Advanced Design Tools for Ocean Energy Systems Innovation, Development and Deployment

Deliverable D9.9

Knowledge exchange of educational and training material

Lead Beneficiary	The University of Edinburgh
Delivery Date	30/07/2021
Dissemination Level	Public
Status	Released
Version	1.0
Keywords	Education, Training, Webinar, Workshop, Documentation

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 785921

Disclaimer

This Deliverable reflects only the author's views and the Agency is not responsible for any use that may be made of the information contained therein

Document Information

Grant Agreement Number	785921
Project Acronym	DTOceanPlus
Work Package	WP9
Related Task(s)	T9.4
Deliverable	D9.9
Title	Knowledge exchange of educational and training material
Author(s)	Donald R Noble (UEDIN), Pablo Ruiz-Minguela (Tecnalia), Mélusine Gaillard (FEM)
File Name	DTOceanPlus_D9.9 Education Training Material_UEDIN_v1.0.docx

Revision History

Revision	Date	Description	Reviewer
0.1	30 April 2021	First draft of content	Tecnalia, FEM
0.2	7 July 2021	Updated draft of contents	WP9
0.3	15 July 2021	Updated draft of contents and annexes	WP9
0.4	20 July 2021	Version for QA review	WavEC
1.0	30 July 2021	Released version for the EC	EC

EXECUTIVE SUMMARY

This report collates the materials used throughout the DTOceanPlus project on knowledge exchange and training. This was coordinated in Task 9.4 "education and training" of the project. The aim of this task is to promote the DTOceanPlus tools, plus develop and deliver training materials for the suite of tools. The overall aims of this task were:

- Firstly, to promote the suite of tools and showcase the capabilities thereof, and
- Secondly, to develop a range of open-source materials to help end users understand and learn to use the software

Five channels of actions were proposed and delivered during the project:

- **Webinars** to raise awareness and explain the principals of the tools being developed.
- **Training sessions** to explain in detail how to use the suite tools.
- **Workshops** to present and gain feedback on the DTOceanPlus tools and other project results.
- **Visits** to the facilities/test-sites of project partners to showcase ocean energy more widely and improve investor confidence.
- **Tutorials** and documentation for self-training in use of the tools.

Due to the global COVID–19 pandemic, many of the education and training activities had to be revised to an online format, rather than the in-person events originally proposed. Despite this, the education and training activities were broadly successful in achieving the aims of promoting the tools and producing materials for future training. Indeed, both the webinars and training sessions exceeded their targets in terms of number held and number of participants engaged.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ABBREVIATIONS AND ACRONYMS

API	Application Programming Interface
CPX	Complexity (level of)
EC	Energy Capture
ED	Energy Delivery
ESA	Environmental and Social Acceptance
ET	Energy Transformation
ETIP	European Technology and Innovation Platform (for Ocean Energy)
GUI	Graphic User Interface
LCOE	Levelised Cost of Energy
LMO	Logistics and Marine Operations
MC	Machine Characterisation
O&M	Operation and Maintenance
RAMS	Reliability, Availability, Maintainability, Survivability
SC	Site Characterisation
SG	Stage Gate
SI	Structured Innovation
SK	Station Keeping
SLC	System Lifetime Costs
SPEY	System Performance and Energy Yield
WEC	Wave Energy Converter

1. INTRODUCTION

1.1 SCOPE OF REPORT

This report collates the materials used throughout the DTOceanPlus project on knowledge exchange and training. This was coordinated in Task 9.4 "education and training" of the project. The aim of this task is to promote the DTOceanPlus tools, develop and deliver training materials for the suite of tools, as summarised below.

Due to the global COVID–19 pandemic, many of the education and training activities had to be revised to an online format, rather than the in-person events originally proposed. This is covered within the reporting of the activities in Chapter 3.

In addition to the education and training activities, wider dissemination and communication actions were coordinated in Task 9.2 "communication activities and dissemination of project results". These include presentations at conferences and events, scientific publications, dissemination through both mainstream and social media, and via the project website. These will be reported at the end of the project in D9.5 "Impact of dissemination and communication activities – 3rd annual report".

1.1.1 TASK DESCRIPTION

The task description for the Education and Training Activities is as follows:

> General education and training production will start after the first six months of the project. This includes:
>
> - Development of education materials (tools tutorials for self-training) to be integrated within the ETIP Ocean, MARINET2 and the upcoming Erasmus+ Sector Skills Alliance for Maritime Technology
> - Giving training sessions in premises of strategic targeted audience with a dedicated team that will visit and train stakeholders to the new tools
> - Webinars will be organized once a year. The first one will be about the general methodology and the digital twin concept, the second one will be connected to the stage-gate and structured innovation approaches, and the last one will be based on the global tool set

This task will also open the test facilities to the stakeholders, including students and institutional representatives, by organizing specific practice-oriented education and knowledge exchange actions in pilot, demonstration site or laboratories. At least two visits connected to real projects will be organized based on each energy conversion approach: one on tidal conversion site and the second one linked to wave energy extraction. Several options are possible, and the consortium will look for the most appropriate one taking into account the progress of undergoing projects. One can mention the following sites and projects: Paimpol Bréhat, Wello project at EMEC, BiMEP or any other site where partner projects will take place (Nova, OH, CPO).

1.2 OUTLINE OF REPORT

This report is structured as follows:

- Chapter 1 introduces the scope of the report and summarises the DTOceanPlus tools.
- Chapter 2 summarises the education and training plan developed at the start of the project.
- Chapter 3 gives details of all the education and training activities conducted during the project.
- Chapter 4 offers some conclusions.
- Annexes I-IV collated the materials presented (slides etc), and examples of the documentation.

1.3 OVERVIEW OF THE DTOCEANPLUS TOOLS

DTOceanPlus will accelerate the commercialisation of the Ocean Energy sector by developing and demonstrating an open-source suite of design tools for the selection, development, deployment, and assessment of ocean energy systems (including sub-systems, energy capture devices and arrays).

At a high level, the suite of tools developed in DTOceanPlus will include:

- **Structured Innovation Tool (SI)**, for concept creation, selection, and design.
- **Stage Gate Tool (SG)**, using metrics to measure, assess and guide technology development.
- **Deployment Tools**, supporting optimal device and array deployment:
  - *Site Characterisation (SC):* to characterise the site, including metocean, geotechnical, and environmental conditions
  - *Machine Characterisation (MC):* to characterise the prime mover
  - *Energy Capture (EC):* to characterise the device at an array level
  - Energy Transformation (ET): to design PTO and control solutions
  - *Energy Delivery (ED):* to design electrical and grid connection solutions
  - *Station Keeping (SK):* to design moorings and foundations solutions
  - *Logistics and Marine Operations (LMO):* to design logistical solutions operation plans related to the installation, operation, maintenance, and decommissioning operations
- **Assessment Tools**, to evaluate projects in terms of key parameters:
  - *System Performance and Energy Yield (SPEY):* to evaluate projects in terms of energy performance
  - *System Lifetime Costs (SLC):* to evaluate projects from the economic perspective
  - *System Reliability, Availability, Maintainability, Survivability (RAMS):* to evaluate the reliability aspects of a marine renewable energy project
  - *Environmental and Social Acceptance (ESA):* to evaluate the environmental and social impacts of a given wave and tidal energy projects

Underlying common digital models and a global database will support these tools, as shown graphically in Figure 1.1.

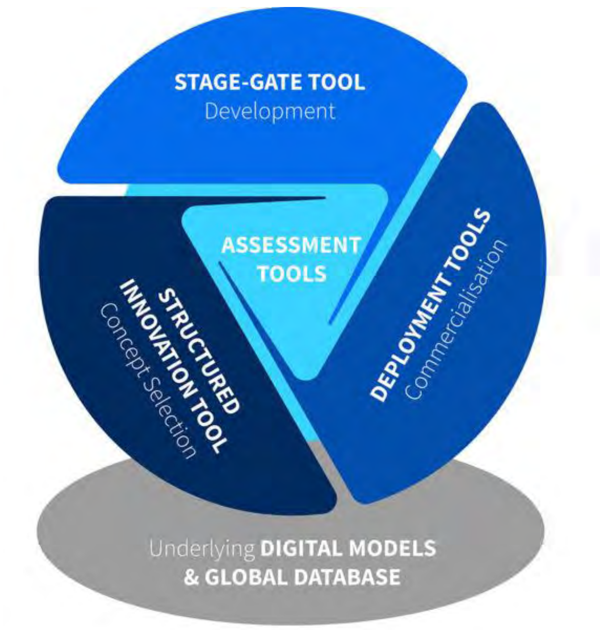


FIGURE 1.1: REPRESENTATION OF DTOCEANPLUS TOOLS

2. SUMMARY OF EDUCATION AND TRAINING PLAN

This section summarises D9.8 Education and training plan [1], produced in month nine of the DTOceanPlus project. As noted above, the global COVID–19 pandemic meant that many of the education and training activities had to be revised to an online format, rather than the in-person events originally proposed. The project duration was also extended by four months, to facilitate remote working; some education and training activities were correspondingly delayed.

2.1 TARGET AUDIENCE GROUPS AND OTHER STAKEHOLDERS

As noted in D9.2 Dissemination and communication plan [2], the target audience for the dissemination activities falls into three broad groups as shown in Table 2.1. Much of the technical training on how DTOceanPlus works will be aimed at users or potential users, however wider training activities will also be directed towards all audience groups.

The main users that the software tools are designed for are device and project developers, together with public and private investors. Other key stakeholders are also expected to use the software, particularly researchers, and university students/teachers.

TABLE 2.1 DTOCEANPLUS TARGET AUDIENCE GROUPS

Target groups	Subgroups
Primary users of the design tools	▫ Technology developers ▫ Project developers ▫ Design offices ▫ Public funding bodies ▫ Private investors
Other key stakeholders	▫ Policy makers ▫ Regulators ▫ Standards organizations ▫ Insurance providers ▫ Other actors in the supply chain ▫ Research organizations
General public	▫ Environmental NGOs ▫ Citizen organisations ▫ Students ▫ Individual citizens

2.2 CHANNELS AND TOOLS PROPOSED

The key instruments for education and training materials envisaged at the start of the project were:

- **Online webinars** to explain the suite of tools and approach planned. Held towards the start of the project, to showcase the planed tools to a wide audience. Targeted at prospective users of the suite of tools, in the stakeholder categories shown above.

- Production of **tutorials** for self-training on how to use the software. These explain the capabilities of the software and assist users on how to use the software. Produced in the second half of the project once the tools were largely developed.
- **Training sessions** for strategic targeted audiences, to explain and demonstrate how to use the tools developed in the project. At least four sessions were planned, each using similar content but perhaps targeted to the audience using relevant cases or examples.
- Two **workshops** to present the DTOceanPlus project to key stakeholders, and gain feedback. These were planned to happen alongside conferences or other industry events.
  - The first to showcase the draft software tools.
  - A final workshop, towards the end of the project, could present results from the project.
- **Visits** to the facilities of project partners coordinated as part of the education and training offered within the DTOceanPlus project, and potentially held in conjunction with appropriate industry events. These would increase both awareness in the ocean energy sector and investor confidence in real project deployments.

Further details of the purpose, target audience, proposed content, and proposed timing for these were included in the D9.8 Education and training plan [1].

3. EDUCATION AND TRAINING ACTIVITIES

This section provides details of all the education and training activities conducted during the project, tabulating the actions and key partners involved in these. The number of participants engaged in each activity is reported where possible. Slides presented at these events are collated in Annexes I-III of this report.

3.1 WEBINARS HELD TO EXPLAIN THE TOOLS

Four explanatory webinars were held in the first year of the project to explain the suite of tools and approach planned. These were held in conjunction with the European Technology and Innovation Platform for Ocean Energy 'ETIP Ocean 2' project[1].

Recordings of the webinars were made available after the event on the DTOceanPlus website at dtoceanplus.eu/Publications/Training, which significantly increased their effectiveness. The final webinar had to be re-scheduled due to internet connectivity issues related to the COVID–19 pandemic, which might partly explain the lower participation.

Details of the webinars are given in Table 3.1, including links to the recorded webinars hosted on the project website. The slides used are reproduced in Annex I: Slides presented on webinars.

TABLE 3.1: DETAILS OF WEBINARS HELD

Date	Title and topics covered	Partner(s)	Participants
6 July 2018	**DTOceanPlus user needs consultation – Introductory webinar** ▫ To inform potential users of tools about planned developments in the framework of DTOceanPlus. ▫ The objectives and the structure of the project were explained, and the tools of the suite were detailed. ▫ Participants were invited to answer an online questionnaire to assist in identifying the needs of future users. https://www.dtoceanplus.eu/Publications/Training/Webinar-1-DTOceanPlus-user-needs-consultation	UEDIN, ESC, WES, Tecnalia	35 attended + 304 watched later = 339 in total
23 Jan. 2020	**Digital representation of standard data formats for ocean energy systems** ▫ Introduction of DTOceanPlus project & tools ▫ Standard data formats for OES covering: Digitalisation in other sectors; the Four guiding principles of Flexibility, Expandability, Aggregation, and Communication; Digital Objects; the Hierarchical Structure; Intra- and Inter-relationships; plus some examples and the implementation in DTOceanPlus. ▫ Summary and future work https://www.dtoceanplus.eu/Publications/Training/Webinar-2-Digital-Representation-of-Standard-Data-Formats-for-Ocean-Energy-Systems	Tecnalia	72 attended + 74 watched later = 146 in total

[1] European Technology and Innovation Platform for Ocean Energy (ETIP Ocean 2). H2020 grant agreement number 826033. https://www.etipocean.eu/

Date	Title and topics covered	Partner(s)	Participants
25 Feb. 2020	**Stage Gate design tool for ocean energy** ▫ Introduction of DTOceanPlus project & tools ▫ Stage gate process for ocean energy ▫ Introducing the DTOcean+ Stage Gate design tool, walking through the main steps of the tools ▫ Summary and future work https://www.dtoceanplus.eu/Publications/Training/Webinar-3-Stage-Gate-Design-Tool-for-Ocean-Energy	WES	75 attended + 54 watched later = 129 in total
6 April 2020	**Structured innovation design tool** ▫ Introduction of DTOceanPlus project & tools ▫ Innovation approaches used in the automotive and aerospace industries, plus energy sector. Highlighting the lack of a standard structured innovative process for Ocean Energy technologies. ▫ Introducing the DTOcean+ Structured Innovation design tool, walking through the main steps of the tools ▫ Summary & Next steps https://www.dtoceanplus.eu/Publications/Training/Webinar-4-Structured-innovation-design-tool-for-ocean-energy	ESC	49 attended + 39 watched later = 88 in total

3.2 TRAINING SESSIONS

There were five external training sessions given during the project covering the use of the tools. Details are given in Table 3.2, with the slides reproduced in Annex II: Slides presented at training sessions. These were all held virtually due to the COVID–19 pandemic.

Two of these sessions were in conjunction with the MaRINET2 short course programme[2]. Note that these two sessions had a wider scope and had other organisations co-presenting; only the content specifically relate to DTOceanPlus is reported here. Full details, including all the materials presented, can be found on the MaRINET2 website[2].

In addition to these public events, multiple internal training sessions were held to explain the use of the tools to the industrial partners of the consortium – the early adopters of the tools. This facilitated the verification and validation tasks in work-package 7 and helped to refine the external training materials produced.

[2] Marine Renewable Infrastructure Network for Enhancing Technologies 2 (MaRINET2), H2020 grant agreement number 731084, Short courses: https://www.marinet2.eu/training/shortcourses/

TABLE 3.2: DETAILS OF TRAINING SESSIONS HELD

Date	Title and topics covered	Partner(s)	Participants

19 Nov. 2020	**MaRINET2 short course webinars: Reducing uncertainty in LCOE**
	▫ *Project feasibility: Use of design tools Introduction to DTOceanPlus*
	  ▫ Linked to previous sessions that tools such as DTOceanPlus can assist with calculation & quantifying uncertainty
	  ▫ Summarising the project and the tools to be developed
	  ▫ Presenting a user journey of the whole suite of tools
	▫ *Use of Design Tools to support techno-economic model – Real project examples.* Showcasing use of DTOcean and DTOceanPlus (alpha version) tools in real projects
	  ▫ Provide reference mooring solutions for the UMACK project[3]
	  ▫ Provide inputs for cost modelling in the IMAGINE project[4]
	  ▫ Contribute to array optimisation in the EnFAIT project[5]
		UEDIN, WavEC	52 participants for topic 3

25 March 2021	**Lecture to students of a wave energy course at Uppsala University (Sweden) about DTOceanPlus** ▫ Introduction to Tecnalia and the DTOceanPlus project ▫ Summary of the tools including a user journey ▫ More detail on the SG, SI, SK, and SPEY modules ▫ Live demo of SK and SPEY modules	Tecnalia	20 students on course

11-12 May 2021	**MARINET2 short course webinars: Installation and O&M of Offshore Renewable Energy systems**
	▫ *Logistics and Marine Operations (LMO) Planning Tool*
	  ▫ Overview of the DTOceanPlus project
	  ▫ LMO tool objectives, functionality, and inputs/outputs
	  ▫ Live demo walkthrough of the LMO tool
		WavEC	125–135 participants on course

1 July 2021	**Deployment and Assessment Design Tools for Ocean Energy Systems (focus on SC, SK, ESA)**
	▫ Introduction to the DTOceanPlus project and suite of tools
	▫ Summary of main interface functionality and short demo
	▫ Focus on three of the modules, with a description of features and presentation of interface.
	  ▫ Site Characterisation (SC)
	  ▫ Station Keeping (SK)
	  ▫ Environmental and Social Acceptance (ESA)
		FEM, UEDIN	47 attended

3 Universal Mooring, Anchor & Connectivity Kit Demonstration (UMACK), https://www.corpowerocean.com/projects/umack/
4 Innovative Method for Affordable Generation IN ocean Energy (IMAGINE), H2020 grant agreement number 764066, https://h2020-imagine.eu/
5 Enabling Future Arrays in Tidal (EnFAIT), H2020 grant agreement number 745862, https://www.enfait.eu/

Date	Title and topics covered	Partner(s)	Participants

6 July 2021	**Using the DTOceanPlus suite of tools to Guide Technology Development of Ocean Energy Systems**
	▫ Context of Technology Development
	▫ Guiding technology development ~ link to Deployment & Assessment tools
	  ▫ Using the Stage Gate tool's Activity Checklist as a guide for Stage Gate Assessment
	  ▫ Full Stage Gate Assessment using Deployment & Assessment tools
	▫ Guiding technology development ~ link to Structured Innovation tool
	  ▫ Link between Improvement Areas and Structured Innovation tool
	  ▫ Overall purpose of the Stage Gate tool and detailed look at the Report
	▫ Practical applications of Stage Gate tool in Industry
	  ▫ Examples of real use cases of Stage Gate tool
		WES, UEDIN	28 attended

3.3 WORKSHOPS

There were two workshops held in the final year of the project. Firstly, in conjunction with the Ocean Energy Europe conference, and secondly an end of project workshop hosted virtually on the project website. The purpose of the workshops was to present the whole DTOceanPlus project to key stakeholders and gain feedback. The online format restricted slightly the latter objective, but it allowed wider participation in the events.

The first workshop was held alongside the Ocean Energy Europe OEE2020 conference as planned; however, this was switched to a completely virtual format. As well as the main presentation, the technical partners were available on a "virtual stand" throughout the conference for all conference attendees to contact. This first workshop was effective at educating potential users of the tools about their proposed functionality, and showcasing progress to date, but it was not possible to offer in-person training sessions as had been hoped.

Due to ongoing uncertainty due to the pandemic, and to allow for summer vacations, it was decided that the final workshop would also follow a virtual format. This was based on the successful online approach adopted by the International Conference on Ocean Energy ICOE2021. Short, recorded video presentations outlining the main results of the project and how these address sector needs were made available on the project website at dtoceanplus.eu/Publications/Training/Technical-Workshop-2, with a question-and-answer panel session at the end of the project on 31 August 2021.

Details of the workshops are given in Table 3.3 with the slides used at OEE2020 reproduced in Annex III: Slides presented at OEE2020 workshop.

TABLE 3.3: DETAILS OF WORKSHOPS HELD

Date	Title and topics covered	Partner(s)	Participants
2 Dec. 2020	**DTOceanPlus Workshop in conjunction with Ocean Energy Europe (Online) 2020** ▫ Introduction to the workshop & project ▫ Overview of the tools – Functionality and architecture ▫ Assisting decision-makers and identifying opportunities using the Stage Gate and Structured innovation tools ▫ Design and Assessment of an array project using the Station keeping and System performance and energy yield modules ▫ Q&A Sessions, Wrap up and next steps	Tecnalia, UEDIN, WES, ESC, FEM	149 attended
Jul. 2021 onwards	**End of project workshop** Final details TBC, but will include videos on topics such as: ▫ Overall suite of tools developed ▫ Need for innovation address by Structured Innovation tool ▫ Need for informed decision making & Stage Gate tool ▫ Need for reference data & summarising datasets produced ▫ Need for a common way to represent ocean energy projects, and showing digital representation ▫ Need for efficient financing (to lower costs of ocean energy)	Tecnalia, UEDIN, ESC, WES, FEM, WavEC, AAU	–

3.4 VISITS TO PROJECTS OF INDUSTRIAL PARTNERS

Due to the COVID–19 pandemic, the proposed visits to the project of the industrial partners were not possible. As an alternative, 'virtual visits' were recorded at made available towards the end of the project, to showcase these projects and ocean energy in general whilst also further promoting the use of the DTOceanPlus tools. These will be publicised alongside the end of project workshop discussed above. Details are given in Table 3.4.

TABLE 3.4: DETAILS OF VIRTUAL VISITS TO PROJECTS

Title and topics covered	Partner(s)
Wave energy projects ▫ First full-scale prototype C4 wave energy converter to be deployed for ocean demonstration in 2021 at the Aguçadoura site in Portugal ▫ Optimisation of the full-scale technology successful demonstration with the MARMOK-A-5 prototype	FEM, CPO, IDOM
Tidal energy projects ▫ Successful deployment of O2 2 MW commercial tidal turbine at EMEC in Orkney ▫ Redeployment of grid-connected D10 tidal energy converter at Ushant Island ▫ Deployment of an array of 4 tidal turbines in Shetland Islands	FEM, OMP, Sabella, NOVA

3.5 DOCUMENTATION FOR SELF TRAINING

The original plan was to produce separate user and technical manuals to respectively document the how the tools work and the underlying code, as had been produced for the original DTOcean tools. A set of tutorials was also proposed to explain how to use the tools.

An alternative approach was adopted to offer a better, more streamlined, experience for users of the DTOceanPlus tools. This builds on feedback from the use of DTOcean v1.0 in the EnFAIT project, and the difficulty in understanding where functionalities are documented.

The documentation produced for the DTOceanPlus tools follows an established 'best-practice' standard for software tools as discussed in the next section. This documentation is hosted alongside the code of the tools, making it easier to update in parallel with development. It is anticipated that this will be updated with any future additions to the DTOceanPlus tools.

3.5.1 DOCUMENTATION FORMAT

There is documentation for the overall suite of tools, with a separate set of documentation for each module. The main documentation will cover areas including installing and running the tools; use cases and user journeys, including linkages between the various parts of the suite; and how to manage projects and studies. Although developed as separate modules, the main module and catalogue module are covered within the overall documentation, as this makes most sense conceptually for a user of the suite of tools.

To provide a dynamic and useful documentation system for the DTOceanPlus suite of tools, this has been developed with a linked hierarchical structure that can be viewed in a browser or exported as a document format if required. The documentation will follow an established system[6], split into four main areas preceded by a brief overview of the functionalities and workflow:

- **Tutorials** to give step-by-step instructions on using the tool for new Users.
- **How-to guides** that show how to achieve specific outcomes using the tool.
- An **explanation of features and calculation methods** gives technical background on how the tool works to give confidence in the tools.
- The **API reference section** documents the code of modules, classes, API, and GUI.

This can be visualised graphically as Figure 3.1. As explained in the documentation of the system [3] "… the characteristics of each quadrant of the documentation overlap with those of its neighbours in the scheme …

  - *tutorials and how-to guides* are both concerned with **describing practical steps**
  - *how-to guides and technical reference* are both **what we need when we are at work, coding**
  - *reference guides and explanation* are both concerned with **theoretical knowledge**

[6] The Documentation System, https://documentation.divio.com/

- *tutorials and explanation* are both **most useful when we are studying**, rather than actually working"

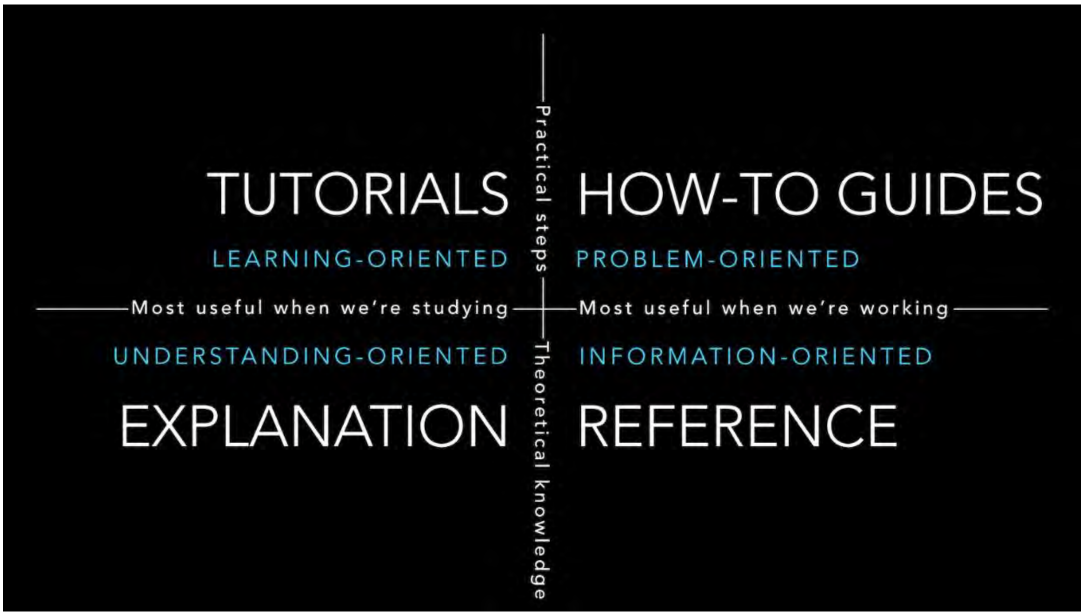


FIGURE 3.1: SCHEMATIC REPRESENTATION OF THE DOCUMENTATION SYSTEM [3]

The documentation is produced using the Sphinx Python Documentation Generator[7], and open-source tool to produce "intelligent and beautiful documentation". This should help users find the information they need without having to search through multiple long reports or project deliverables.

The documentation content builds on the work done within the project. The *tutorials* expand on those produced to train the partners for the verification activities described in D3.3, D4.3. D.5.9, and D6.6 [4, 5, 6, 7]. These are complimented by succinct *how to* guides that go into more detail. The *explanation of features and calculation methods* updates the comprehensive details outlined in the alpha-version deliverables [8, 9] [10, 11, 12, 13, 14, 15] [16, 17, 18, 19]. Finally, the *API reference* section documents the code of the modules based on the code docstrings written alongside the module code.

The results of the verification activities have been used to improve the documentation; improving tutorials and how-to guides to address shortcomings identified and feedback received.

3.5.2 DOCUMENTATION STRUCTURE

The documentation structure covers the four areas outlined in The Documentation System, as discussed in the previous section. Firstly, it covers the overall suite of tools, then covers each of the modules in turn. The main module, catalogue module, and digital representation are all covered within the overall DTOceanPlus tools section. Conceptually to a user, these are not separate modules, and individually they are each quite simple to document.

[7] Sphinx Python Documentation Generator https://www.sphinx-doc.org/en/master/

The overall structure of the documentation is summarised in Figure 3.2. For each module there is a brief outline giving an overview of the functionalities, workflow of using the tools, and data requirements. A few examples from the documentation are given in Annex IV: Examples of DTOceanPlus Documentation.

FIGURE 3.2. OVERALL STRUCTURE OF THE DOCUMENTATION

- **Overall DTOceanPlus documentation**
  - ***Introduction to DTOceanPlus***, including what is DTOceanPlus and who should use it, use cases and user journeys.
  - ***Tutorials***, on how to use the suite of tools at a high level, and with details of using the main module and catalogues.
  - ***How-to Guides***, on understanding both levels of complexity and the modular architecture of the DTOceanPlus tools, use of the main module and catalogue module.
  - ***Background and Theory***, including detailed use-cases and the development of the tools.
  - ***API Reference***, for the main module and catalogues
- **Structured Innovation**
  - Tutorials, How-to Guides, Background and Theory, API Reference.
- **Stage Gate**
  - Tutorials, How-to Guides, Background and Theory, API Reference.
- *Deployment Design Tools*
  - **Site Characterisation**
    - Tutorials, How-to Guides, Background and Theory, API Reference.
  - **Machine Characterisation**
    - Tutorials, How-to Guides, Background and Theory, API Reference.
  - **Energy Capture**
    - Tutorials, How-to Guides, Background and Theory, API Reference.
  - **Energy Transformation**
    - Tutorials, How-to Guides, Background and Theory, API Reference.
  - **Energy Delivery**
    - Tutorials, How-to Guides, Background and Theory, API Reference.
  - **Station Keeping**
    - Tutorials, How-to Guides, Background and Theory, API Reference.
  - **Logistics and Marine Operations**
    - Tutorials, How-to Guides, Background and Theory, API Reference.
- *Assessment Tools*
  - **System Performance and Energy Yield**
    - Tutorials, How-to Guides, Background and Theory, API Reference.
  - **System Lifetime Costs**
    - Tutorials, How-to Guides, Background and Theory, API Reference.
  - **System Reliability, Availability, Maintainability, Survivability**
    - Tutorials, How-to Guides, Background and Theory, API Reference.
  - **Environmental and Social Acceptance**
    - Tutorials, How-to Guides, Background and Theory, API Reference.

4. CONCLUSIONS

The education and training activities conducted within the DTOceanPlus project were broadly successful in achieving the primary aims below, however the global COVID–19 pandemic did prevent in-person delivery of events planned for the latter part of the project. The aims were:

- Firstly, to promote the suite of tools and showcase the capabilities thereof, and
- Secondly, to develop a range of open-source materials to help end users understand and learn to use the software [1].

The bulk of the activities was related to the first of these aims. Promotion of the tools and their functionalities was achieved through four webinars, five training sessions, and two workshops, in addition to the wider dissemination activities of the project. These sessions have been recorded, so will be available alongside the documentation to assist with the secondary aim of helping users (and potential users) to understand and learn how to use the software tools developed.

The target was to have three webinars with 100 participants each. This was exceeded in both number of webinars and total participation in each event. Hosting these on the project website allowed for asynchronous delivery throughout the project, increasing their effectiveness.

The proposal was to hold four training sessions with 30 participants each. The online format allowed a much broader reach for the training sessions. It is however noted that in-person hands-on training sessions could be much more impactful. Future in-person training sessions could be held by project partners (or others) beyond the end of the project, once this type of activity is more practicable.

A workshop was held alongside the OEE2020 conference as planned. Like the conference however, this was held in a virtual format. The final workshop was also revised to an online format, with video presentations to showcase project results and an online Q&A session held to mark the conclusion of the project.

It was not possible to hold visits to the projects of industrial partners as planned. Videos were proposed as an alternative to present the real tidal and wave projects and to illustrate how design tools can help technology developers to achieve their goals.

Finally, a comprehensive set of documentation has been prepared for the suite of tools to assist in their use. This includes tutorials, how-to guides, explanation of the background and theory, plus documentation of the code written. These use an established structure, with hierarchical hyperlinked pages to facilitate use. The documentation is hosted alongside the code of the tools and will be developed in parallel with any future additions to the DTOceanPlus tools.

Needs for future training activities are being reviewed as part of the exploitation actions within the project. It is hoped that in future it will be possible to hold in-person training sessions, to offer guided 'hands-on' experience of using the tools. Due to ongoing uncertainty with the global COVID–19 situation, it is not possible to plan these within the timeframe of the project.

5. REFERENCES

[1] D. R. Noble, "DTOceanPlus D9.8 Education and training plan," DTOceanPlus Consortium, 2019.

[2] M. Gaillard and N. Germain, "DTOceanPlus D9.2 DTOceanPlus Dissemination and communication plan," DTOceanPlus Consortium, 2018.

[3] D. Procida, "About the structure – Documentation system documentation," [Online]. Available: https://documentation.divio.com/. [Accessed 30 April 2021].

[4] Tunga, I., Ball, K., Tatlock, B., Abrahams, M., Khan, H., Sanchez-Lara, M.J., Ruiz-Minguela, P., Robles, E., "DTOceanPlus D3.3 "Testing and verification results of the Structured Innovation tool - Beta version"," DTOceanPlus Consortium, 2020.

[5] Marques, M.I., Langiano, S., Harvey, C., Lourenço, T., Ruiz-Minguela, P., Nava, V., Henderson, J., Hudson, B., Tunga, I., Fonseca, F., "DTOceanPlus D4.3 "Testing and verification results of the Stage Gate tool - Beta version"," DTOceanPlus Consortium, 2020.

[6] Marques, M.I., Langiano, S., Harvey, C., Lourenço, T., Tunga, I., Ruiz-Minguela, P., Nava, V., Fonseca, F., Amaral, L., Safi, G., Araignous, E., Yang, Y., "DTOceanPlus D6.6 "Testing and verification results of the Assessment Design tools – beta version"," DTOceanPlus Consortium, 2021.

[7] Marques, M.I., Langiano, S., Harvey, C., Lourenço, T., Tunga, I., Ruiz-Minguela, P., Nava, V., Grispiani, L., Robles, E., Lopez Mendia, J., Fonseca, F., Luxcey, N., Michelet, N., Araignous, E., Ferri, F., Noble, D., "DTOceanPlus D5.8 "Testing and verification results of the Deployment Design tools - Beta version"," DTOceanPlus Consortium, 2021.

[8] I. Tunga, M. Abrahams, H. Khan, B. Tatlock, D. R. Noble, J. Hodges, J. Henderson, O. Roberts, B. Hudson, V. Nava and P. Ruiz-Minguela, "DTOceanPlus D3.2 Structured Innovation design tool – Alpha version," DTOceanPlus Consortium, 2020.

[9] B. Hudson, J. Henderson, J. Hodges, M. Holland, D. R. Noble, I. Tunga, F. Fonseca and P. Ruiz-Minguela, "DTOceanPlus D4.2 Stage Gate tool – Alpha version," DTOceanPlus Consortium, 2020.

[10] Y. Kervella, "DToceanPlus D5.2 Site Characterisation – alpha version," DTOceanPlus Consortium, 2020.

[11] A. Tetu, F. Ferri, V. Nava and D. R. Noble, "DTOceanPlus D5.3 Energy Capture Tools - alpha version," DTOceanPlus Consortium, 2020.

[12] J. Lopez-Mendia, I. Touzon, E. Robles, J. Lopez-Queija, J. Henderson and F. Ferri, "DTOceanPlus D5.4 Energy Transformation tools – Alpha version," DTOceanPlus Consortium, 2020.

[13] D. R. Noble and A. Nambiar, "DTOceanPlus D5.5 Energy Delivery Tools – Alpha version," DTOceanPlus Consortium, 2020.

[14] N. Luxcey, R. Isorna, N. Germain, V. Nava, I. Tunga and D. R. Noble, "DTOceanPlus D5.6 Station Keeping Tools – alpha version," DTOceanPlus Consortium, 2020.

[15] F. X. Correia da Fonseca, L. Amaral, M. Rentschler, F. Arede, P. Chainho, Y. Yang, D. R. Noble, A. Petrov, V. Nava, N. Germain, N. Lariviere-Gillet, J. Henderson and B. Hudson, "DTOceanPlus D5.7 Logistics and Marine Operations Tools – Alpha version," DTOceanPlus Consortium, 2020.

[16] V. Nava, I. T. Gonzalez, J. L. Mendia, D. R. Noble, I. Tunga, F. Fonseca, J. Henderson, B. Hudson, F. Ferri, F. Pons and A. Petrov, "DTOceanPlus D6.2 Performance and Energy Yield Tools – alpha version," DTOceanPlus Consortium, 2019.

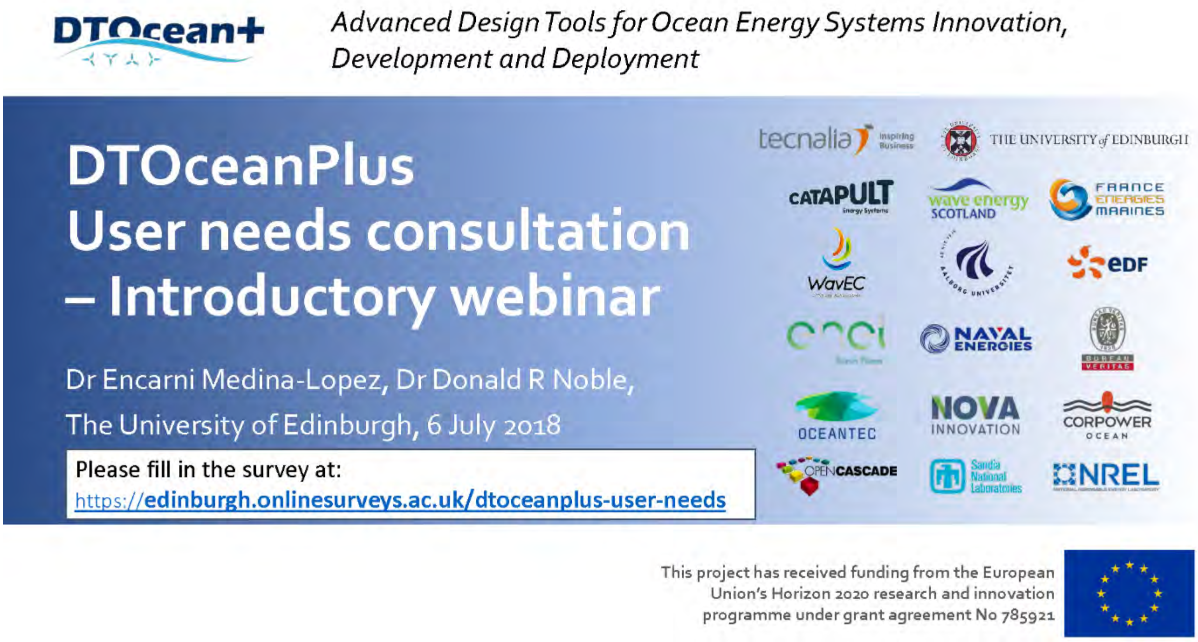
[17] Y. Yang, A. Nambiar, N. L. F. Fonseca and L. Amaral, "DTOceanPlus D6.3 Reliability, Availability, Maintainability and Survivability Assessment Tool – Alpha version," DTOceanPlus Consortium, 2020.

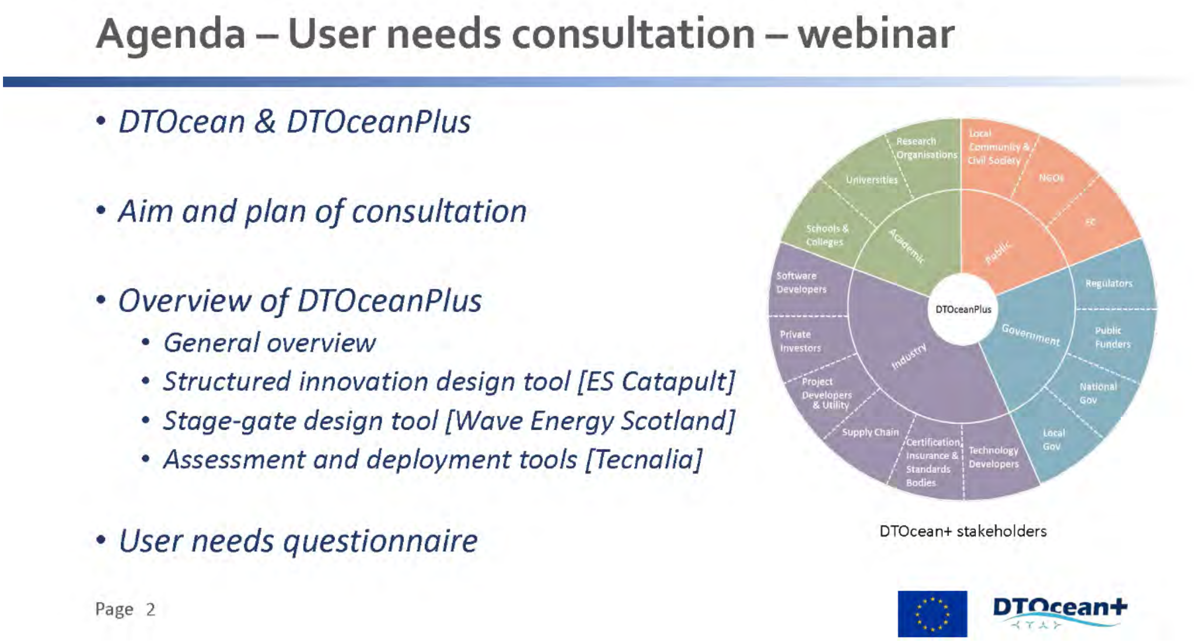
[18] F. X. Correia da Fonseca, L. Amaral, A. G. Armayor, J. Cândido, F. Arede, J. Henderson, B. Hudson, V. Nava, I. Tunga and A. Petrov, "DTOceanPlus D6.4 System Lifetime Costs tools – Alpha version," DTOceanPlus Consortium, 2020.

[19] E. Araignous and G. Safi, "DTOceanPlus D6.5 Environmental and Social Acceptance Tools – alpha version," DTOceanPlus Consortium, 2020.

ANNEX I: SLIDES PRESENTED ON WEBINARS

WEBINAR 1: DTOCEANPLUS USER NEEDS CONSULTATION – INTRODUCTORY WEBINAR





DTOcean & DTOceanPlus

- **DTOcean**: EU funded 2013 - 2016

  7th Framework Programme for R&D
  ENERGY 2013-1

- Accelerate development of ocean energy – design tools for ocean energy 1st generation deployment.

DTOcean

DTOceanPlus: EU funded 2018 – 2021
H2020 Programme, LCE-16-2017
"Advanced Design Tools for Ocean Energy Systems Innovation, Development and Deployment"

Page 3

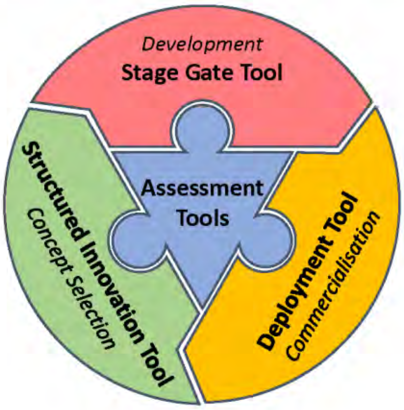
User needs consultation – aims and plans

- Refinement of user needs
  - Collect inputs from different stakeholders in a multi-level approach
  - Produce user requirements in terms of metrics, functionalities, and demonstration case studies.
- User consultation
  - Webinar to explain project and proposed tools
  - Questionnaire to gauge user needs
  - Follow up interviews with key stakeholders

Page 4

DTOceanPlus Objectives

- To develop and demonstrate an open source, integrated suite of 2nd generation design tools
- For ocean energy technologies including sub-systems, energy capture devices, and arrays
- That support the entire technology innovation process (i.e. from concept, through development, to deployment)
- Relevant and of great value to a wider group of key stakeholders



Underlying Digital models:

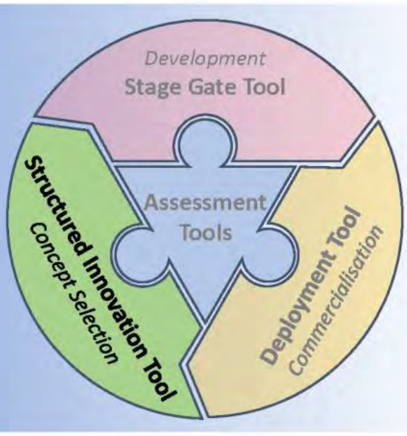
- A standard framework for the description of sub-systems, devices and arrays
- Communication method for the various tools
- Common language for the entire sector

Page 5

User needs consultation – Internal webinar

Overview of Structured Innovation Tool

Nick Eraut,
Energy Systems Catapult



Page 6

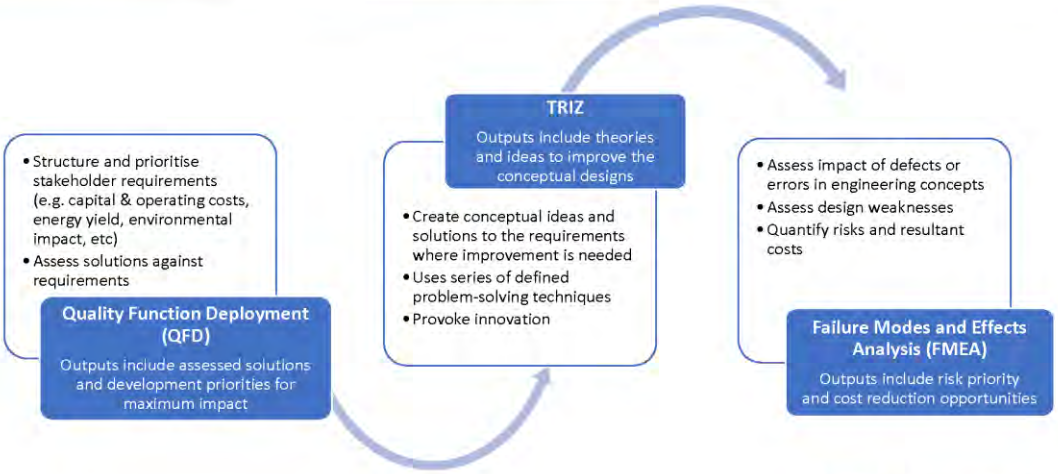
Structured Innovation

Aims:

- Capture the "Voice of the Stakeholder"
- Provide an innovation toolkit, with validated input data and methods
- Link to Stage Gate Design Tools with innovative solutions, priorities, and risks

Page 7

Structured Innovation – Three Tools



Page 8

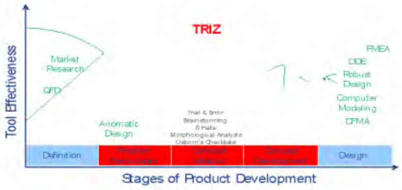
Structured Innovation

Puts rigour and innovation at the heart of concept creation, using QFD, TRIZ and FMEA

- Captures and prioritises requirements
  - What does the customer really want?
- Assesses solutions for impact
  - How can we meet those needs?
- Provides problem solving for contradictions
  - I want power, but low cost
- Encourages risk assessment and mitigation
  - How can I overcome my design reliability without adding cost?

