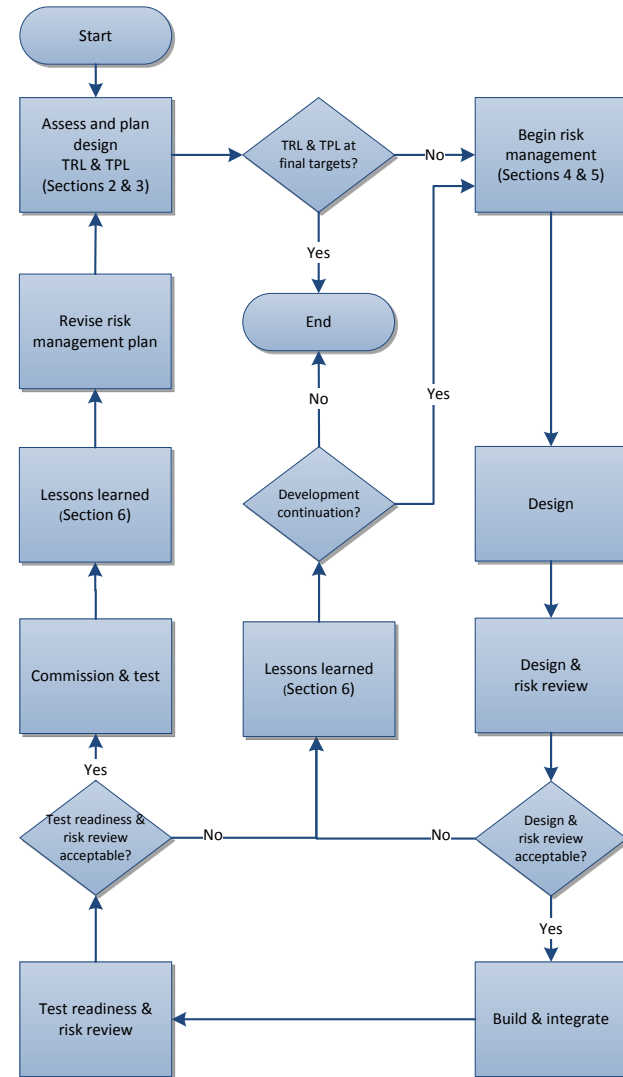
## The Impact

- Improvement of reliability
- Improvement of durability
- Improvement of availability
- De-risk technology development timelines
- De-risk technology development cost
- Application of the risk management tool has the potential to increase investor engagement and confidence.
- Consistent use of risk framework by all DOE project awardees will allow capturing the challenges and risks facing the industry today, and thus serves the U.S. portfolio decision makers to focus informed future decisions on high-impact areas in which to invest next.
- Final Product: MHK technology development and demonstration risk management methodology and framework with risk management tool in form of a risk register; empowers users to effectively de-risk their projects

- Identify methodology of existing risk guidelines
- Select relevant components
- Compose consistent and complete risk management methodology, guidelines, and tool
- Provide example case for tool – Excel risk register with risk examples entered
- Obtain subject-matter expert to review the risk management methodology, tool, and overall project outcome
- Past failures serve as lessons learned and thus will reduce likelihood of future failure by managing the encountered risks

The risk management is imbedded in the technology development, and is organized as a sequential process and displayed in a flowchart. Key elements in this process include:

- Design,
- Design risk review,
- Building and integrating,
- Test readiness risk review,
- Commission and testing,
- Lessons learned, and
- Revision of risk management plan.