Gives development direction and impact

- Improve the impact per unit development cost
- Improve commercial acceptability

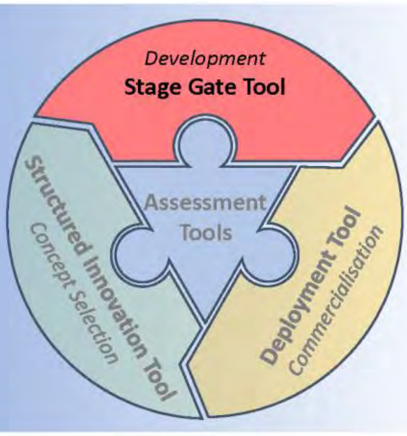


Page 9

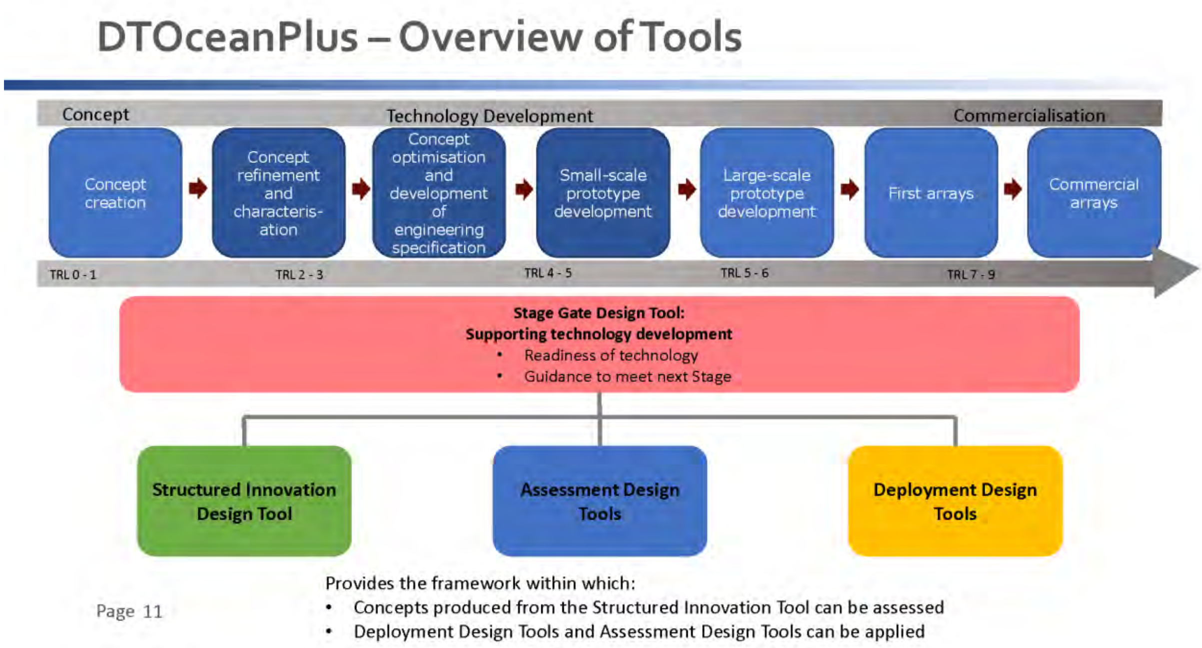
User needs consultation – Internal webinar

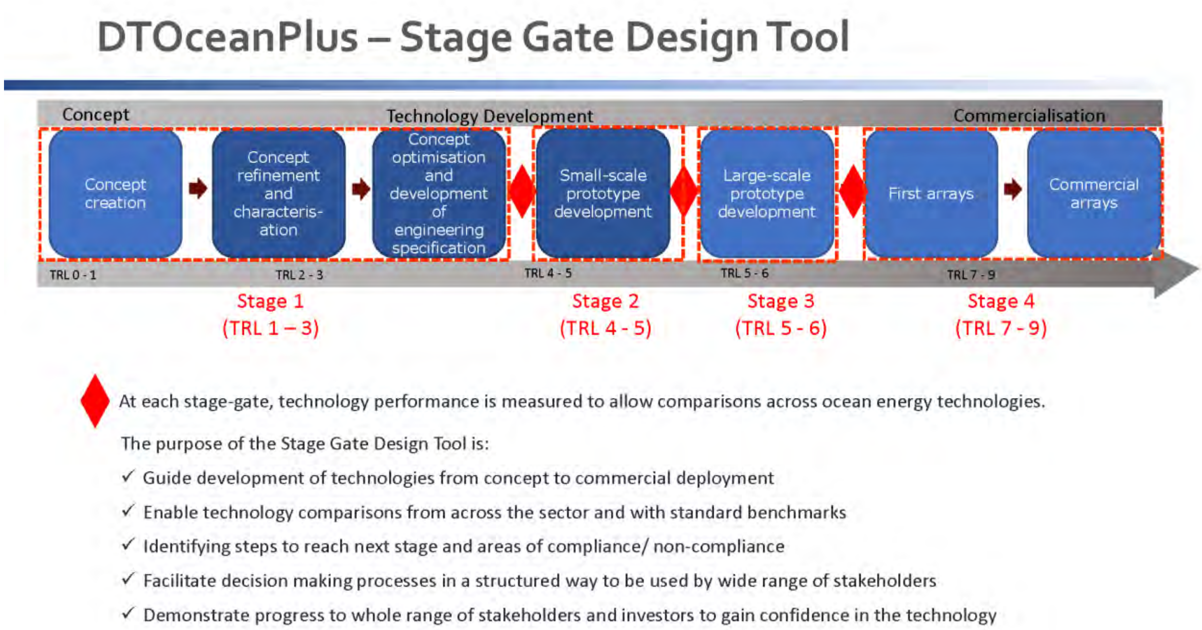
Overview of Stage Gate Tool

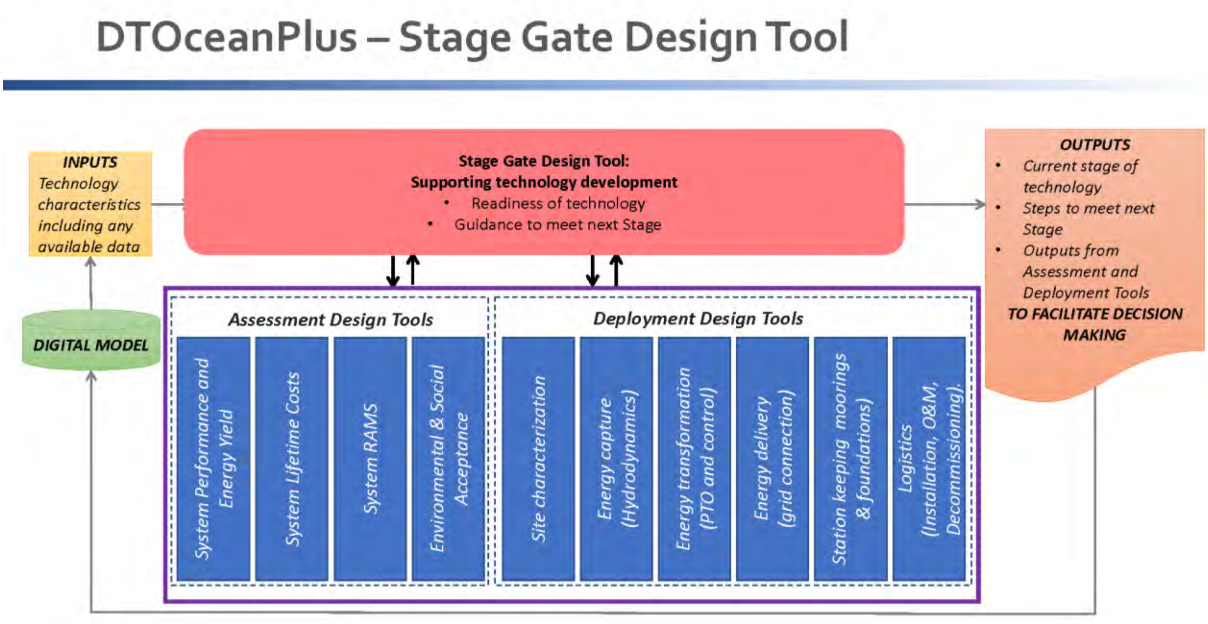
Jillian Henderson,
Wave Energy Scotland



Page 10


DTOceanPlus – Overview of Tools
Concept
Technology Development
Commercialisation
Concept creation
Concept refinement and characteris-ation
Concept optimisation and development of engineering specification
Small-scale prototype development
Large-scale prototype development
First arrays
Commercial arrays
TRL 0 - 1
TRL 2 - 3
TRL 4 - 5
TRL 5 - 6
TRL 7 - 9
Stage Gate Design Tool:
Supporting technology development
• Readiness of technology
• Guidance to meet next Stage
Structured Innovation Design Tool
Assessment Design Tools
Deployment Design Tools
Provides the framework within which:
• Concepts produced from the Structured Innovation Tool can be assessed
• Deployment Design Tools and Assessment Design Tools can be applied
Page 11


DTOceanPlus – Stage Gate Design Tool
Concept
Technology Development
Commercialisation
Concept creation
Concept refinement and characteris-ation
Concept optimisation and development of engineering specification
Small-scale prototype development
Large-scale prototype development
First arrays
Commercial arrays
TRL 0 - 1
TRL 2 - 3
TRL 4 - 5
TRL 5 - 6
TRL 7 - 9
Stage 1 (TRL 1 – 3)
Stage 2 (TRL 4 - 5)
Stage 3 (TRL 5 - 6)
Stage 4 (TRL 7 - 9)
At each stage-gate, technology performance is measured to allow comparisons across ocean energy technologies.
The purpose of the Stage Gate Design Tool is:
✓ Guide development of technologies from concept to commercial deployment
✓ Enable technology comparisons from across the sector and with standard benchmarks
✓ Identifying steps to reach next stage and areas of compliance/ non-compliance
✓ Facilitate decision making processes in a structured way to be used by wide range of stakeholders
✓ Demonstrate progress to whole range of stakeholders and investors to gain confidence in the technology


DTOceanPlus – Stage Gate Design Tool
INPUTS
Technology characteristics including any available data
DIGITAL MODEL
Stage Gate Design Tool:
Supporting technology development
• Readiness of technology
• Guidance to meet next Stage
OUTPUTS
• Current stage of technology
• Steps to meet next Stage
• Outputs from Assessment and Deployment Tools
TO FACILITATE DECISION MAKING
Assessment Design Tools
System Performance and Energy Yield
System Lifetime Costs
System RAMS
Environmental & Social Acceptance
Deployment Design Tools
Site characterization
Energy capture (Hydrodynamics)
Energy transformation (PTO and control)
Energy delivery (grid connection)
Station keeping moorings & foundations)
Logistics (Installation, O&M, Decommissioning)


User needs consultation – Internal webinar
Overview of Deployment & Assessment Tools
Pablo Ruiz Minguela & Vincenzo Nava, Tecnalia
Development Stage Gate Tool
Assessment Tools
Structured Innovation Tool Concept Selection
Deployment Tool Commercialisation
Page 14

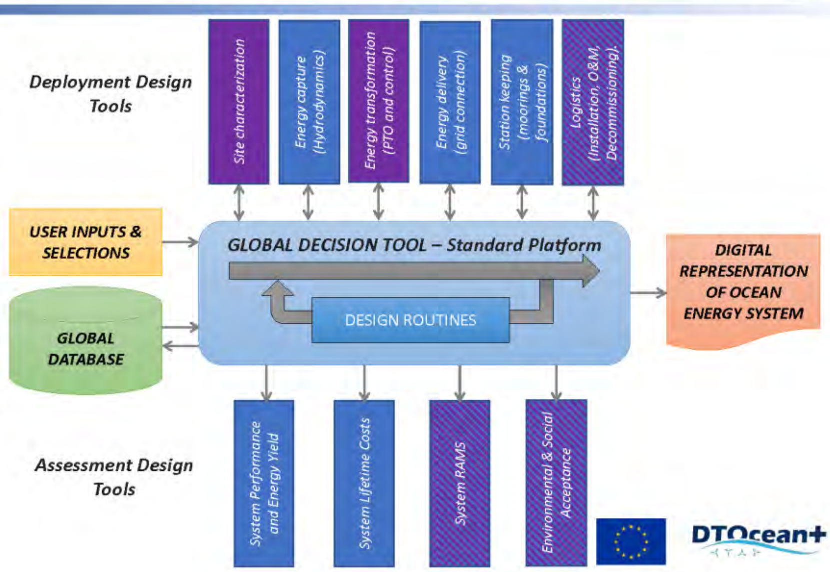
DTOceanPlus - Deployment & Assessment Design Tools

- New toolset built upon the **DTOcean platform**. Improvements in terms of:
  - ✓*Design accuracy*
  - ✓*Management of uncertainties*
  - ✓*Usability*
  - ✓*Running time*
- Use of a **standard digital representation of ocean energy systems.**
- Use of a **standard core platform** (Salome).
- Ability to manage **different levels of** granularity/coarseness of input **data.**
- **Interface** with already available **commercial options**.

Page 15

DTOceanPlus - Deployment & Assessment Design Tools

- **Scope to be widened** with new modules (**purple**) and improved functionality on the 1st gen. tools (**blue**)
- Provide **optimal system designs** (devices & arrays)



Page 16

User needs consultation – Internal webinar

User needs questionnaire

Dr Donald R Noble,
The University of Edinburgh

Page 17

User needs questionnaire – General

- 35 questions over 5 pages:
  - Your Details;
  - General DTOceanPlus;
  - Structured Innovation;
  - Stage Gate;
  - Deployment & Assessment
- *About 15 minutes to complete*
- *Multiple choice, rankings, and free text input*
- *Please add in comments if you want to further explain your choices*

- Project engagement – *optional contact details*
  - Hold details for the project duration to keep you informed
  - Participation in optional follow up interviews
- Organisation details – *type, name, role, country*
  - You can respond anonymously, but details help us understand our users
  - Responses will be aggregated and not individually attributable

Page 18

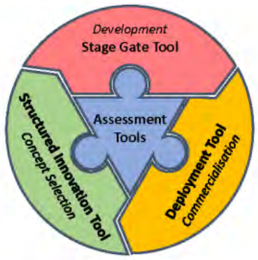
User needs – General – Project lifecycle

- Project lifecycle – DTOceanPlus used at multiple stages:
  - **Concept definition:** (TRL 1-3) early stage analysis of potential device or site. Gives an overview of capabilities and next development steps, but may be based on limited data.
  - **Feasibility:** (TRL4-6) includes an in-depth study of the topics covered in the concept definition. More accurate than previous stage, with additional data requirements.
  - **Design:** (TRL 7-9) key project features are planned in this stage, informed by the previous phases. Makes use of detailed information about the project.
- At each stage:
  - Likelihood of use?
  - Balance between speed of computation or the detail (accuracy and complexity) of results?
  - Duration expected for data formatting and inputting?
  - Training to use software, or get a colleague/consultant to use?

Page 19

User needs – Questions on the tools

- For each of the tools:
  - Structured Innovation; • Stage Gate; • Deployment & Assessment



- How well you understand (conceptually) what the tool will do
- How likely are you to use these tools, and importance for:
  - Sub-system • Device • Array
- Tool specific questions… (next slides)
- Free text boxes to add specific requirements and other comments on each tool.

Page 20

User needs – Structured innovation (SI) tool

- SI for specific/general problems:
  - Specific problem. Short-term solution and path to reach next level.
  - General problem. Long-term solution and path to reach final goal.

- Importance of using SI within DTOceanPlus for:
  - Identifying and quantifying challenges
  - Identifying enabling technologies
  - Generating ideas to optimise a device/array
  - Identifying areas of opportunity
  - Designing of funding calls

Very important → Not important

Page 21

User needs – Stage gate tool

- Importance that you can use Stage Gates to:

Very important → Not important

1. Assess development stage of different aspects
   - Reliability
   - Availability
   - Maintainability
   - Survivability
   - Performance
   - Lifetime Cost
   - Energy Yield
   - Environmental
   - Social aspects

2. Assess various characteristics
   - Comparison with standard benchmarks
   - Assessing the stage a device/technology is at
   - Assessing areas of compliance and non-compliance
   - Identifying steps to reach next stage
   - Providing evidence for investors/market

Page 22

User needs – Deployment & assessment tools

- Importance of using DTOceanPlus tools for:
  1. Comparing devices and locations
  2. Assess & optimise different aspects & characteristics of a project:

Very important → Not important

- Site characterisation (e.g. metocean, geotechnical and environmental conditions)
- Energy capture (e.g. array layout)
- Energy transformation (e.g. power take-off)
- Energy delivery (e.g. cabling layout)
- Station keeping (e.g. foundations and moorings)
- Logistics, Operations and Maintenance
- Optimising balance of plant
- Identifying areas for cost reduction
- Maximising energy delivery
- Quantifying social and environmental benefits
- Assessing optimal location for a given device
- Assessing optimal device for a given location
- Planning deployment and operations

Page 23

User needs – Final

- Any other comments
  - Regarding the survey or the DTOceanPlus project
- Submit & thanks for your contribution!
  - Help us guide development to meet needs of users like you.
- Please fill in the questionnaire at: https://edinburgh.onlinesurveys.ac.uk/dtoceanplus-user-needs
  - You should have the link in the webinar invite or shared on social media

Page 24

WEBINAR 2: DIGITAL REPRESENTATION OF STANDARD DATA FORMATS FOR OCEAN ENERGY SYSTEMS


You can find the presentations and the webinar recording at:
etipocean.eu and dtoceanplus.eu
ETIPOCEAN
DTOcean+
2


DTOcean+
Advanced Design Tools for Ocean Energy Systems Innovation, Development and Deployment
Webinar
Digital Representation of Standard Data Formats for Ocean Energy Systems
Vincenzo Nava, Pablo Ruiz-Minguela
Tecnalia, 2020
tecnalia
THE UNIVERSITY of EDINBURGH
CATAPULT
wave energy SCOTLAND
FRANCE ENERGIES MARINES
WavEC
enel
IDOM
NOVA INNOVATION
CORPOWER OCEAN
OPEN CASCADE
ORBITAL
sabella
Sandia National Laboratories
NREL
This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 785921

Contents

1. Introduction to DTOceanPlus (I)

- An **integrated open-source suite of design tools** to support the entire innovation and development process for ocean energy sub-systems, devices and arrays.
- Continuing **the development of DTOcean,** which produced a 1st generation of freely available, **open-source design tools for wave and tidal energy** arrays.
- Its operational capabilities and value will be **demonstrated (TRL6) with data from real case technology projects**.

1. Introduction to DTOceanPlus (II)

- **Structured Innovation Tool**

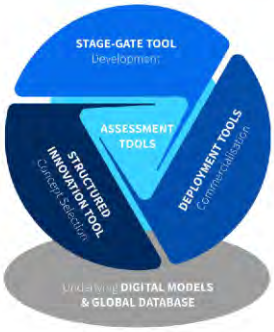
  For concept creation, selection and design.
- **Stage Gate Tool**

  Assisting decision-making through the use of metrics to measure, assess and guide technology development.
- **Deployment Tools**: Site characterisation, Energy capture, Energy transformation, Energy delivery, Station-keeping, Logistics and Marine Operations

  Supporting optimal device and array deployment.
- **Assessment Tools:** Performance & Energy Yield, RAMS, Lifetime Costs, Environmental and Social Acceptance

  Providing objective information to the developer or investor on the suitability of a technology and project.
- **Common digital models – Digital Representation**

  Standard framework for the description of sub-systems, devices and arrays to allow sharing of design information.



Page 6

1. Introduction to DTOceanPlus (III)

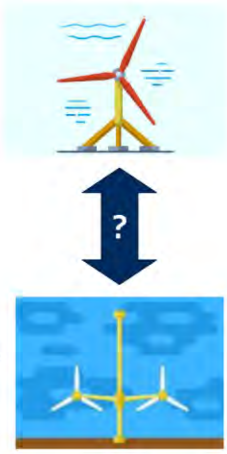
- A 3-year EU project (May 2018 - April 2021) with a total budget of **8 M€**.
- **Multidisciplinary team** of 16 partners from 7 EU countries, with the collaboration of 2 leading research laboratories from the USA.

Page 7

2. Standard data formats for OES (I)

Motivation and objectives

- Lack of a **standard method** for describing the key characteristics and attributes of Ocean Energy technologies:
  - Makes it difficult to impartially analyse innovative designs.
  - Renders impossible to objectively compare competing technologies.
  - Hinders knowledge sharing activities.
  - Can lead to misuse of limited funding and resources.

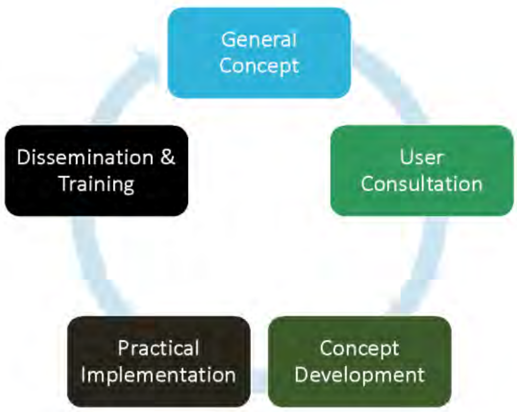


- The **Digital Representation** aims to:
  - Provide a common language and architecture for storing project information.
  - Facilitate data and information exchange.
  - Enable objective comparisons between various technologies.
  - Enhance the ability of sector stakeholders to work collaboratively.

Page 8

2. Standard data formats for OES (II)

Methodology

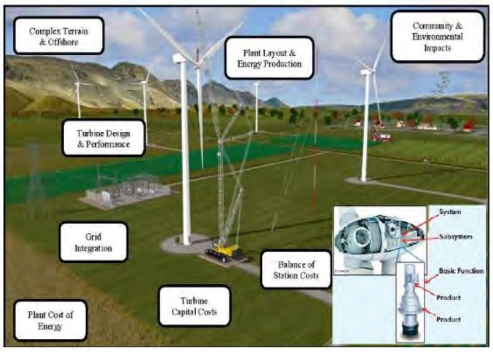


Page 9

2. Standard data formats for OES (III)

Digitalisation in other sectors

Construction sector: Digital objects/twins over the project lifetime



Wind sector: Guidelines for a common conceptual architecture for wind turbines and plants

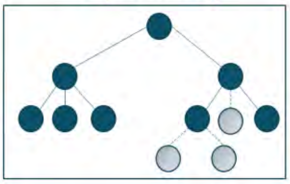
2. Standard data formats for OES (IV)

Four guiding principles

Flexibility

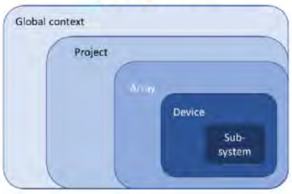
Different levels of data granularity to match technology maturity (TRL)

Expandability



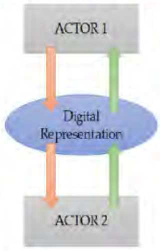
Avoid early obsolescence as the sector evolves and brings in new objects and lower levels of detail

Aggregation



Facilitate objective comparisons of individual sub-systems, devices and arrays

Communication

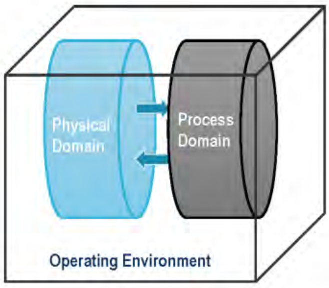


Seamless exchange of information among software tools and stakeholders

2. Standard data formats for OES (V)

Digital Objects

Three Design Components



Two Model Perspectives

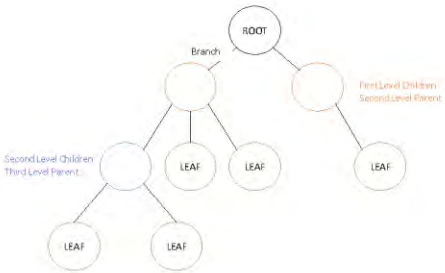
Single Object Structure

Page 12

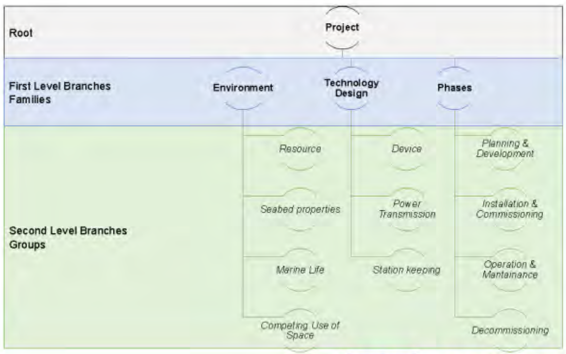
2. Standard data formats for OES (VI)

Hierarchical Structure

Rooted tree



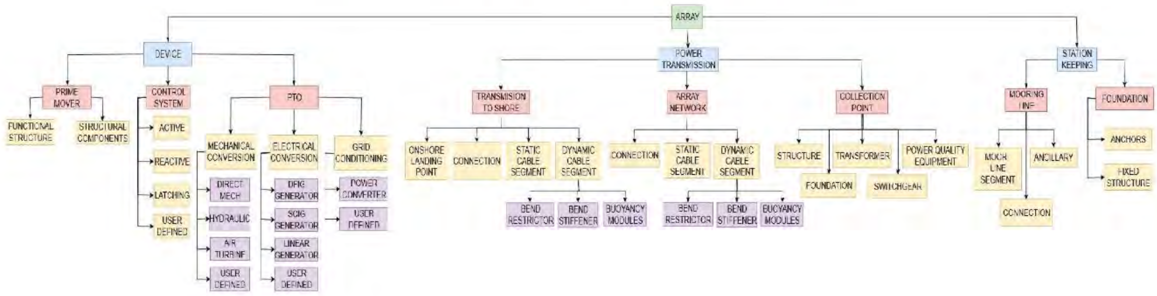
Ocean Energy Families and Groups



Page 13

2. Standard data formats for OES (VII)

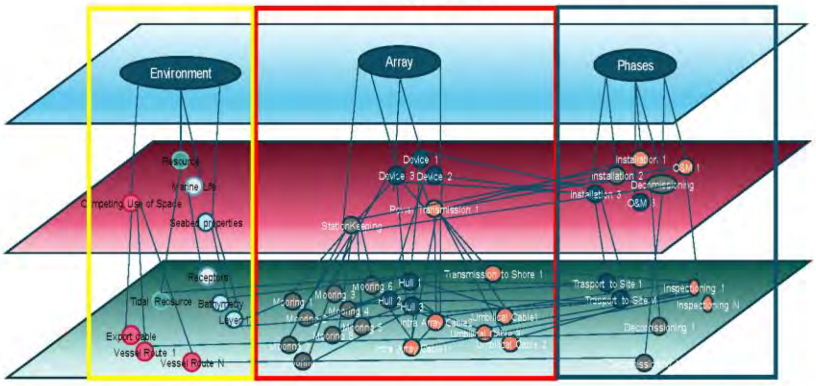
Example of the Technology Design Family



2. Standard data formats for OES (VIII)

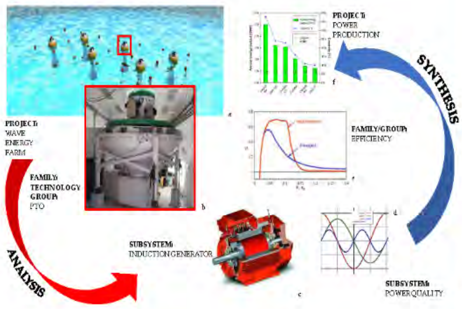
Intra- and Inter-relationships

Environment Technology Design Phases



2. Standard data formats for OES (IX)

Example of DR for an Induction Generator for the PTO of a WEC



PTO

ID		PTO-1	String
LOCATION	[x, y, z]	[0,0,0], [0,0,2]	1D Array
PHYSICAL AND FUNCTIONAL PROPERTIES			
	Type of mechanical conversion	Air Turbine	String
	Number of PTO	2	Scalar
	Type of electrical conversion	SCIG	String
	Type of grid conditioning	Power Converter	String
	Pnom	500 kW	Scalar
	Name Material & weight	Steel & 500 kg	Array
ASSESSMENTS			
	CAPEX	5e4 €	Scalar
	OPEX	1e5€	Scalar
	Failure rate	1e-4 hr-1	Scalar
	Risk priority number	-	Scalar
HIERACHICAL CONNECTION			
	Part of {Device ID}	Device01	List of Strings
	Mechanical conversion {IDs}	Mech01	List of Strings
	Electrical Conversion {IDs}	Elec02	List of Strings
	Grid conditioning {IDs}	Grid04	List of Strings
CONNECTION		-	
	Installation of PTO {Operation IDs}	[Inst01, Inst02, Inst03]	List of Strings
	O&M of PTO {Operation IDs}	[Op1, Op2, Op3]	List of Strings
	Decommissioning of PTO {Operation IDs}	[Dec1, Dec2]	List of Strings

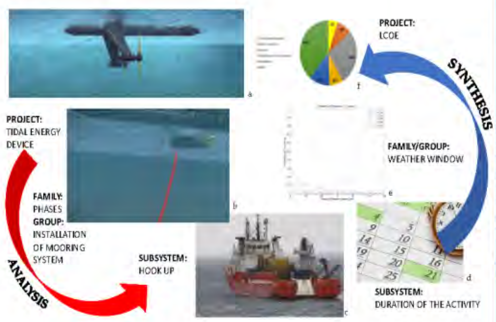
SCIG GENERATOR

ID		SCG1	String
LOCATION	[x, y, z]	m	1D Array
PHYSICAL AND FUNCTIONAL PROPERTIES			
	Pnom	250 kW	Scalar
	Name Material & weight	Steel & 10 kg	Array
ASSESSMENTS			
	Efficiency	75%	Scalar
	Cost	1e3€	Scalar
	Failure rate	0.001	Scalar
HIERACHICAL CONNECTION			
	Part of: {Elect Conversion ID}	Elec02	Scalar
CONNECTION			
	Installation of Mech. Conv {Operation ID}	Inst1	String
	O&M of Mech. Conv {Operation ID}	Op1	String
	Decommissioning of Mech. Conv {Operation ID}	Dec2	String

Page 16

2. Standard data formats for OES (X)

Example of DR for the Installation of a Mooring Line for a TEC



INSTALLATION

ID		INST-01	String
NAME		Installation of Mooring System	String
TYPE	Installation		String
START/END			
	Start date	20/02/2020	Date
	End Date	28/02/2020	Date
DURATION			
	Total Duration	168 h	Scalar
	Duration at Sea	100 h	Scalar
	Duration at Port	15 h	Scalar
	Waiting time	20 h	Scalar
	Mobilisation Time	33 h	Scalar
VESSELS, PORTS, EQUIPMENT			
	Type of Vessel		String
	Number of Vessels	1	Scalar
	Port	Santander	String
	Other Equipment	-	String
	Operating Limiting Conditions [Hs, Tp, Vc, Vw]	[1.5,7, -, -]	List of scalars
ASSESSMENTS			
	Downtime Hours [h]	-	Scalar
	Vessel/equipment consumption	25	Scalar
	Vessel Route [list of coordinates]	[0,0], [0,1], ... [125,345]	List of coord
	Operation cost	1e5 €	Scalar
	Production of CO2 and other pollutants	1e4	Scalar
	Number of crew/workers	10	Scalar
	Risk of Collision (in case of Vessel operation)	25/100	Scalar
	Underwater nois	24/100	Scalar
CONNECTION WITH PHASE			
	Is Part of {Operation ID}	-	List of strings
CONNECTION WITH TECHNOLOGY DESIGN			
	Technology (ies) involved	Moorign1-	List of strings
CONNECTION WITH SITE			
	Id of the Time Series	TimeSeries1	List of strings

CONNECTION

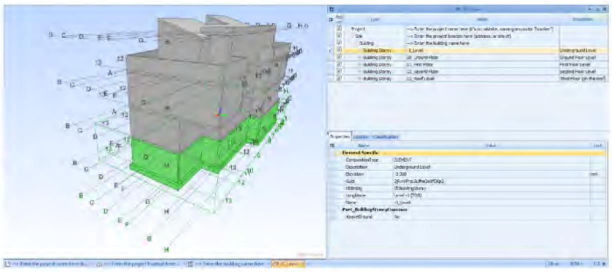
ID	HOOK-01	-	String
NAME	Hook up of Mooring System	-	String
TYPE	Hook up		String
START/END			
	Start date	22/02/2020	Date
	End Date	22/02/2020	Date
DURATION			
	Total Duration	8 h	Scalar
	Duration at Sea	8 h	Scalar
	Duration at Port	- h	Scalar
	Waiting time	- h	Scalar
	Mobilisation Time	- h	Scalar
VESSELS, PORTS, EQUIPMENT			
	Type of Vessel		String
	Number of Vessels	1	Scalar
	Port	Santander	String
	Other Equipment	-	String
	Operating Limiting Conditions [Hs, Tp, Vc, Vw]	[1.5,7, -, -]	List of scalars
ASSESSMENTS			
	Downtime Hours [h]		Scalar
	Vessel/equipment consumption		Scalar
	Vessel Route [list of coord.]		List of coord.
	Operation cost	1e5 €	Scalar
	Production of CO2 and other pollutants	-	Scalar
	Number of crew/workers	10	Scalar
	Risk of Collision (in case of Vessel operation)	25/100	Scalar
	Underwater noise	24/100	Scalar
CONNECTION WITH PHASE			
	Is Part of {Operation ID}	INST-01	List of strings
CONNECTION WITH TECHNOLOGY DESIGN			
	Technology (ies) involved	Moorign1-	List of strings
CONNECTION WITH SITE			
	Id of the Time Series	TimeSeries1	List of strings

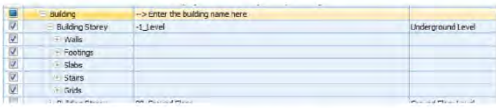
Page 17

2. Standard data formats for OES (XI)

Practical implementation in DTOceanPlus

- XML and JSON file formats are being considered
  - Widely used (e.g. BIM)
  - Human readable
  - Provide a schema that can be tailored (= future expandability)
  - Ensure document consistency and validity
- One main file with reference to external files (in their native format, e.g. cvs, pdf, …)
  - Stored in the same directory, or
  - Packed together in self-extractable archive





Images courtesy of
https://www.engipedia.com/revit-organizing-template-ifc-export/

Page 18

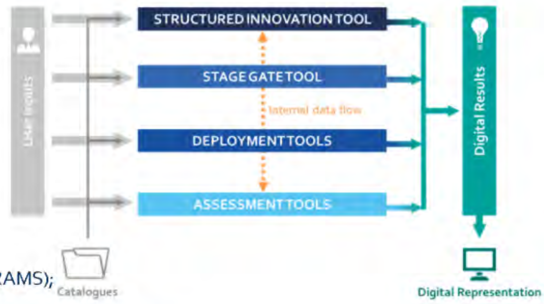
3. Summary and future work (I)

- Standard representation of data formats for OE Systems to:
  - Provide a common language and architecture for storing project information.
  - Facilitate data and information exchange.
  - Enable objective comparisons between various technologies.
  - Enhance the ability of sector stakeholders to work collaboratively.
- Digital objects:
  - Integrate in a single structure two model perspectives (physical design and assessment) for three different design elements (environment, physical entities and processes)
  - Hierarchical structure to allow future expandability and different levels of aggregation and complexity.
  - Connectivity to represent the inter- and intra-relationships between instantiated objects.

Page 19

3. Summary and future work (II)

- The Digital Representation will be built in practical terms during the implementation of the different tools and modules of DTOceanPlus:
  - Structured Innovation Tool (SI).
  - Stage Gate Tool (SG).
  - Deployment Tools:
    - Site Characterisation (SC);
    - Energy Capture (EC);
    - Energy Transformation (ET);
    - Energy Delivery (ED);
    - Station Keeping (SK);
    - Logistics and Marine Operations (LMO).
  - Assessment Tools:
    - System Performance and Energy Yield (SPEY);
    - System Lifetime Costs (SLC);
    - System Reliability, Availability, Maintainability, Survivability (RAMS);
    - Environmental and Social Acceptance (ESA).



- ... and tested with data from real case technology projects

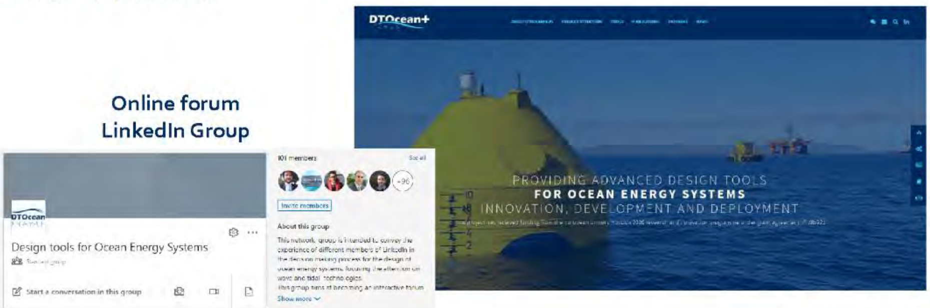
Page 20

3. Summary and future work (III)

- The concept of the Digital Representation will be presented to stakeholders during a set of dissemination and training actions:
  - Conferences such as EWTEC 2019 or ICOE2020
  - Scientific publications
  - Webinars and tutorials

dtoceanplus.eu

Online forum
LinkedIn Group



Page 21

4. Reference Material

Advanced Design Tools for Ocean Energy Systems Innovation, Development and Deployment

Deliverable D7.1

Standard Data Formats of Ocean Energy Systems

Lead Beneficiary	Tecnalia
Delivery Date	29/10/2019
Dissemination Level	Public
Status	Released
Version	1.0
Keywords	Data formats, Digital Representation, Ocean Energy Systems

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 785921

Page 22

Deliverable D7.1 "Standard Data Formats of Ocean Energy Systems" of the DTOceanPlus project is a report, collecting the outcome of the work carried out during task T7.1 of the project, aiming at fully describing the data used for a generic ocean energy system design in a structured manner.

Section 6 (Annex) contains the full list of data structures for the Digital Representation of Ocean Energy Systems

Document Information

Grant Agreement Number	785921
Project Acronym	DTOceanPlus
Work Package	WP7
Related Task(s)	T7.1
Deliverable	D7.1
Title	Standard Data Formats of Ocean Energy Systems
Author(s)	Vincenzo Nava, Miren Josune Sanchez-Lara, Pablo Ruiz-Minguela (Tecnalia), Donald R Noble, Anup Nambiar (UEDIN), Inès Tunga (ESC), Jonathan Hodges, Jillian Henderson (WES), Neil Luxcey, Rocio Isorna, Emma Araignous, Georges Safi, Nicolas Germain (FEM), Francisco Fonseca (WavEC), Francesco Ferri, Yi Yang (AAU), Nicolas Relun (EDF), Frederic Pons (OCC)
File Name	DTOceanPlus_D7.1_Standard_Data_Formats_of_OES_Tecnalia_20191029_v1.0.docx

Advanced Design Tools for Ocean Energy Systems Innovation, Development and Deployment

Thank you – Questions?

Vincenzo Nava, Pablo Ruiz-Minguela

Disclaimer: This presentation reflects only the author's views and the Agency is not responsible for any use that may be made of the information contained therein.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 785921

WEBINAR 3: STAGE GATE DESIGN TOOL FOR OCEAN ENERGY

Advanced Design Tools for Ocean Energy Systems Innovation, Development and Deployment

Webinar

Stage Gate Design Tool

Jillian Henderson, Ben Hudson
Wave Energy Scotland
25 Feb 2020

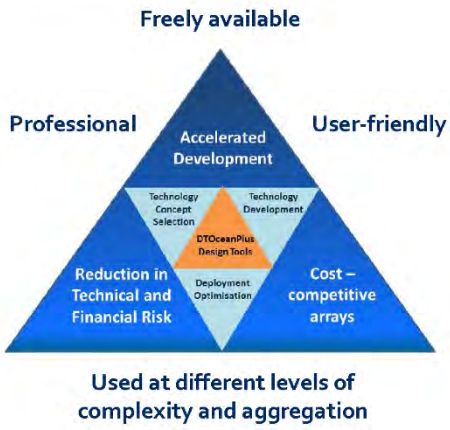
This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 785921

Contents

Page 2

1. Introduction to DTOceanPlus (I)

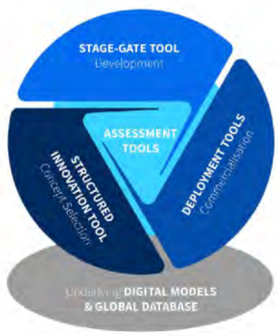
- An **integrated open-source suite of design tools** to support the entire innovation and development process for ocean energy sub-systems, devices and arrays.
- Continuing **the development of DTOcean,** which produced a 1st generation of freely available, **open-source design tools for wave and tidal energy** arrays.
- Its operational capabilities and value will be **demonstrated (TRL6) with data from real case technology projects**.



Page 3

1. Introduction to DTOceanPlus (II)

- **Structured Innovation Tool**
  - For concept creation, selection and design.
- **Stage Gate Tool**
  - Assisting decision-making through the use of metrics to measure, assess and guide technology development.
- **Deployment Tools**: Site characterisation, Machine Characterisation, Energy capture, Energy transformation, Energy delivery, Station-keeping, Logistics and Marine Operations
  - Supporting optimal device and array deployment.
- **Assessment Tools:** Performance & Energy Yield, RAMS, Lifetime Costs, Environmental and Social Acceptance
  - Providing objective information to the developer or investor on the suitability of a technology and project.
- **Common digital models – Digital Representation**
  - Standard framework for the description of sub-systems, devices and arrays to allow sharing of design information.



Page 4

1. Introduction to DTOceanPlus (III)

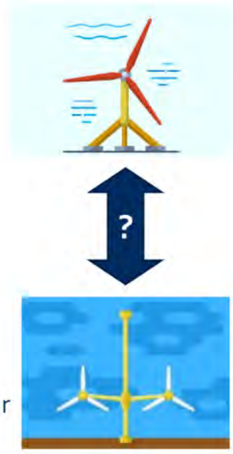
- A 3-year EU project (May 2018 - April 2021) with a total budget of **8 M€**.
- **Multidisciplinary team** of 16 partners from 7 EU countries, with the collaboration of 2 leading research laboratories from the USA.

Page 5

2. Stage Gate process for ocean energy (I)

Motivation and objectives

- Why it's needed
  - No consensus on technologies in ocean energy sector
  - Difficult to compare different concepts
  - Urgently need consistency in assessment processes
  - Pathway to demonstrate progress to investors
- The **Stage Gate design tool** aims to:
  - Provide a framework to assess ocean energy technology
  - Facilitate clear consistent assessment
  - Enable technology developers to demonstrate success
  - Enhance the DTO+ suite by bringing all assessment processes together



Page 6

2. Stage Gate process for ocean energy (II)

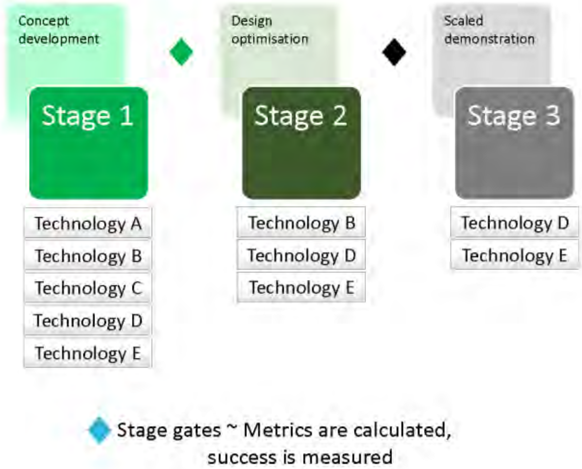
Who benefits from it?

- Technology developers ~ to track progress of their development
- Public funders ~ to help allocate funding in a clear and objective way
- Investors ~ to give confidence in technologies' performance and investment opportunities

Page 7

Page 8

2. Stage Gate process for ocean energy (III)



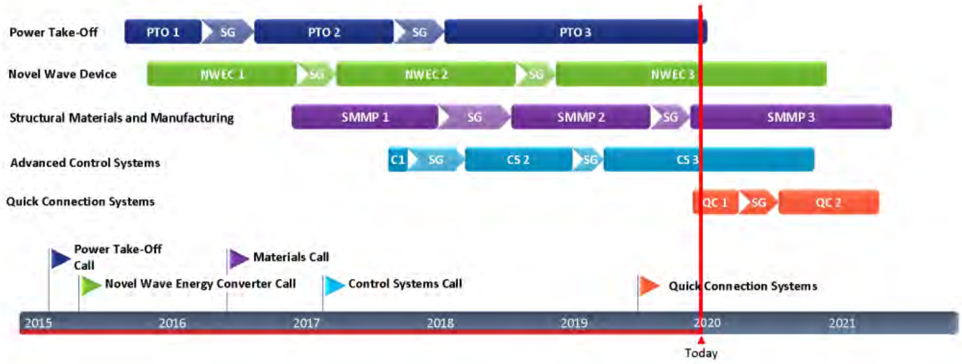
Page 9

2. Stage Gate process for ocean energy (IV)

Page

2. Stage Gate process for ocean energy (V)

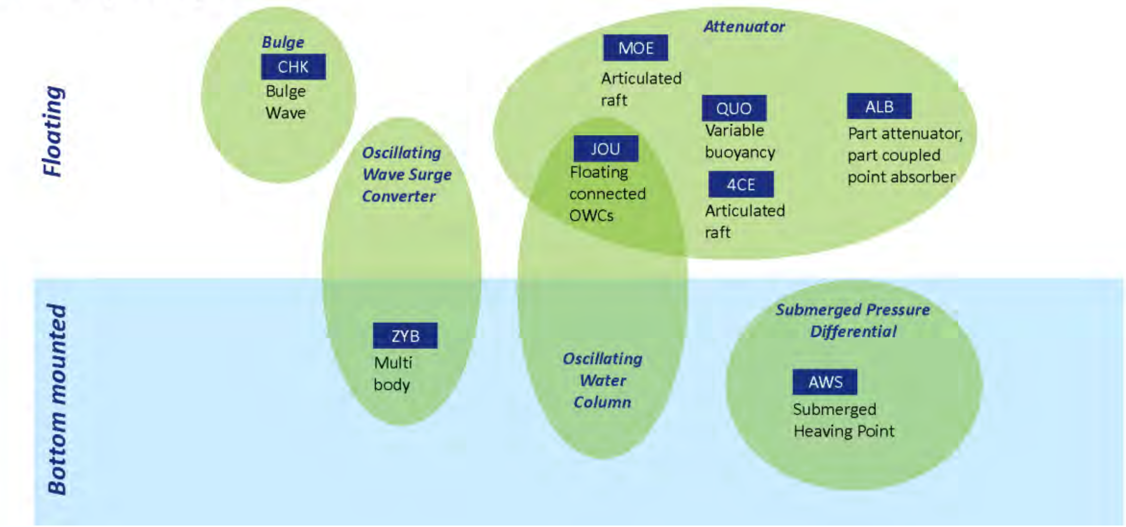
WES Technology Programmes



Page 11

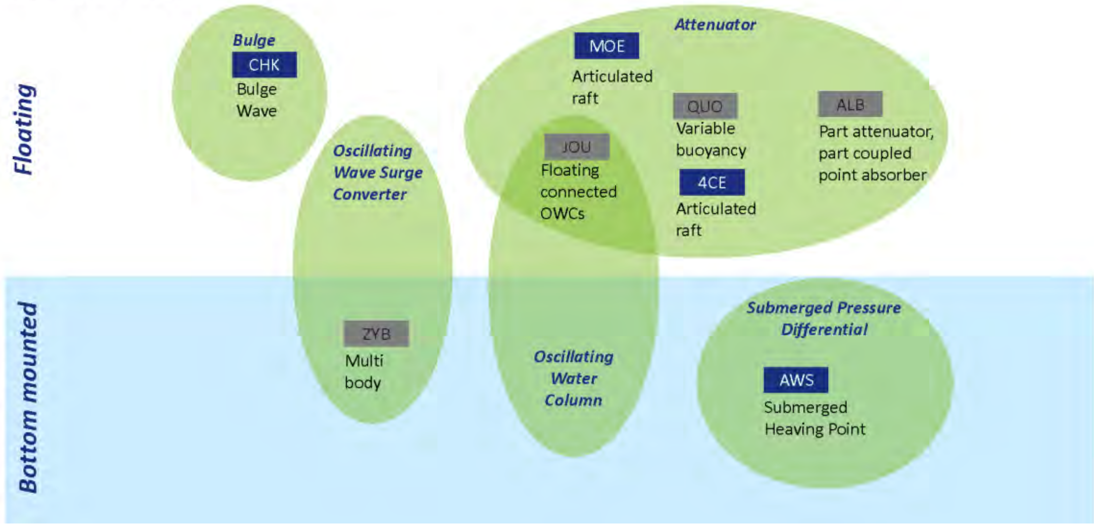
2. Stage Gate process for ocean energy (VI)

NWEC Projects Stage 1



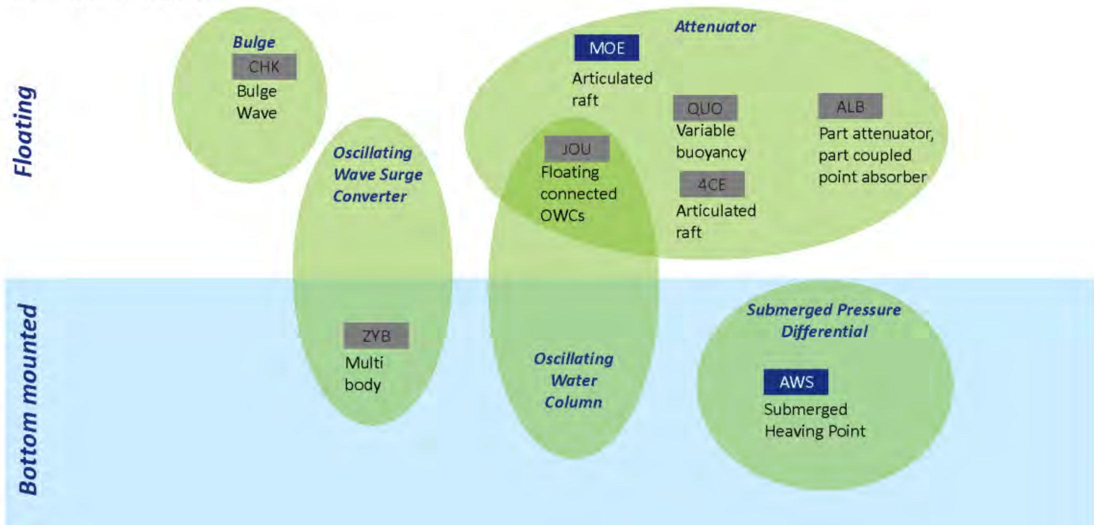
2. Stage Gate process for ocean energy (VII)

NWEC Projects Stage 2



2. Stage Gate process for ocean energy (VIII)

NWEC Projects Stage 3

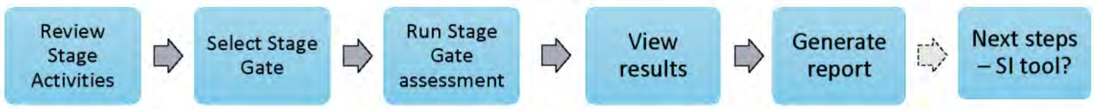


3. DTO+ Stage Gate design tool (I)

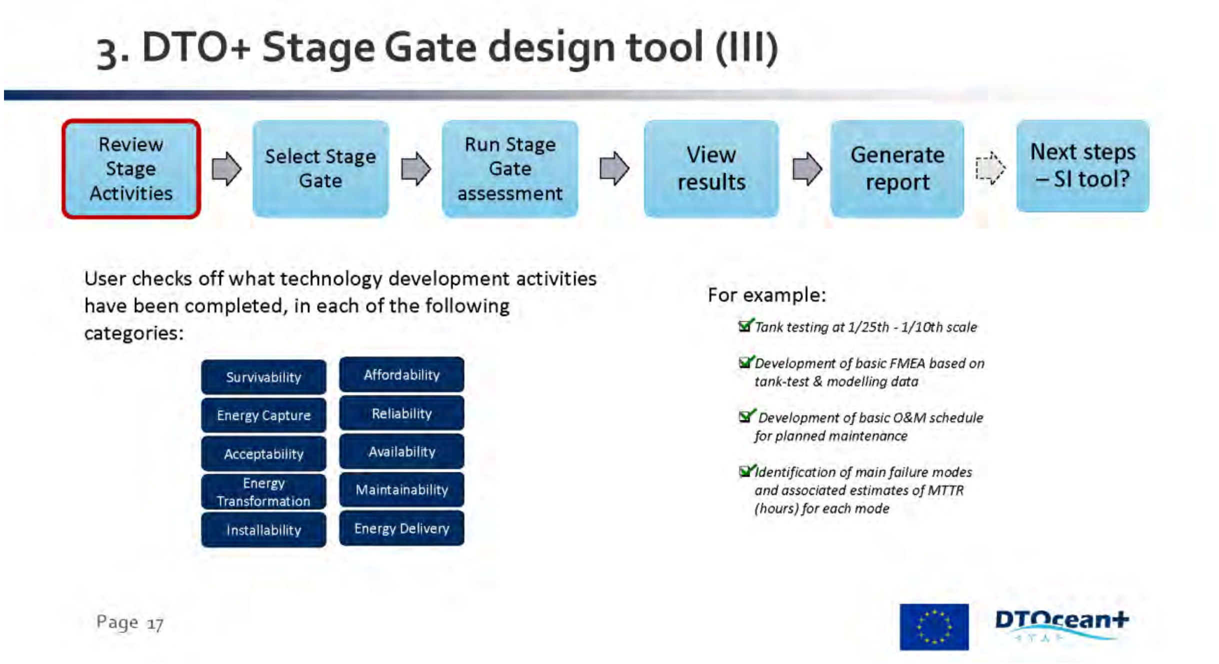
- Taking experience from WES stage gate programme, developing a module for DTO+ "Stage Gate design tool"
- Applicable for wave and tidal energy sub-systems, devices and arrays
- To be used by:
  - Funders and investors
  - Innovators and developers
  - Project developers
  - Policy makers and regulators

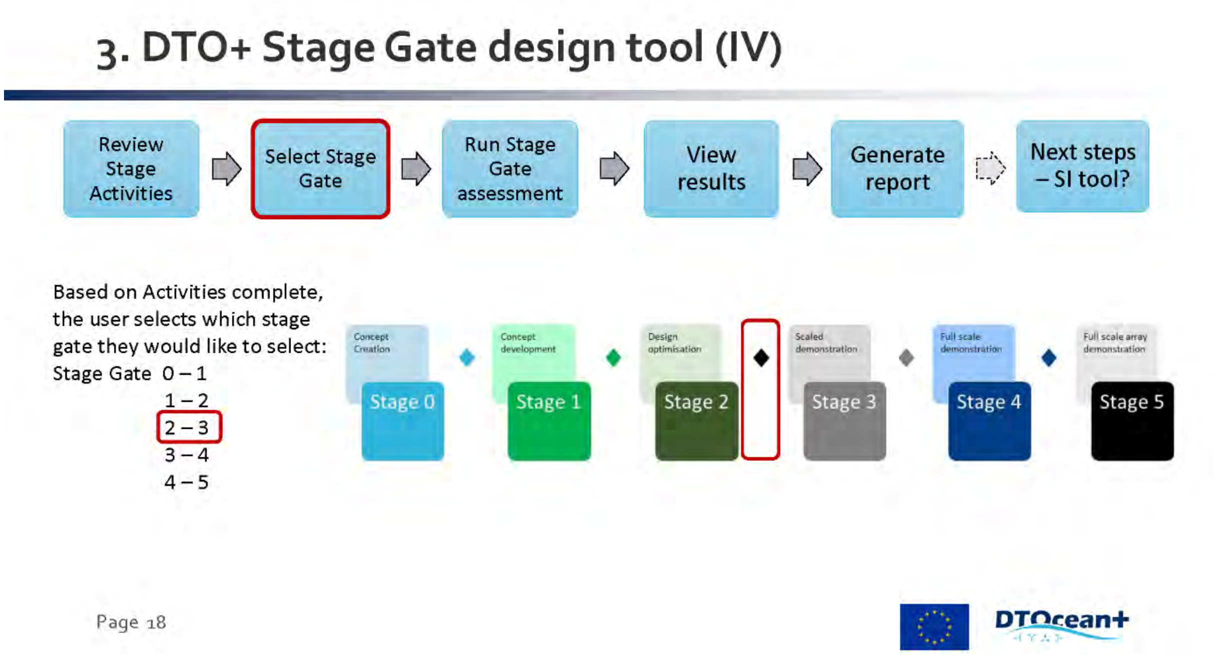
Page 15

3. DTO+ Stage Gate design tool (II)



Page 16


3. DTO+ Stage Gate design tool (III)
Review Stage Activities
Select Stage Gate
Run Stage Gate assessment
View results
Generate report
Next steps – SI tool?
User checks off what technology development activities have been completed, in each of the following categories:
Survivability
Affordability
Energy Capture
Reliability
Acceptability
Availability
Energy Transformation
Maintainability
Installability
Energy Delivery
For example:
Tank testing at 1/25th - 1/10th scale
Development of basic FMEA based on tank-test & modelling data
Development of basic O&M schedule for planned maintenance
Identification of main failure modes and associated estimates of MTTR (hours) for each mode
Page 17
DTOcean+


3. DTO+ Stage Gate design tool (IV)
Review Stage Activities
Select Stage Gate
Run Stage Gate assessment
View results
Generate report
Next steps – SI tool?
Based on Activities complete, the user selects which stage gate they would like to select:
Stage Gate 0 – 1
1 – 2
2 – 3
3 – 4
4 – 5
Concept Creation
Concept development
Design optimisation
Scaled demonstration
Full scale demonstration
Full scale array demonstration
Stage 0
Stage 1
Stage 2
Stage 3
Stage 4
Stage 5
Page 18
DTOcean+

3. DTO+ Stage Gate design tool (V)

Review Stage Activities → Select Stage Gate → **Run Stage Gate assessment** → **View results** → Generate report → Next steps – SI tool?

Run Deployment and Assessment tools

When the Stage Gate assessment is run, the user will be asked to fill out **questions** about their technology

To calculate metrics, the user will be prompted to open each of the relevant Deployment and Assessment tools

In order to run the Deployment and Assessment tools, the user will be asked to provide **critical input parameters** about the technology being assessed

Page 19

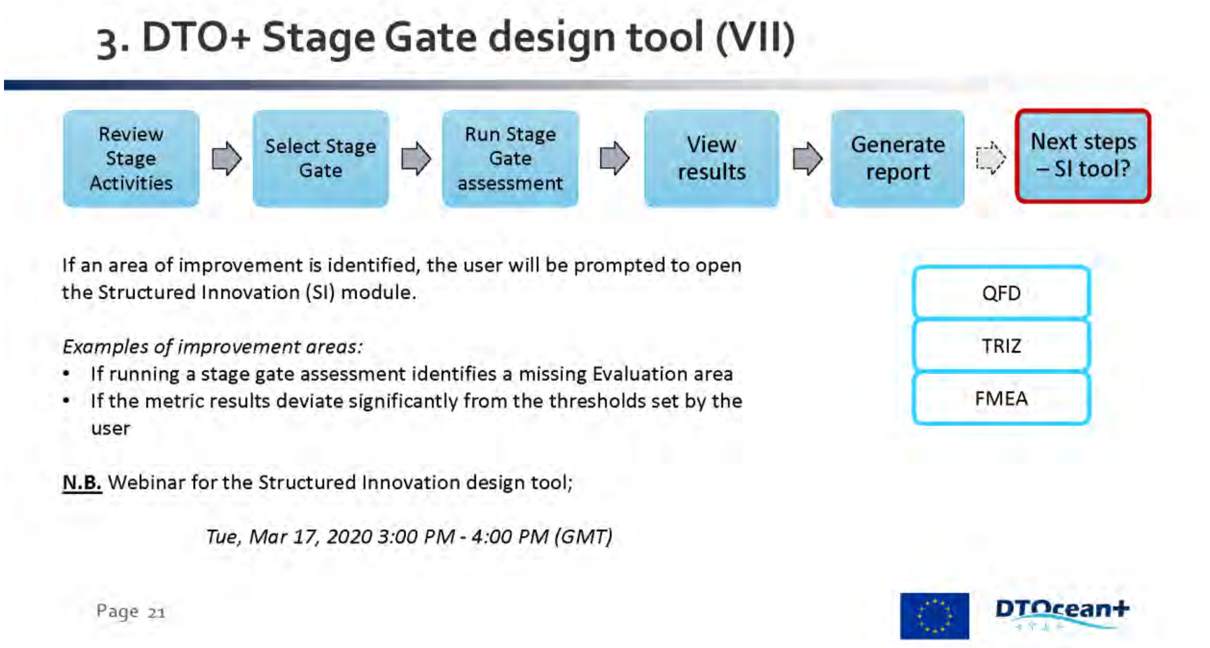
3. DTO+ Stage Gate design tool (VI)

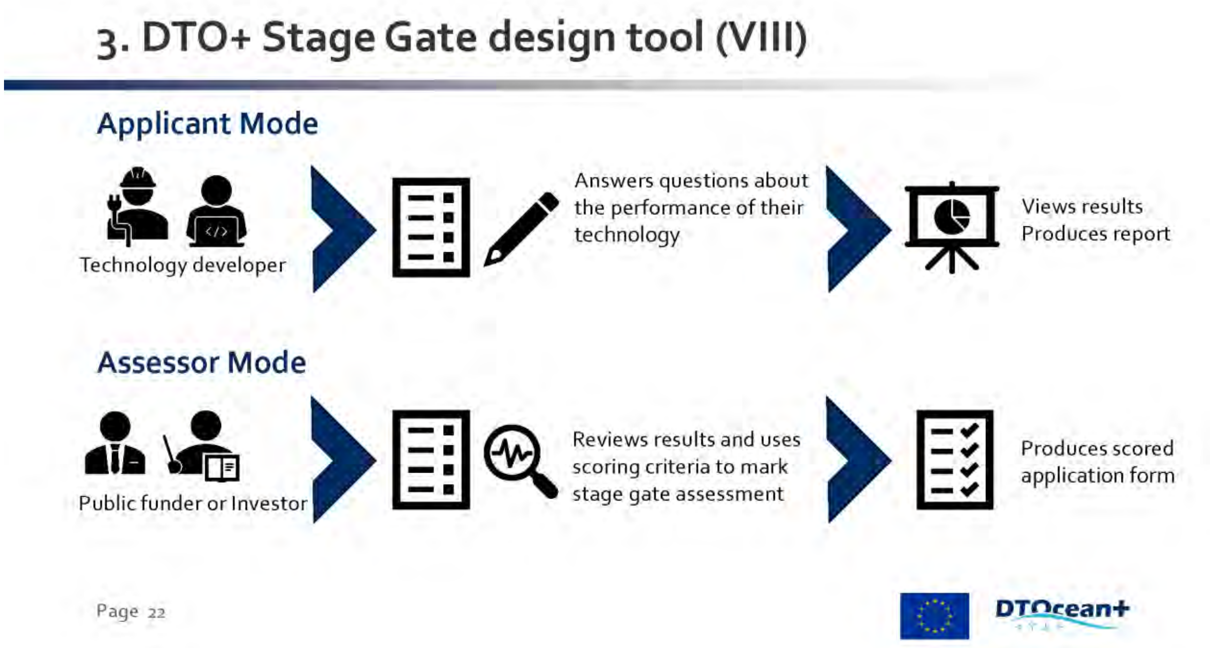
Review Stage Activities → Select Stage Gate → Run Stage Gate assessment → View results → **Generate report** → Next steps – SI tool?

One of the main outputs of the Stage Gate design tool is a standardised report that summarises all the input and output data of the module

Example results shown later

Page 20


3. DTO+ Stage Gate design tool (VII)
Review Stage Activities
Select Stage Gate
Run Stage Gate assessment
View results
Generate report
Next steps – SI tool?
If an area of improvement is identified, the user will be prompted to open the Structured Innovation (SI) module.
Examples of improvement areas:
• If running a stage gate assessment identifies a missing Evaluation area
• If the metric results deviate significantly from the thresholds set by the user
N.B. Webinar for the Structured Innovation design tool;
Tue, Mar 17, 2020 3:00 PM - 4:00 PM (GMT)
QFD
TRIZ
FMEA
Page 21
DTOcean+


3. DTO+ Stage Gate design tool (VIII)
Applicant Mode
Technology developer
Answers questions about the performance of their technology
Views results
Produces report
Assessor Mode
Public funder or Investor
Reviews results and uses scoring criteria to mark stage gate assessment
Produces scored application form
Page 22
DTOcean+

3. DTO+ Stage Gate design tool (IX)

- Tested and validated using data supplied by the project's industrial partners
- Important step in the development of DTO+

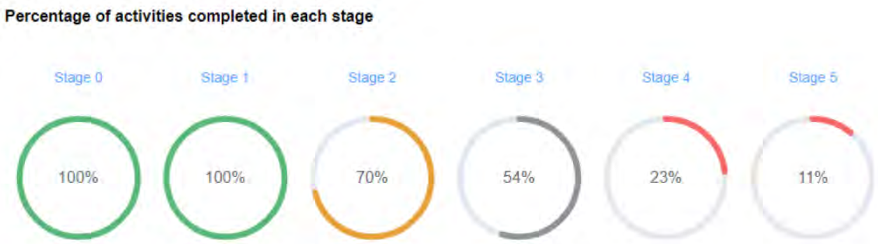
To satisfy the use cases of:

Technology developers
- Identify what needs to be done to meet the next stage
- Assess what stage their technology is at

Public and private investors
- Identify R&D opportunities
- Assist in investment decisions

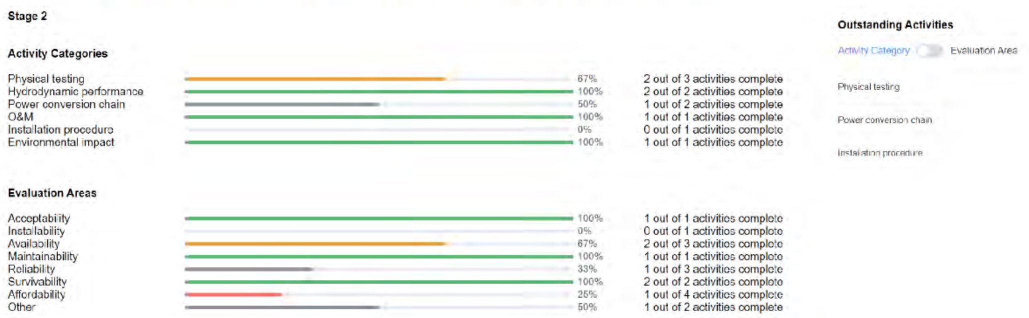
3. DTO+ Stage Gate design tool (X)

- Main outputs include:
  - A summary of the status of the technology



3. DTO+ Stage Gate design tool (XI)

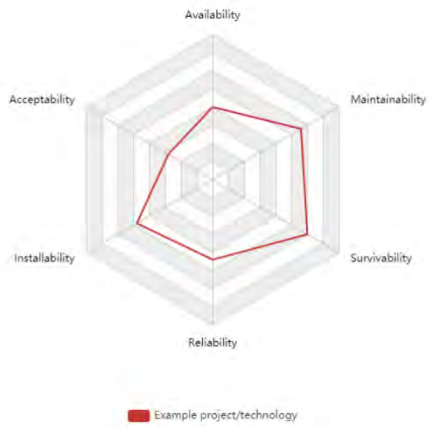
- Main outputs include:
  - Breakdown of completed and outstanding activities



Page 25

3. DTO+ Stage Gate design tool (XII)

- Main outputs include:
  - Graphical and tabular results for metrics/evaluation areas



Page 26

3. DTO+ Stage Gate design tool (XIII)

- Main outputs include:
  - **Standardised report** summarising all input and output data

Page 27

4. Summary and future work (I)

- Stage gate design tool aims to:
  - Provide a consistent assessment framework
  - Facilitate the comparison of different technologies
  - Enable a range of stakeholders to perform a guided and objective assessment
  - Enhance the DTO+ suite by bringing all assessment processes together
- Benefits to stakeholders:
  - Guide technology developers
  - Allow investors to see standardized assessment processes to gain confidence in ocean energy technology progress

IEA-OES Task 12:

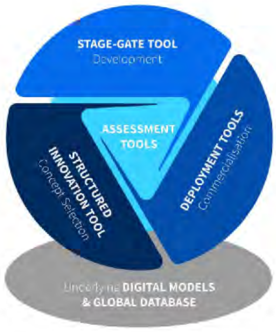
- Task aims to achieve consensus on how success is measured in ocean energy i.e. Metrics
- The objective is to establish a common international stage gate metrics framework to be used by technology developers, investors and funders.
- 25 contracting parties from around the world

OES OCEAN ENERGY SYSTEMS

Page 28

4. Summary and future work (II)

- The Stage Gate design tool will be integrated with the other DTOceanPlus design tools
  - **Structured Innovation Tool (SI).**
  - **Deployment Tools**
  - **Assessment Tools**
- … and tested with data from real case technology projects



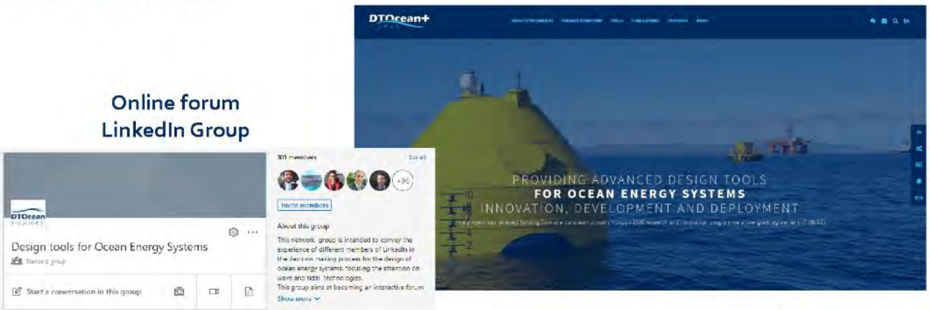
Page 29

4. Summary and future work (III)

- The concept of the Stage Gate design tool has been/ will be presented to stakeholders during a set of dissemination and training actions:
  - Conferences such as All Energy 2020, Ocean Energy Europe 2020, etc.
  - Scientific publications
  - Webinars and tutorials

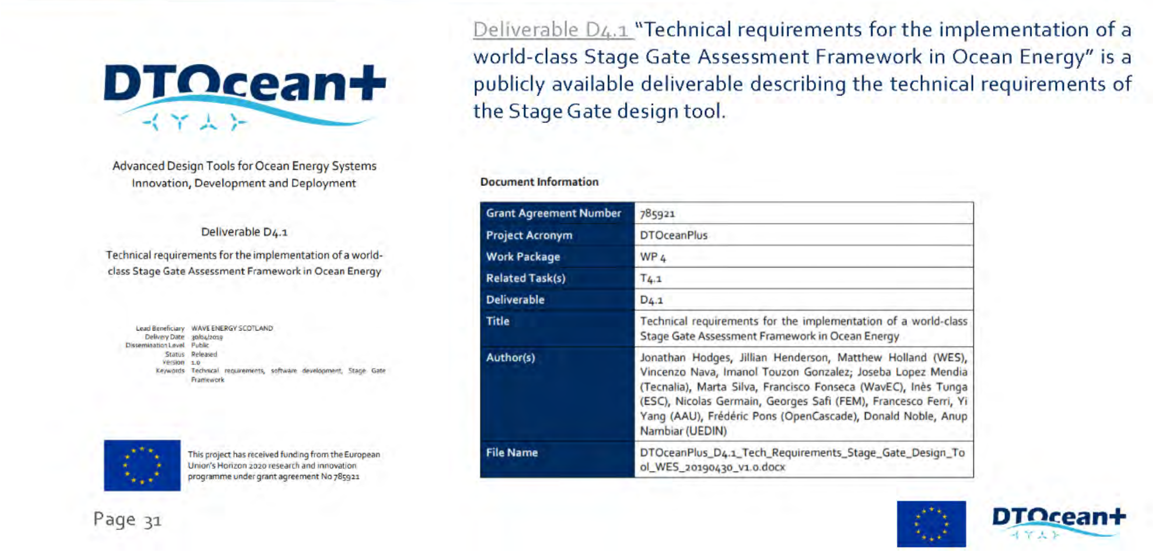
dtoceanplus.eu

Online forum LinkedIn Group



Page 30

5. Reference Material



Deliverable D4.1 "Technical requirements for the implementation of a world-class Stage Gate Assessment Framework in Ocean Energy" is a publicly available deliverable describing the technical requirements of the Stage Gate design tool.

DTOcean+

Advanced Design Tools for Ocean Energy Systems Innovation, Development and Deployment

Deliverable D4.1

Technical requirements for the implementation of a world-class Stage Gate Assessment Framework in Ocean Energy

Lead Beneficiary WAVE ENERGY SCOTLAND
Delivery Date 30/04/2019
Dissemination Level Public
Status Released
Version 1.0
Keywords Technical requirements, software development, Stage Gate Framework

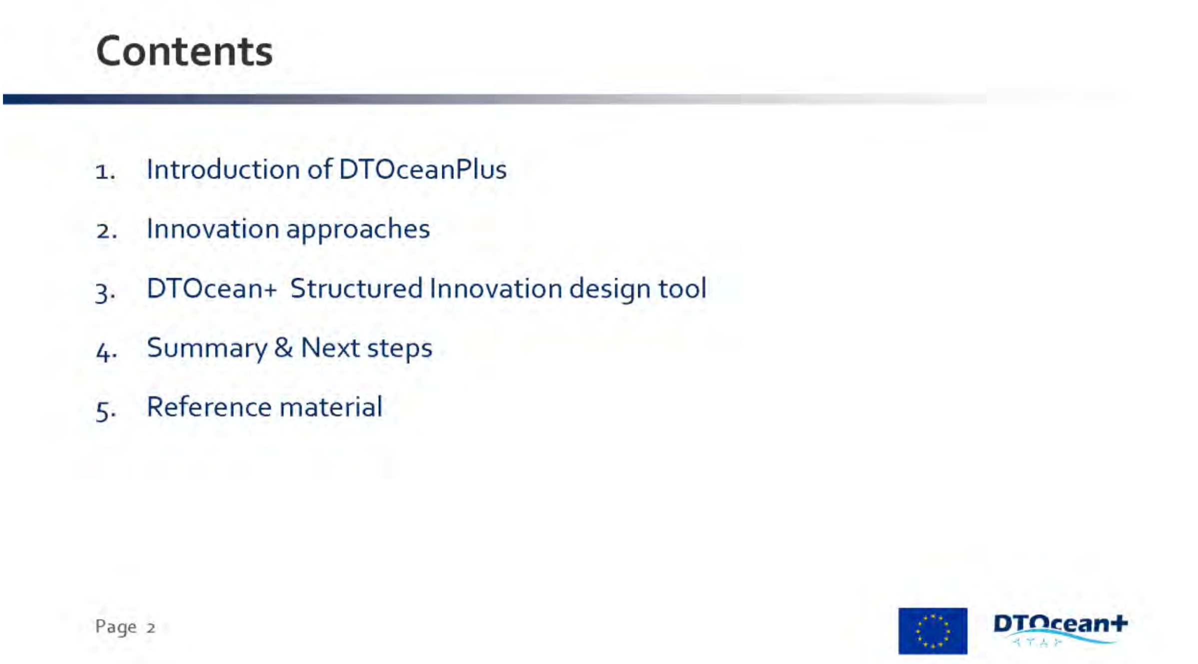
This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 785921

Page 31

Document Information

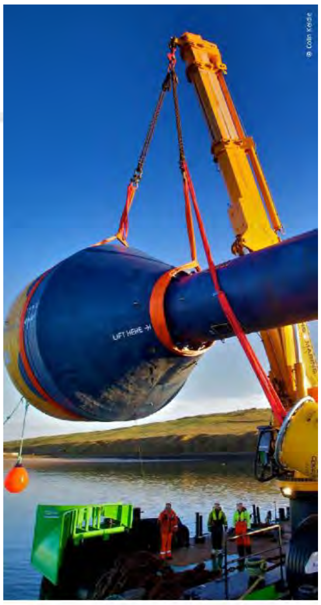
Grant Agreement Number	785921
Project Acronym	DTOceanPlus
Work Package	WP 4
Related Task(s)	T4.1
Deliverable	D4.1
Title	Technical requirements for the implementation of a world-class Stage Gate Assessment Framework in Ocean Energy
Author(s)	Jonathan Hodges, Jillian Henderson, Matthew Holland (WES), Vincenzo Nava, Imanol Touzon Gonzalez; Joseba Lopez Mendia (Tecnalia), Marta Silva, Francisco Fonseca (WavEC), Inès Tunga (ESC), Nicolas Germain, Georges Safi (FEM), Francesco Ferri, Yi Yang (AAU), Frédéric Pons (OpenCascade), Donald Noble, Anup Nambiar (UEDIN)
File Name	DTOceanPlus_D4.1_Tech_Requirements_Stage_Gate_Design_Tool_WES_20190430_v1.0.docx

WEBINAR 4: STRUCTURED INNOVATION DESIGN TOOL



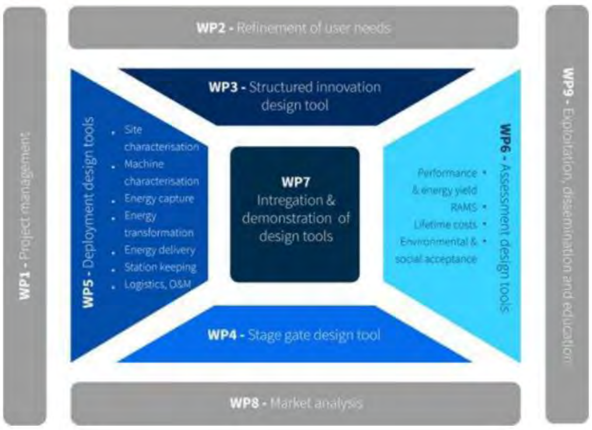
1. DTOceanPlus: Motivation (I)

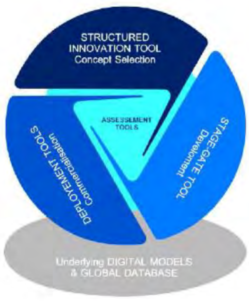
- To support the **entire technology innovation process**, from concept to deployment.
- To propose advanced design tools for **sub-systems, energy capture** devices and **arrays**.
- To bring tools to TRL6 by **demonstration scenarios in real world cases**.
- To make **freely available** tools as **open source** to the entire ocean energy sector.
- To develop an integrated suite of tools that will be a **professional user-friendly product**.



Page 3

1. DTOceanPlus: Structure (II)





Page 4

1. DTOceanPlus: Collaboration (III)

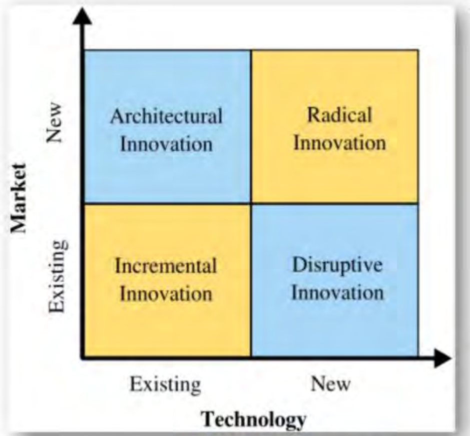
- A 3-year EU project (May 2018 - April 2021) with a total budget of **8 M€**.
- **Multidisciplinary team** of 16 partners from 7 EU countries, with the collaboration of 2 leading research laboratories from the USA.

Page 5

2. Innovation approaches (I)

Common approaches

- Incremental or Sustainable
- Disruptive
- New Markets/ Open innovation
- Radical approaches



Page 6

2. Innovation approaches (II)

Automotive sector

- Design for Six Sigma
- Requirement capture & management
- Design Characterise Optimise Verify
- Enhanced customer integration tool
- QFD & DFMEA application

Courtesy of Rolls Royce

Page 7

2. Innovation approaches (III)

Aerospace

- Incremental approach
- Disruptive innovation
- QFD & TRIZ approach
- System implementation

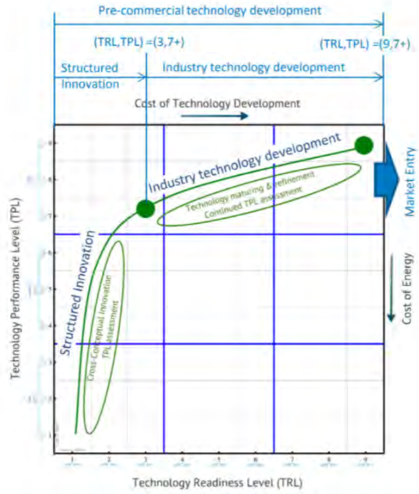
Page 8

2. Innovation approach in the sector (IV)

Energy Sector

- Wind sector
  - Disruptive - Additive manufacturing
  - GE- Novel electric drive systems
  - Adoption of QFD & Cost analysis

- Ocean Energy Sector
  - NREL, Sandia Lab- from intuitive invention
  - WES Structured approach



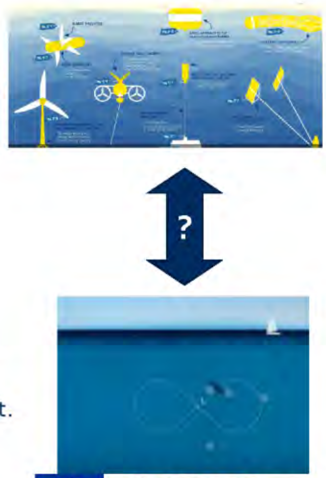
Page 9

2. Innovation approaches in the sector (V)

DTOceanPlus-Motivation and objectives

- Lack of a **standard structured innovative process** for Ocean Energy technologies:
  - Makes it difficult to impartially analyse innovative designs.
  - Renders impossible to objectively compare competing technologies.
  - Can lead to functional fixedness

- The **Structured Innovation tool** aims to:
  - Provoke innovation and help represent the voice of the customer
  - Allow the design to understand the art-of-the possible for concept targets
  - Enable objective comparisons between various technologies.
  - Enhance systematic thinking for design beyond the current state-of-the-art.
  - Create new or improve concepts



Page 10

3. DTOcean+ Structured Innovation tool (I)

DTOcean+ Structured Innovation tool

Page 11

3. DTOcean+ Structured Innovation tool (II)

Who benefits from it?

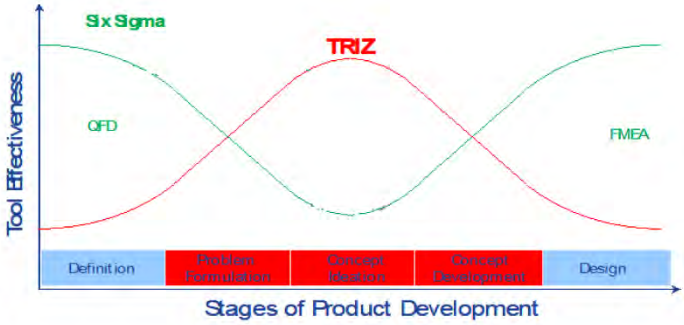
- Technology developers – to create/ assess areas of improvement and technical challenges
- Funders & Investors– to identify attractive areas of innovation for investment
- Innovators & Developers– to assess novelty in technology at any level of aggregation

Page 12

3. DTOcean+ Structured Innovation tool (III)

Innovation at the heart of concept creation, using QFD, TRIZ and FMEA

- Captures and prioritises requirements
- Assesses solutions for impact
- Provides problem solving for contradictions
- Encourages risk assessment and mitigation
- Gives development direction and impact
- Improve commercial acceptability



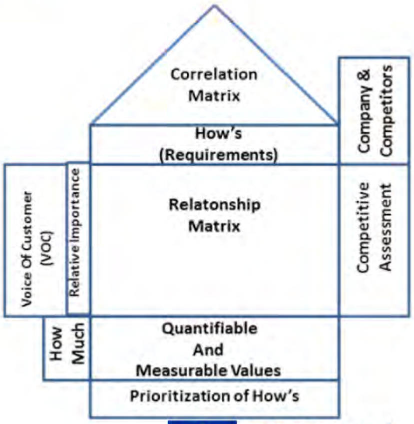
** Freely available, user-friendly, Used at different levels of complexity and aggregation

Page

3. DTOcean+ Structured Innovation tool (IV)

Quality Function Deployment

- Concept selection methods
  - Prioritise product requirements
  - Gain insights into conflicts
  - Understand relationships and impact
  - Assess difficulty in engineering and delivering
  - Impact and organisational efforts
  - Potential for Ideality

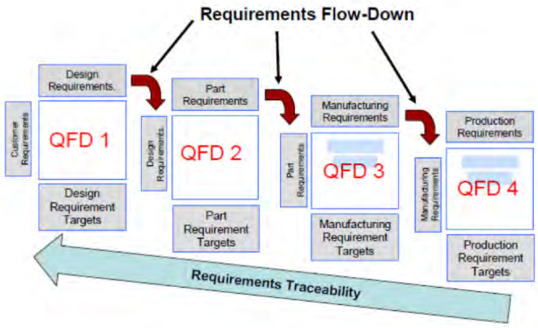


Page 14

3. DTOcean+ Structured Innovation tool (V)

Quality Function Deployment

- Strengths
  - Multi level analysis
  - Multiple solutions to Needs
  - Subjective and Objectives measures
  - Impact and Organisation Efforts
- Weaknesses
  - No direct inventive thinking tool
  - Functional fixedness

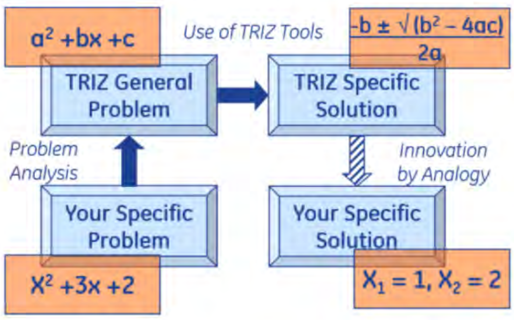


Page 15

3. DTOcean+ Structured Innovation tool (VI)

TRIZ- Theory of Inventive Problem Solving

- Library of problems & solutions
- Engineering field patents
- Evolution of technical systems
- Impact analysis (quality)
- Functional performance Vs conflicts
- State of ideality



Page

3. DTOcean+ Structured Innovation tool (VII)

Failure Modes and Effect Analysis (FMEA)

- Concept & design evaluation
- Possible causes & failures
- Risk Priority Number
- Threshold for mitigation
- Criteria for corrective actions

Warning - Occ higher than 4 MUST be mitigated

RPN Action Level 70

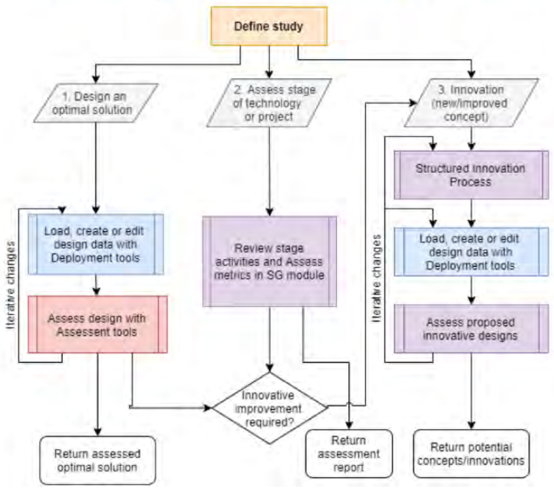
Requirements	Failure Mode(s)	Effect(s) of Failure	SEV	Cause(s) of Failure	OCC	Design & Process Control(s)	DET	RPN	Remedial Action: Recommended Solution(s)	SEV	OCC	DET	RPN
To provide wind assisted thrust to the ship	Thrust produced incorrect, lack of lift vs drag	Increased fuel consumption, loss of profit, increased emissions, loss of confidence, reputation, operational on-costs,	6	Electrical power loss and failure to restart **one** Rotor	3	Electrical system test	3	54					
				Electrical power loss and failure to restart **all** Rotors	3	Electrical system test	3	54					
				Electrical sensor loss	3	Electrical system test	3	54					
				Rotor Seizure	2	Root Cause Investigation	3	36					
				Device not able to use to wind resource (Direction)	4	Design Review	3	72	Minimum 2 wind sensors installed. Control system reverts to "idle mode" to reduce drag. No thrust produced from FRS.	6	3	2	36
				Device not able t			3	72	Minimum 2 wind sensors installed. Control system reverts to "idle mode" to reduce drag. No thrust produced from FRS.	6	3	2	36
				Main Bearing system (SRB) failure	2	Design Review	3	36					
				Main Bearing system (ASRB) failure	2	Design Review	3	36					

RPN= Severity X Occurence X Detection

Page 17

3. DTOcean+ Structured Innovation tool (VIII)

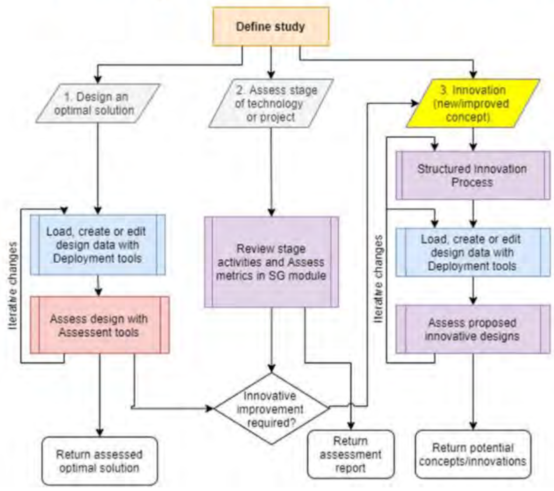
Overall process of using DTOcean+



Page 18

3. DTOcean+ Structured Innovation tool (IX)

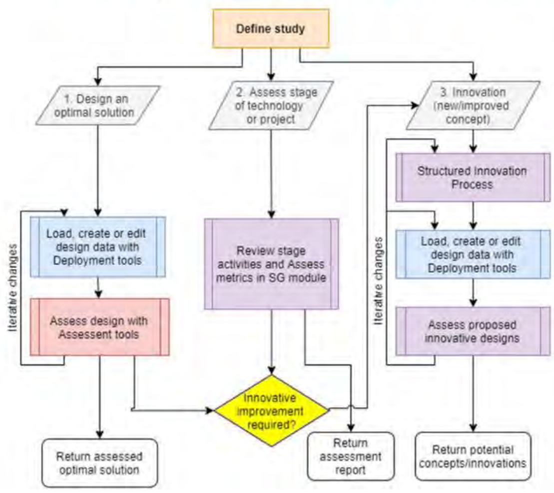
Overall process of using DTOcean+



Page 19

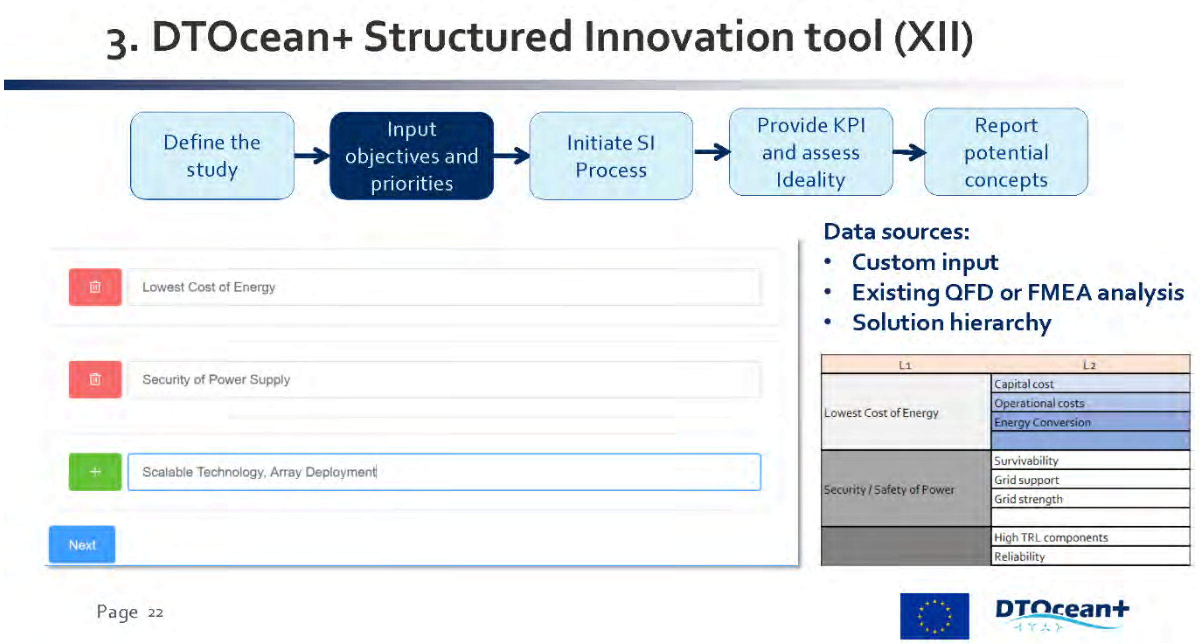
3. DTOcean+ Structured Innovation tool (X)

Overall process of using DTOcean+



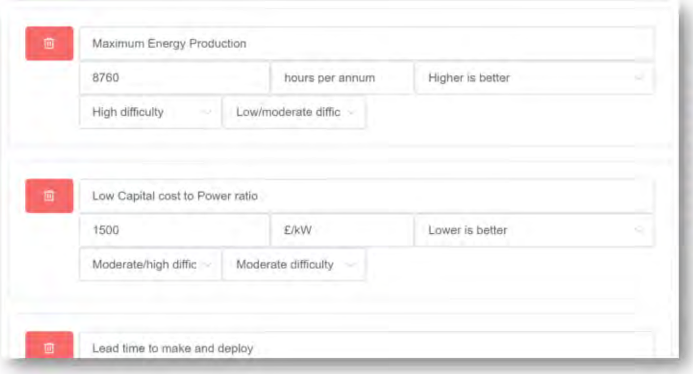
Page 20


3. DTOcean+ Structured Innovation tool (XI)
Define the study
Input objectives and priorities
Initiate SI Process
Provide KPI and assess Ideality
Report potential concepts
Please Enter Details below to start QFD
Webinar Demo
Identify attractive business cases for exploitation of wave energy resources
Submit
Page 21
DTOcean+


3. DTOcean+ Structured Innovation tool (XII)
Define the study
Input objectives and priorities
Initiate SI Process
Provide KPI and assess Ideality
Report potential concepts
Lowest Cost of Energy
Security of Power Supply
Scalable Technology, Array Deployment
Next
Data sources:
• Custom input
• Existing QFD or FMEA analysis
• Solution hierarchy
L1
L2
Lowest Cost of Energy
Capital cost
Operational costs
Energy Conversion
Security / Safety of Power
Survivability
Grid support
Grid strength
High TRL components
Reliability
Page 22
DTOcean+

3. DTOcean+ Structured Innovation tool (XIII)

Define the study → Input objectives and priorities → **Initiate SI Process** → Provide KPI and assess Ideality → Report potential concepts



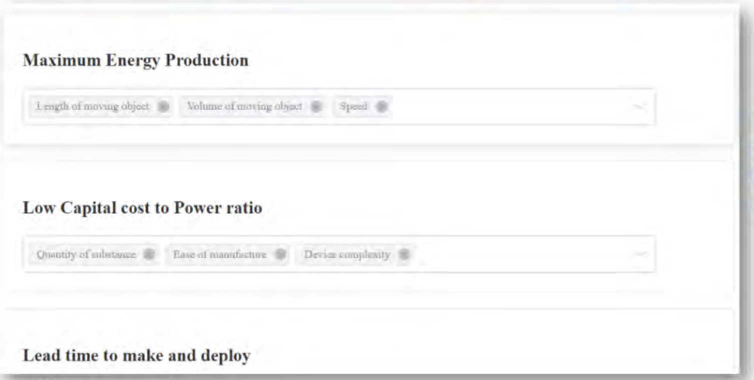
Data sources:

- **Custom input**
- **Existing QFD or FMEA analysis**
- **Metric thresholds**
- **Metric results**
- **Deployment parameters**
- **Fundamental relationships (Art of the possible)**

Page 23

3. DTOcean+ Structured Innovation tool (XIV)

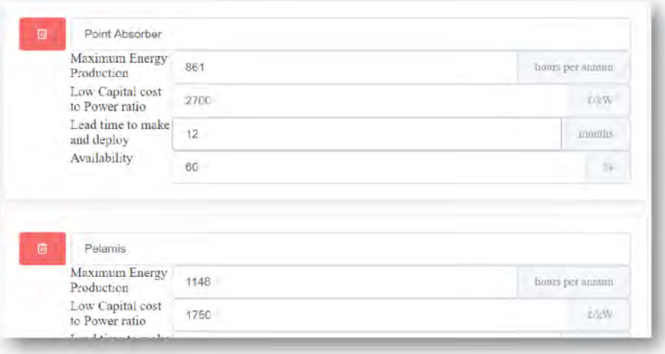
Define the study → Input objectives and priorities → **Initiate SI Process** → Provide KPI and assess Ideality → Report potential concepts



TRIZ is integrated into the QFD process, complementing the roof of the House of Quality in the traditional process.