## Risk Management Activity As Function of Technology Readiness Levels

Activity required at TRL level									Risk Management Activity	Section
1	2	3	4	5	6	7	8	9		
x	x	x	x	x	x	x	x	x	Risk management plan	4.1
x	x	x	x	x	x	x	x	x	Project plan	4.2
x	x	x	x	x	x	x	x	x	Risk register	4.3
x	x	x	x	x	x	x	x	x	Design basis—requirements	4.4
			x	x	x	x	x	x	Design basis—loads	4.5
			x	x	x	x	x	x	Design description	4.6
			x	x	x	x	x	x	Design analysis	4.7
x	x	x	x	x	x	x	x	x	Define survivability targets and strategies	4.8
				x	x	x	x	x	Define reliability and maintainability targets and strategies	4.9
			x	x	x	x	x	x	Failure mode effects analysis (FMEA)	4.10
x	x	x	x	x	x	x	x	x	Technology qualification plan	4.11
x	x	x	x	x	x	x	x	x	Lessons learned	4.12

As learned from failures, early consideration of risk is essential.

- MHK risk framework and risk register are published
- MHK Risk Management Framework is required by DOE in Funding Opportunity Announcement (FOA) proposals and project management (e.g. go/no-go decision points) and used in multiple projects: Used in awards from the two FY15 MHK FOAs, plus three (all) of the MHK TD awards from FY16 FOA. Thirteen total is a very good penetration, with considerable increase in success of this project.
- **Testimonial:** *“Littoral Power Systems is using the Risk Register to capture and track risks. . . . It has been an especially useful means to capture engineering decisions that mitigate technical risks. We have benefitted most from monthly risk review sessions and the added risk summary tab that puts the most urgent information in a single page view.”* Kathie Leighton, Littoral Power Systems
- Positive feedback by individual stakeholders and users of the MHK Risk Management Framework



- Project started in January 2014
- Roll-out webinar was held on December 16, 2014
- Project completed, including NREL publication, in September 2015
- Project was completed on time and within budget

## Risk Framework



### Marine and Hydrokinetic Technology Development Risk Management Framework

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[Link to Risk Register Template](#)

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Technical Report  
NREL/TP-5000-43228  
September 2015

Contract No. DE-AC36-08GO28308

## Risk Register

IDENTIFY RISKS PROCESS						ANALYZE RISKS PROCESS				RISK RESPONSE PROCESS—STRATEGY & TIMING					
RBS						Baseline Risk (before response)				Risk Response					
Revision	RBS Level 1	RBS Level 2	Risk Name	TRL	TPL	Technology Life Phase	Risk Owner	Y	S	F	R	Description (with assumptions); Include Timing and Triggers	Strategy	Response Timing	
Date								P	V	Q	N				
7	4-Sep-14	External	4.1 Legislation	feed-in tariff	all	all	Normal power production	Barb Johnson (CFO)	-	C	4	4	16	mitigate	now
8	5-Sep-14	Management	2.7 Communication	Media coverage	all	all	NA	Diane Briggs (CEO)	+	Q	2	3	enhance	now	
9	3-Sep-14	Management	2.6 Funding	no funding	4	6	manufacturing	Barb Johnson (CFO)	-	C	4	4	16	accept	now

Budget History					
FY2014		FY2015		FY2016	
DOE	Cost-Share	DOE	Cost-Share	DOE	Cost-Share
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- Project was funded fully in FY13 (\$300k)
- All funds (100%) were spent by the end of the project in September 2015

## Partners, Subcontractors, and Collaborators

- DOE and DOE subcontractors
- DNV-GL subject-matter expert reviewed product
- Numerous MHK stakeholder engagements provided feedback and input

## Communications and Technology Transfer

- Webinar with more than 50 attendees
- Published Framework document and Risk Register
- Engagement with users for feedback and improvement
- Document and Risk Register available at <http://www.nrel.gov/docs/FY15osti/63258.pdf>
- **Outcome to Date:** More than 800 downloads since Sept. 2015.

## FY17 / Current Applications

Known direct application by NREL in three MHK and Hydro projects:

- Verdant Power—Tidal current technology
- Littoral Power Systems—Small hydro power
- Dehlsen / Ecomerit—Wave energy

Further application under FOA requirement to deliver risk register, encouraging use of risk framework

## Proposed Future Research

Minor adjustments from experience through use cases and user feedback are planned in September FY17