Page 24

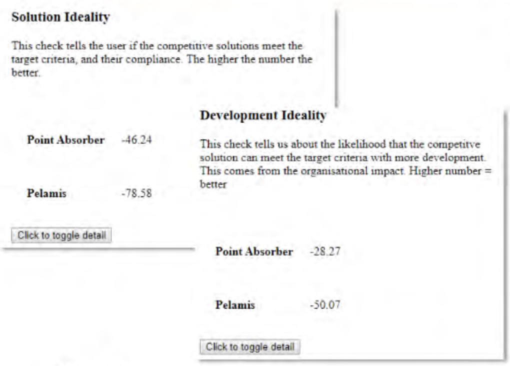
3. DTOcean+ Structured Innovation tool (XV)



Data sources:

- **Custom input**
- **Stage Gate metrics**
- **Design modules**

3. DTOcean+ Structured Innovation tool (XVI)

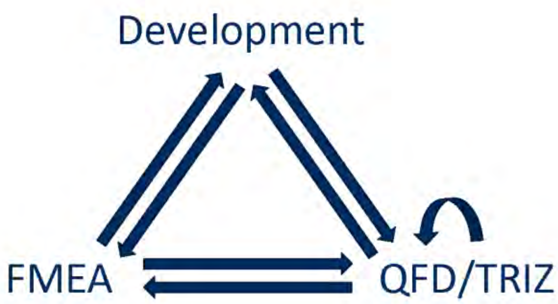


Suggested Inventive Principles

Functional Requirement	Description	Definition	Example	Marine example
	Substitution of Mechanical system	Replace mechanical system with electrical, optical or radiation	Magnetic couplings, Optical sensors	
Maximum Energy Production	Pneumatics or hydraulics	Replace solids with gas or liquids	Air tools, water jets for cutting, inflatable boats	
	Preliminary action	In advance of function, do part or whole action or function	perforation, pre-selection,	install blades before turbine installation

Show more | Show less

3. DTOcean+ Structured Innovation tool (XVII)



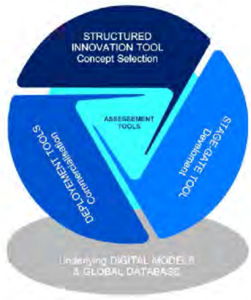
4. Summary and next steps (I)

- Structured Innovation design tool aims to:
  - Provoke innovation and help represent the voice of the customer
  - Allow the design to understand the art-of-the possible for concept targets
  - Enable objective comparisons between various technologies.
  - Enhance systematic thinking for design beyond the current state-of-the-art.
  - Create new or improve concepts

- Benefits to stakeholders:
  - Assess potential of technology
  - Assess novelty in technology
  - Target funding opportunities in sector
  - Assess areas of improvement and technical challenges

4. Summary and next steps (II)

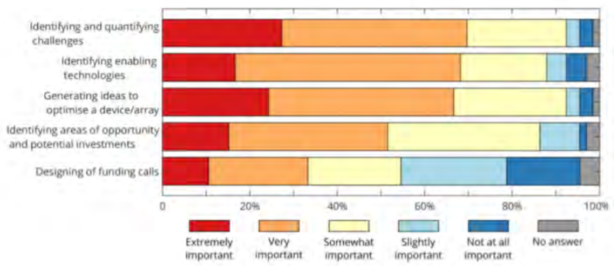
- The Structured Innovation design tool will be integrated with the other DTOceanPlus design tools
  - **Stage Gate Tool**
  - **Deployment Tools**
  - **Assessment Tools**
- … and tested with data from real case technology projects

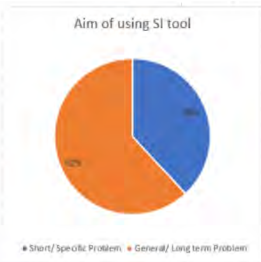


Page 29

4. Summary and next steps (III)

Verification of standalone tool





QFD/TRIZ → FMEA → SI tool

Page 30

4. Summary and next steps (IV)

Validation of the integrated tool

To satisfy the use cases of:

Technology developers
- Create new/improve device concept
- Identifying enabling technologies required (gap analysis)

Public and private investors
- Identify attractive areas of innovation for investment
- Identifying potential areas of opportunity

Page 31

5. Reference material

Deliverable **D3.1** - TECHNICAL REQUIREMENTS FOR THE IMPLEMENTATION OF STRUCTURED INNOVATION IN OCEAN ENERGY SYSTEMS

Deliverable **D3.2**- Structured Innovation design tool alpha version (Due 30th April 2020)

Dissemination:

Date	Event
Sept. 2020	AllEnergy 2020, Glasgow (TBC)
Oct. 2020	RENEW 2020 Lisbon, Portugal
Dec. 2020	OEE 2020 Brussels, Belgium

More on the Project
https://www.dtoceanplus.eu/About-DTOceanPlus

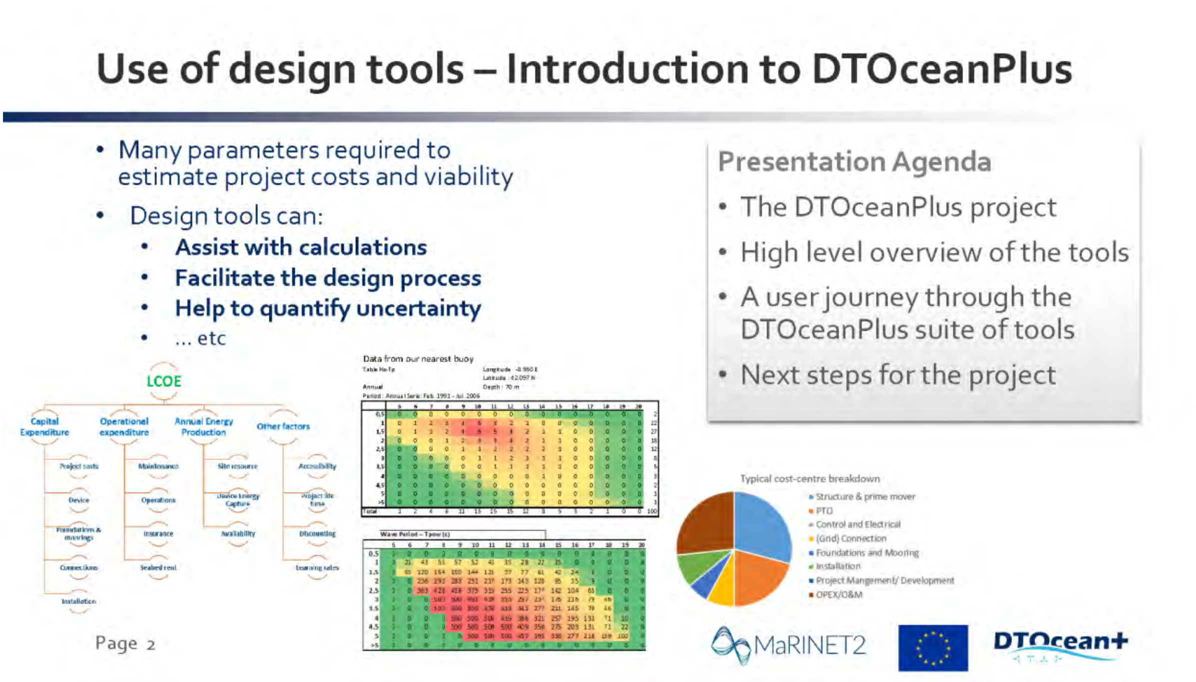
Page 32


Advanced Design Tools for Ocean Energy Systems Innovation, Development and Deployment
Thank you for your attention!
Inès Tunga – ines.tunga@es.catapult.org.uk
Mo Abrahams – mo.Abrahams@es.catapult.org.uk
Disclaimer: This presentation reflects only the author's views and the Agency is not responsible for any use that may be made of the information contained therein.
This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 785921

ANNEX II: SLIDES PRESENTED AT TRAINING SESSIONS

TRAINING SESSION 1: MARINET2 SHORT COURSE WEBINAR SERIES ON REDUCING UNCERTAINTY IN LCOE

Note, only slides directly related to the DTOceanPlus project are reproduced here, not the whole three-day course.



The DTOceanPlus project

- Developing an advanced, freely available, **open-source** suite of tools for the **selection, development, deployment** and **assessment** of ocean energy systems
- 3-year H2020 funded EU project (May 2018 – August 2021) with a total budget of **8 million euros**
- Continuing the **development of DTOcean** which produced a 1st generation of **design tools for wave and tidal energy** arrays

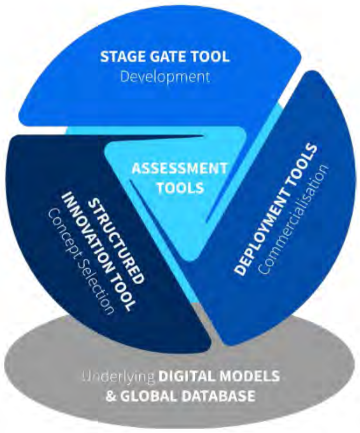
16 partners from 7 European countries plus 2 leading US research laboratories

Page 3

MaRINET2

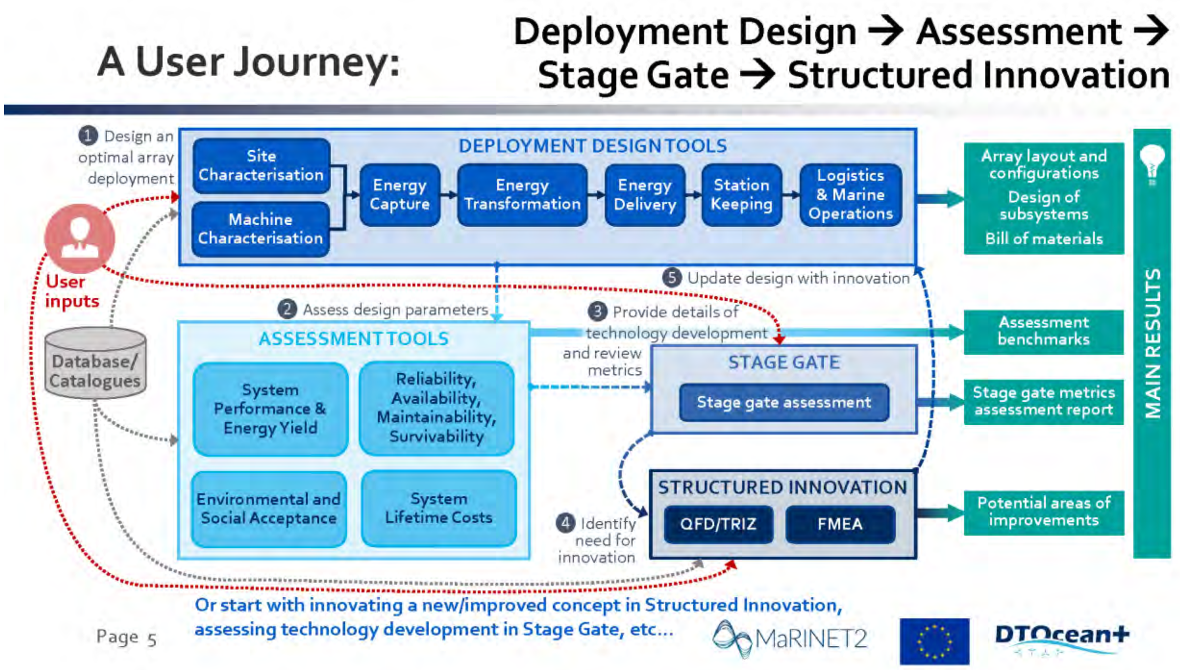
The DTOceanPlus suite of tools

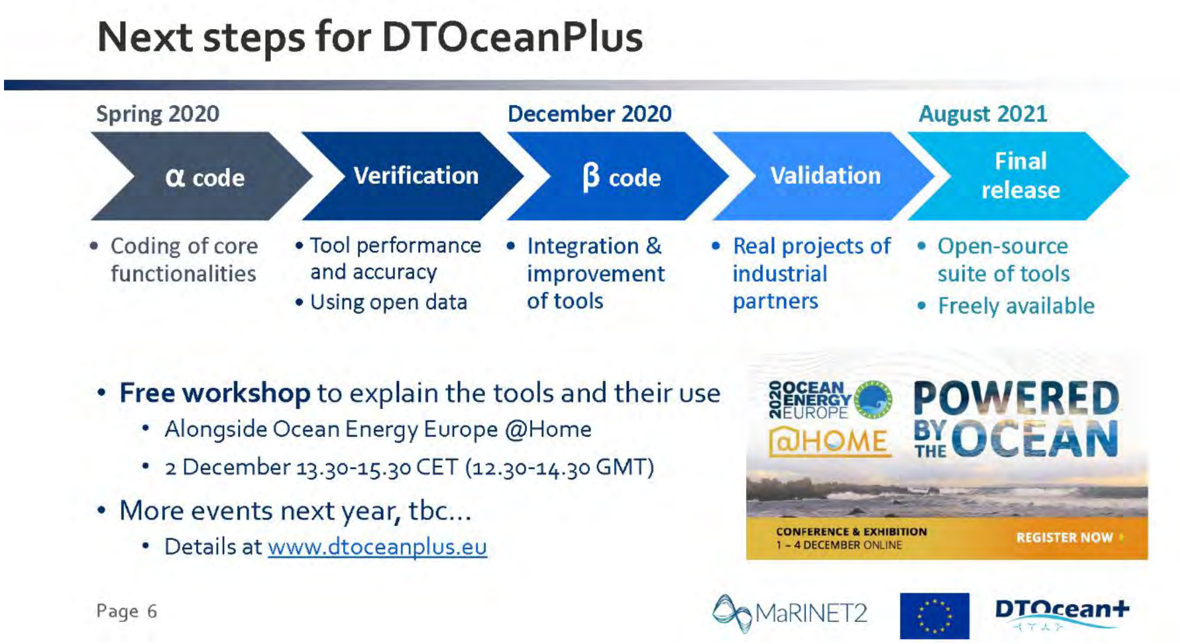
- **Deployment design tools**
  - Supporting optimal device and array deployment
- **Assessment tools**
  - To evaluate projects in terms of key parameters
- **Stage Gate** tool
  - Assisting decision-making through the use of metrics to measure, assess and guide technology development.
- **Structured Innovation** tool
  - Methodologies to provide a structured approach to innovation in concept creation, selection, and design
- **Data Management** tools
  - Digital Representation, Catalogues
  - Maintains underlying data for ocean energy projects and allows sharing of design information.



Page 4

MaRINET2


A User Journey:
Deployment Design → Assessment → Stage Gate → Structured Innovation
1 Design an optimal array deployment
User inputs
Database/ Catalogues
DEPLOYMENT DESIGN TOOLS
Site Characterisation
Machine Characterisation
Energy Capture
Energy Transformation
Energy Delivery
Station Keeping
Logistics & Marine Operations
5 Update design with innovation
2 Assess design parameters
3 Provide details of technology development and review metrics
ASSESSMENT TOOLS
System Performance & Energy Yield
Reliability, Availability, Maintainability, Survivability
Environmental and Social Acceptance
System Lifetime Costs
STAGE GATE
Stage gate assessment
4 Identify need for innovation
STRUCTURED INNOVATION
QFD/TRIZ
FMEA
Array layout and configurations
Design of subsystems
Bill of materials
Assessment benchmarks
Stage gate metrics assessment report
Potential areas of improvements
MAIN RESULTS
Or start with innovating a new/improved concept in Structured Innovation, assessing technology development in Stage Gate, etc…
Page 5
MaRINET2
DTOcean+


Next steps for DTOceanPlus
Spring 2020
December 2020
August 2021
α code
Verification
β code
Validation
Final release
• Coding of core functionalities
• Tool performance and accuracy
• Using open data
• Integration & improvement of tools
• Real projects of industrial partners
• Open-source suite of tools
• Freely available
• Free workshop to explain the tools and their use
• Alongside Ocean Energy Europe @Home
• 2 December 13.30-15.30 CET (12.30-14.30 GMT)
• More events next year, tbc…
• Details at www.dtoceanplus.eu
2020 OCEAN ENERGY EUROPE
@HOME
POWERED BY THE OCEAN
CONFERENCE & EXHIBITION
1 – 4 DECEMBER ONLINE
REGISTER NOW
Page 6
MaRINET2
DTOcean+


Advanced Design Tools for Ocean Energy Systems Innovation, Development and Deployment
Thank you for your attention!
Questions at end of this session
Dr Donald R Noble
<D.Noble@ed.ac.uk>
Disclaimer: This presentation reflects only the author's views and the Agency is not responsible for any use that may be made of the information contained therein.
MaRINET2
This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 785921


DTOcean+
Use of Design Tools to support Techno-economic model
Real project examples
Tianna Bloise Thomaz
WavEC
THE UNIVERSITY of EDINBURGH
School of Engineering
Policy and Innovation Group
MaRINET2

Agenda

- Techno-Economic models vs Design Tools
- DTOceanPlus: Deployment tools
- Real examples
  - Wave energy device
  - Tidal energy device
  - PTO component
- Conclusions

Techno-Economic model vs Design Tools

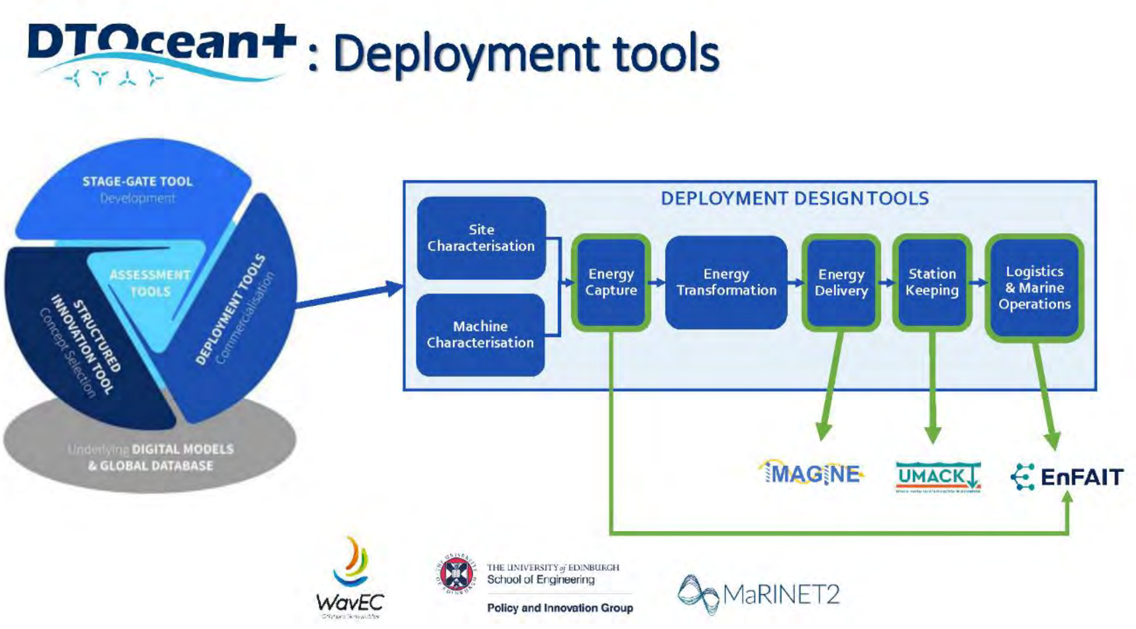
Techno-economic model

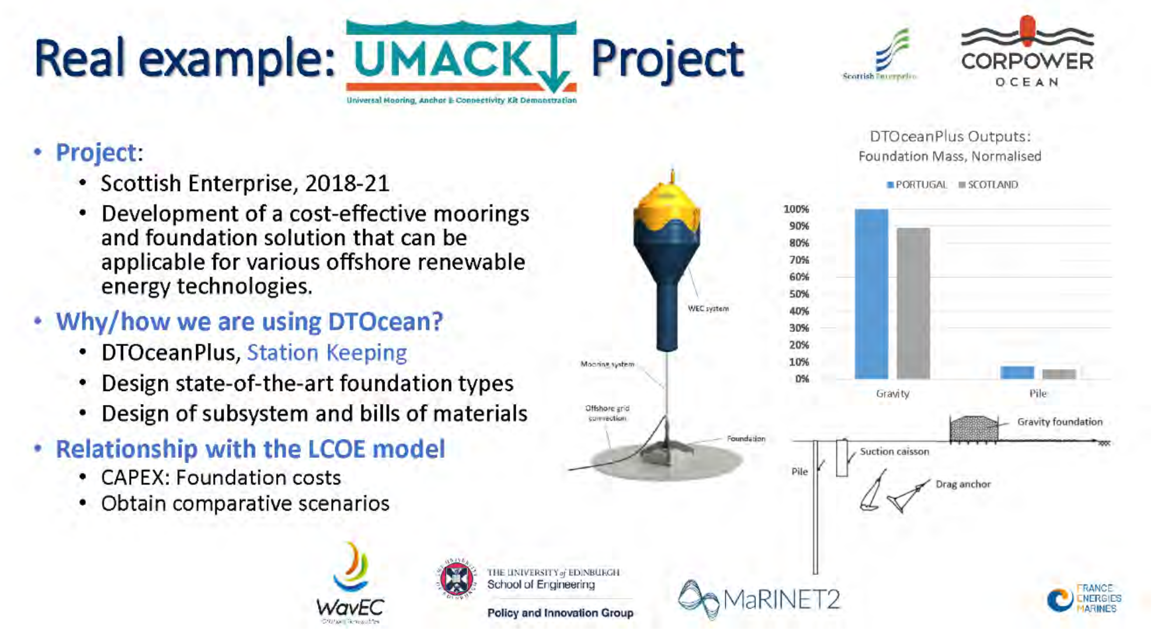
- Metrics
  - E.g. LCOE, NPV, IRR
- Main inputs
  - Capital Expenditure — CAPEX
  - Operational Expenditure — OPEX
  - Annual Energy Production — AEP

$$LCoE = \frac{NPV(CapEx + OpEx + DecEx)}{NPV(AEP)}$$

Design tools

- Bill of materials
- Design of subsystems
- Array layout and configurations

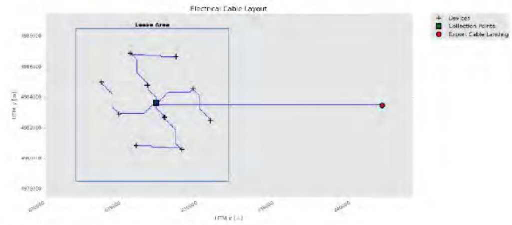

DTOcean+ : Deployment tools
STAGE-GATE TOOL
Development
ASSESSMENT TOOLS
STRUCTURED INNOVATION TOOL
Concept Selection
DEPLOYMENT TOOLS
Commercialisation
Underlying DIGITAL MODELS & GLOBAL DATABASE
DEPLOYMENT DESIGN TOOLS
Site Characterisation
Machine Characterisation
Energy Capture
Energy Transformation
Energy Delivery
Station Keeping
Logistics & Marine Operations
MAGNE
UMACK
EnFAIT
WavEC
THE UNIVERSITY of EDINBURGH School of Engineering
Policy and Innovation Group
MaRINET2


Real example: UMACK Project
Universal Mooring, Anchor & Connectivity Kit Demonstration
Scottish Enterprise
CORPOWER OCEAN
• Project:
• Scottish Enterprise, 2018-21
• Development of a cost-effective moorings and foundation solution that can be applicable for various offshore renewable energy technologies.
• Why/how we are using DTOcean?
• DTOceanPlus, Station Keeping
• Design state-of-the-art foundation types
• Design of subsystem and bills of materials
• Relationship with the LCOE model
• CAPEX: Foundation costs
• Obtain comparative scenarios
WEC system
Mooring system
Offshore grid connection
Foundation
DTOceanPlus Outputs:
Foundation Mass, Normalised
PORTUGAL
SCOTLAND
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Gravity
Pile
Gravity foundation
Suction caisson
Pile
Drag anchor
WavEC
THE UNIVERSITY of EDINBURGH School of Engineering
Policy and Innovation Group
MaRINET2
FRANCE ENERGIES MARINES

Real example: IMAGINE Project

- **Project:**
  - EU H2020, 2018-2021
  - Further development of Electro-Mechanical Generator (EMG)
  - Hardware in the loop testing in Italy
- **Why/how we are using DTOcean?**
  - DTOcean, Energy Delivery
  - Design electrical and grid connection solutions to transmit power to shore
- **Relationship with the LCOE model**
  - CAPEX: Electrical infrastructure costs

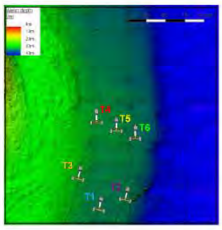
DTOcean outputs

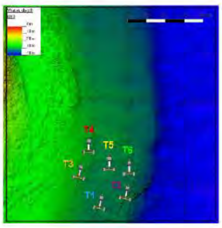


UMBRA GROUP · WavEC · The University of Edinburgh School of Engineering, Policy and Innovation Group · MaRINET2

Real example: EnFAIT Project

- **Project:**
  - EU H2020, 2017-2022
  - Demonstrate grid-connected tidal energy array at real-world tidal energy site
- **Why/how we will use DTOcean?**
  - DTOceanPlus, Energy Capture and Logistics & Marine Operations
  - Define OPEX and downtime
  - Define optimal device locations and array interaction
- **Relationship with the LCOE model**
  - Explore optimal array solutions for the EnFAIT array





NOVA INNOVATION · WavEC · The University of Edinburgh School of Engineering, Policy and Innovation Group · MaRINET2

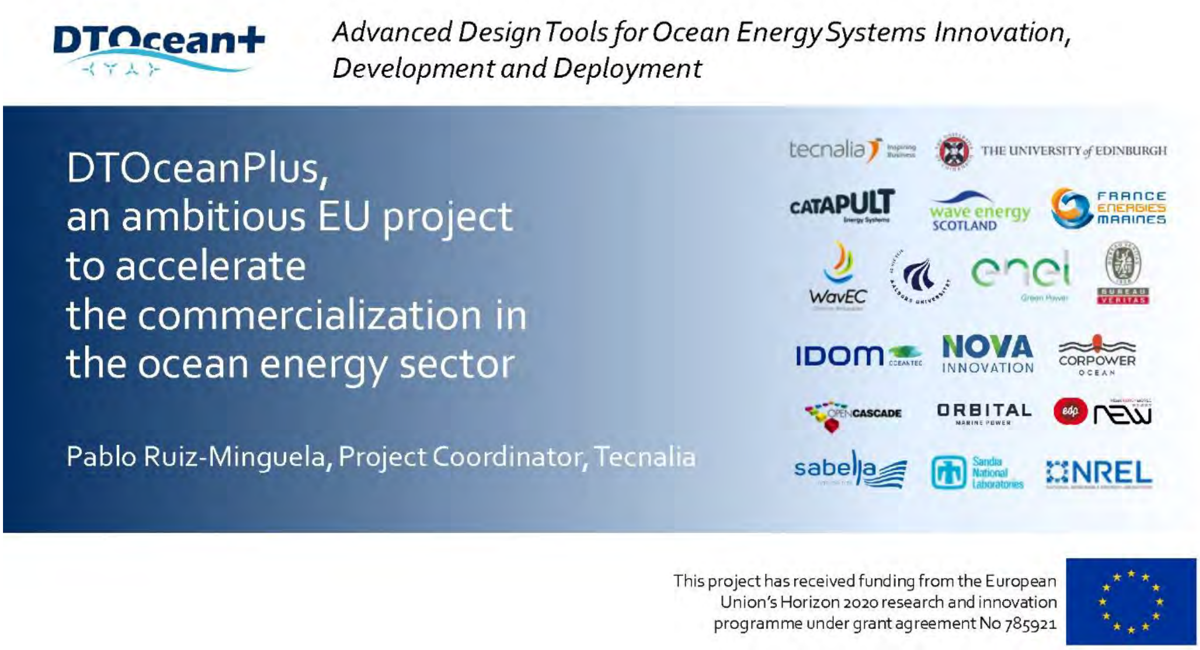
Conclusions

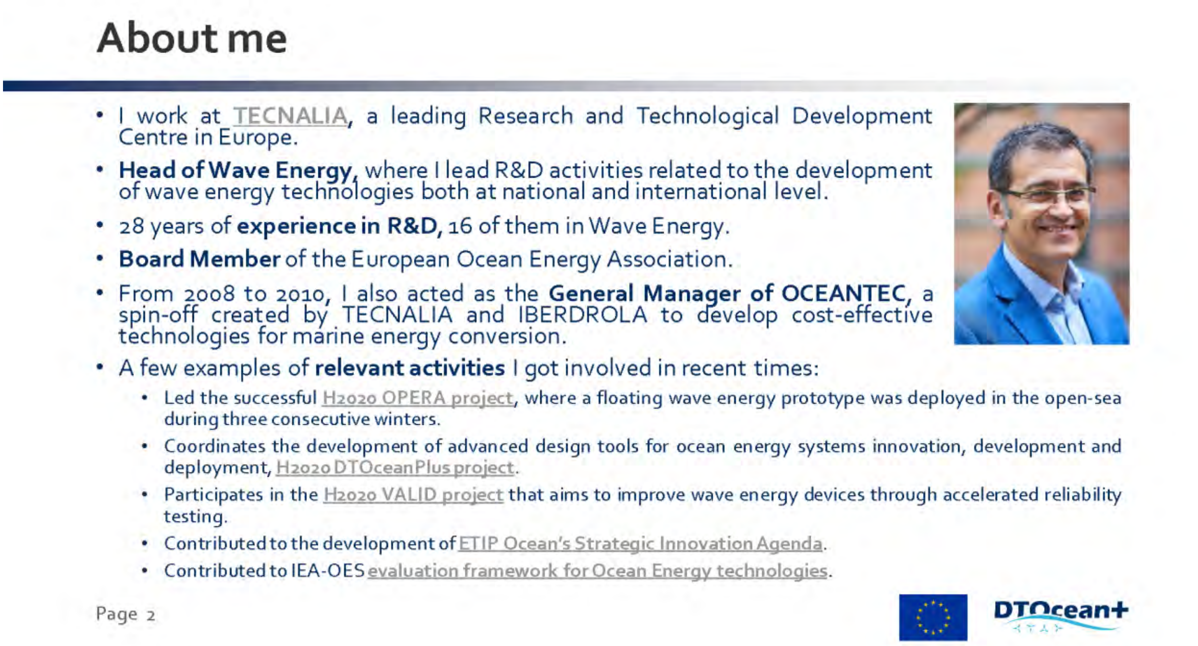
- Design Tools are assisting European and Scottish funded projects to build techno-economic models and to perform economic assessment of different array layouts:
  - Station Keeping tool: design and estimate cost for state-of-the-art anchor solutions
  - Energy Delivery tool: design, estimate cost and energy transmission losses
  - Logistics and Marine Operations tool: calculate costs and downtime
  - Energy Capture tool: define array interaction and energy production
- DTOceanPlus: expanded capabilities
  - Complete suit of tools will be release in 2021

Thank you for your attention!

tbloise@ed.ac.uk

TRAINING SESSION 2: LECTURE TO STUDENTS OF A WAVE ENERGY COURSE AT UPPSALA UNIVERSITY (SWEDEN) ABOUT DTOCEANPLUS





About Tecnalia

- A Research and Technological Development Centre **transforming technology into value added** for individuals (quality of life) and companies (business opportunities)
  - Headquarters in the North of Spain (Basque Country)
  - Multisectoral / multi-technology
  - 1,472 experts from 31 nationalities

SCOPES OF ACTION

IMPACT SERVICES

Laboratory Services

R&D and Innovation Projects

Development of Investment Opportunities

> 7.800 CLIENT COMPANIES

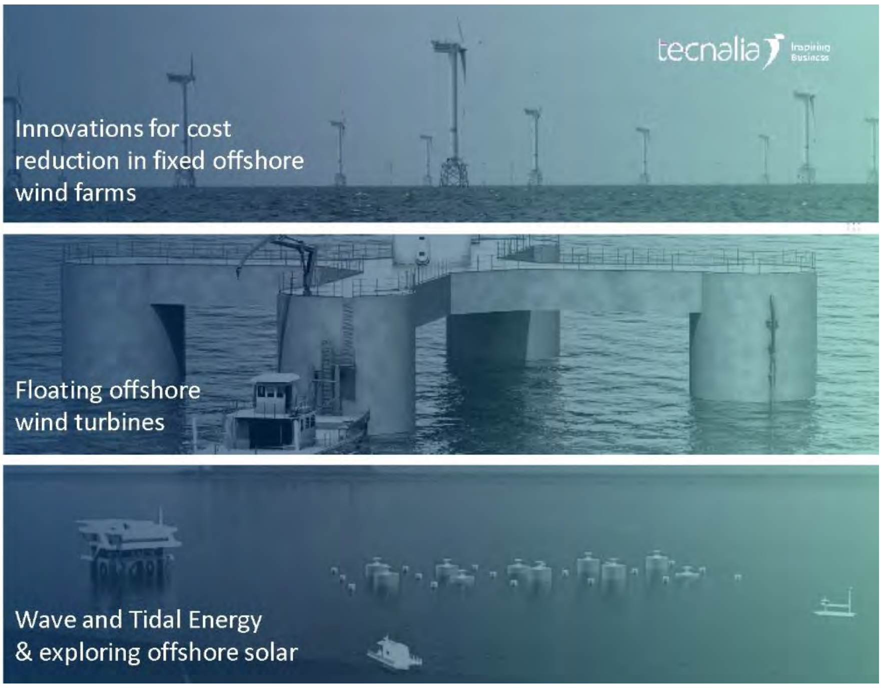
(2011 - 2020) 75% SMEs 25% Large companies

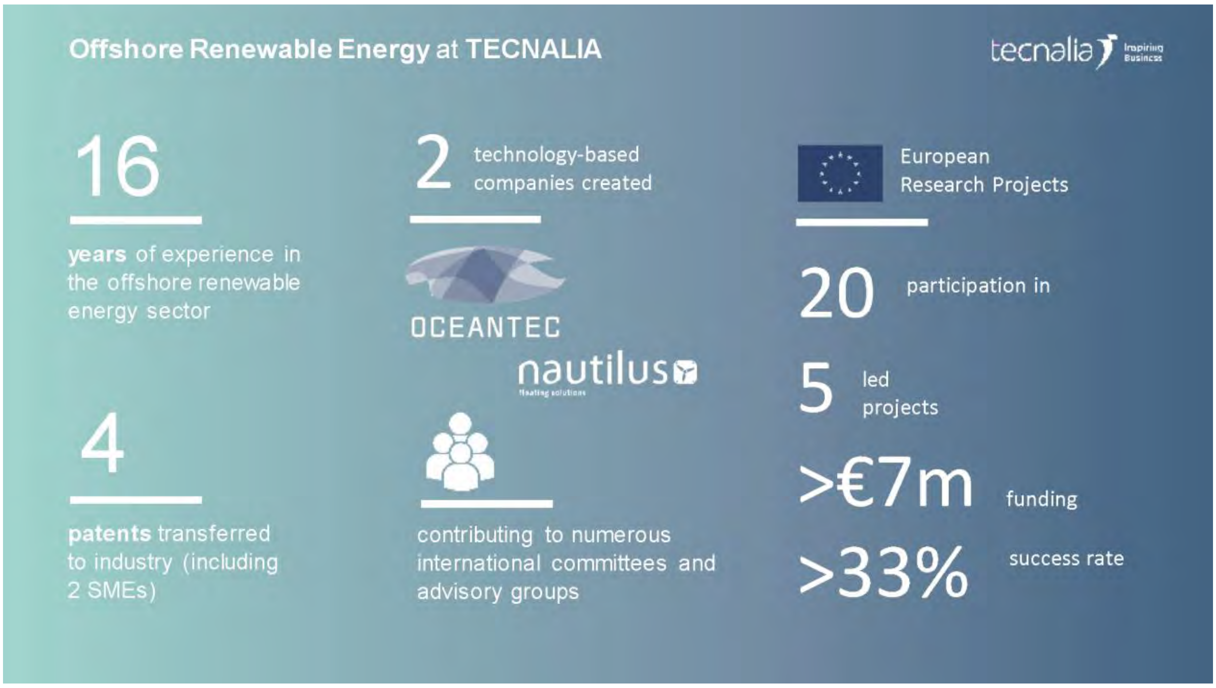
Page

About TECNALIA

Offshore Renewable Energy

- New solutions for installation and O&M
- Optimised designs for reducing costs of foundations and electrical infrastructure
- Test and analysis of materials and components for harsh environments
- Design tools for floating platforms
- Tank testing and numerical analysis
- Analysis and design of mooring systems and electrical connections
- Design tools for the optimisation of arrays
- Performance assessment
- Optimisation of Power Take-Off and Control systems





Why DTOceanPlus?

- Ocean energy could meet 10% of the EU power demand by 2050.
- Technologies to harness ocean energy are **not yet mature enough** for widespread use.
- Performance, reliability and survivability challenges lead to **high costs of energy** in comparison with other energy sources.
- Such challenges are typical of **early industries**.
- They can be overcome with the **correct tools and processes** to support market growth and technology innovation.
- DTOceanPlus aims to accelerate the development of the Ocean Energy sector by developing and demonstrating **a suite of 2nd generation advanced design tools.**

Page 6

Expected Impact

- Reduce the **technical and financial risks** of wave and tidal technologies.
  - At all development stages (concept, development, deployment) and scales (subsystem, device, array).
  - Attract investors
- Improve technology **performance, reliability and survivability**.
  - Design and optimise main subsystems: Device, PTO, Stationkeeping, Electrical network
  - Produce an assessment of key technology attributes and characteristics
- Reduce the **installation, operation and maintenance costs,** resulting in more cost-effective arrays.
  - Design the logistics and marine operations
  - Users can select, develop and deploy technologies that have been optimised for cost effectiveness
- Reduce the life-cycle **environmental and socio-economic impacts**.
  - Establish both the costs and benefits that technologies will have for society and the environment
  - Results can support applications for project licences, inform and reassure local communities

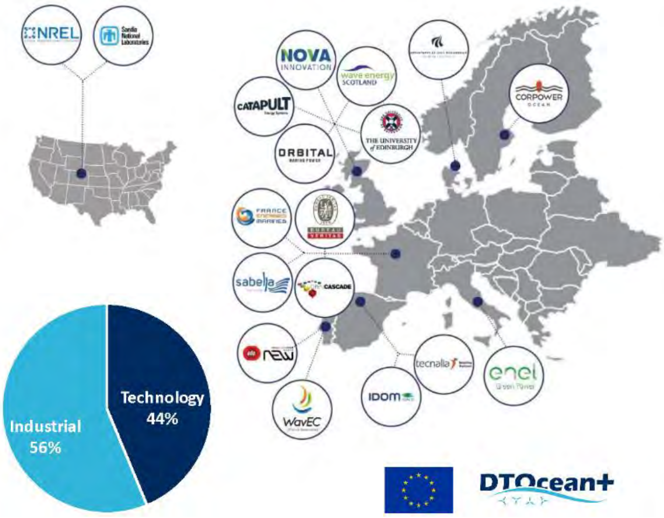
Page 7

Key Project Info

- An EU project running from May 2018 till August 2021 with a total budget of **8 M€**.

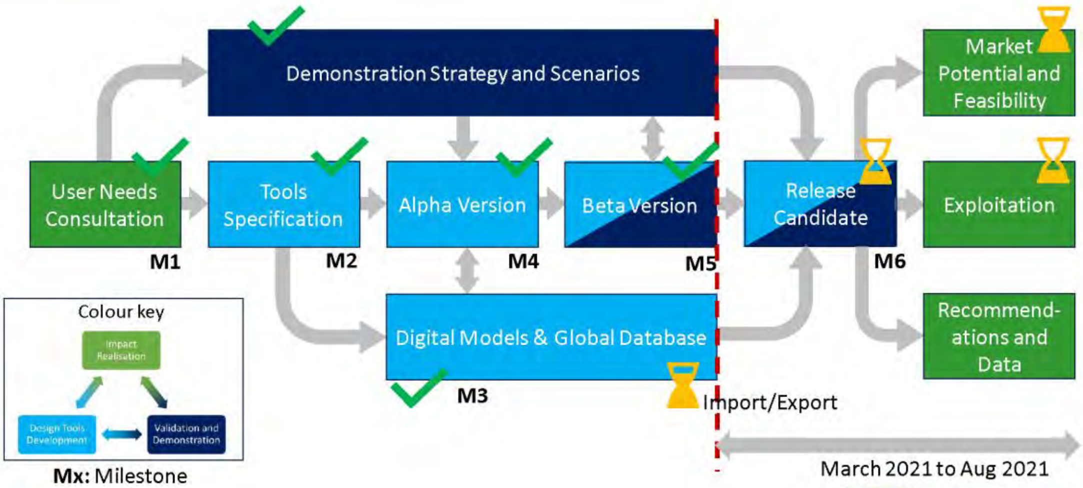
- **Multidisciplinary team** of 16 partners from 7 EU countries, with the collaboration of 2 leading research laboratories from the USA.

https://www.dtoceanplus.eu/



Page 8

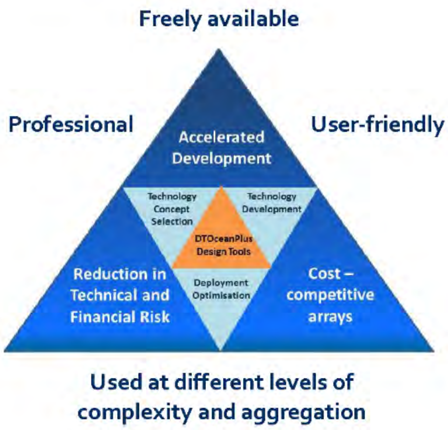
Where we are now



Page 9

DTOceanPlus: the Software

- An **integrated open-source suite of design tools** to support the entire innovation and development process for ocean energy sub-systems, devices and arrays.
- Continuing **the development of DTOcean,** which produced a 1st generation of freely available, **open-source design tools for wave and tidal energy** arrays.
- Its operational capabilities and value are be **demonstrated (TRL6) with data from real case technology projects**.



Page 10

DTOceanPlus: Functionality and Architecture (I)

- **Wave** and **tidal stream** technologies – fixed or floating devices
  - Subsystems, single devices, and arrays of devices
- Considering different levels of technology maturity
  - Early stage concepts to commercial feasibility & design

Low Complexity → **Medium** → **High**

Low Complexity:
- Fewer inputs
- Simpler data
- Quicker analysis

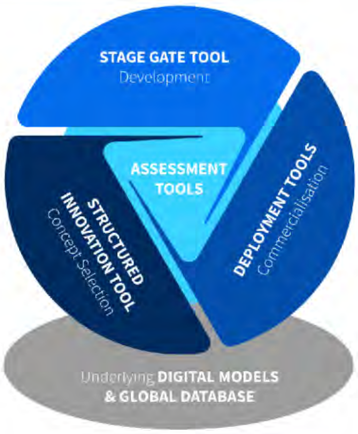
High:
- More complex data requirements
- Longer computation
- More accurate results

- Tools run as an **integrated suite** or in **standalone** mode

Page

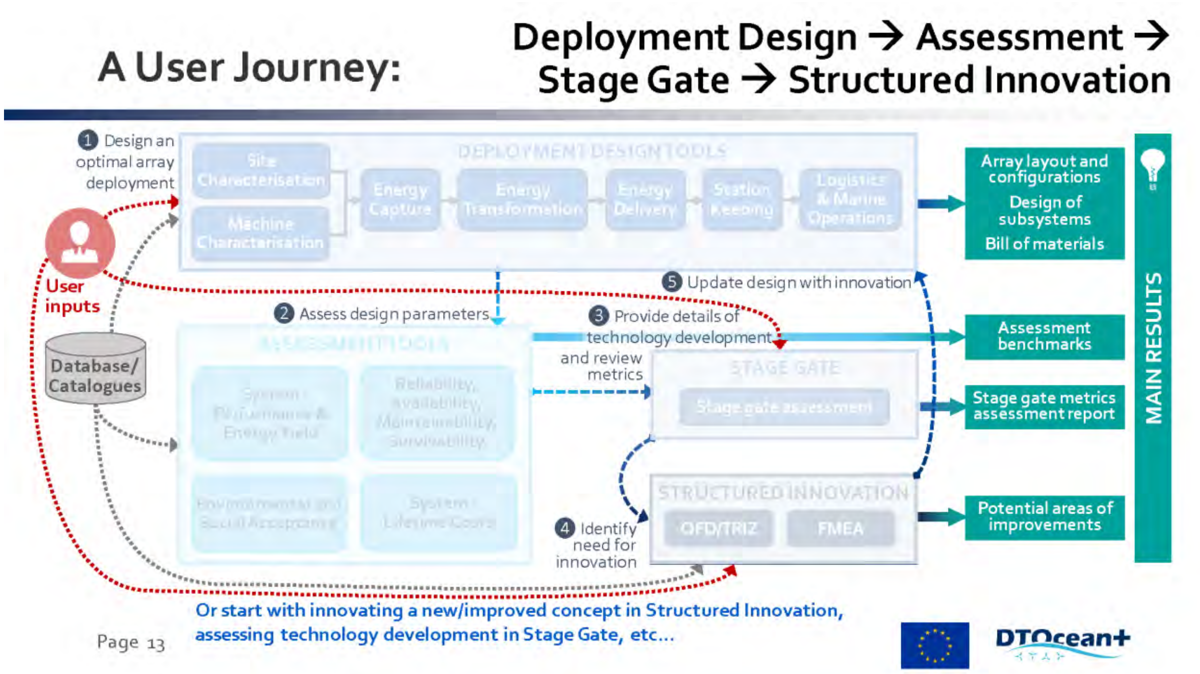
DTOceanPlus: Functionality and Architecture (II)

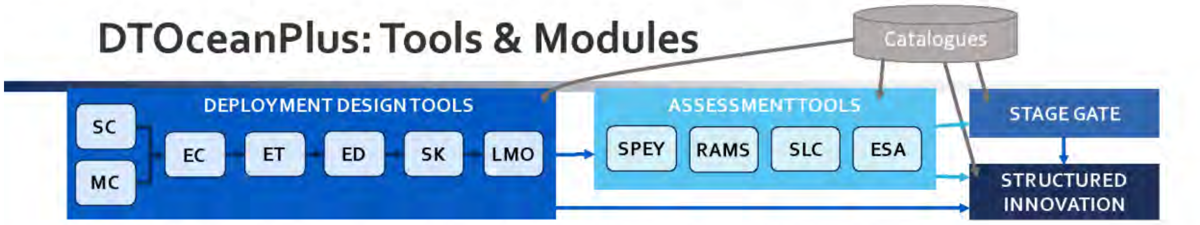
- **Structured Innovation tool**
  - Methodologies to provide a structured approach to innovation in concept creation, selection and design.
- **Stage Gate tool**
  - Assisting decision-making through the use of metrics to measure, assess and guide technology development.
- **Deployment design tools**
  - Supporting optimal device and array deployment
- **Assessment tools**
  - To evaluate projects in terms of key parameters
- **Data Management tools**
  - To maintain underlying data for ocean energy projects and allow sharing of design information (DR, Catalogues).



Tools run integrated or standalone

Page 12





SC	**Site Characterisation** – Characterise the site, including metocean, geotechnical, and environmental conditions.
MC	**Machine Characterisation** – Characterise the device prime mover
EC	**Energy Capture** – Calculate and optimise the hydrodynamic capture performance of single devices and arrays
ET	**Energy Transformation** – Design PTO and control solutions
ED	**Energy Delivery** – Design electrical and grid connection solutions to transmit power to shore
SK	**Station Keeping** – Design moorings and foundations solutions
LMO	**Logistics & Marine Operations** – Design logistical solutions and operation plans related to installation, operation, maintenance, and decommissioning operations
SPEY	**System Performance and Energy Yield** – Evaluate projects in terms of energy performance.
RAMS	System **Reliability, Availability, Maintainability, Survivability** – Evaluate the reliability aspects of a marine renewable energy project.
SLC	**System Lifetime Costs** – Evaluate projects from the economic perspective
ESA	**Environmental and Social Acceptance** – Evaluate the environmental and social impacts of a given wave and tidal energy projects.
SG	**Stage Gate** – Using metrics to measure, assess and guide technology development
SI	**Structured Innovation** – Methodologies to provide a structured approach to innovation in concept creation, selection, and design

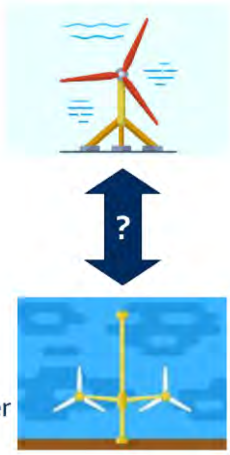
Stage Gate design tool

Why it's needed

- No consensus on technologies in ocean energy sector
- Difficult to compare different concepts
- Urgently need consistency in assessment processes
- Pathway to demonstrate progress to investors

The Stage Gate design tool aims to

- Provide a framework to assess ocean energy technology
- Facilitate clear consistent assessment
- Enable technology developers to demonstrate success
- Enhance the DTO+ suite by bringing all assessment processes together



Page 15

Overview of the Stage Gate tool

Page 16

Overview of the Stage Gate tool

Select Framework → Activity Checklist → Run Stage Gate Assessment → Assessor Mode → Generate Report → Improvement Areas (Link to SI tool)

Selecting the framework

- Review and select pre-defined frameworks
- Edit thresholds to metrics

Page 17

Overview of the Stage Gate tool

Select Framework → Activity Checklist → Run Stage Gate Assessment → Assessor Mode → Generate Report → Improvement Areas (Link to SI tool)

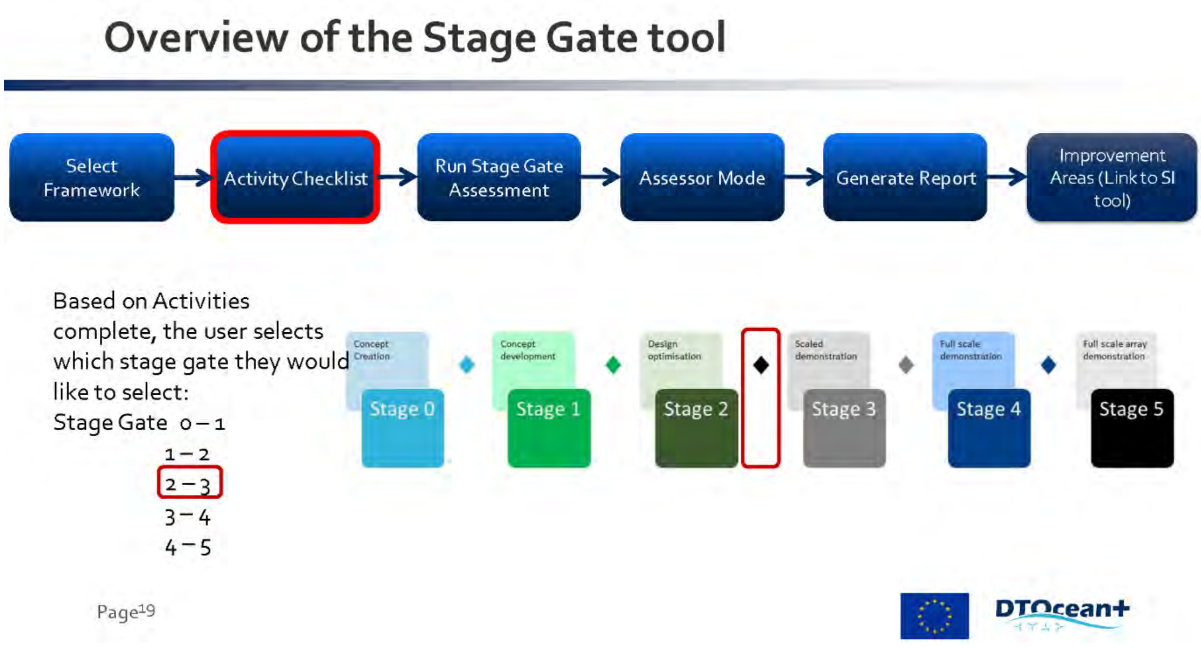
User checks off what technology development activities have been completed, in each of the following categories:

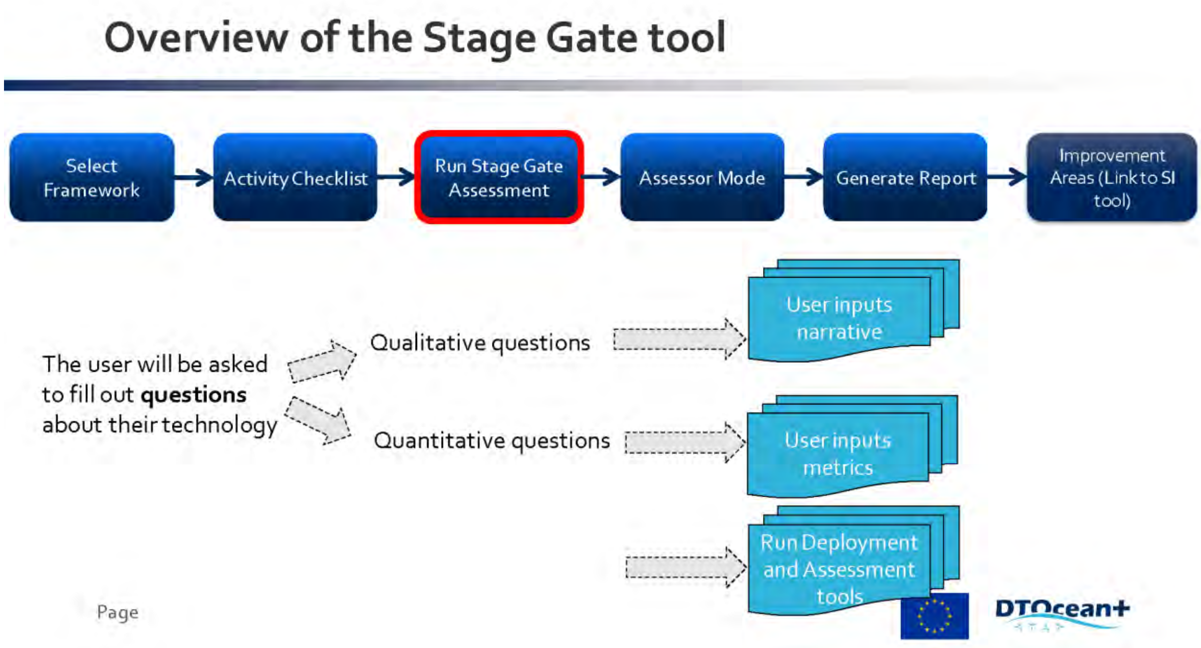
Survivability	Affordability
Energy Capture	Reliability
Acceptability	Availability
Energy Transformation	Maintainability
Installability	Energy Delivery

For example:

- ❑ *Tank testing at 1/25th - 1/10th scale*
- ❑ *Development of basic FMEA based on tank-test & modelling data*
- ❑ *Development of basic O&M schedule for planned maintenance*
- ❑ *Identification of main failure modes and associated estimates of MTTR (hours) for each mode*

Page 18


Overview of the Stage Gate tool
Select Framework
Activity Checklist
Run Stage Gate Assessment
Assessor Mode
Generate Report
Improvement Areas (Link to SI tool)
Based on Activities complete, the user selects which stage gate they would like to select:
Stage Gate 0 – 1
1 – 2
2 – 3
3 – 4
4 – 5
Concept Creation
Stage 0
Concept development
Stage 1
Design optimisation
Stage 2
Scaled demonstration
Stage 3
Full scale demonstration
Stage 4
Full scale array demonstration
Stage 5
Page 19
DTOcean+


Overview of the Stage Gate tool
Select Framework
Activity Checklist
Run Stage Gate Assessment
Assessor Mode
Generate Report
Improvement Areas (Link to SI tool)
The user will be asked to fill out questions about their technology
Qualitative questions
User inputs narrative
Quantitative questions
User inputs metrics
Run Deployment and Assessment tools
Page
DTOcean+

Overview of the Stage Gate tool

Select Framework → Activity Checklist → Run Stage Gate Assessment → **Assessor Mode** → Generate Report → Improvement Areas (Link to SI tool)

- The applicant scores can be reviewed – both qualitative answers, metric results and justification text
- Scoring criteria used
- There is space for assessor comments

Page

Overview of the Stage Gate tool

Select Framework → Activity Checklist → Run Stage Gate Assessment → Assessor Mode → **Generate Report** → Improvement Areas (Link to SI tool)

Standardised PDF report generated summarising all inputs, results and scores

Page

Overview of the Stage Gate tool

Select Framework → Activity Checklist → Run Stage Gate Assessment → Assessor Mode → Generate Report → Improvement Areas (Link to SI tool)

Examples of improvement areas:

- If running a stage gate assessment identifies a missing Evaluation area
- If the metric results deviate significantly from the thresholds set by the user

QFD

TRIZ

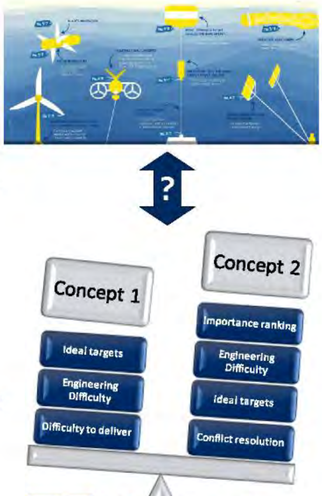
FMEA

Page

Structured Innovation tool

The Structured Innovation tool aims to:

- Help represent the voice of the customer
- Allow the design to understand the art-of-the possible for concept targets
- Enable objective comparisons between various technologies.
- Enhance systematic thinking for design beyond the current state-of-the-art.
- Provoke innovation by creating new or improve concepts



Who benefits from it?

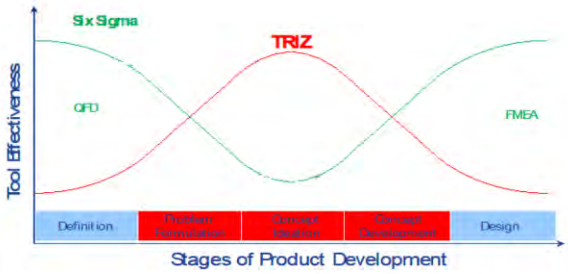
- Technology developers ~ to assess areas of improvement and technical challenges
- Funders & Investors~ to identify attractive areas of innovation for investment
- Innovators & Developers~ to assess novelty in technology

Page 24

Structured Innovation tool

Innovation at the heart of concept creation, using **QFD**, **TRIZ** and **FMEA**

- Captures and prioritises requirements
- Assesses solutions for impact
- Provides problem solving for contradictions
- Encourages risk assessment and mitigation
- Gives development direction and impact
- Improve commercial acceptability



Adapted from BS 7000-1 Design Management systems

Page

Overview of the SI tool

Project details:
- Customer needs
- Mission statement
- Prioritisation

Innovation :
- Improvement (SG)
- New concepts

QFD Process
- Functional requirements
- Relation & interrelationships
- Development impact
- Prioritisation

Target/ideal values:
- SG thresholds
- Commercial targets

Competitive assessments

TRIZ Process
- Synergies & conflicts
- Contradiction matrix
- Inventive principles

FMEA Process
- Concept/Design
- Threshold/Actions
- Mitigation

Report:
- Prioritised functions
- Development impacts
- Ideality assessment
- Conflicts and alternative solutions
- Risk mitigation measures

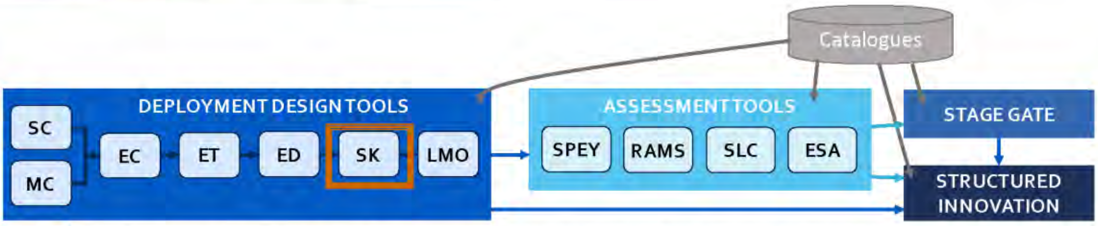
Assessed SoTA achievement against targets	Resource available	Efficiency	CAPEX	Hull Scale
Concept-1 (heave- Barge-Concrete)	100%	1%	13%	-4%
Concept-2 (heave barge-GRP)	5%	82%	104%	100%
Concept-3 (Surge-Barge-GRP)	79%	1%	52%	7%
Concept 4 (Surge-Barge-PU Nylon)	47%	59%	13%	100%

0 0,5 1 1,5 2 2,5 3 3,5 4 4,5 5
Solution Importance Ranking (Least-to-Most impactful)

Page 26

SG refers to Stage Gate design tool

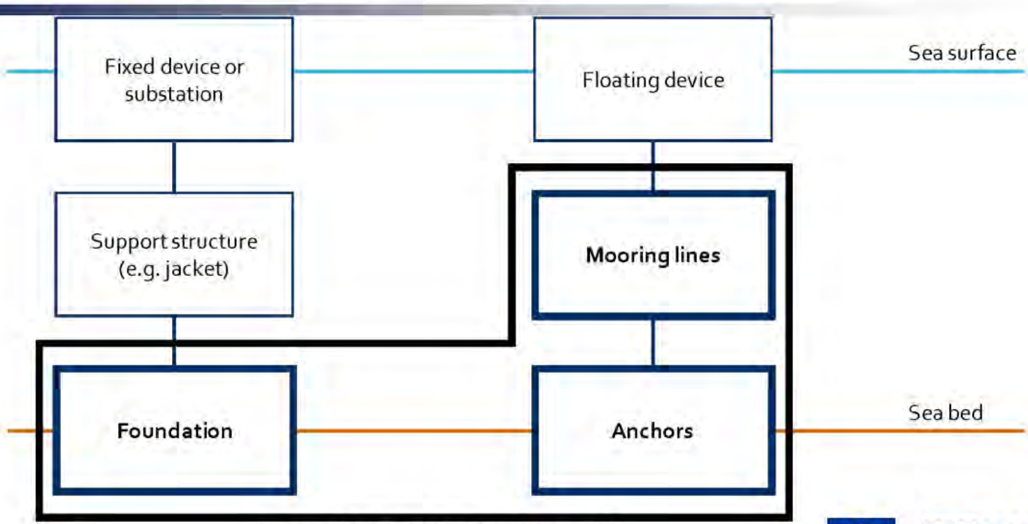
Deployment Design Tools



SC	**Site Characterisation** – Characterise the site, including metocean, geotechnical, and environmental conditions.
MC	**Machine Characterisation** – Characterise the device prime mover
EC	**Energy Capture** – Calculate and optimise the hydrodynamic capture performance of single devices and arrays
ET	**Energy Transformation** – Design PTO and control solutions
ED	**Energy Delivery** – Design electrical and grid connection solutions to transmit power to shore
SK	**Station Keeping** – Design moorings and foundations solutions
LMO	**Logistics & Marine Operations** – Design logistical solutions and operation plans related to installation, operation, maintenance, and decommissioning operations

Page 27

SK module – scope

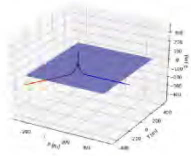


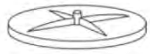
Scope of the Station Keeping module

Page 28

SK module – scope

- Mooring system
  - Catenary
  - Taut
- Anchors
  - Drag anchor
  - Gravity base
  - Pile
  - Suction anchor
- Foundations
  - Gravity base
  - Monopile





Page 29

SK module – main functionalities

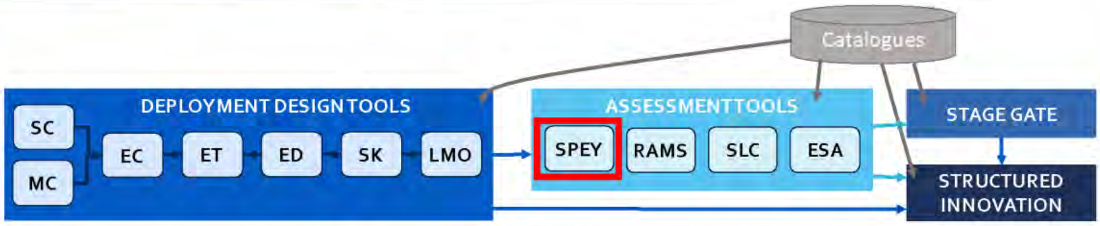
- Assess mooring system
  - Ultimate Limit State (ULS) criteria
  - Fatigue Limit State (FLS) criteria
  - Frequency domain analysis
  - Based on DNVGL-OS-E301
- Assess anchors and foundations
  - Ultimate Limit State (ULS) criteria
- Automated design of catenary mooring system
  - Based on maximum offset and ULS criteria
- Automated design of anchors and foundations
  - Based on ULS criteria

Page 30

SK module – workflow

Page 31

Assessment Design Tools

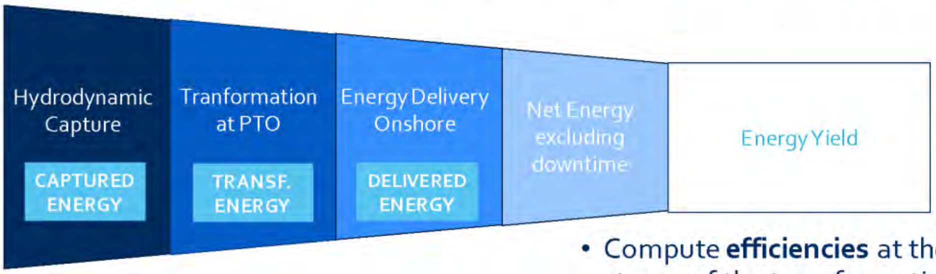


SPEY	**System Performance and Energy Yield** – Evaluate projects in terms of energy performance.
RAMS	**System Reliability, Availability, Maintainability, Survivability** – Evaluate the reliability aspects of a marine renewable energy project.
SLC	**System Lifetime Costs** – Evaluate projects from the economic perspective
ESA	**Environmental and Social Acceptance** – Evaluate the environmental and social impacts of a given wave and tidal energy projects.

Page 32

Objectives of SPEY Module

- Assess the performance of the system in terms of **energy yield** during all the stages of the resource-to-wire conversion including the downtime of the system



- Compute **efficiencies** at the different stages of the transformation
- Assess the **power quality** at the delivery point
- Produce a set of **alternative metrics** against a set of technical parameters

Page 33

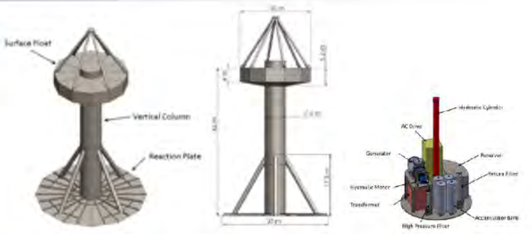
Main Outcomes of SPEY Module

- A set of **Efficiency Metrics,** i.e. dimensionless metrics to compare the efficiency of each stage of the energy flow
  - E.g. the Array Absolute Delivered Efficiency OR Device Relative Transformed Efficiency
- A set of **Alternative Metrics,** i.e. dimensional metrics to assess the energy production against a set of technical parameters, as for example
  - Cable lengths, e.g. Export Cable length to energy production ratio
  - Mass, e.g. Device Captured Energy for unit of mass
  - Rated power, Power to Weight Ratio
  - Characteristic dimension, Capture length per characteristic length
- Active and Reactive Power (**Power Quality**) after the transformation and delivery stages
- Breakdown of **Energy Production** during the project lifetime:
  - Gross, net and lost energy
  - Production per device and array
  - Net production per month and year

Page 34

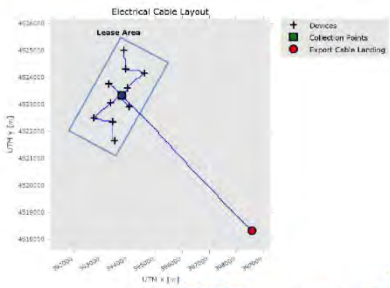
Brief live demo

- Based on Sandia's Reference Model 3 (RM3)
  - Heaving point absorber
  - Hydraulic PTO
  - Rated capacity 260 kW
  - Deployment site 33.5 kW/m
  - Single device or array of 10 devices



- SPEY – System Performance and Energy Yield

- SK – Station Keeping



Page 35

Advanced Design Tools for Ocean Energy Systems Innovation, Development and Deployment

Thank you – Questions?

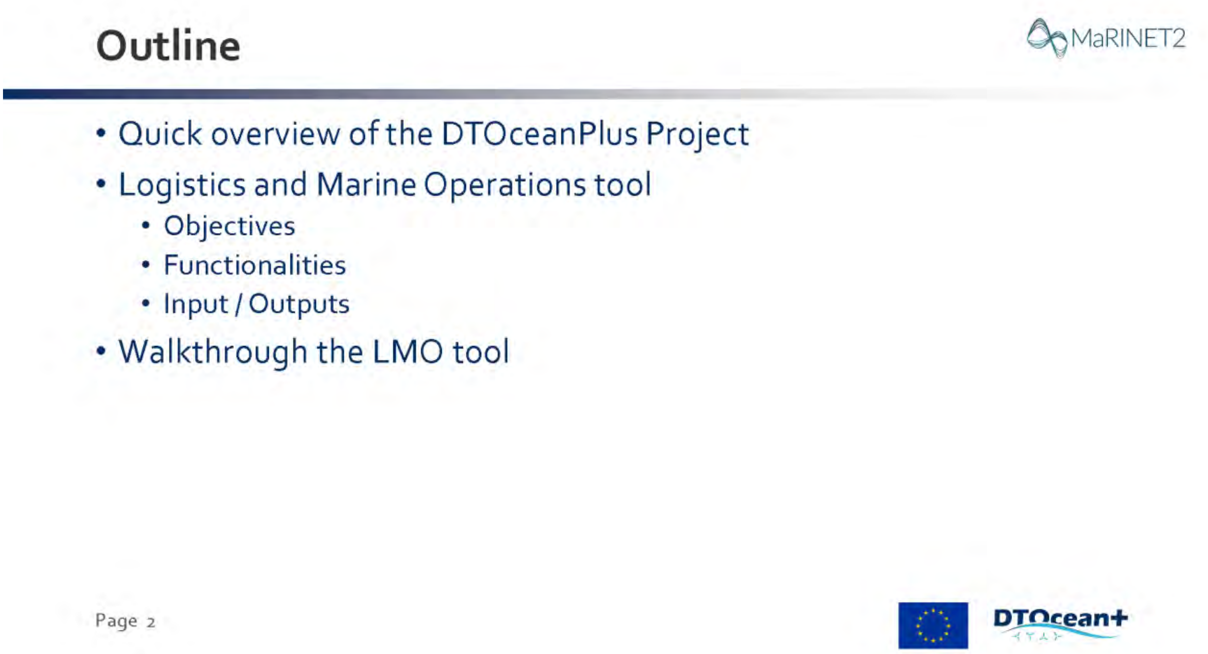
Pablo Ruiz-Minguela
jpablo.ruiz-minguela@tecnalia.com

Disclaimer: This presentation reflects only the author's views and the Agency is not responsible for any use that may be made of the information contained therein.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 785921

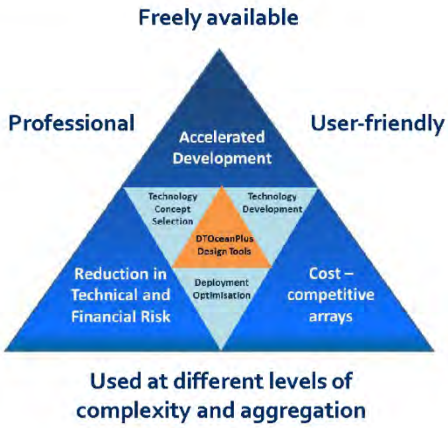
TRAINING SESSION 3: MARINET2 SHORT COURSE WEBINAR SERIES ON INSTALLATION AND O&M OF OFFSHORE RENEWABLE ENERGY SYSTEMS

Note, only slides directly related to the DTOceanPlus project are reproduced here, not the whole two-day course.



DTOceanPlus, an ambitious project

- An ambitious project to accelerate the commercialisation in the ocean energy sector.
- Develop an advanced **open-source** set of design tools for the **selection, development** and **deployment** of ocean energy systems.
- Continuing the development of DTOcean, which produced a 1st generation of freely available design tools.
- **Demonstrate** and validate tools **(TRL6)** with real data from **real technology projects**.



Page 3

DTOceanPlus, an ambitious project

- An EU project running from May 2018 till August 2021 with a total budget of **8 M€**.
- **Multidisciplinary team** of 16 partners from 7 EU countries, with the collaboration of 2 leading research laboratories from the USA.

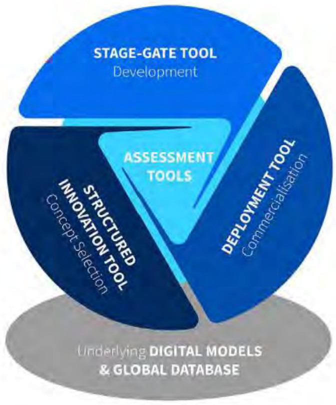
https://www.dtoceanplus.eu/

Page 4

The DTOceanPlus suite of tools

MaRINET2

- **Structured innovation** tool
  - Identification and selection of new concepts and ideas
- **Stage gate design** tool
  - Assist and guide development decision-making
- **Deployment design** tools
  - Design optimal device and array deployment solutions
- **Assessment design** tools
  - For evaluating ocean renewable energy projects
- **Global Database**
- **Digital representation**
  - Definition of data standards for the ocean energy sector



Page 5

DTOcean+

DTOceanPlus Deployment & Assessment tools

MaRINET2

Deployment design tools

1. **Site Characterisation (SC)**
2. **Machine Characterisation (MC)**
3. **Energy Capture (EC)**
4. **Energy Transformation (ET)**
5. **Energy Delivery (ED)**
6. **Station Keeping (SK)**
7. **Logistics & Marine Operations (LMO)**

Assessment design tools

1. **System Performance and Energy Yield (SPEY)**
2. **Reliability, Availability, Maintainability, Survivability (RAMS)**
3. **System Lifetime Costs (SLC)**
4. **Environmental and Social Acceptance (ESA)**

Page

DTOcean+

DTOceanPlus Assessment tools

MaRINET2

Once a design is completed in the deployment design tools perform assessments on different areas as required:

- **System Performance and Energy Yield (SPEY)**
- **Reliability, Availability, Maintainability, Survivability (RAMS)**
- **System Lifetime Costs (SLC)**
- **Environmental and Social Acceptance (ESA)**

SYSTEM PERFORMANCE AND ENERGY YIELD

RELIABILITY AVAILABILITY MAINTAINABILITY SURVIVABILITY

SYSTEM LIFETIME COSTS

ENVIRONMENTAL AND SOCIAL ACCEPTANCE TOOLS

Page 7

DTOceanPlus suite of tools

MaRINET2

- **Wave** and **tidal stream** technologies – fixed or floating devices
  - Devices, arrays, and subsystems
- Tools can be run as an **integrated suite** or in **standalone** mode
- Tools can be run at three different complexity levels
  - Designed for early stage concepts to commercial feasibility & design
  - Considering different levels of technology maturity

Low Complexity → **Medium** → **High**

- Fewer inputs
- Simpler data
- Quicker analysis

- More complex data requirements
- Longer computation
- More accurate results

Page

Logistics and Marine Operations

Why it's needed (1/2)

- Logistics and marine operations are major cost drivers of ocean energy projects
- Planning the installation and maintenance is a highly complex and intertwined process
- Identifying the logistic requirements early in the project may unveil cost-reduction pathways

Page

Logistics and Marine Operations

Why it's needed (2/2)

- Most simulation tools require a large number of inputs, typically not available at early stages of development
- The objective is to propose solutions and guide the user whenever information is incomplete or still unknown

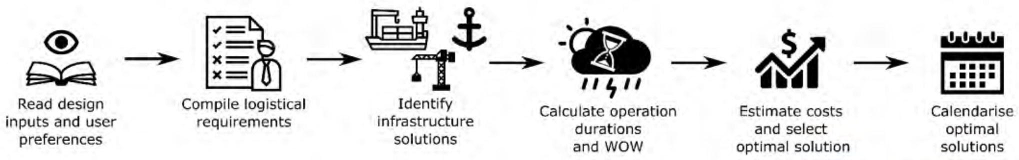
Page

Logistics and Marine Operations

MaRINET2

Design logistical solutions for the installation, maintenance and decommissioning phases of ocean energy projects.

- ✓Propose infrastructure (vessels, ports, equipment)
- ✓Identify marine operations that must be carried out and propose sequence
- ✓Calculate durations and estimate weather delays
- ✓Estimate costs and calculate optimal planning



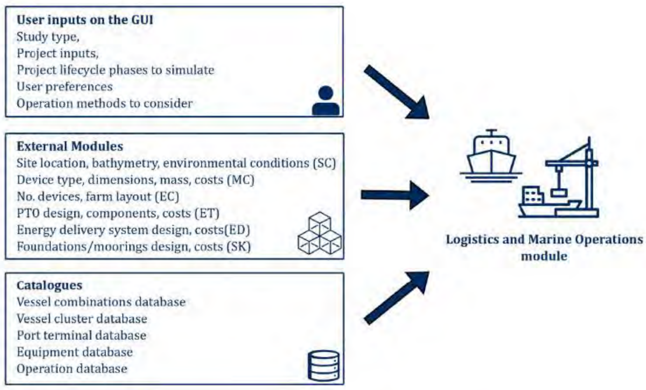
Page

DTOcean+

Logistics and Marine Operations: Inputs

Three sources of inputs:

- User inputs on the GUI
- Other DTOceanPlus modules
- Catalogues



Page

DTOcean+

Logistics and Marine Operations: Outputs

- Installation plans
- Maintenance plans
- Decommissioning plans

LOGISTICAL SOLUTION

For each phase:

- Selected port terminals
- Selected vessel fleet
- Selected equipment
- Activity sequence
- Gantt charts
- Operation durations, start date and end date
- Expected weather delays
- Fuel consumption
- Operation costs

Page 13

Logistics and Marine Operations: Outputs

MaRINET2

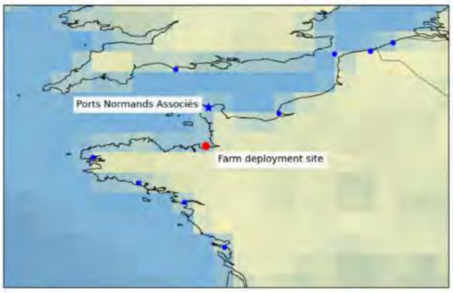
LIVE DEMO

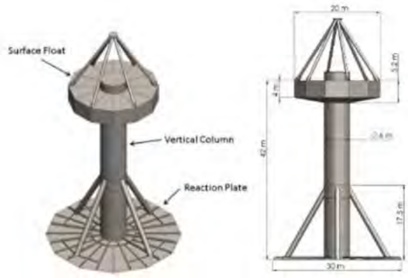
Page 14

Reference test scenario: Floating WEC

A test case for a floating wave energy converter was generated, to demonstrate the functionalities of the tool:

- Floating wave energy converter, inspired on Sandia's Reference Model 3 (RM3)
- Rated power of 260 kW
- Dummy site: North of France





Component	**No.**	**Type**	**Mass**	**Length**	**Width**	**Height**	**Draft**	**Tow draft**
Device	1	Floating WEC	680,000 kg	30 m	30 m	42 m	35 m	15 m
Component	**No.**	**Type**	**Mass**	**Length**	**Width**	**Height**		
Anchor	3	Drag-anchor	9,535 kg	5.4718 m	5.8982 m	3.2908 m		
Component	**No.**	**Material**	**Mass**	**Length**	**Diameter**			
Mooring line	3	Nylon	4,703 kg	340.7 m	0.146 m			
Component	**No.**	**Type**	**Mass**	**Length**	**Diameter**	**Voltage**	**MBR**	**Burial depth**
Power cable	1	Export	8,700 kg	6,680 m	0.079 m	3.3 kV	1.15 m	0.5 m

DTOcean+

Advanced Design Tools for Ocean Energy Systems Innovation, Development and Deployment

Thank you for your attention!

Questions?

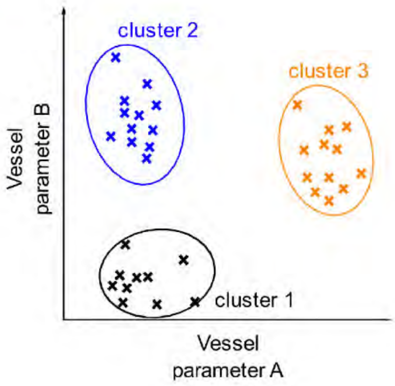
Francisco Correia da Fonseca
francisco.fonseca@wavec.org

www.dtoceanplus.eu

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 785921

Vessel cluster database

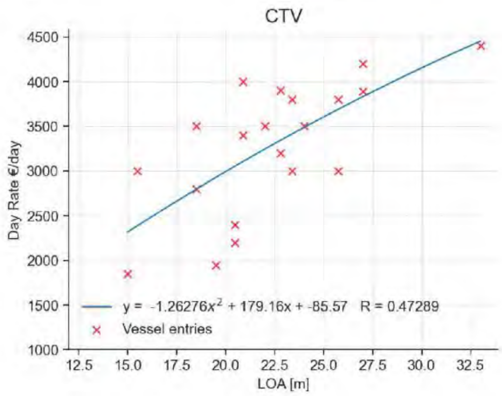
- Original database based on 14,847 vessels
- 46 technical parameters (LOA, draft, beam, deck area,…)
- Vessels of the same type and similar characteristics were grouped together
- Statistical values were generated for each group for each parameter



Page 17

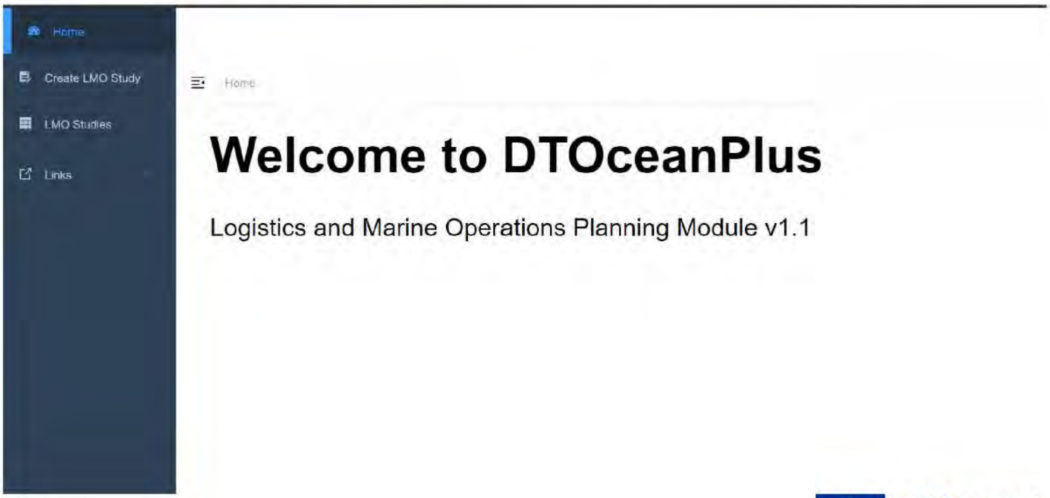
Vessel costs

- Cost functions were developed for each vessel group considered in DTOceanPlus



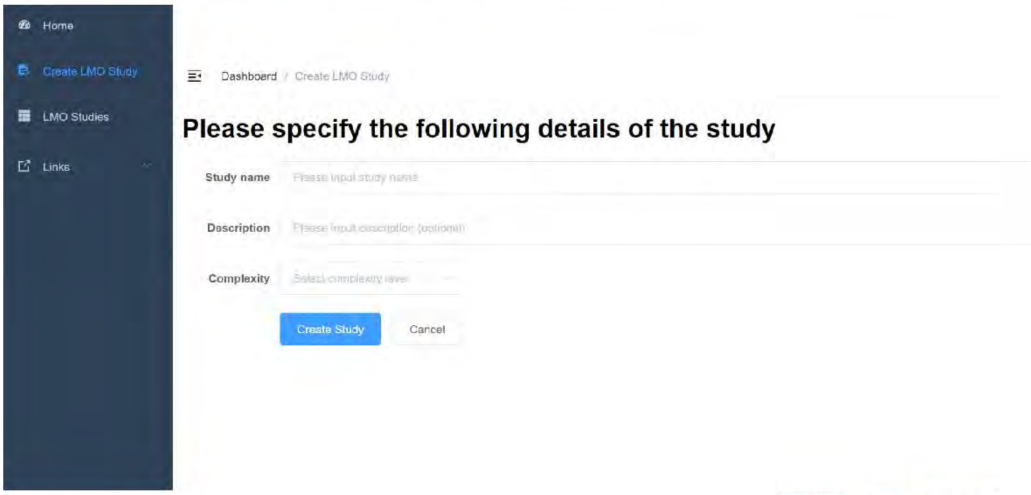
Page 18

LMO Module (standalone version): Initial menu



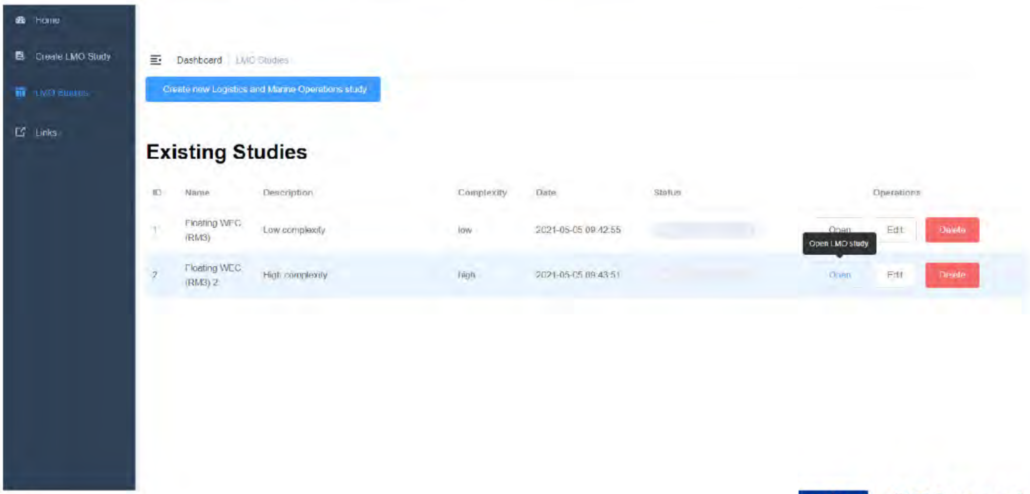
Page

LMO Module: Creating a new study



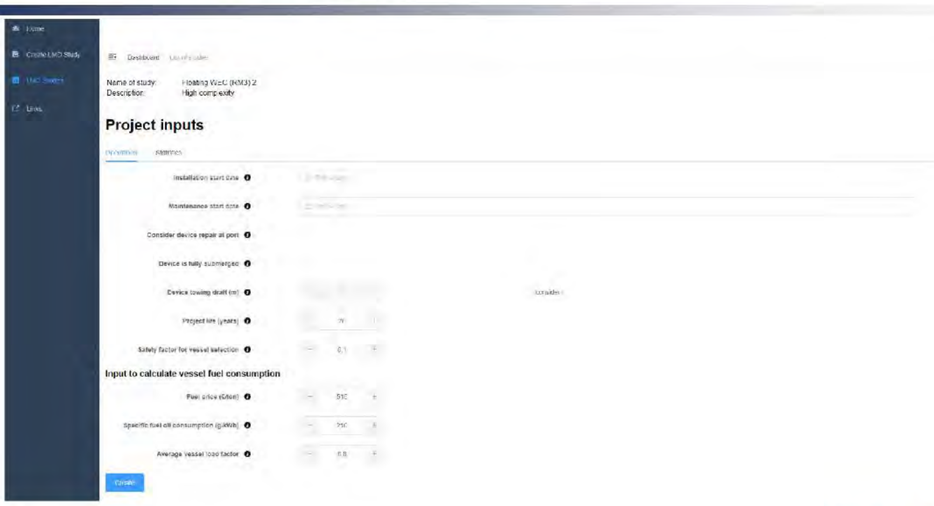
Page

LMO Module: List of studies



Page

LMO Module: List of studies

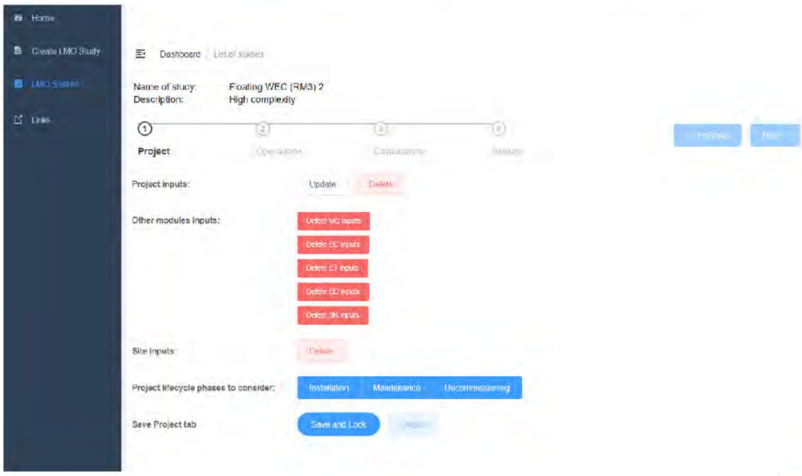


Page

LMO Module: List of studies

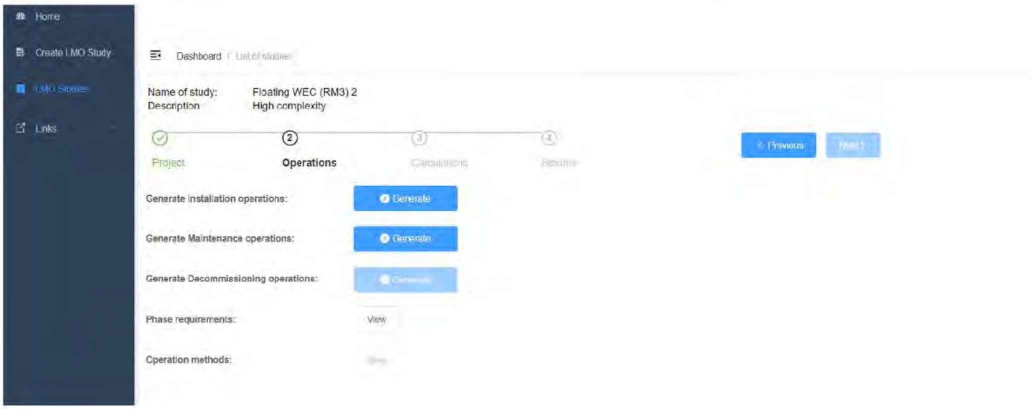
Page

LMO Module: Introduce file inputs



Page

LMO Module: Operations page

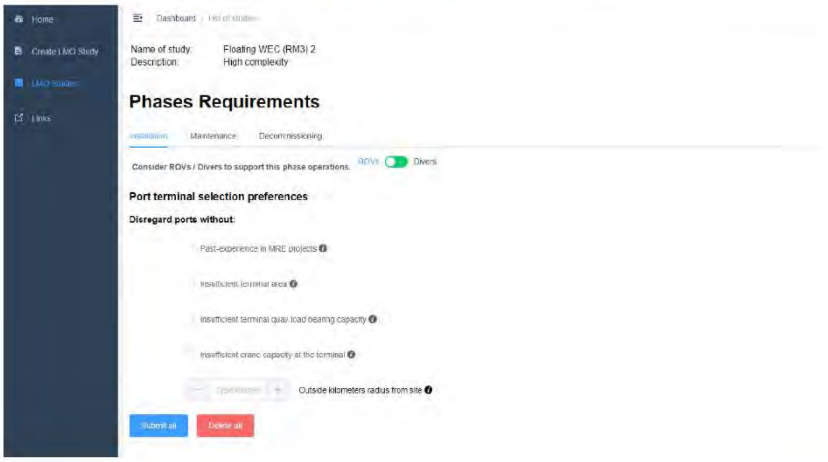


Page

LMO Module: Operations page

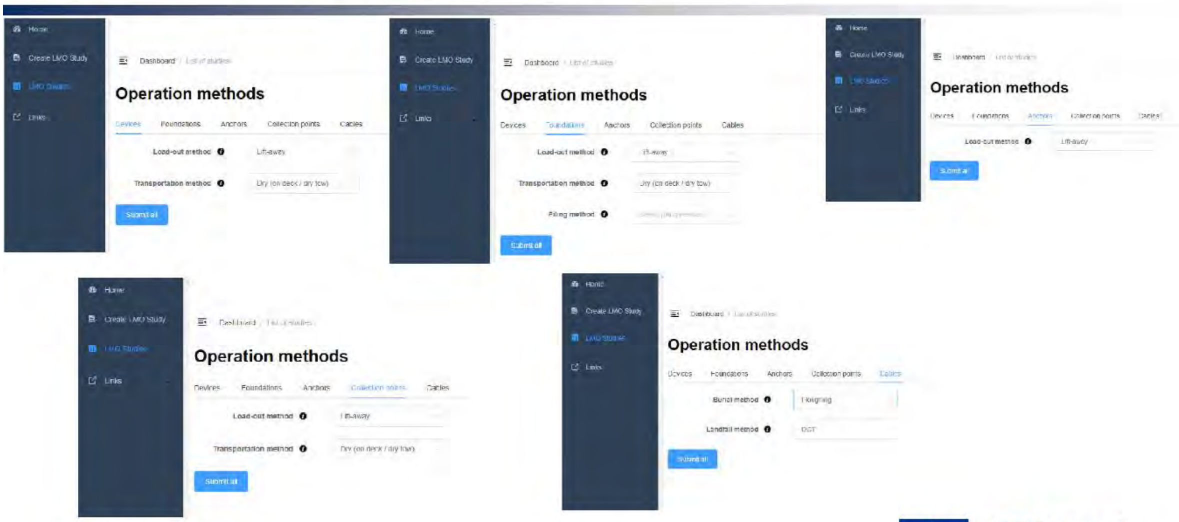
Page

LMO Module: Phase requirements and preferences

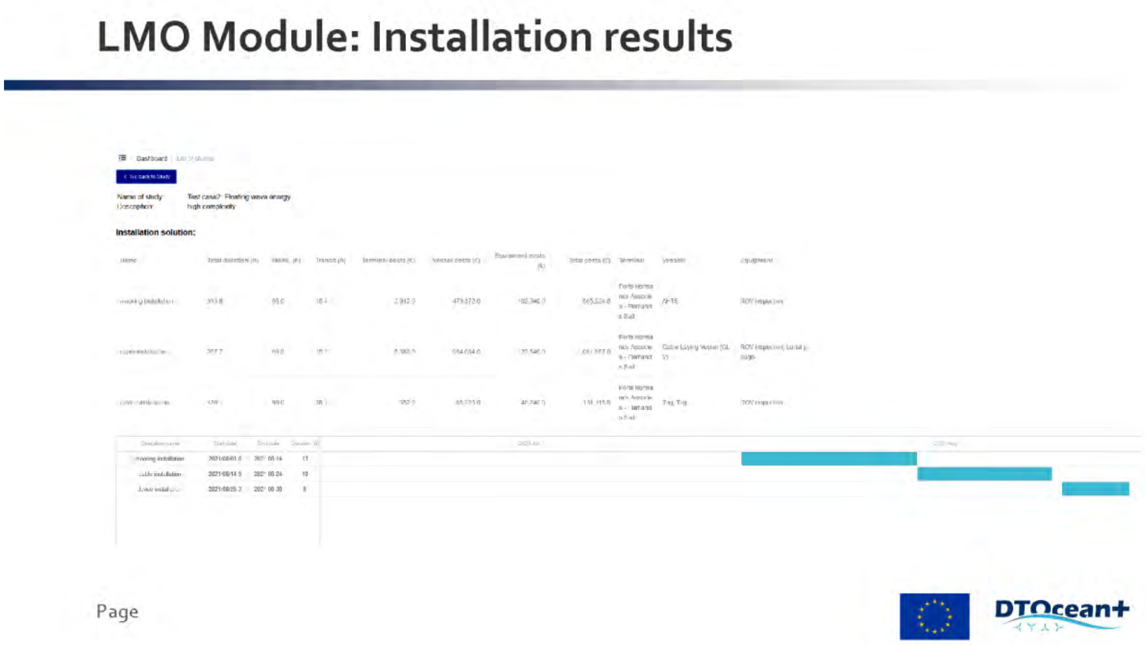


Page

LMO Module: Methods to be considered



Page



TRAINING SESSION 4: DEPLOYMENT AND ASSESSMENT DESIGN TOOLS FOR OCEAN ENERGY SYSTEMS

Content

14:00 - 14:15	Introduction
	• DTOceanPlus project and the software suite philosophy Donald Noble, The University of Edinburgh • Presentation of the DTOceanPlus main interface Frédéric Pons, Open Cascade
14:15 - 15:00	Deployment Design Tool
	• Focus on the Site Characterisation Module Youen Kervella and Nicolas Michelet, France Energies Marines • Focus on the Station Keeping Module Neil Luxcey, France Energies Marines
15:00 - 15:25	Assessment Design Tool
	• Focus on the Environmental and Social Acceptance Module Emma Araignous, France Energies Marines
15:25 - 15:30	To go further
	• Repository, documentation, workshop and final release Donald Noble, The University of Edinburgh
15:30 - 16:00	Q&A Session

Page 2

Introduction

14:00 - 14:15	Introduction
	• DTOceanPlus project and the software suite philosophy Donald Noble, The University of Edinburgh • Presentation of the DTOceanPlus main interface Frédéric Pons, Open Cascade
14:15 - 15:00	Deployment Design Tool
	• Focus on the Site Characterisation Module Youen Kervella and Nicolas Michelet, France Energies Marines • Focus on the Station Keeping Module Neil Luxcey, France Energies Marines
15:00 - 15:25	Assessment Design Tool
	• Focus on the Environmental and Social Acceptance Module Emma Araignous, France Energies Marines
15:25 - 15:30	To go further
	• Repository, documentation, workshop and final release Donald Noble, The University of Edinburgh
15:30 - 16:00	Q&A Session

Page 3

Advanced Design Tools for Ocean Energy Systems Innovation, Development and Deployment

DTOceanPlus project and the software suite philosophy

Dr Donald R Noble (University of Edinburgh)

1 July 2021

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 785921

The DTOceanPlus Project

- **3-year EU H2020** funded project
  - May 2018 – August 2021
  - €8million budget
  - 16 European partners + 2 US labs
- **Objective:**
  To support the **entire technology innovation process,** from concept to deployment of sub-systems, energy capture devices and arrays
- Continuing the **development of DTOcean**
- To produce an advanced **open-source** suite of tools for the **selection, development, deployment and assessment** of ocean energy systems

Page 2

The DTOceanPlus tools

- **Wave** and **tidal stream** technologies – fixed or floating devices
  - Subsystems, single devices, and arrays of devices
- Considering different levels of technology maturity
  - Early stage concepts to commercial feasibility & design

Low Complexity → **Medium** → **High**

Low Complexity:
- Fewer inputs
- Simpler data
- Quicker analysis

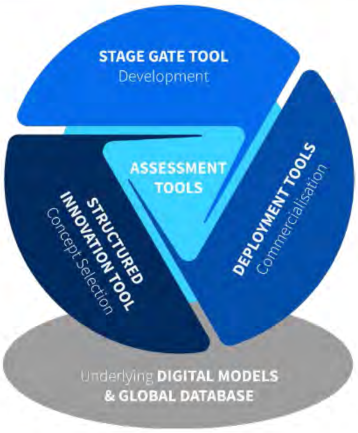
High:
- More complex data requirements
- Longer computation
- More accurate results

- Tools run as an **integrated suite** or in **standalone** mode
- Accessed via a web-browser interface

Page 3

The DTOceanPlus suite of tools

- **Deployment design tools**
  - Supporting optimal device and array deployment
- **Assessment tools**
  - To evaluate projects in terms of key parameters
- **Stage Gate** tool
  - Assisting decision-making through the use of metrics to measure, assess and guide technology development.
- **Structured Innovation** tool
  - Methodologies to provide a structured approach to innovation in concept creation, selection, and design
- **Main Module** and **Data Management** tools
  - Manage projects and studies
  - Catalogues of components and reference data
  - Digital Representation to allow sharing of design information.



Tools run integrated or standalone

Page 4

Use of the DTOceanPlus tools

Design

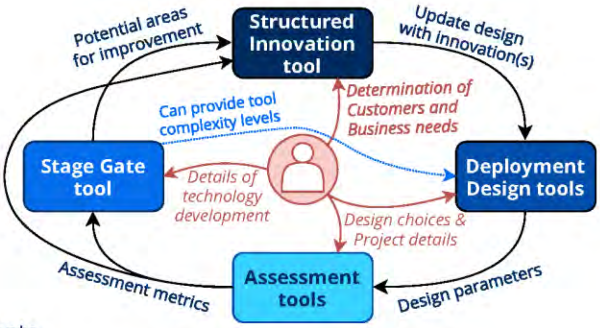
- Assisting with developing optimal design of a subsystem, device, or array

Assess

1. Performance of a subsystem, device, or array in the context of a site and project
2. Status of a technology's development

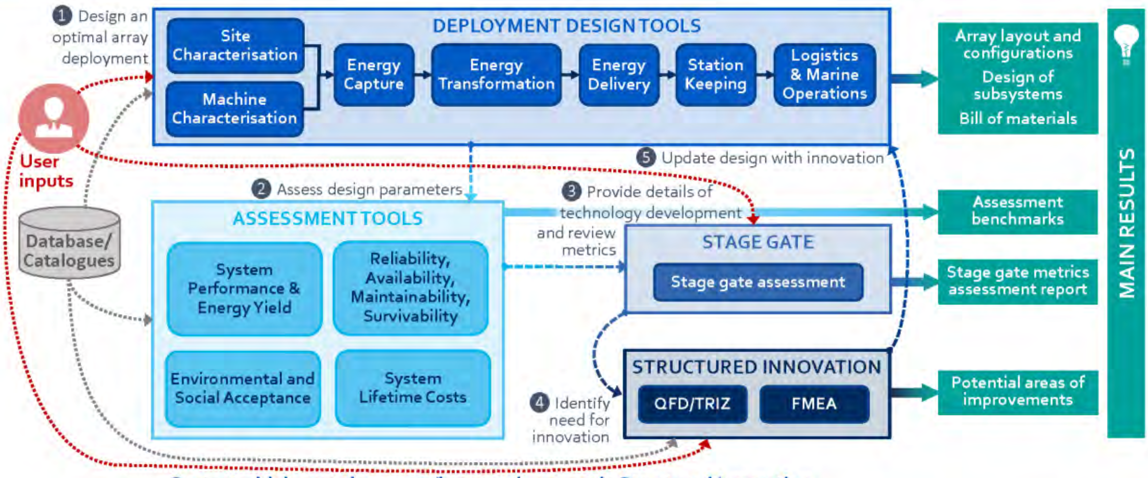
Innovate

- Facilitate structured innovation of new concepts and improvements to existing technology.



Page 5

A User Journey: Deployment Design → Assessment → Stage Gate → Structured Innovation



Or start with innovating a new/improved concept in Structured Innovation, assessing technology development in Stage Gate, etc…

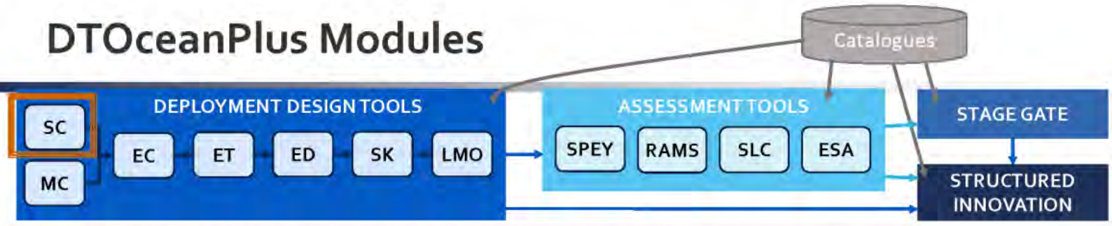
Page 6

Deployment Design Tool

14:00 - 14:15	**Introduction**
	• DTOceanPlus project and the software suite philosophy Donald Noble, The University of Edinburgh • Presentation of the DTOceanPlus main interface Frédéric Pons, Open Cascade
14:15 - 15:00	**Deployment Design Tool**
	• Focus on the Site Characterisation Module Youen Kervella and Nicolas Michelet, France Energies Marines • Focus on the Station Keeping Module Neil Luxcey, France Energies Marines
15:00 - 15:25	**Assessment Design Tool**
	• Focus on the Environmental and Social Acceptance Module Emma Araignous, France Energies Marines
15:25 - 15:30	**To go further**
	• Repository, documentation, workshop and final release Donald Noble, The University of Edinburgh
15:30 - 16:00	Q&A Session

Page 4

DTOceanPlus Modules



SC	**Site Characterisation** – Characterise the site, including metocean, geotechnical, and environmental conditions.
MC	**Machine Characterisation** – Characterise the device prime mover
EC	**Energy Capture** – Calculate and optimise the hydrodynamic capture performance of single devices and arrays
ET	**Energy Transformation** – Design PTO and control solutions
ED	**Energy Delivery** – Design electrical and grid connection solutions to transmit power to shore
SK	**Station Keeping** – Design moorings and foundations solutions
LMO	**Logistics & Marine Operations** – Design logistical solutions and operation plans related to installation, operation, maintenance, and decommissioning operations
SPEY	**System Performance and Energy Yield** – Evaluate projects in terms of energy performance.
RAMS	System **Reliability, Availability, Maintainability, Survivability** – Evaluate the reliability aspects of a marine renewable energy project.
SLC	**System Lifetime Costs** – Evaluate projects from the economic perspective
ESA	**Environmental and Social Acceptance** – Evaluate the environmental and social impacts of a given wave and tidal energy projects.
SG	**Stage Gate** – Using metrics to measure, assess and guide technology development
SI	**Structured Innovation** – Methodologies to provide a structured approach to innovation in concept creation, selection, and design

Advanced Design Tools for Ocean Energy Systems Innovation, Development and Deployment

Training session

Site Characterisation module

Youen Kervella, Nicolas Michelet (FEM)

July, 2021

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 785921

SC module – Objectives & Functionalities

- **Objectives**:

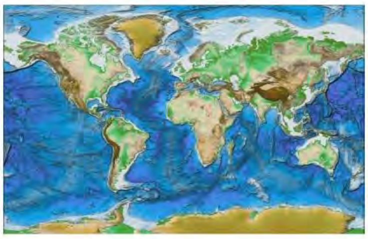
  SC receives as input environmental data and outputs ready-to-use data (other modules and user).

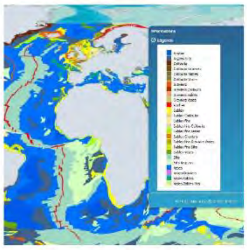
- **Functionalities:**

- **Databases extractions**: selected by the user.
- **Statistics Computation**: from basic ones to multivariate extreme values analysis.
- **3 levels of complexity**:
  - CPX1: inputs in 1D, the user defines the level of energy for waves and tidal currents.
  - CPX2: the same but inputs in 2D.
  - CPX3: the user chooses his own databases, in 1D or in 2D.

Page 2 https://www.dtoceanplus.eu/Publications/Deliverables/Deliverable-D5.2-Site-Characterisation-alpha-version

SC module – Inputs





- **Bathymetry**: World GEBCO_2019 gridded bathymetry [1]
- **Bottom sediments**: SHOM World Bottom Sediment Map [2]
- **Endangered Marine Species**: probabilities of presence of 26 species, based on AquaMaps [3]
- **Waves, tidal currents, winds and water levels**: Ifremer HOMERE database [4] (=> connections to online databases in the future).
- **User inputs**.

[1] GEBCO Compilation Group (2019) GEBCO 2019 Grid (doi:10.5285/836f016a-33be-6ddc-e053-6c86abc0788e)

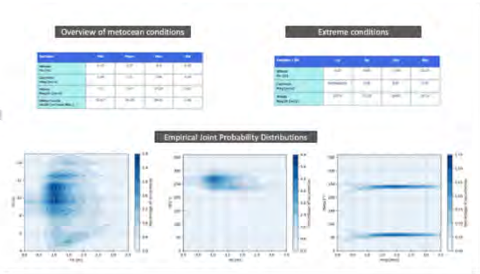
[2] Garlan, Thierry & Gabelotaud, Isabelle & Lucas, S. & Marchès, Elodie. (2018). A World Map of Seabed Sediment Based on 50 Years Knowledge.

[3] Kaschner, K., K. Kesner-Reyes, C. Garilao, J. Rius-Barile, T. Rees, and R. Froese. (2016). AquaMaps: Predicted range maps for aquatic species. World wide web electronic publication, www.aquamaps.org, Version 10/2019

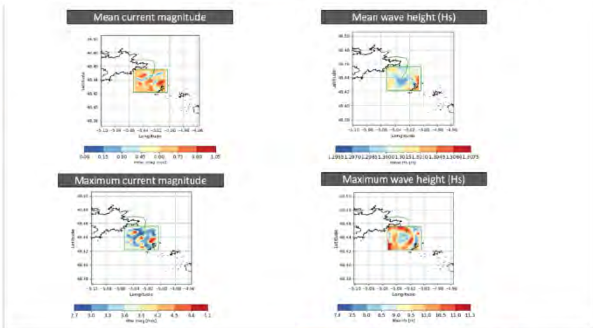
[4] Boudiere Edwige, Maisondieu Christophe, Ardhuin Fabrice, Accensi Mickael, Pineau-Guillou Lucia, Lepesqueur Jeremy (2013). A suitable metocean hindcast database for the design of Marine energy converters. International Journal of Marine Energy, 3-4, e40-e52. Publisher's official version: http://dx.doi.org/10.1016/j.ijome.2013.11.010, Open Access version: http://archimer.ifremer.fr/doc/00164/27524/

Page 3

SC module – Outputs



- 2D bathymetry, seabed types and endangered species.
- Waves, tidal currents, winds and water levels:
  - Timeseries of main parameters
  - Statistics (basics, EPD, EJPD, Extreme, Environmental contours, ..)
- All outputs => other DTO+ modules
- Selection of outputs => user.



Page 4

Verification cases

Marine Energy Conversion (MEC) technology Reference Models for producing renewable electricity from water currents and waves.

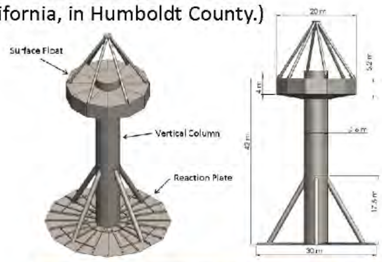
Reference: Neary S. V., et al., 2014. *Methodology for Design and Economic Analysis of Marine Energy Conversion (MEC) Technologies.* https://energy.sandia.gov/wp-content/gallery/uploads/SAND2014-9040-RMP-REPORT.pdf

RM1: reference tidal current energy resource (Tacoma Narrows in Puget Sound, Washington).

Inputs description	Value	Units
Water depth (bathymetry)	50	m
Seabed type	No data	-
Maximum velocity	3.0	m/s

Page 5

RM3: reference wave energy resource (Eureka, California, in Humboldt County.)

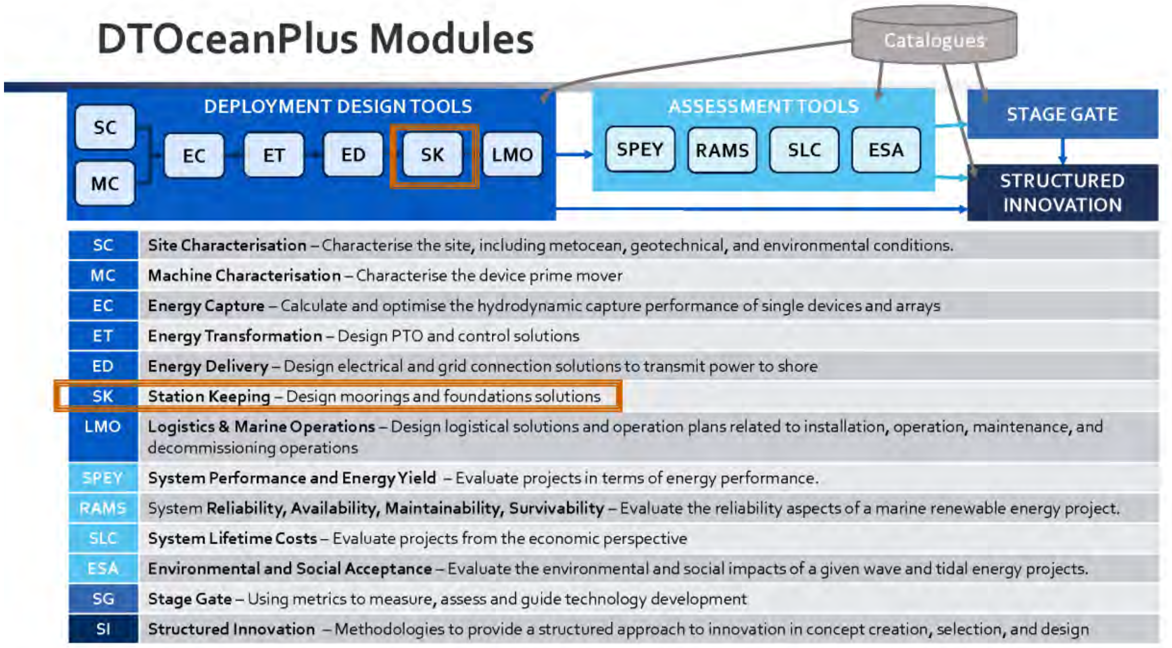


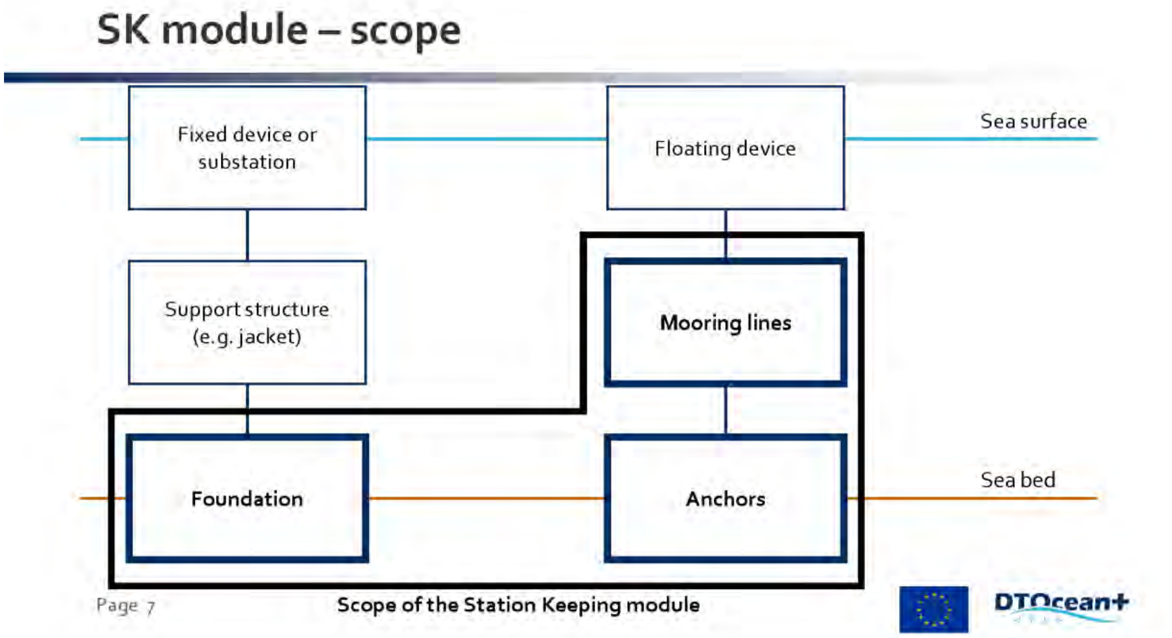
Inputs description	Value	Units
Water depth (bathymetry)	Between 40 and 100, gently sloping	m
Seabed type	Sand and clay	-
Hs 100	Between 11 and 12	m

GUI Presentation

GUI Presentation

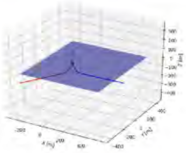
Page 6

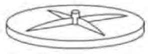

DTOceanPlus Modules
Catalogues
DEPLOYMENT DESIGN TOOLS
SC
MC
EC
ET
ED
SK
LMO
ASSESSMENT TOOLS
SPEY
RAMS
SLC
ESA
STAGE GATE
STRUCTURED INNOVATION
SC Site Characterisation – Characterise the site, including metocean, geotechnical, and environmental conditions.
MC Machine Characterisation – Characterise the device prime mover
EC Energy Capture – Calculate and optimise the hydrodynamic capture performance of single devices and arrays
ET Energy Transformation – Design PTO and control solutions
ED Energy Delivery – Design electrical and grid connection solutions to transmit power to shore
SK Station Keeping – Design moorings and foundations solutions
LMO Logistics & Marine Operations – Design logistical solutions and operation plans related to installation, operation, maintenance, and decommissioning operations
SPEY System Performance and Energy Yield – Evaluate projects in terms of energy performance.
RAMS System Reliability, Availability, Maintainability, Survivability – Evaluate the reliability aspects of a marine renewable energy project.
SLC System Lifetime Costs – Evaluate projects from the economic perspective
ESA Environmental and Social Acceptance – Evaluate the environmental and social impacts of a given wave and tidal energy projects.
SG Stage Gate – Using metrics to measure, assess and guide technology development
SI Structured Innovation – Methodologies to provide a structured approach to innovation in concept creation, selection, and design


SK module – scope
Fixed device or substation
Floating device
Sea surface
Support structure (e.g. jacket)
Mooring lines
Foundation
Anchors
Sea bed
Page 7
Scope of the Station Keeping module
DTOcean+

SK module – scope

- Mooring system
  - Catenary
  - Taut
- Anchors
  - Drag anchor
  - Gravity base
  - Pile
  - Suction anchor
- Foundations
  - Gravity base
  - Monopile





SK module – main functionalities

- Assess mooring system
  - Ultimate Limit State (ULS) criteria
  - Fatigue Limit State (FLS) criteria
  - Frequency domain analysis
  - Based on DNVGL-OS-E301
- Assess anchors and foundations
  - Ultimate Limit State (ULS) criteria
- Automated design of catenary mooring system
  - Based on maximum offset and ULS criteria
- Automated design of anchors and foundations
  - Based on ULS criteria

SK module – anchors/foundations – ULS criteria

- Pile anchor and Monopile
  - Lateral capacity
  - Axial tension capacity
  - Axial compression capacity
  - Steel stress analysis
- Gravity based
  - Overturning moment limit
  - Uplift capacity
  - Bearing capacity
  - Sliding resistance
- Drag anchors
  - Ultimate Holding Capacity (UHC)
- Suction anchors
  - Uplift capacity
  - Lateral capacity
  - General loading capacity

Page 10

SK module – workflow

Page 11

Walkthrough the SK Module

Example

In this example, we'll use the Reference Model RM1 (rated power of 1100 kW) developed by Sandia.

The chosen site will be the Takoma site, and the simulation.

The input data are based on the SANDIA Report (SAND2014-9040 Methodology for Design and Economic Analysis of Marine Energy Conversion (MEC) Technologies)

Some inputs are derived and adapted from a published DTOcean study of the site (Topper et al 2020)

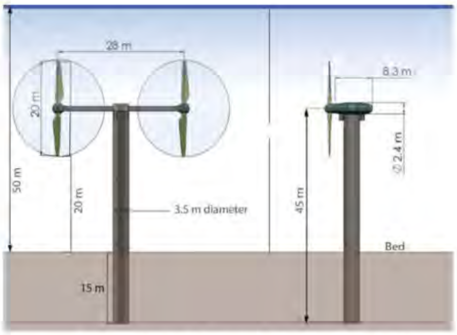


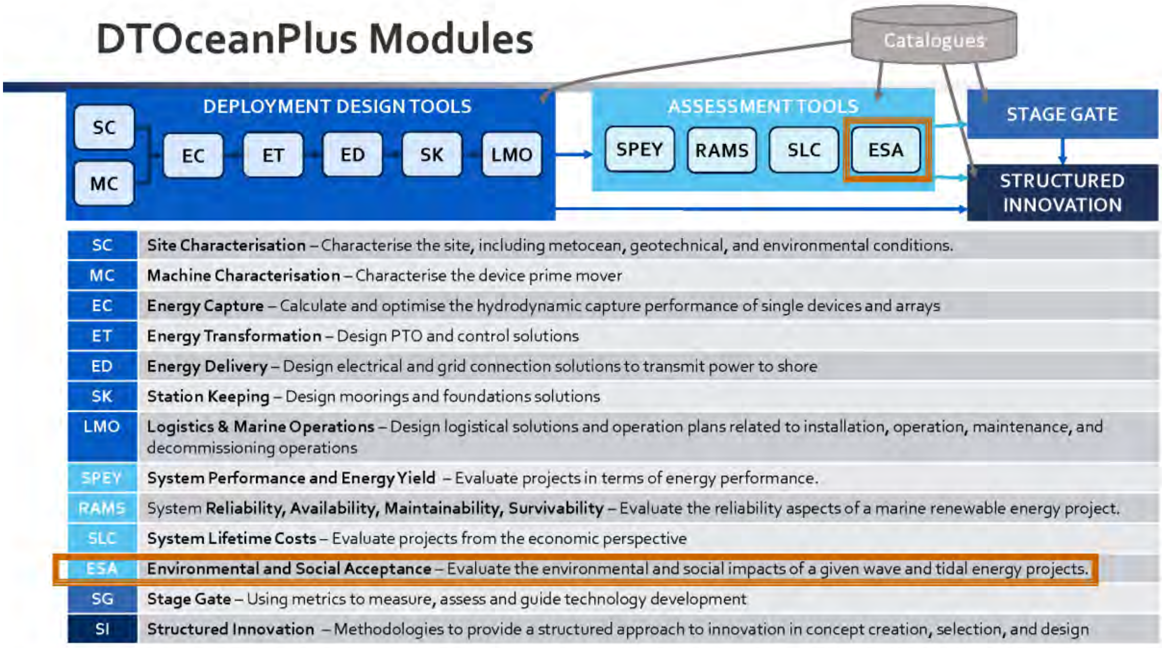
Image from SANDIA Report SAND2014-9040 Methodology for Design and Economic Analysis of Marine Energy Conversion (MEC) Technologies

Page 12

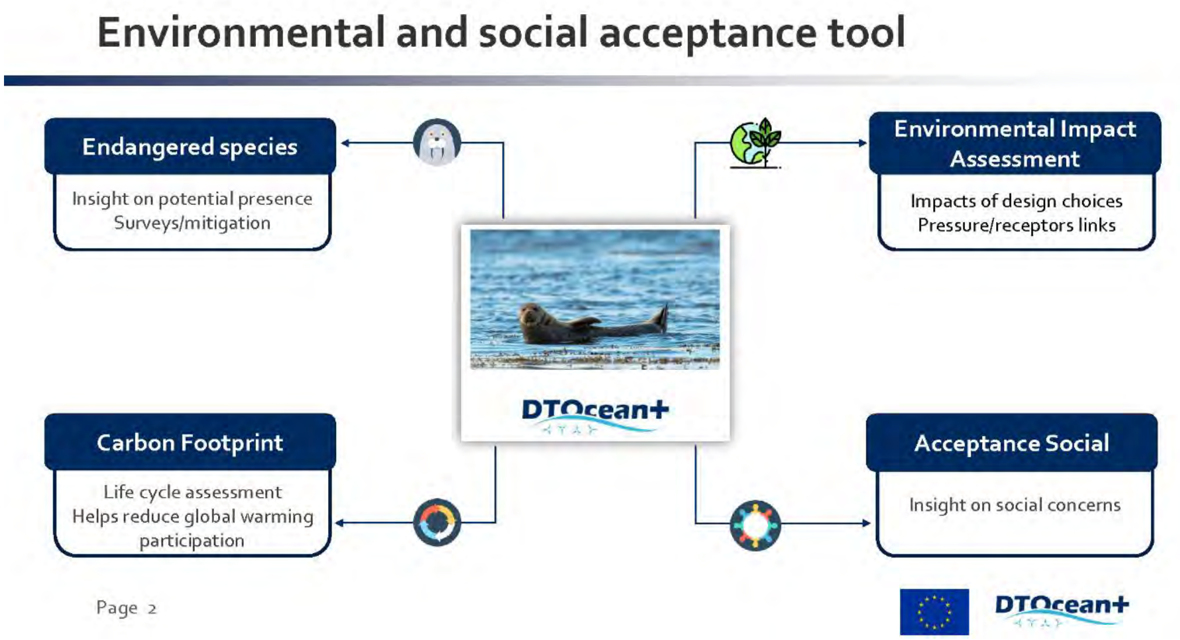
Assessment Design Tool

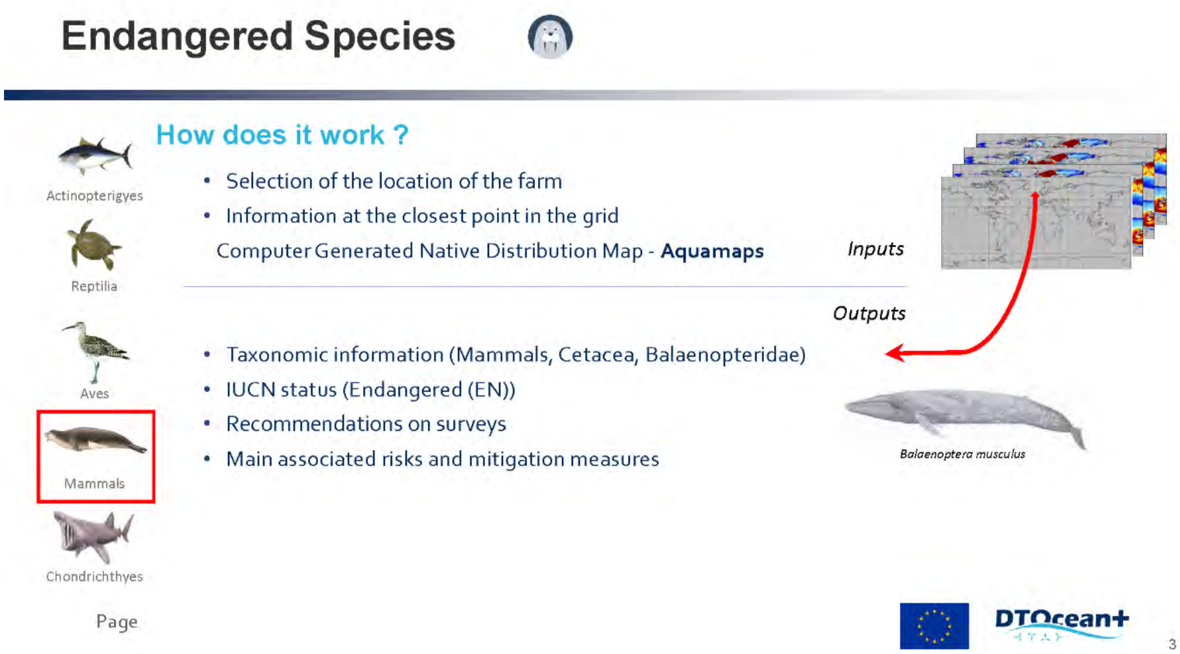
14:00 - 14:15	**Introduction**
	• DTOceanPlus project and the software suite philosophy Donald Noble, The University of Edinburgh • Presentation of the DTOceanPlus main interface Frédéric Pons, Open Cascade
14:15 - 15:00	**Deployment Design Tool**
	• Focus on the Site Characterisation Module Youen Kervella and Nicolas Michelet, France Energies Marines • Focus on the Station Keeping Module Neil Luxcey, France Energies Marines
15:00 - 15:25	**Assessment Design Tool**
	• Focus on the Environmental and Social Acceptance Module Emma Araignous, France Energies Marines
15:25 - 15:30	**To go further**
	• Repository, documentation, workshop and final release Donald Noble, The University of Edinburgh
15:30 - 16:00	**Q&A Session**

Page 13


DTOceanPlus Modules
Catalogues
DEPLOYMENT DESIGN TOOLS
SC
MC
EC
ET
ED
SK
LMO
ASSESSMENT TOOLS
SPEY
RAMS
SLC
ESA
STAGE GATE
STRUCTURED INNOVATION
SC Site Characterisation – Characterise the site, including metocean, geotechnical, and environmental conditions.
MC Machine Characterisation – Characterise the device prime mover
EC Energy Capture – Calculate and optimise the hydrodynamic capture performance of single devices and arrays
ET Energy Transformation – Design PTO and control solutions
ED Energy Delivery – Design electrical and grid connection solutions to transmit power to shore
SK Station Keeping – Design moorings and foundations solutions
LMO Logistics & Marine Operations – Design logistical solutions and operation plans related to installation, operation, maintenance, and decommissioning operations
SPEY System Performance and Energy Yield – Evaluate projects in terms of energy performance.
RAMS System Reliability, Availability, Maintainability, Survivability – Evaluate the reliability aspects of a marine renewable energy project.
SLC System Lifetime Costs – Evaluate projects from the economic perspective
ESA Environmental and Social Acceptance – Evaluate the environmental and social impacts of a given wave and tidal energy projects.
SG Stage Gate – Using metrics to measure, assess and guide technology development
SI Structured Innovation – Methodologies to provide a structured approach to innovation in concept creation, selection, and design

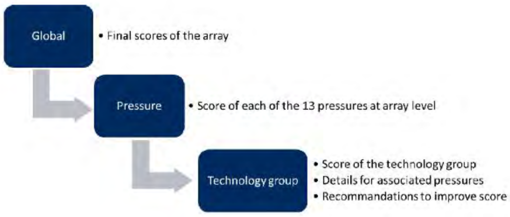

DTOcean+
Advanced Design Tools for Ocean Energy Systems Innovation, Development and Deployment
ASSESSING THE ENVIRONMENTAL AND SOCIAL ACCEPTANCE OF OCEAN ENERGY ARRAY USING DTOCEANPLUS DESIGN TOOLS
Training session
Araignous Emma
tecnalia
THE UNIVERSITY of EDINBURGH
CATAPULT
wave energy SCOTLAND
FRANCE ENERGIES MARINES
WavEC
enel
IDOM
NOVA INNOVATION
CORPOWER
OPEN CASCADE
ORBITAL
sabella
Sandia National Laboratories
NREL
This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 785921


Environmental and social acceptance tool
Endangered species
Insight on potential presence
Surveys/mitigation
Environmental Impact Assessment
Impacts of design choices
Pressure/receptors links
DTOcean+
Carbon Footprint
Life cycle assessment
Helps reduce global warming participation
Acceptance Social
Insight on social concerns
Page 2
DTOcean+


Endangered Species
How does it work ?
Selection of the location of the farm
Information at the closest point in the grid
Computer Generated Native Distribution Map - Aquamaps
Inputs
Outputs
Taxonomic information (Mammals, Cetacea, Balaenopteridae)
IUCN status (Endangered (EN))
Recommendations on surveys
Main associated risks and mitigation measures
Actinopterigyes
Reptilia
Aves
Mammals
Chondrichthyes
Balaenoptera musculus
Page
DTOcean+
3

Environmental Impacts

- Concept of stressors/receptors
- 13 pressures considered:
  - 10 "negative" impacts
  - 3 "positive" impacts
- 3 Levels of outputs:

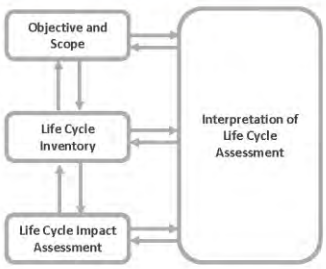


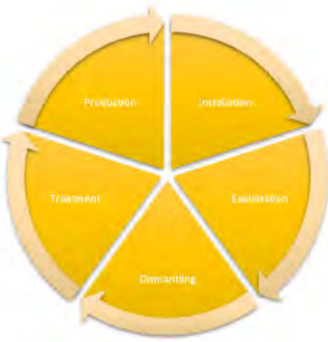
Page 4

Carbon Footprint

Life Cycle Assessment

- All the stages of its life cycle, from manufacturing up to its potential recycling
- Follows the structure of LCA processes defined by the standards ISO 14040 and ISO 14044





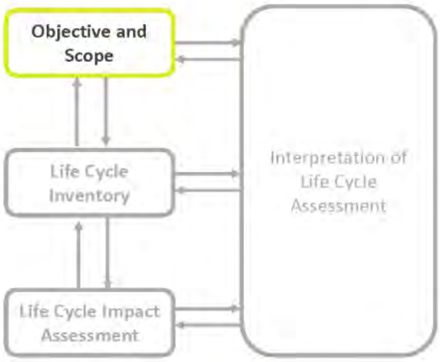
Page

5

Carbon Footprint

Life Cycle Assessment

- Objectives
  - Translate the preliminary flows into midpoint indicators
  - Situate a project among its alternative concepts
- Scope
  - Attributional approach
  - The system's limits : Levels of the International Reference Life Cycle Data System (ILCD) Handbook :
    - Level 0: MRE array allowing the conversion of renewable energy into electricity.
    - Level 1: manufacturing, assembly and processing activities of the constituent components of the MRE array.
    - Level 2: processes participating physically in the installation, operation and dismantling of the MRE array (e.g. maritime means for installation).
    - Level 3: processes involved in the installation, operation and dismantling of the MRE array, without physical involvement (e.g. design offices, administrative services).

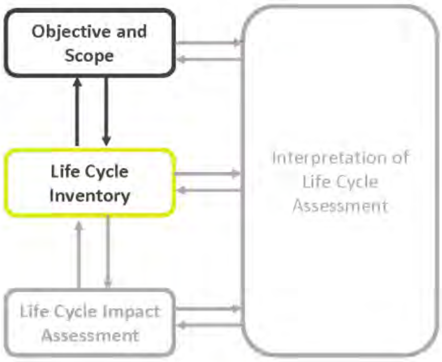


Page 6

Carbon Footprint

Life Cycle Assessment

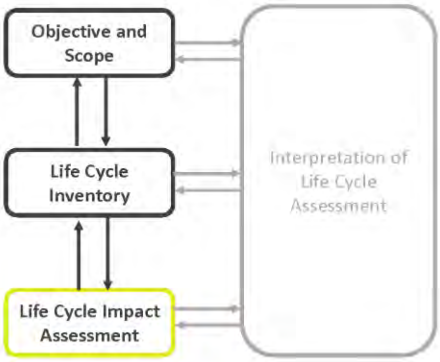
- Characterizes the flows entering and leaving the system
- Two main sources of inputs :
  - Other DTOceanPLUS tools/User
  - Local database (Ecoinvent3)



Page 7

Carbon Footprint

Life Cycle Assessment



- Three midpoint indicators :
  - The Global Warming Potential (GWP, g CO2-eq/kWh)
  - The Cumulative Energy Demand (CED, MJ/kWh)
  - The Energy Pay-back Period (EPP)

Page

8

Social Acceptance

Provide insight on relevant social acceptance concerns

- Cost of consenting
  - Levelized Cost Of Energy in €/kWh
- Jobs creation
  - Physical involvement in marine operations

Page

10

Demonstration

Welcome to the Environmental and Social Acceptance module v1.0

This module assess the environmental and social impacts generated
by the various technology choices and array configurations of wave or tidal devices.

DTOcean+

Page 10

DTOcean+

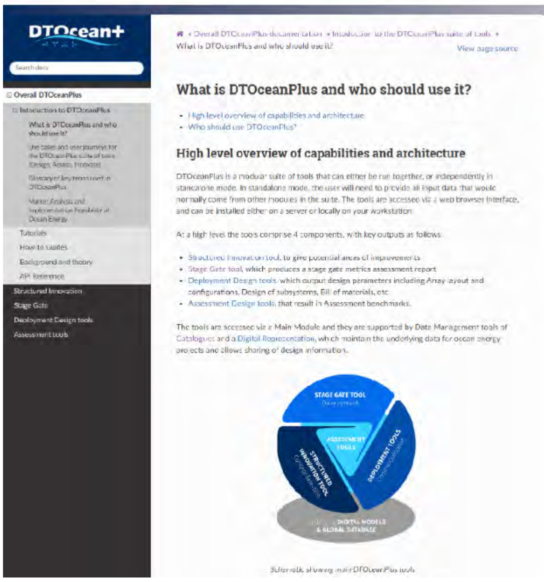
To go further

14:00 - 14:15	Introduction
	• DTOceanPlus project and the software suite philosophy Donald Noble, The University of Edinburgh • Presentation of the DTOceanPlus main interface Frédéric Pons, Open Cascade
14:15 - 15:00	Deployment Design Tool
	• Focus on the Site Characterisation Module Youen Kervella and Nicolas Michelet, France Energies Marines • Focus on the Station Keeping Module Neil Luxcey, France Energies Marines
15:00 - 15:25	Assessment Design Tool
	• Focus on the Environmental and Social Acceptance Module Emma Araignous, France Energies Marines
15:25 - 15:30	To go further
	• Repository, documentation, workshop and final release Donald Noble, The University of Edinburgh
15:30 - 16:00	Q&A Session

Page 15

DTOcean+

Documentation of DTOceanPlus



- Alongside the software & code:
- Online documentation to explain the use of the tools
- For overall tools & for each module:
  1. Step-by-step **tutorials** for new users
  2. More detailed **how-to guides**
  3. **Background and theory** explaining how the tools work
  4. **API reference** documenting the code functions and OpenAPI

DTOcean+

Training session on Stage Gate tool

Tuesday **6 July** 2021

14:00 – 16:00 (CEST)
13:00 – 15:00 (BST)

register at:
dtoceanplus.eu

- Context of Technology Development
- Guiding technology development ~ link to Deployment & Assessment tools
  - Using the **Stage Gate tool's Activity Checklist** as a guide for Stage Gate Assessment
  - **Full Stage Gate Assessment** using Deployment & Assessment tools
- Guiding technology development ~ link to Structured Innovation tool
  - Link between **Improvement Areas and Structured Innovation** tool
  - Overall purpose of the Stage Gate tool and detailed look at the Report
- **Practical applications** of Stage Gate tool in Industry
  - Examples of real use cases of Stage Gate tool

Page

DTOcean+

Tools Release & (Virtual) Final Workshop

- Tools will be released at the end of August
  - Open-source, GNU Affero General Public License v3.0
  - Will be available in online repository (GitHub/GitLab)

- Final Workshop (virtual)
  - Short videos **to present the main outcomes** of the project
  - Hosted on the **DTOceanPlus website** over the summer
  - Facility to submit questions through the website
  - **Q&A session** held at the end of August

- More details on dtoceanplus.eu and social media

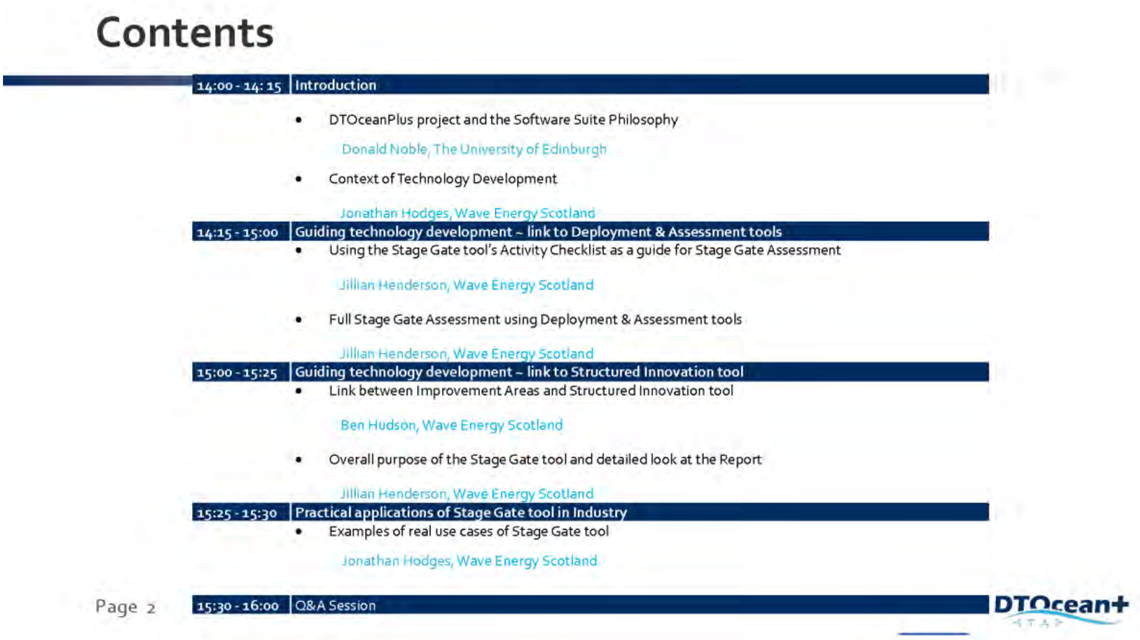
Page

Q&A Session

14:00 - 14:15	**Introduction**
	• DTOceanPlus project and the software suite philosophy Donald Noble, The University of Edinburgh • Presentation of the DTOceanPlus main interface Frédéric Pons, Open Cascade
14:15 - 15:00	**Deployment Design Tool**
	• Focus on the Site Characterisation Module Youen Kervella and Nicolas Michelet, France Energies Marines • Focus on the Station Keeping Module Neil Luxcey, France Energies Marines
15:00 - 15:25	**Assessment Design Tool**
	• Focus on the Environmental and Social Acceptance Module Emma Araignous, France Energies Marines
15:25 - 15:30	**To go further**
	• Repository, documentation, workshop and final release Donald Noble, The University of Edinburgh
15:30 - 16:00	Q&A Session

Page 16

TRAINING SESSION 5: USING THE DTOCEANPLUS SUITE OF TOOLS TO GUIDE TECHNOLOGY DEVELOPMENT OF OCEAN ENERGY SYSTEMS



Advanced Design Tools for Ocean Energy Systems Innovation, Development and Deployment

DTOceanPlus project and the software suite philosophy

Dr Donald R Noble (University of Edinburgh)

6 July 2021

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 785921

The DTOceanPlus Project

- **3-year EU H2020** funded project
  - May 2018 – August 2021
  - €8million budget
  - 16 European partners + 2 US labs
- **Objective:**
  To support the **entire technology innovation process,** from concept to deployment of sub-systems, energy capture devices and arrays
- Continuing the **development of DTOcean**
- To produce an advanced **open-source** suite of tools for the **selection, development, deployment and assessment** of ocean energy systems

Page 2

The DTOceanPlus tools

- **Wave** and **tidal stream** technologies – fixed or floating devices
  - Subsystems, single devices, and arrays of devices
- Considering different levels of technology maturity
  - Early stage concepts to commercial feasibility & design

Low Complexity → **Medium** → **High**

- Fewer inputs
- Simpler data
- Quicker analysis

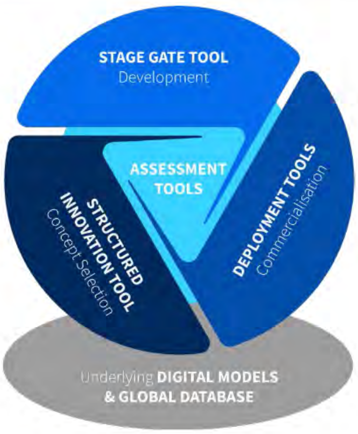
- More complex data requirements
- Longer computation
- More accurate results

- Tools run as an **integrated suite** or in **standalone** mode
- Accessed via a web-browser interface

Page 3

The DTOceanPlus suite of tools

- **Deployment design tools**
  - Supporting optimal device and array deployment
- **Assessment tools**
  - To evaluate projects in terms of key parameters
- **Stage Gate** tool
  - Assisting decision-making through the use of metrics to measure, assess and guide technology development.
- **Structured Innovation** tool
  - Methodologies to provide a structured approach to innovation in concept creation, selection, and design
- **Main Module** and **Data Management** tools
  - Manage projects and studies
  - Catalogues of components and reference data
  - Digital Representation to allow sharing of design information.



Tools run integrated or standalone

Page 4

Use of the DTOceanPlus tools

Design

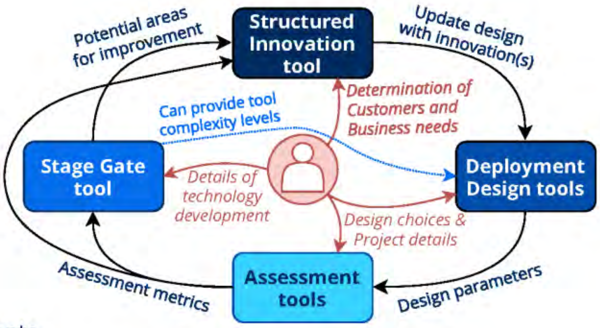
- Assisting with developing optimal design of a subsystem, device, or array

Assess

1. Performance of a subsystem, device, or array in the context of a site and project
2. Status of a technology's development

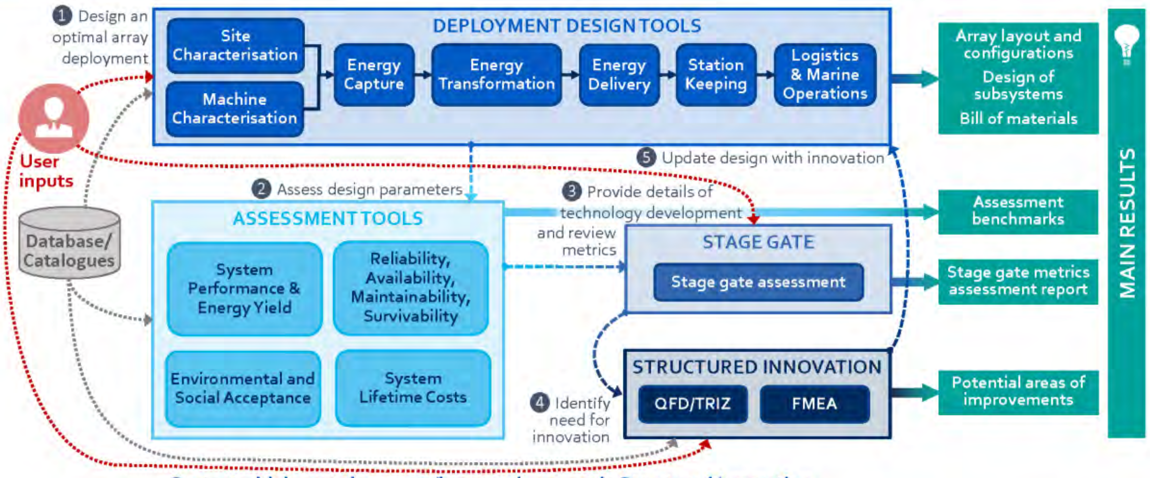
Innovate

- Facilitate structured innovation of new concepts and improvements to existing technology.



Page 5

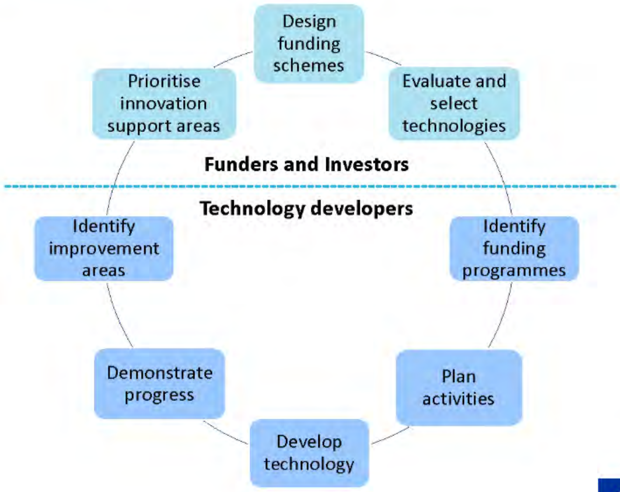
A User Journey: Deployment Design → Assessment → Stage Gate → Structured Innovation



Or start with innovating a new/improved concept in Structured Innovation, assessing technology development in Stage Gate, etc…

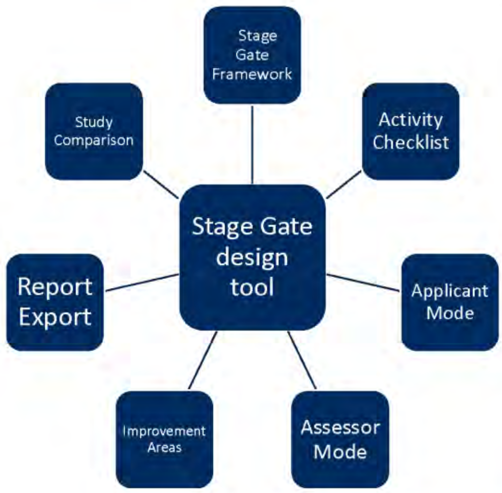
Page 6

Context of technology development



Page 3

DTO+ Stage Gate design tool



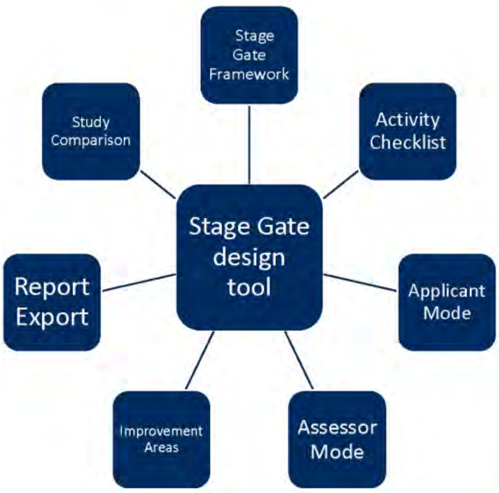
Page 4

Real life example – CorPower Ocean

- Early stage development
- WES PTO call – 3 stages – increasing value
    - Stage 1 - Concept Characterisation
    - Stage 2 - Concept Optimisation & Demonstration
    - Stage 3 – Small Prototype Development
- Array deployment
- Commercial arrays

Page 5

DTO+ Stage Gate design tool



Page 6

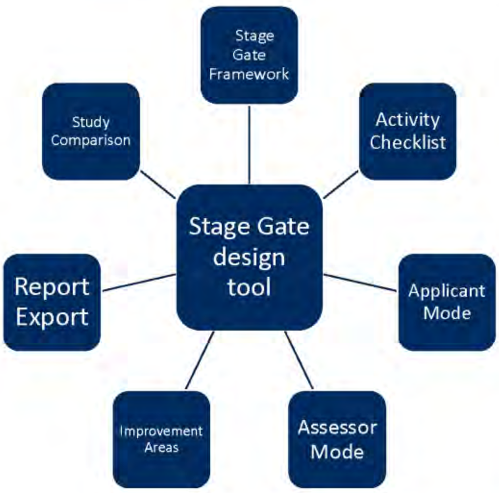
Real life example – CorPower Ocean

- Common thread of assessment provided by DTOceanPlus
- Common expectation from funders and developers
- Common dataset format

Technology Passport

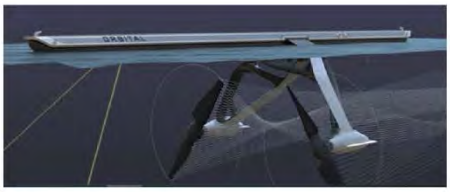
Page 7

DTO+ Stage Gate design tool



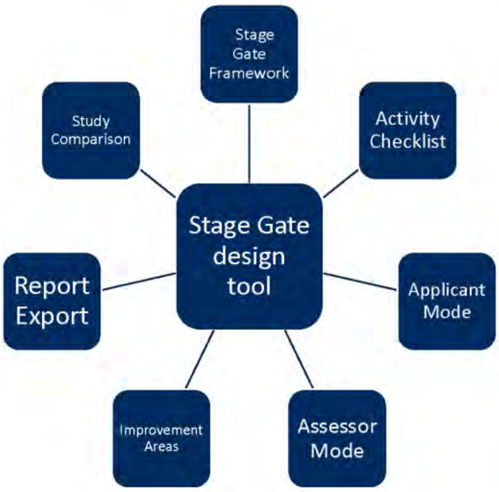
Page 8

Real life example – Orbital Marine



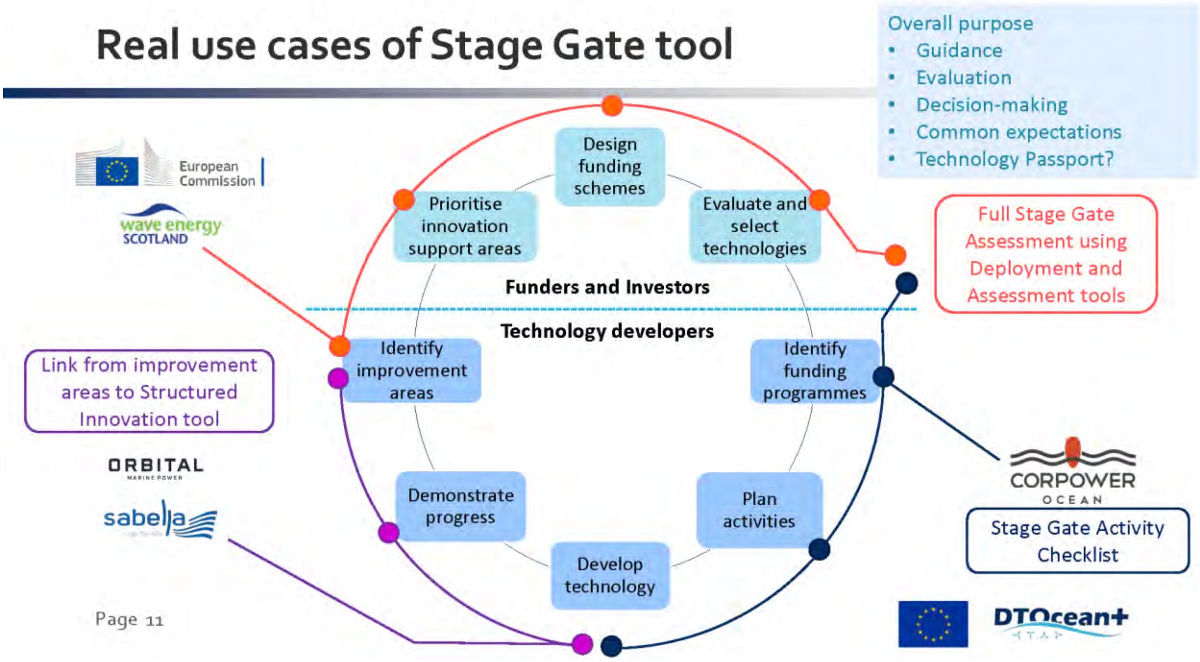
Page 9

DTO+ Stage Gate design tool



Page 10

Real use cases of Stage Gate tool



Page 11

Q & A Session

Page 12


Advanced Design Tools for Ocean Energy Systems Innovation, Development and Deployment
Thank you for your attention!
Wave Energy Scotland
Jillian Henderson: jillian.Henderson@waveenergyscotland.co.uk
Jonathan Hodges: Jonathan.hodges@waveenergyscotland.co.uk
Disclaimer: This presentation reflects only the author's views and the Agency is not responsible for any use that may be made of the information contained therein.
This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 785921

ANNEX III: SLIDES PRESENTED AT OEE2020 WORKSHOP

SIDE EVENT AT OCEAN ENERGY EUROPE (ONLINE) 2020

WELCOME

A workshop to learn more about the software

- The DTOcean+ software suite will be **released mi-2021** following **validation** by industrial partners in the consortium
- The workshop will give a **general overview** of the suite of tools and their capabilities, plus explain **how to run** them with **relevant user cases**
- The speakers will be the **developers** of the different tools

Page 2

Agenda of the workshop

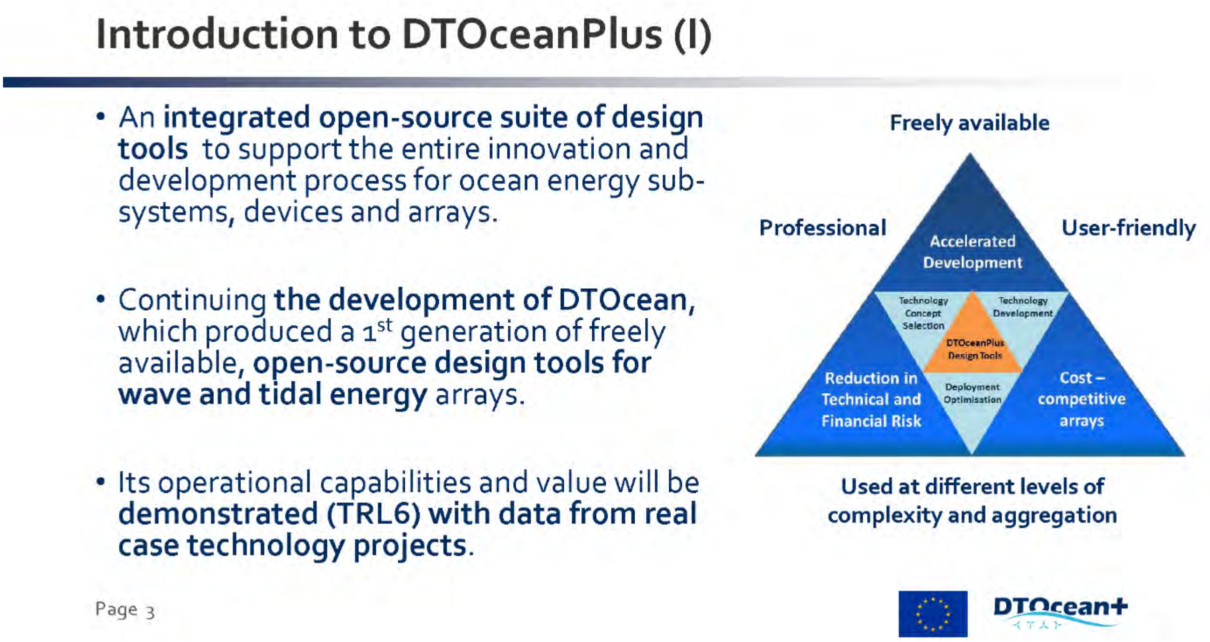
Introduction to the **project**	Pablo Ruiz-Minguela Head of Wave Energy	tecnalia
Overview of the tools **Functionality and architecture**	Donald Noble Research Associate in Marine Energy	
Q&A Session		
Technology development: Assisting decision-makers **Stage gate tool**	Jillian Henderson, Research Engineer Ben Hudson, Research Engineer	Wave Energy Scotland
Technology innovation: Identifying opportunities **Structured innovation tool**	Inès Tunga, Practice Manager for Renewables Mo Abrahams, Transport Systems & Infrastructure Analyst	CATAPULT
Q&A Session		
Technology in context: Design of an array project **Station keeping module**	Neil Luxcey, Mooring Systems and ORE Projects Management Research Engineer	France Energies Marines
Technology in context: Assessment of an array project **System performance and energy yield module**	Vincenzo Nava, Senior Researcher	tecnalia
Q&A Session		
Wrap up and **next steps**	Donald Noble, Research Associate in Marine Energy	

Page 3


© Tecnalia
DTOcean+ workshop
2nd polling question
Why are you taking part in this workshop?
☐ To have a better overview of the whole project
☐ To find out about the different functionalities of the software suite
☐ To learn more about the verification phase of the software
☐ To find out what the graphical interface of the software looks like
☐ For another reason
2020 OCEAN ENERGY EUROPE


© Tecnalia
DTOcean+ workshop
3rd polling question
Why are you taking part in this workshop?
☐ Structured innovation tool - concept creation, selection and improvement
☐ Stage gate tool - assisting decision-making through the use of metrics
☐ Deployment tool - supporting optimal device and array deployment
☐ Assessment tool - providing objective information on the suitability of a technology and project
2020 OCEAN ENERGY EUROPE

INTRODUCTION TO THE PROJECT



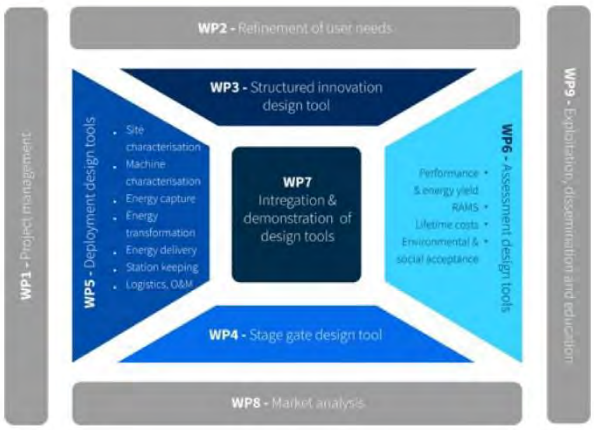
Introduction to DTOceanPlus (II)

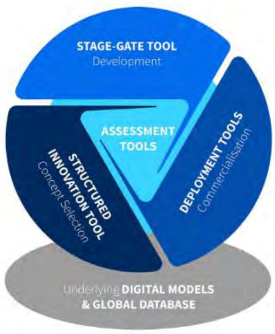
- An EU project running from May 2018 till August 2021 with a total budget of **8 M€**.
- **Multidisciplinary team** of 16 partners from 7 EU countries, with the collaboration of 2 leading research laboratories from the USA.

https://www.dtoceanplus.eu/

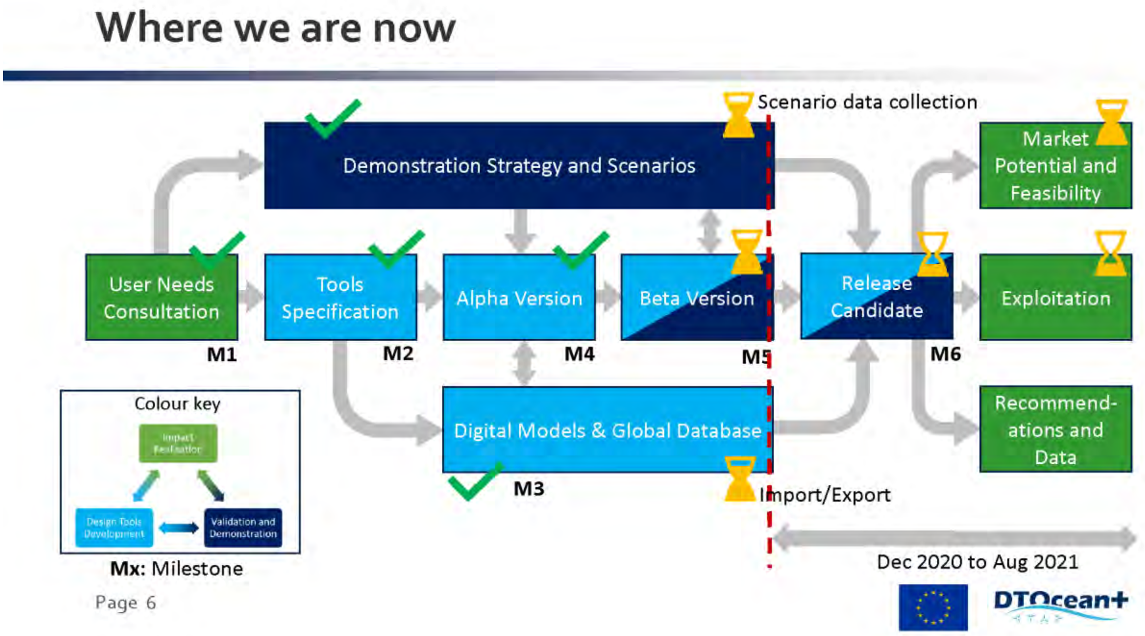
Page 4

Introduction to DTOceanPlus (III)





Page 5



OVERVIEW OF THE TOOLS: FUNCTIONALITY AND ARCHITECTURE

The DTOceanPlus tools

- **Wave** and **tidal stream** technologies – fixed or floating devices
  - Subsystems, single devices, and arrays of devices
- Considering different levels of technology maturity
  - Early stage concepts to commercial feasibility & design

Low Complexity → **Medium** → **High**

- Fewer inputs
- Simpler data
- Quicker analysis

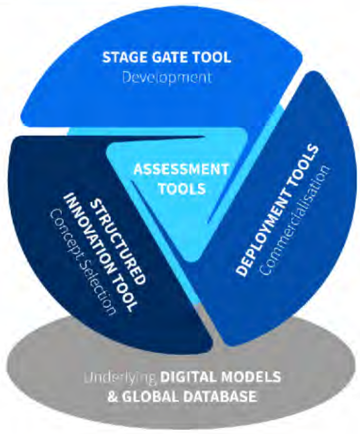
- More complex data requirements
- Longer computation
- More accurate results

- Tools run as an **integrated suite** or in **standalone** mode
  - Today we are demonstrating the standalone versions
  - Development of these is still ongoing…

Page

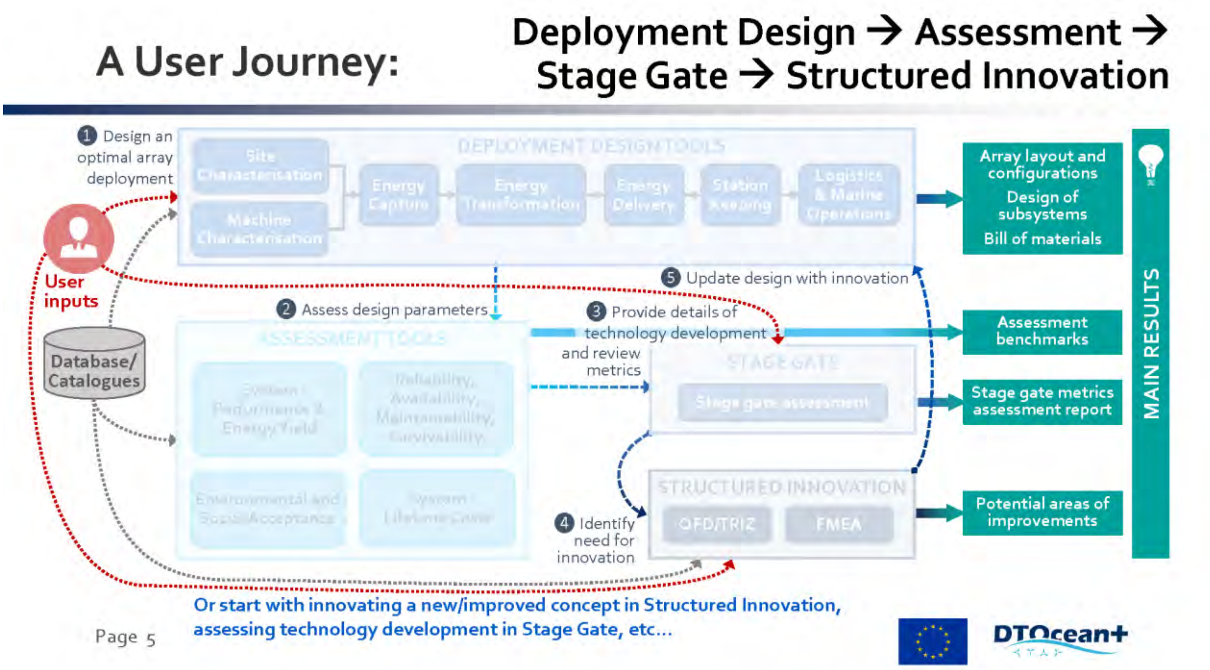
The DTOceanPlus suite of tools

- **Deployment design tools**
  - Supporting optimal device and array deployment
- **Assessment tools**
  - To evaluate projects in terms of key parameters
- **Stage Gate** tool
  - Assisting decision-making through the use of metrics to measure, assess and guide technology development.
- **Structured Innovation** tool
  - Methodologies to provide a structured approach to innovation in concept creation, selection, and design
- **Data Management** tools
  - Digital Representation, Catalogues
  - Maintains underlying data for ocean energy projects and allows sharing of design information.



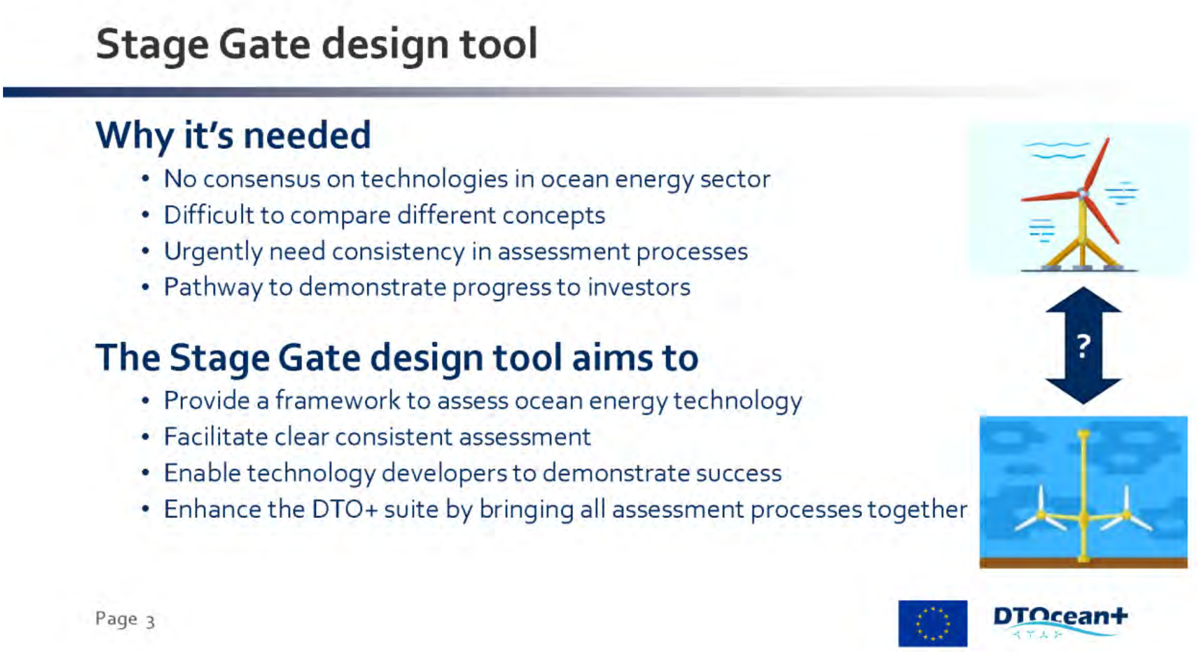
Tools run integrated or standalone

Page 4


A User Journey:
Deployment Design → Assessment → Stage Gate → Structured Innovation
1 Design an optimal array deployment
User inputs
Database/ Catalogues
2 Assess design parameters
3 Provide details of technology development and review metrics
4 Identify need for innovation
5 Update design with innovation
Array layout and configurations
Design of subsystems
Bill of materials
Assessment benchmarks
Stage gate metrics assessment report
Potential areas of improvements
MAIN RESULTS
Or start with innovating a new/improved concept in Structured Innovation, assessing technology development in Stage Gate, etc…
Page 5
DTOcean+


DTOcean+ workshop
Q&A Session #1
© Tecnalia
2020 OCEAN ENERGY EUROPE

TECHNOLOGY DEVELOPMENT: ASSISTING DECISION-MAKERS STAGE GATE TOOL



Overview of the Stage Gate tool

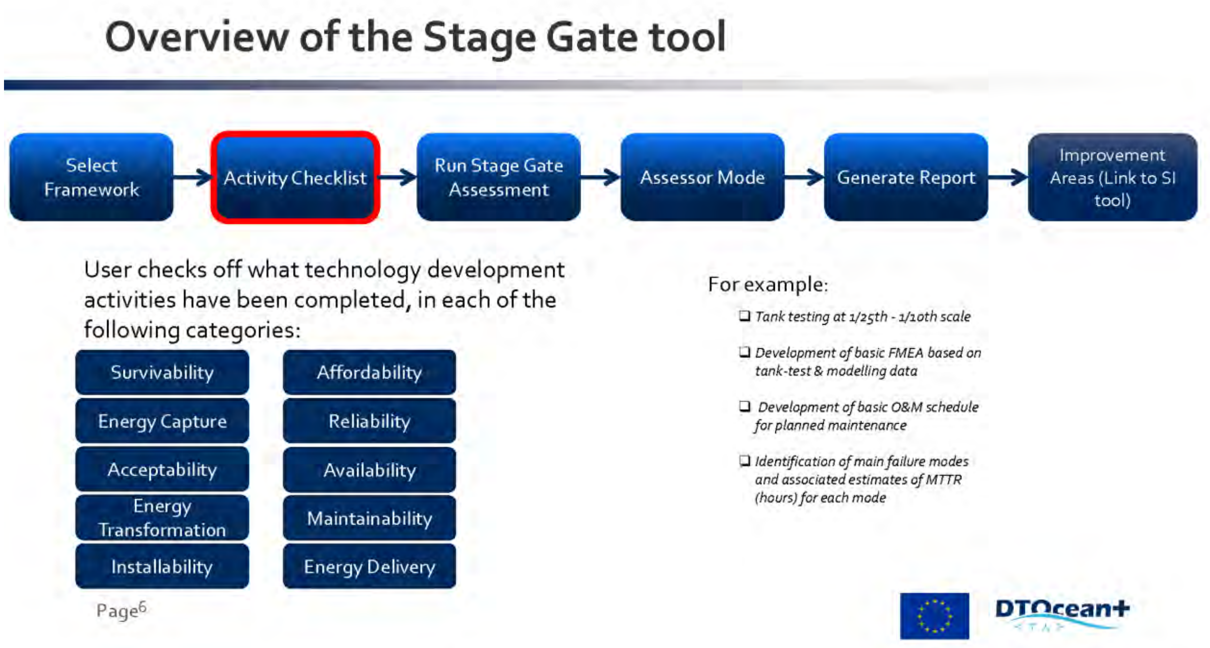
Page 4

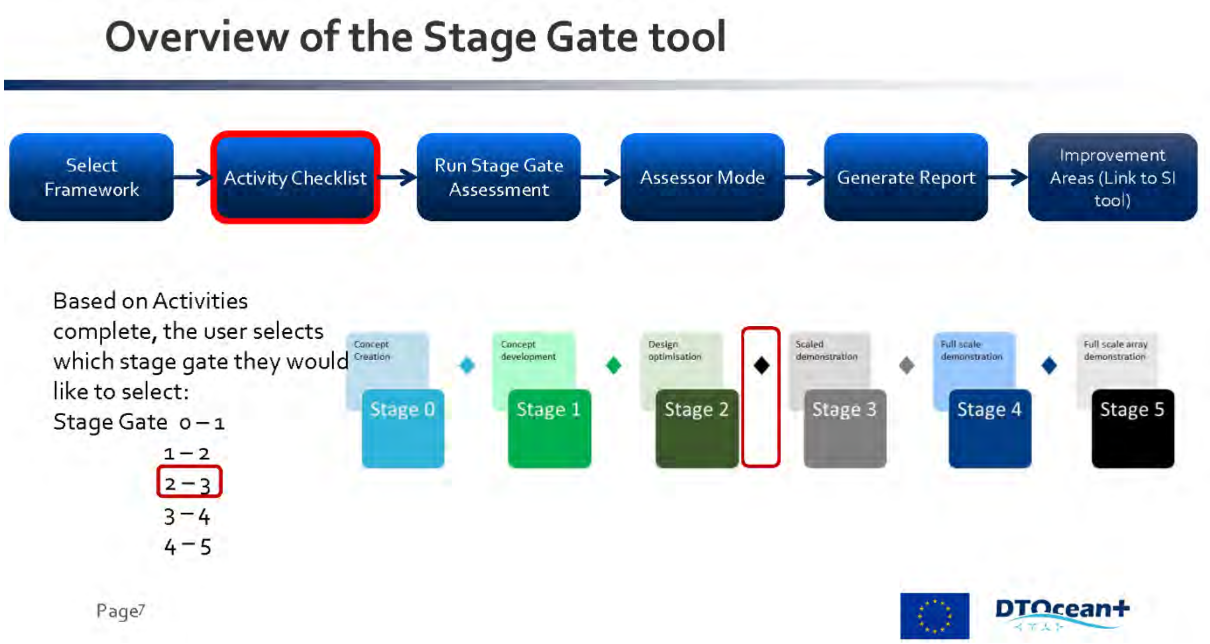
Overview of the Stage Gate tool

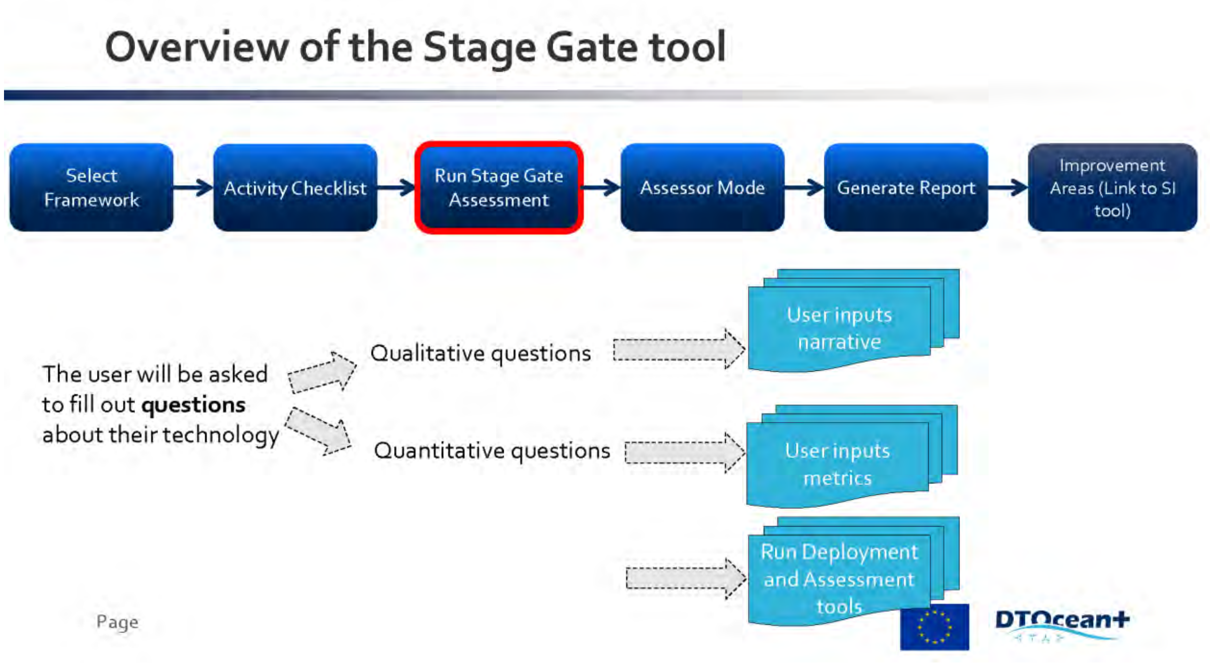
Selecting the framework

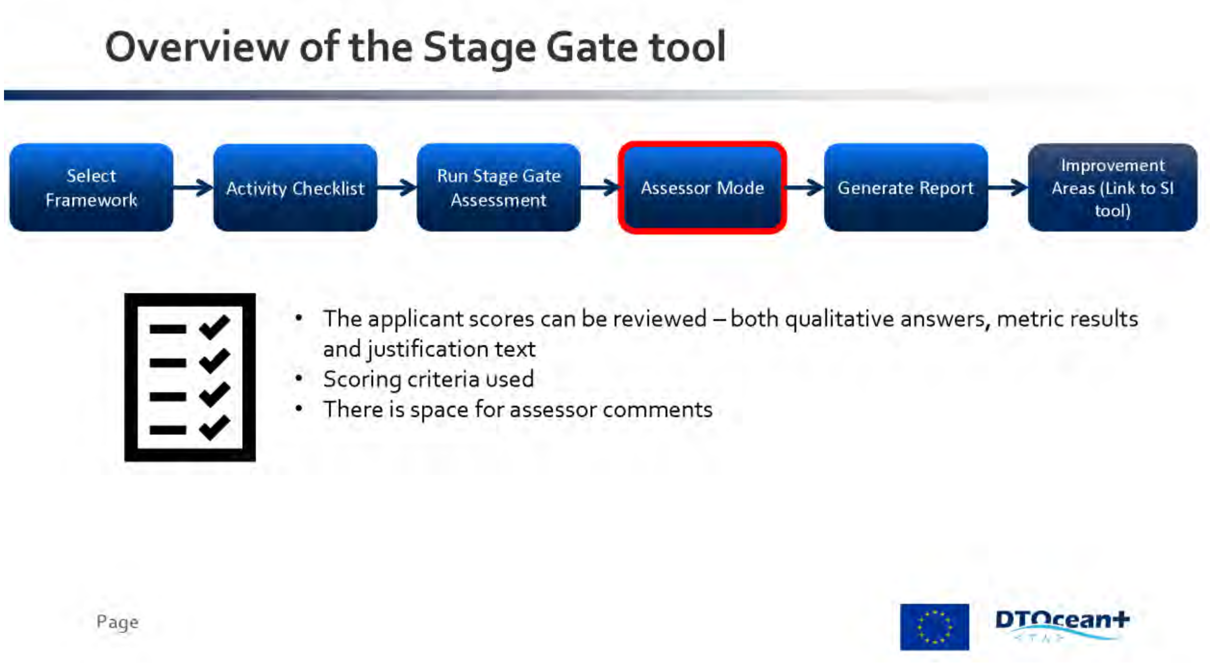
- Review and select pre-defined frameworks
- Edit thresholds to metrics

Page 5


Overview of the Stage Gate tool
Select Framework
Activity Checklist
Run Stage Gate Assessment
Assessor Mode
Generate Report
Improvement Areas (Link to SI tool)
User checks off what technology development activities have been completed, in each of the following categories:
Survivability
Affordability
Energy Capture
Reliability
Acceptability
Availability
Energy Transformation
Maintainability
Installability
Energy Delivery
For example:
Tank testing at 1/25th - 1/10th scale
Development of basic FMEA based on tank-test & modelling data
Development of basic O&M schedule for planned maintenance
Identification of main failure modes and associated estimates of MTTR (hours) for each mode
Page6
DTOcean+


Overview of the Stage Gate tool
Select Framework
Activity Checklist
Run Stage Gate Assessment
Assessor Mode
Generate Report
Improvement Areas (Link to SI tool)
Based on Activities complete, the user selects which stage gate they would like to select:
Stage Gate 0 – 1
1 – 2
2 – 3
3 – 4
4 – 5
Concept Creation
Stage 0
Concept development
Stage 1
Design optimisation
Stage 2
Scaled demonstration
Stage 3
Full scale demonstration
Stage 4
Full scale array demonstration
Stage 5
Page7
DTOcean+


Overview of the Stage Gate tool
Select Framework
Activity Checklist
Run Stage Gate Assessment
Assessor Mode
Generate Report
Improvement Areas (Link to SI tool)
The user will be asked to fill out **questions** about their technology
Qualitative questions
Quantitative questions
User inputs narrative
User inputs metrics
Run Deployment and Assessment tools
Page
DTOcean+


Overview of the Stage Gate tool
Select Framework
Activity Checklist
Run Stage Gate Assessment
Assessor Mode
Generate Report
Improvement Areas (Link to SI tool)
The applicant scores can be reviewed – both qualitative answers, metric results and justification text
Scoring criteria used
There is space for assessor comments
Page
DTOcean+

Overview of the Stage Gate tool

Select Framework → Activity Checklist → Run Stage Gate Assessment → Assessor Mode → **Generate Report** → Improvement Areas (Link to SI tool)

Standardised PDF report generated summarising all inputs, results and scores

Page

Overview of the Stage Gate tool

Select Framework → Activity Checklist → Run Stage Gate Assessment → Assessor Mode → Generate Report → **Improvement Areas (Link to SI tool)**

Examples of improvement areas:

- If running a stage gate assessment identifies a missing Evaluation area
- If the metric results deviate significantly from the thresholds set by the user

QFD

TRIZ

FMEA

Page

Demo – Outline

- 3 use cases to demonstrate the key features of the tool
- Consider the following scenario:

A wave energy technology developer is working on a novel wave energy device, at an early stage ~ TRL 3

Page 12

Demo – Use Cases

Activity Checklist

1) The technology developer wants to identify the stage of development that they have reached

Run Stage Gate Assessment

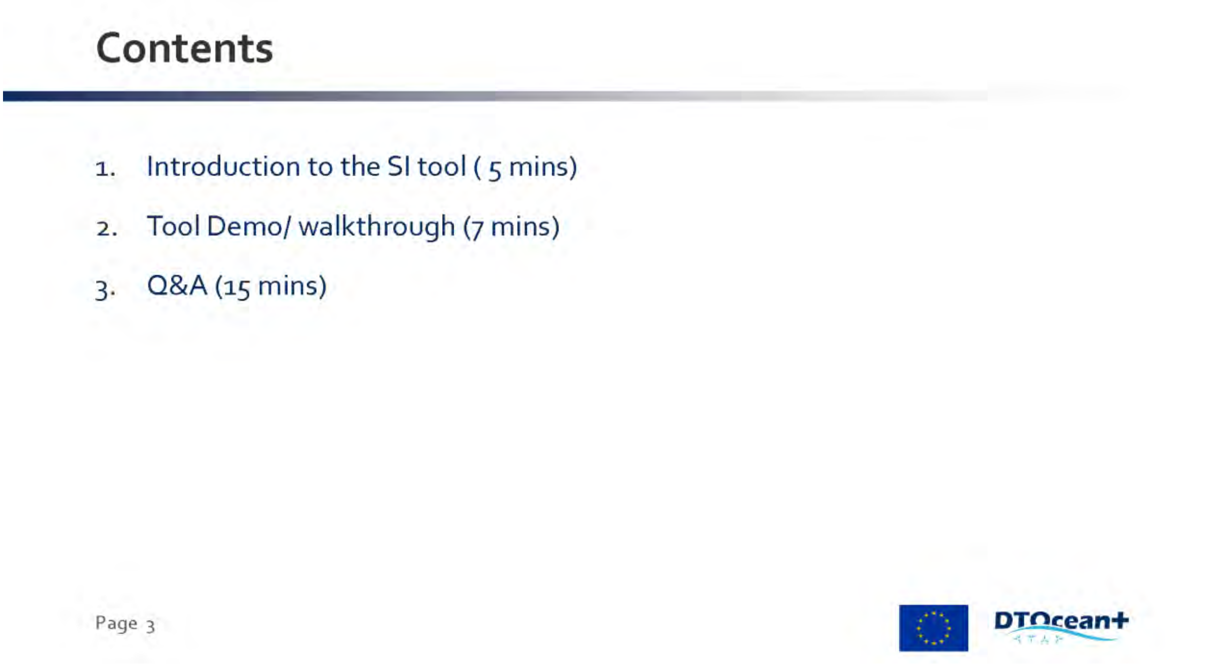
2) After completing the outstanding tasks for a Stage, they want to simulate running a Stage Gate assessment to see if they are ready to progress to the next stage

Improvement Areas (Link to SI tool)

3) A technology developer wants to understand which areas of their technology need to be improved upon. This is one of the key integration points with the Structured Innovation tool. Can be used for concept improvement

Page 13

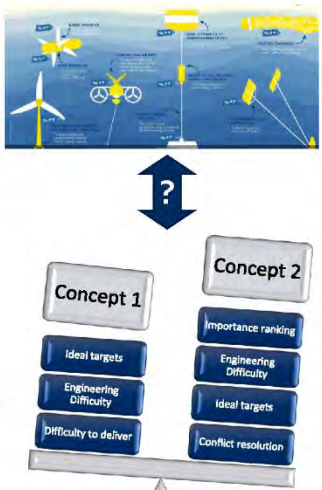
TECHNOLOGY INNOVATION: IDENTIFYING OPPORTUNITIES STRUCTURED INNOVATION TOOL



Introduction to the SI tool

The Structured Innovation tool aims to:

- Help represent the voice of the customer
- Allow the design to understand the art-of-the possible for concept targets
- Enable objective comparisons between various technologies.
- Enhance systematic thinking for design beyond the current state-of-the-art.
- Provoke innovation by creating new or improve concepts



Who benefits from it?

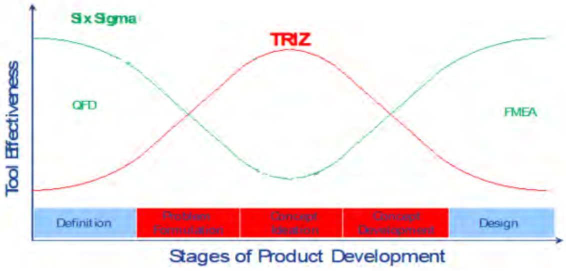
- Technology developers ~ to assess areas of improvement and technical challenges
- Funders & Investors~ to identify attractive areas of innovation for investment
- Innovators & Developers~ to assess novelty in technology

Page 4

Introduction to the SI tool

Innovation at the heart of concept creation, using **QFD, TRIZ** and **FMEA**

- Captures and prioritises requirements
- Assesses solutions for impact
- Provides problem solving for contradictions
- Encourages risk assessment and mitigation
- Gives development direction and impact
- Improve commercial acceptability



Adapted from BS 7000-1 Design Management systems

Page

Introduction to the SI tool

Define Objective of study → Scan Design space → Assess areas of innovation → Identify and solve contradictions → Identify Risks & mitigate → Propose areas of innovation & further assessment

Project details:
- Customer needs
- Mission statement
- Prioritisation

Innovation :
- Improvement (SG)
- New concepts

QFD Process
- Functional requirements
- Relation & interrelationships
- Development impact
- Prioritisation

Target/ideal values:
- SG thresholds
- Commercial targets

Competitive assessments

TRIZ Process
- Synergies & conflicts
- Contradiction matrix
- Inventive principles

FMEA Process
- Concept/Design
- Threshold/Actions
- Mitigation

Report:
- Prioritised functions
- Development impacts
- Ideality assessment
- Conflicts and alternative solutions
- Risk mitigation measures

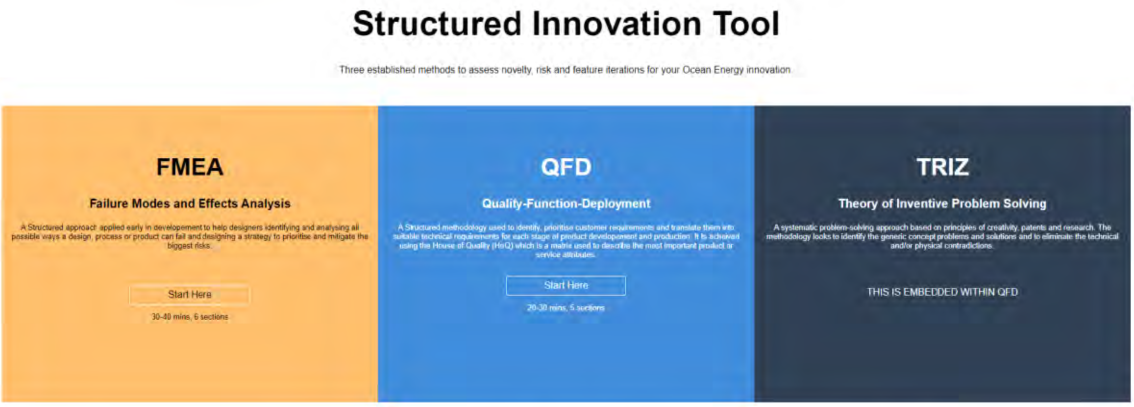
Assessed SoTA achievement against targets	Resource available	Efficiency	CAPEX	Hull Scale
Concept-1 (heave- Barge-Concrete)	100%	1%	13%	4%
Concept-2 (heave barge-GRP)	5%	82%	104%	100%
Concept-3 (Surge-Barge-GRP)	79%	1%	52%	7%
Concept 4 (Surge-Barge-PU Nylon)	47%	59%	18%	100%

0 0.5 1 1.5 2 2.5 3 3.5 4 4.5 5
Solution Importance Ranking (Least- to- Most impactful)

Page 6

SG refers to Stage Gate design tool

SI Tool demo/ walkthrough



Page

Use case- improvement cycle WEC (TRL3) from SG tool

Structured Innovation & Stage Gate design tools

Page 8

TECHNOLOGY IN CONTEXT: DESIGN OF AN ARRAY PROJECT STATION KEEPING MODULE

Advanced Design Tools for Ocean Energy Systems Innovation, Development and Deployment

Deployment Design Tools

Station Keeping

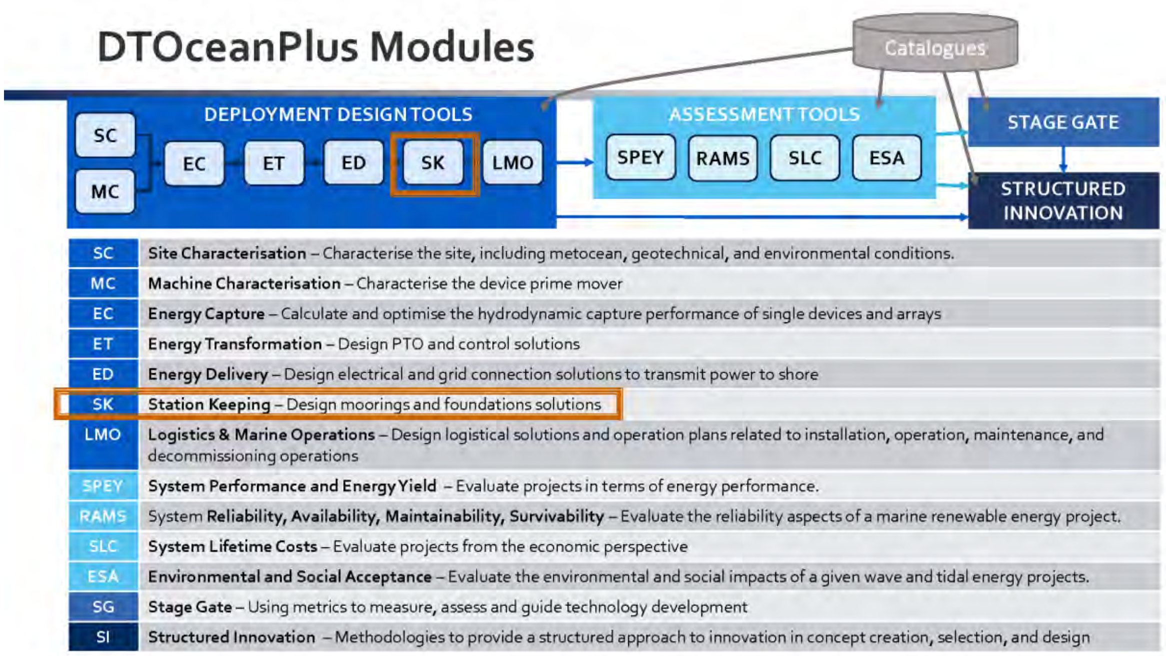
OEE, 02/12/2020

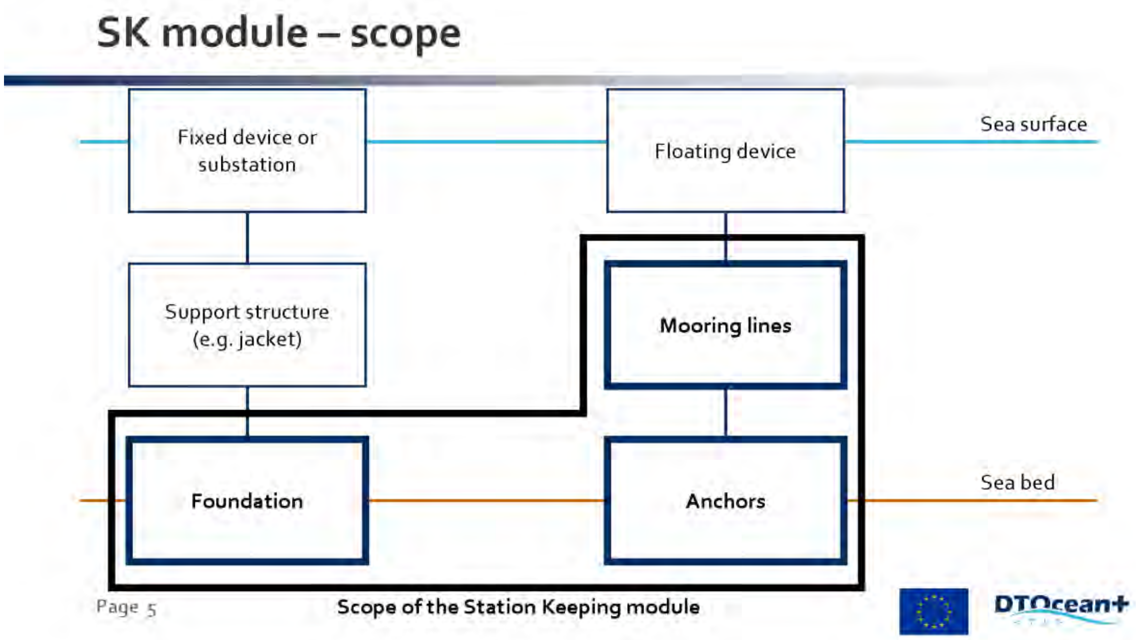
This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 785921

Content

- The Deployment Design Tools of DTOceanPlus
- Presentation of SK Module
- Walkthrough the SK Module

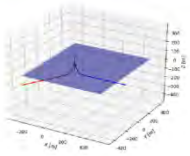
Page 3

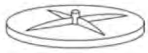

DTOceanPlus Modules
Catalogues
DEPLOYMENT DESIGN TOOLS
SC
MC
EC
ET
ED
SK
LMO
ASSESSMENT TOOLS
SPEY
RAMS
SLC
ESA
STAGE GATE
STRUCTURED INNOVATION
SC Site Characterisation – Characterise the site, including metocean, geotechnical, and environmental conditions.
MC Machine Characterisation – Characterise the device prime mover
EC Energy Capture – Calculate and optimise the hydrodynamic capture performance of single devices and arrays
ET Energy Transformation – Design PTO and control solutions
ED Energy Delivery – Design electrical and grid connection solutions to transmit power to shore
SK Station Keeping – Design moorings and foundations solutions
LMO Logistics & Marine Operations – Design logistical solutions and operation plans related to installation, operation, maintenance, and decommissioning operations
SPEY System Performance and Energy Yield – Evaluate projects in terms of energy performance.
RAMS System Reliability, Availability, Maintainability, Survivability – Evaluate the reliability aspects of a marine renewable energy project.
SLC System Lifetime Costs – Evaluate projects from the economic perspective
ESA Environmental and Social Acceptance – Evaluate the environmental and social impacts of a given wave and tidal energy projects.
SG Stage Gate – Using metrics to measure, assess and guide technology development
SI Structured Innovation – Methodologies to provide a structured approach to innovation in concept creation, selection, and design


SK module – scope
Fixed device or substation
Floating device
Sea surface
Support structure (e.g. jacket)
Mooring lines
Foundation
Anchors
Sea bed
Page 5
Scope of the Station Keeping module
DTOcean+

SK module – scope

- Mooring system
  - Catenary
  - Taut
- Anchors
  - Drag anchor
  - Gravity base
  - Pile
  - Suction anchor
- Foundations
  - Gravity base
  - Monopile





Page 6

SK module – main functionalities

- Assess mooring system
  - Ultimate Limit State (ULS) criteria
  - Fatigue Limit State (FLS) criteria
  - Frequency domain analysis
  - Based on DNVGL-OS-E301
- Assess anchors and foundations
  - Ultimate Limit State (ULS) criteria
- Automated design of catenary mooring system
  - Based on maximum offset and ULS criteria
- Automated design of anchors and foundations
  - Based on ULS criteria

Page 7

SK module – workflow

Page 8

Walkthrough the SK Module

User Story

A Tidal Energy developer wants to use the "standalone" **SK** module of DTOceanPlus to assess the monopile foundation, given a certain site.

The developer wants to focus on the following:

1) Compute the **monopile dimensions** that satisfy the ULS criteria
2) Get an estimation of the **cost** of the foundation

Page 9

Walkthrough the SK Module

Example

In this example, we'll use the Reference Model RM1 (rated power of 1100 kW) developed by Sandia.

The chosen site will be the Takoma site, and the simulation.

The input data are based on the SANDIA Report (SAND2014-9040 Methodology for Design and Economic Analysis of Marine Energy Conversion (MEC) Technologies)

Some inputs are derived and adapted from a published DTOcean study of the site (Topper et al 2020)

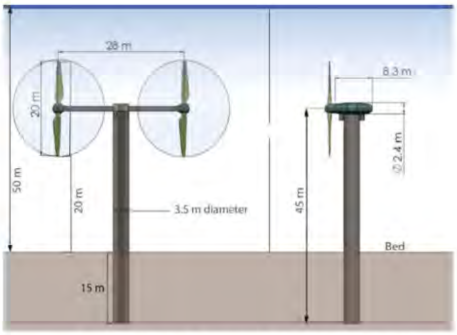


Image from SANDIA Report SAND2014-9040 Methodology for Design and Economic Analysis of Marine Energy Conversion (MEC) Technologies

Page 10

Walkthrough the SK Module

Device Inputs

Inputs description	Value	Units
Type of technology	Fixed tidal machine with two rotors	-
Mass without monopile	119700	kg
Position of rotor 1	[x,y,z] = [0,-14,30]	m
Position of rotor 2	[x,y,z] = [0,14,30]	m
Rotor diameter	20	m
Rotor thrust coefficients	Function of fluid velocity	-

Page 11

Walkthrough the SK Module

Site Inputs

Inputs description	Value	Units
Water depth	50	m
Design Hs (100-years return period)	8	m
Design Tp (100-years return period)	10	s
Design Current velocity	2.85	m/s
Soil type	dense sand	-

Page 12

Walkthrough the SK Module

Analysis parameters

Inputs description	Value	Units
Maximum deflection of pile (% of diameter)	5	%

Page 13

Walkthrough the SK Module

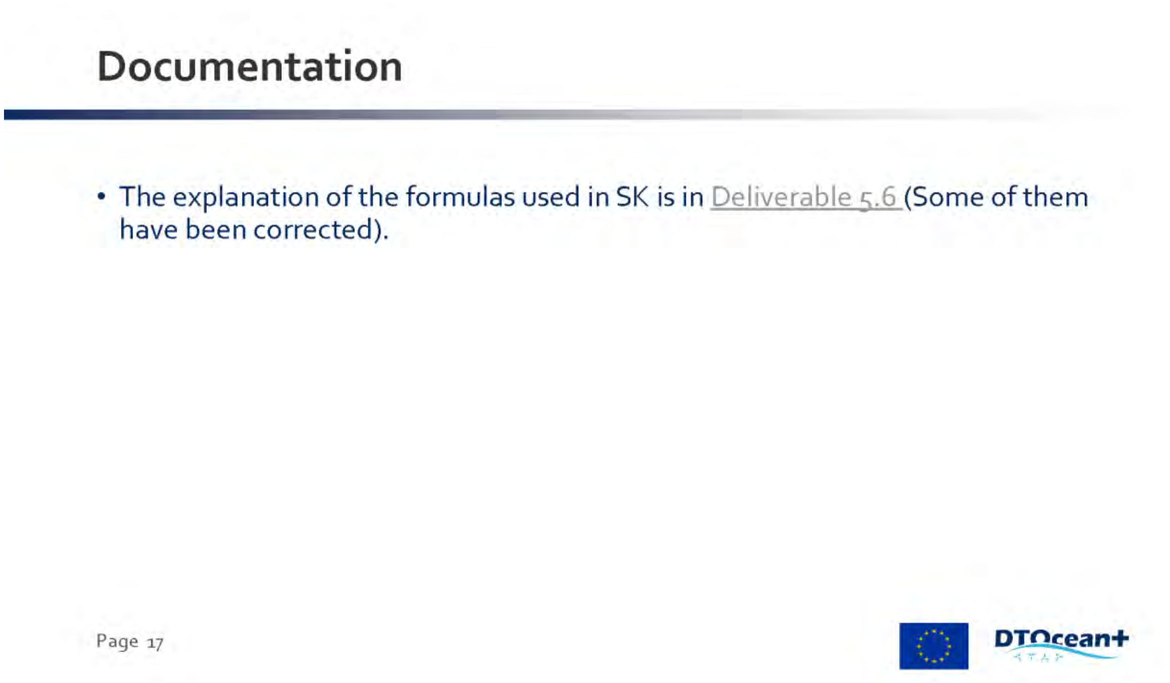
Main results

Main results description	Sensitive to
Monopile dimensions & Cost	Maximum current velocity Thrust coefficient curve
ULS Criteria	Maximum current velocity Thrust coefficient curve

Page 14

Live Demo

Page 16

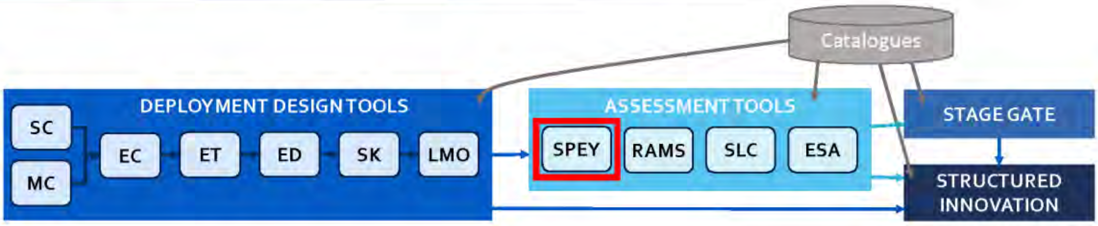


TECHNOLOGY IN CONTEXT: ASSESSMENT OF AN ARRAY PROJECT SYSTEM PERFORMANCE AND ENERGY YIELD MODULE

Outline

- The Assessment Design Tools of DTOceanPlus
- Objectives of SPEY Module
- Main Outcomes of SPEY Module
- Walkthrough the tool SPEY

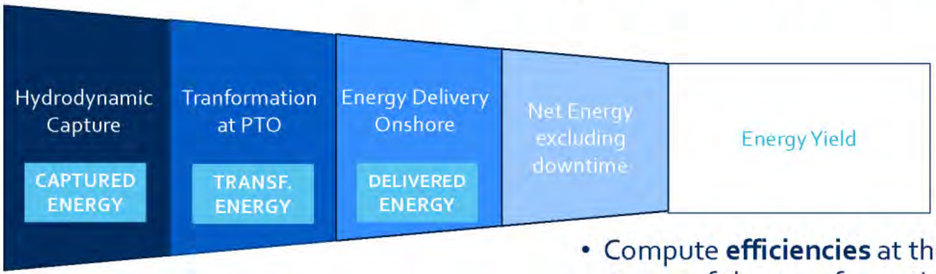
The Assessment Design Tools of DTOceanPlus



SPEY	**System Performance and Energy Yield** – Evaluate projects in terms of energy performance.
RAMS	System **Reliability, Availability, Maintainability, Survivability** – Evaluate the reliability aspects of a marine renewable energy project.
SLC	**System Lifetime Costs** – Evaluate projects from the economic perspective
ESA	**Environmental and Social Acceptance** – Evaluate the environmental and social impacts of a given wave and tidal energy projects.

Objectives of SPEY Module

- Assess the performance of the system in terms of **energy yield** during all the stages of the resource-to-wire conversion including the downtime of the system



- Compute **efficiencies** at the different stages of the transformation
- Assess the **power quality** at the delivery point
- Produce a set of **alternative metrics** against a set of technical parameters

Page 4

Main Outcomes of SPEY Module

- A set of **Efficiency Metrics,** i.e. dimensionless metrics to compare the efficiency of each stage of the energy flow
  - E.g. the Array Absolute Delivered Efficiency OR Device Relative Transformed Efficiency
- A set of **Alternative Metrics,** i.e. dimensional metrics to assess the energy production against a set of technical parameters, as for example
  - Cable lengths, e.g. Export Cable length to energy production ratio
  - Mass, e.g. Device Captured Energy for unit of mass
  - Rated power, Power to Weight Ratio
  - Characteristic dimension, Capture length per characteristic length
- Active and Reactive Power (**Power Quality**) after the transformation and delivery stages
- Breakdown of **Energy Production** during the project lifetime:
  - Gross, net and lost energy
  - Production per device and array
  - Net production per month and year

Page 5

Walkthrough of the SPEY Module

User Story

A Tidal Energy developer wants to use the "standalone" **SPEY** module to assess the energy performance of an *array of 10 machines*, given a certain site.

The developer wants to focus on the performance of the **electrical dispatch infrastructure** by estimating:

1) The **array relative efficiency** of the delivery stage in the energy flow
2) The **phase** between active and reactive power at the delivery point for each tidal condition considered

And also assess

1) The **ratio between the energy production** of each device and the **mass** of the prime mover
2) The **lifetime ratio between net energy and gross energy,** accounting for downtime

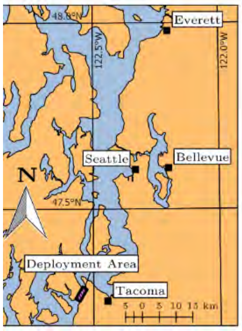
Page 6

Walkthrough of the SPEY Module

Example

In this example, we'll use the Reference Model RM1 (rated power of 1,100 kW) developed by Sandia National Laboratories.

The chosen site is the Tacoma Narrows, WA, USA.



The input data are derived from a published DTOcean study of the site (Topper et al 2020), adapted to showcase some additional SPEY functionalities such as the estimation of Power Quality and Alternative Metrics.

Image from Topper, M.B.R., Olson, S.S. , Roberts, J.D., Techno-economic modelling of tidal energy converter arrays in the tacoma narrows, Journal of Marine Science and Engineering, 2020, 8(9), 646

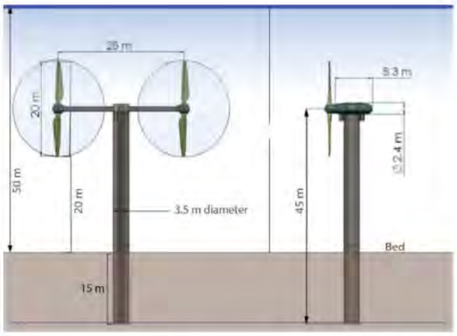


Image from SANDIA Report SAND2014-9040 Methodology for Design and Economic Analysis of Marine Energy Conversion (MEC) Technologies

Live Demo

Page 8

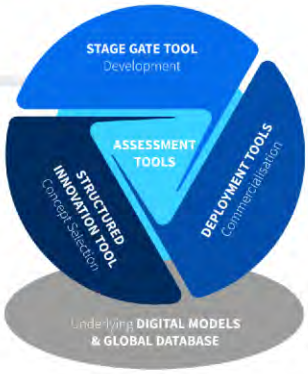
Documentation

- The explanation of the formulas used in SPEY is in Deliverable 6.2 (Some of them have been corrected).
- The definition of the Digital representation is in Deliverable 7.1

Page 9

WRAP UP AND NEXT STEPS

Summary of the workshop



Today we have outlined:

1. Overall architecture of the tools
   - Runs as an **integrated suite** or in **standalone** mode
   - Different way to use some or all tools
2. How the **Stage Gate** and **Structured Innovation** tools can
   - Guide technology development,
   - Identify areas for improvement,
   - Facilitate innovation through a combined QFD-TRIZ approach
3. How the **Deployment** and **Assessment** tools can be used to assist optimal device and array development, illustrated by
   - Station Keeping, designing foundations and mooring systems
   - System Performance & Energy Yield, collating metrics on energy performance and losses
   - *More events next year to explain the other tools…*

Page

DTOcean+

Market Analysis and Implementation Feasibility (WP8)

Also analysing markets and enablers for ocean energy within the project

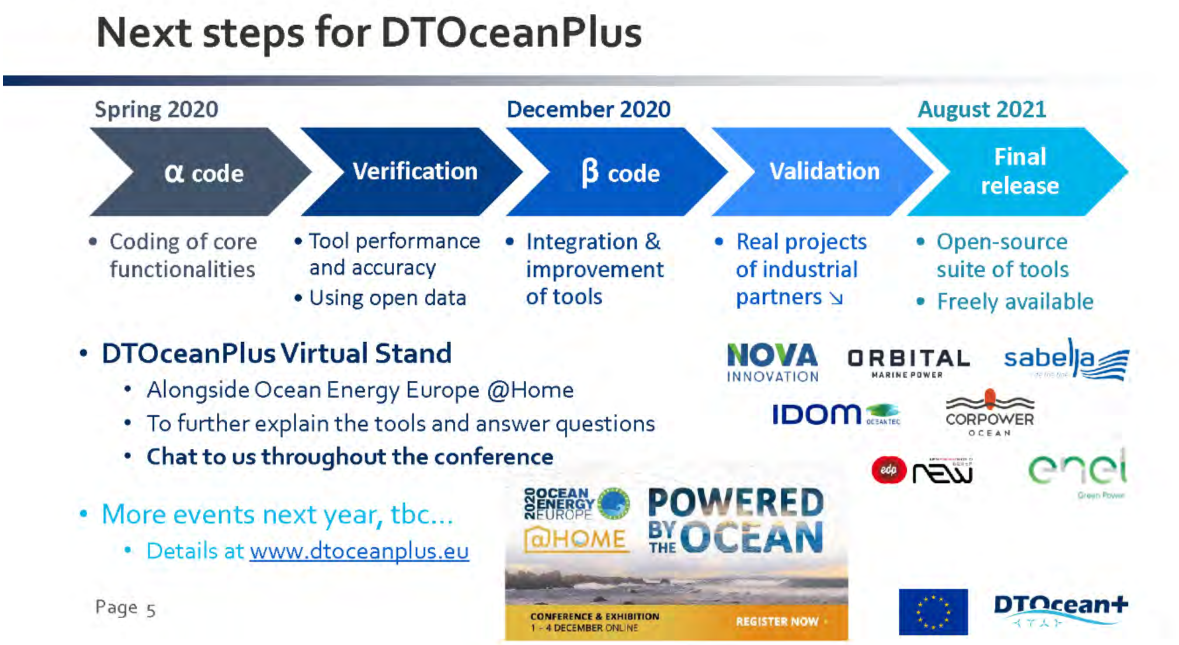
- Set of 5 reports (2 already published, 3 next year)

1. Potential Markets for Ocean Energy
2. Analysis of the European Supply Chain
3. Feasibility & Cost-benefit Analysis
4. Business Models for Ocean Energy
5. Legal, Institutional & Political Frameworks

Available at www.dtoceanplus.eu/Publications/Deliverables

Page

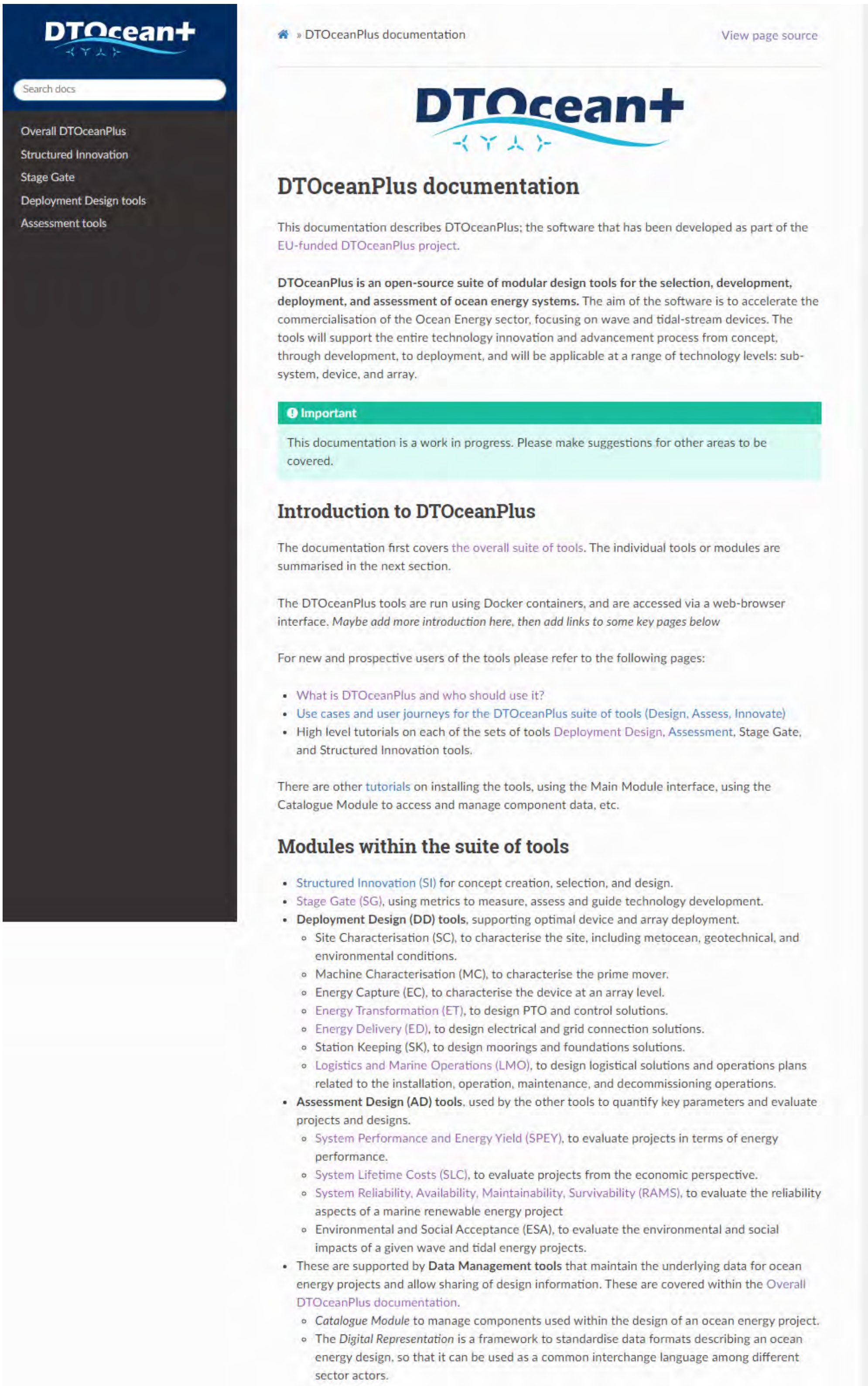
DTOcean+


Next steps for DTOceanPlus
Spring 2020
December 2020
August 2021
α code
Verification
β code
Validation
Final release
• Coding of core functionalities
• Tool performance and accuracy
• Using open data
• Integration & improvement of tools
• Real projects of industrial partners ↘
• Open-source suite of tools
• Freely available
• DTOceanPlus Virtual Stand
• Alongside Ocean Energy Europe @Home
• To further explain the tools and answer questions
• Chat to us throughout the conference
• More events next year, tbc…
• Details at www.dtoceanplus.eu
POWERED BY THE OCEAN
CONFERENCE & EXHIBITION
1 - 4 DECEMBER ONLINE
REGISTER NOW
Page 5


Advanced Design Tools for Ocean Energy Systems Innovation, Development and Deployment
Thank you for your attention!
Dr Donald R Noble
<D.Noble@ed.ac.uk>
Disclaimer: This presentation reflects only the author's views and the Agency is not responsible for any use that may be made of the information contained therein.
This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 785921

ANNEX IV: EXAMPLES OF DTOCEANPLUS DOCUMENTATION

FIGURE IV.1 DOCUMENTATION HOME PAGE



Search docs

Overall DTOceanPlus
Structured Innovation
Stage Gate
Deployment Design tools
Assessment tools

» DTOceanPlus documentation

View page source

DTOceanPlus documentation

This documentation describes DTOceanPlus; the software that has been developed as part of the EU-funded DTOceanPlus project.

DTOceanPlus is an open-source suite of modular design tools for the selection, development, deployment, and assessment of ocean energy systems. The aim of the software is to accelerate the commercialisation of the Ocean Energy sector, focusing on wave and tidal-stream devices. The tools will support the entire technology innovation and advancement process from concept, through development, to deployment, and will be applicable at a range of technology levels: sub-system, device, and array.

Important

This documentation is a work in progress. Please make suggestions for other areas to be covered.

Introduction to DTOceanPlus

The documentation first covers the overall suite of tools. The individual tools or modules are summarised in the next section.

The DTOceanPlus tools are run using Docker containers, and are accessed via a web-browser interface. *Maybe add more introduction here, then add links to some key pages below*

For new and prospective users of the tools please refer to the following pages:

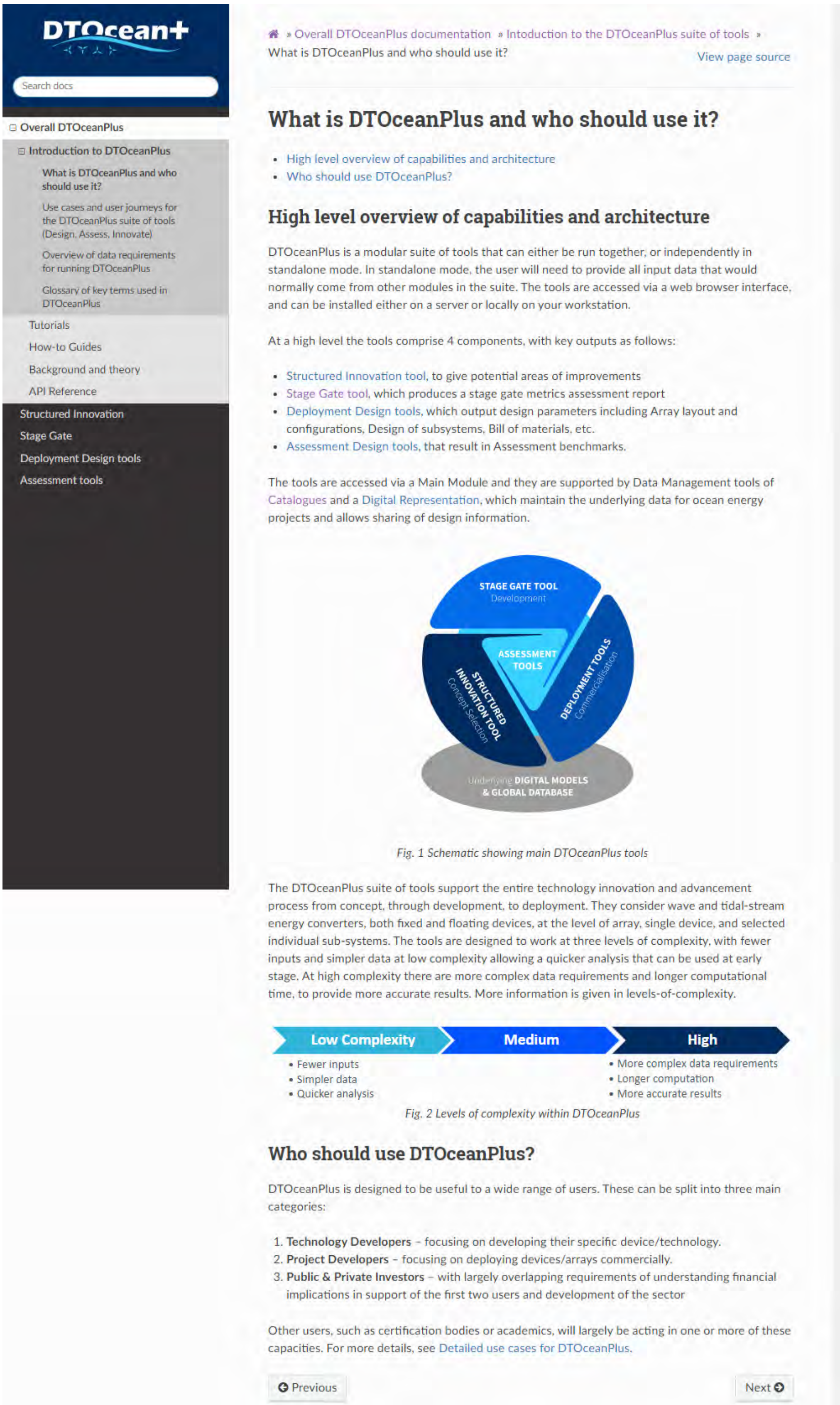
- What is DTOceanPlus and who should use it?
- Use cases and user journeys for the DTOceanPlus suite of tools (Design, Assess, Innovate)
- High level tutorials on each of the sets of tools Deployment Design, Assessment, Stage Gate, and Structured Innovation tools.

There are other tutorials on installing the tools, using the Main Module interface, using the Catalogue Module to access and manage component data, etc.

Modules within the suite of tools

- Structured Innovation (SI) for concept creation, selection, and design.
- Stage Gate (SG), using metrics to measure, assess and guide technology development.
- **Deployment Design (DD) tools**, supporting optimal device and array deployment.
  - Site Characterisation (SC), to characterise the site, including metocean, geotechnical, and environmental conditions.
  - Machine Characterisation (MC), to characterise the prime mover.
  - Energy Capture (EC), to characterise the device at an array level.
  - Energy Transformation (ET), to design PTO and control solutions.
  - Energy Delivery (ED), to design electrical and grid connection solutions.
  - Station Keeping (SK), to design moorings and foundations solutions.
  - Logistics and Marine Operations (LMO), to design logistical solutions and operations plans related to the installation, operation, maintenance, and decommissioning operations.
- **Assessment Design (AD) tools**, used by the other tools to quantify key parameters and evaluate projects and designs.
  - System Performance and Energy Yield (SPEY), to evaluate projects in terms of energy performance.
  - System Lifetime Costs (SLC), to evaluate projects from the economic perspective.
  - System Reliability, Availability, Maintainability, Survivability (RAMS), to evaluate the reliability aspects of a marine renewable energy project
  - Environmental and Social Acceptance (ESA), to evaluate the environmental and social impacts of a given wave and tidal energy projects.
- These are supported by **Data Management tools** that maintain the underlying data for ocean energy projects and allow sharing of design information. These are covered within the Overall DTOceanPlus documentation.
  - *Catalogue Module* to manage components used within the design of an ocean energy project.
  - The *Digital Representation* is a framework to standardise data formats describing an ocean energy design, so that it can be used as a common interchange language among different sector actors.

FIGURE IV.2 OVERALL DOCUMENTATION – SUMMARY OF TOOLS



Search docs

- Overall DTOceanPlus
  - Introduction to DTOceanPlus
    - What is DTOceanPlus and who should use it?
    - Use cases and user journeys for the DTOceanPlus suite of tools (Design, Assess, Innovate)
    - Overview of data requirements for running DTOceanPlus
    - Glossary of key terms used in DTOceanPlus
  - Tutorials
  - How-to Guides
  - Background and theory
  - API Reference
- Structured Innovation
- Stage Gate
- Deployment Design tools
- Assessment tools

» Overall DTOceanPlus documentation » Intoduction to the DTOceanPlus suite of tools » What is DTOceanPlus and who should use it?

View page source

What is DTOceanPlus and who should use it?

- High level overview of capabilities and architecture
- Who should use DTOceanPlus?

High level overview of capabilities and architecture

DTOceanPlus is a modular suite of tools that can either be run together, or independently in standalone mode. In standalone mode, the user will need to provide all input data that would normally come from other modules in the suite. The tools are accessed via a web browser interface, and can be installed either on a server or locally on your workstation.

At a high level the tools comprise 4 components, with key outputs as follows:

- Structured Innovation tool, to give potential areas of improvements
- Stage Gate tool, which produces a stage gate metrics assessment report
- Deployment Design tools, which output design parameters including Array layout and configurations, Design of subsystems, Bill of materials, etc.
- Assessment Design tools, that result in Assessment benchmarks.

The tools are accessed via a Main Module and they are supported by Data Management tools of Catalogues and a Digital Representation, which maintain the underlying data for ocean energy projects and allows sharing of design information.

Fig. 1 Schematic showing main DTOceanPlus tools

The DTOceanPlus suite of tools support the entire technology innovation and advancement process from concept, through development, to deployment. They consider wave and tidal-stream energy converters, both fixed and floating devices, at the level of array, single device, and selected individual sub-systems. The tools are designed to work at three levels of complexity, with fewer inputs and simpler data at low complexity allowing a quicker analysis that can be used at early stage. At high complexity there are more complex data requirements and longer computational time, to provide more accurate results. More information is given in levels-of-complexity.

Fig. 2 Levels of complexity within DTOceanPlus

Who should use DTOceanPlus?

DTOceanPlus is designed to be useful to a wide range of users. These can be split into three main categories:

1. **Technology Developers** – focusing on developing their specific device/technology.
2. **Project Developers** – focusing on deploying devices/arrays commercially.
3. **Public & Private Investors** – with largely overlapping requirements of understanding financial implications in support of the first two users and development of the sector

Other users, such as certification bodies or academics, will largely be acting in one or more of these capacities. For more details, see Detailed use cases for DTOceanPlus.

Previous   Next

FIGURE IV.3 OVERALL DOCUMENTATION – DEPLOYMENT TOOLS TUTORIAL

DTOcean+

Search docs

⊟ Overall DTOceanPlus
- Introduction to DTOceanPlus
- ⊟ Tutorials
  - **Use the Deployment Design tools to design an optimal array layout**
  - Use the Assessment Design tools to assess device/array metrics
  - Installing DTOceanPlus on Windows 10
  - Getting started with DTOceanPlus
  - Create Project & Studies
  - Fork & Compare Studies
  - Export project information using the Digital Representation
  - Manage users
  - Browse Catalogs
  - Edit Catalogs
- How-to Guides
- Background and theory
- API Reference

Structured Innovation
Stage Gate
Deployment Design tools
Assessment tools

» Overall DTOceanPlus documentation » Tutorials » Use the Deployment Design tools to design an optimal array layout

View page source

Use the Deployment Design tools to design an optimal array layout

This guide outlines the steps needed to design an optimal array layout using the Deployment Design tools in sequential order. It only covers the steps at a high level, further details of the detailed steps required in each tool is provided within the documentation of that tool, as linked below.

Before outlining the steps taken in each tool, it is important to note that unlike the other tools within the suite, the Deployment Design tools should be run in sequential order.

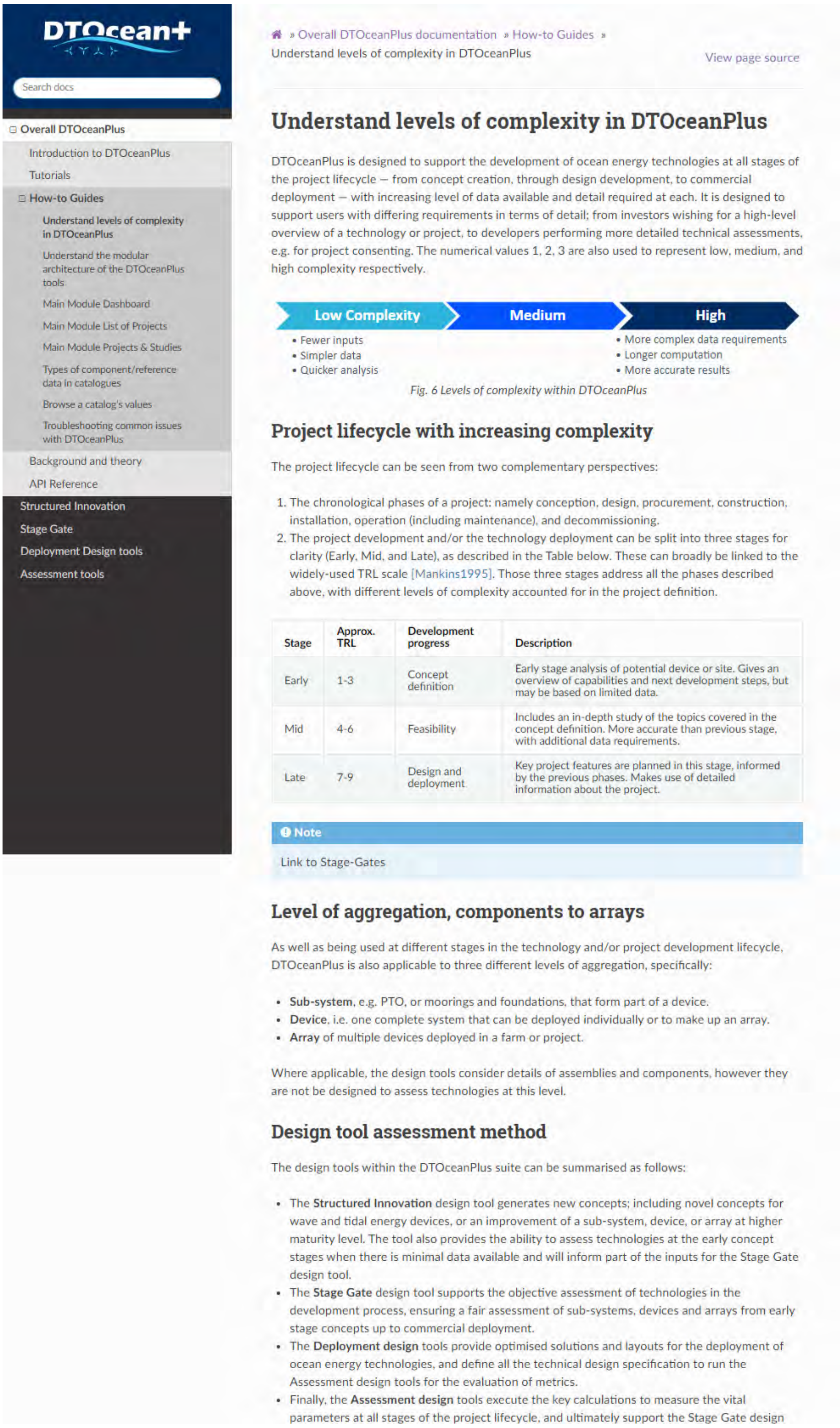
Fig. 4 Deployment Design tools run in sequence

1. Start with the Site Characterisation (SC) tool, to select/enter details about the site including the resource available.
   a. Select or import databases:
      1. At low complexity, select bathymetry and 1D resource data for a reference site.
      2. At medium complexity, select bathymetry and 2D resource data for a reference site.
      3. At high complexity, enter bathymetry and 1D/2D resource data for a custom site.
   b. Extract variables from the database and compute statistics.
   c. See a graphical overview of results with site information then provied to other tools.
2. In the Machine Charaterisation (MC) tool, Enter properties of the wave or tidal energy converter.
   a. Input general parameters: unit cost, power rating, material, plus cable and seabed connection types
   b. Input dimensions: length, width, height, charateristic dimension, wet & dray areas, submerged volume, etc.
   c. Model the efficiency, limits, and number of generators. For high complexity level for WECs, the tool also calculates hydrodynamic coefficients.
3. In the Energy Capture (EC) tool, calculate the hydrodynamic energy captured by the device including array interactions in the module.
   a. Input the farm [, site, and machine data] UPDATE
   b. The tool can be used in two design modes:
      1. Estimate the array performance based on a given array layout.
      2. Find the array layout that maximises the energy production of the array.
   c. View results of the farm layout, farm & device energy production & array efficiency
4. In the Energy Transformation (ET), design the different energy transformation steps:
   1. Hydrodynamic to Mechanical (Mechanical Transformation);
   2. Mechanical to Electrical (Electrical Transformation) and Control;
   3. Electricsl to Grid (Grid Conditioning).

   by:

   a. Select configuration parameters/design options
   b. Perform assessment of the design options
   c. View results at PTO/device/array level, in terms of performance, reliability, cost, mass, and bill of materials of the three energy transformation steps.
5. In the Energy Delivery (ED), design the electrical infrastructure to transmit power to shore.
   a. Select configuration options for the electrical infrastructure, including one of six network topologies (e.g. direct, radial, star), plus cable installation and protection options.
   b. Run the design algorthim to calculate a network layout. Components such as cables and connectors are selected from the electrical network equipment catalogue.
   c. Review optputs of the network design option(s): the energy/power delivered to shore and network losses, the total cost and bill of materials for the electrical components used, plus a hierarchy of how they are connected.
   d. Select the design option to use.
6. In the Station Keeping (SK) tool, design mooring and foundation subsytems to keep the device on station. This includes mooring lines for floating structure, anchors, and foundation for fixed structures.
   a. Input mooring system and foundation properties
   b. Run analysis:
      1. Optional design of catenary mooring system,
      2. ULS & FLS analyses of mooring systems,
      3. Optional design of foundations and anchors,
      4. ULS analyses of foundations and anchors.

FIGURE IV.4 OVERALL DOCUMENTATION – HOW-TO GUIDE ON COMPLEXITY



DTOcean+

Search docs

- Overall DTOceanPlus
  - Introduction to DTOceanPlus
  - Tutorials
  - How-to Guides
    - Understand levels of complexity in DTOceanPlus
    - Understand the modular architecture of the DTOceanPlus tools
    - Main Module Dashboard
    - Main Module List of Projects
    - Main Module Projects & Studies
    - Types of component/reference data in catalogues
    - Browse a catalog's values
    - Troubleshooting common issues with DTOceanPlus
  - Background and theory
  - API Reference
- Structured Innovation
- Stage Gate
- Deployment Design tools
- Assessment tools

» Overall DTOceanPlus documentation » How-to Guides » Understand levels of complexity in DTOceanPlus

View page source

Understand levels of complexity in DTOceanPlus

DTOceanPlus is designed to support the development of ocean energy technologies at all stages of the project lifecycle – from concept creation, through design development, to commercial deployment – with increasing level of data available and detail required at each. It is designed to support users with differing requirements in terms of detail; from investors wishing for a high-level overview of a technology or project, to developers performing more detailed technical assessments, e.g. for project consenting. The numerical values 1, 2, 3 are also used to represent low, medium, and high complexity respectively.

Low Complexity | Medium | High

- Fewer inputs
- Simpler data
- Quicker analysis

- More complex data requirements
- Longer computation
- More accurate results

Fig. 6 Levels of complexity within DTOceanPlus

Project lifecycle with increasing complexity

The project lifecycle can be seen from two complementary perspectives:

1. The chronological phases of a project: namely conception, design, procurement, construction, installation, operation (including maintenance), and decommissioning.
2. The project development and/or the technology deployment can be split into three stages for clarity (Early, Mid, and Late), as described in the Table below. These can broadly be linked to the widely-used TRL scale [Mankins1995]. Those three stages address all the phases described above, with different levels of complexity accounted for in the project definition.

Stage	Approx. TRL	Development progress	Description
Early	1-3	Concept definition	Early stage analysis of potential device or site. Gives an overview of capabilities and next development steps, but may be based on limited data.
Mid	4-6	Feasibility	Includes an in-depth study of the topics covered in the concept definition. More accurate than previous stage, with additional data requirements.
Late	7-9	Design and deployment	Key project features are planned in this stage, informed by the previous phases. Makes use of detailed information about the project.

Note

Link to Stage-Gates

Level of aggregation, components to arrays

As well as being used at different stages in the technology and/or project development lifecycle, DTOceanPlus is also applicable to three different levels of aggregation, specifically:

- **Sub-system**, e.g. PTO, or moorings and foundations, that form part of a device.
- **Device**, i.e. one complete system that can be deployed individually or to make up an array.
- **Array** of multiple devices deployed in a farm or project.

Where applicable, the design tools consider details of assemblies and components, however they are not be designed to assess technologies at this level.

Design tool assessment method

The design tools within the DTOceanPlus suite can be summarised as follows:

- The **Structured Innovation** design tool generates new concepts; including novel concepts for wave and tidal energy devices, or an improvement of a sub-system, device, or array at higher maturity level. The tool also provides the ability to assess technologies at the early concept stages when there is minimal data available and will inform part of the inputs for the Stage Gate design tool.
- The **Stage Gate** design tool supports the objective assessment of technologies in the development process, ensuring a fair assessment of sub-systems, devices and arrays from early stage concepts up to commercial deployment.
- The **Deployment design** tools provide optimised solutions and layouts for the deployment of ocean energy technologies, and define all the technical design specification to run the Assessment design tools for the evaluation of metrics.
- Finally, the **Assessment design** tools execute the key calculations to measure the vital parameters at all stages of the project lifecycle, and ultimately support the Stage Gate design

FIGURE IV.5 STAGE GATE DOCUMENTATION – BACKGROUND AND THEORY

DTOcean+

Search docs

Overall DTOceanPlus
Structured Innovation
⊟ Stage Gate
Tutorials
How-to Guides
⊟ Background and theory
Stages and Stage Gates
Evaluation Areas
Stage Activities
Data Input
Metrics
Questions
API Reference
Deployment Design tools
Assessment tools

» Stage Gate » Background and theory   View page source

Background and theory

The Stage Gate module is an application of a *Stage Gate process* that is used in research and industry to provide structure to the technology development process. This approach supports the R&D pathway towards producing reliable and cost-effective ocean energy sub-systems, devices and arrays.

This section of the documentation describes the background and theory of the Stage Gate process and the data provided within the Stage Gate module. The data that forms the basis of this tool come from two main sources:

- The *International Evaluation and Guidance Framework for Ocean Energy Technology* written by the International Energy Agency – Ocean Energy Systems [IEA-OES]
- The Wave Energy Scotland (WES) stage gate programme

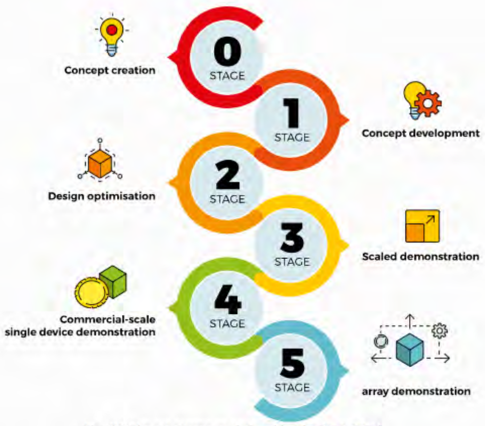


Fig. 23 The six stages as defined by the [IEA-OES]

The following sections of the report are divided according to the main features of the Stage Gate framework:

- Stages and Stage Gates; The key feature of the stage gate design tool is the technology development pathway split up into distinct stages, separated by stage gates. The stage gates are an opportunity for users of the tool to assess the technology and make critical decisions on whether to progress to the next stage.
- Evaluation Areas; The areas in which the user wishes to measure the success of ocean energy technology to demonstrate progress and performance.
- Stage Activities; This is a list of the research, development and demonstration activities that should be carried out during the prescribed stages.
- Data Input; The types of data which must be input to support a Stage Gate Assessment, including stage gate question responses, performance data e.g. tank and sea testing results and project data, e.g. site resource data which the user inputs to support the metrics calculations.
- Metrics; The parameters used to evaluate how well a technology performs in the Evaluation Areas. These are outputs of the Deployment and Assessment tools.
- Questions; Qualitative and quantitative questions to support the Stage Gate Assessment, covering topics such as scientific and engineering credibility, future targets and readiness for the next stage.

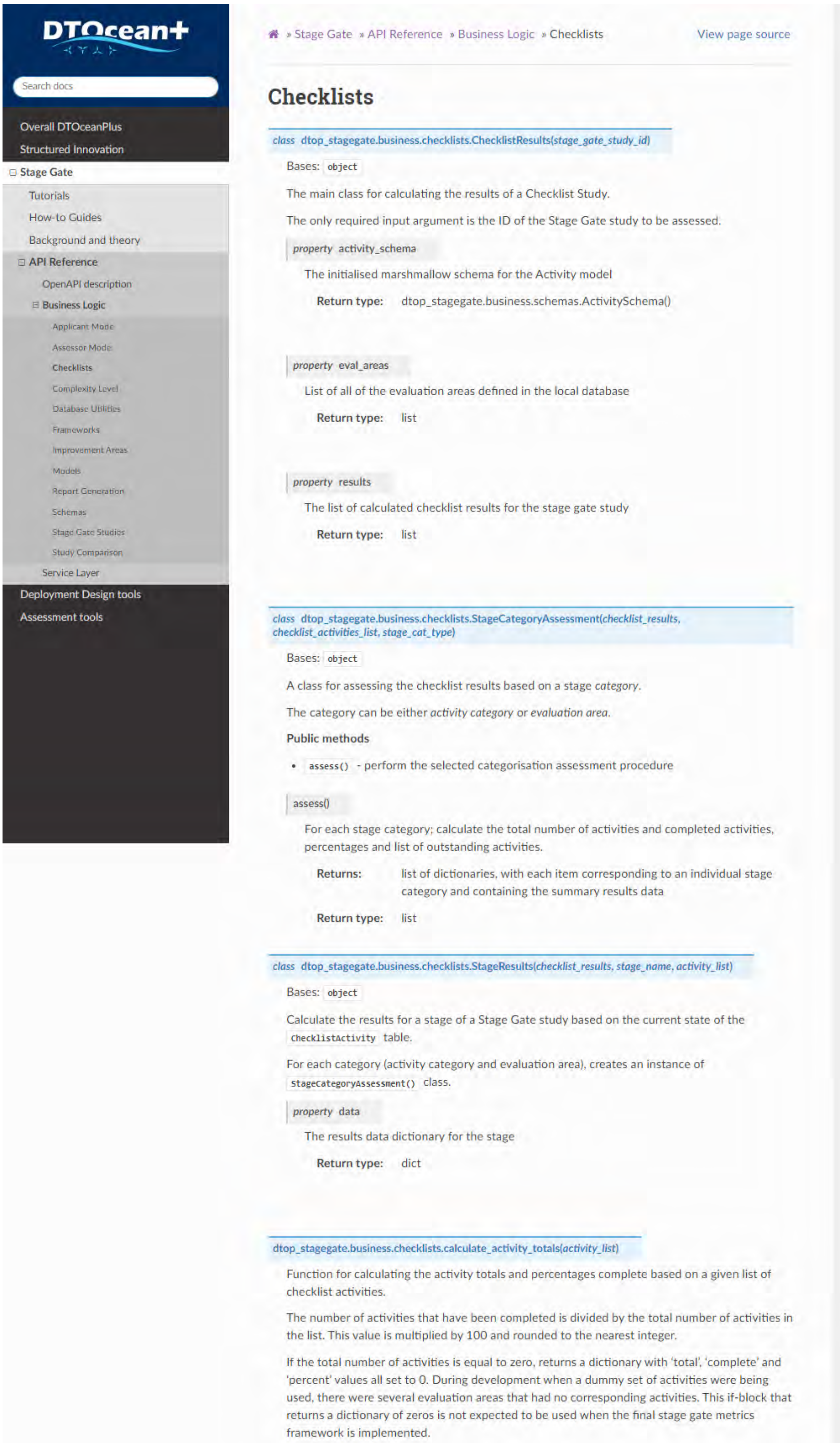
References

IEA-OES(1,2)

International Energy Agency - Ocean Energy Systems (2021) *An International Evaluation and Guidance Framework for Ocean Energy Technology*, Hodges J., Henderson J., Ruedy L., Soede M., Weber J., Ruiz-Minguela P., Jeffrey H., Bannon E., Holland M., Maciver R., Hume D., Villate J-L, Ramsey T., Available: https://www.ocean-energy-systems.org/publications/oes-documents/ Accessed: 2021-07-02

Previous   Next

FIGURE IV.6 STAGE GATE DOCUMENTATION – API REFERENCE FOR BUSINESS LOGIC



DTOcean+

Search docs

Overall DTOceanPlus
Structured Innovation
Stage Gate
Tutorials
How-to Guides
Background and theory
API Reference
OpenAPI description
Business Logic
Applicant Mode
Assessor Mode
Checklists
Complexity Level
Database Utilities
Frameworks
Improvement Areas
Models
Report Generation
Schemas
Stage Gate Studies
Study Comparison
Service Layer
Deployment Design tools
Assessment tools

» Stage Gate » API Reference » Business Logic » Checklists   View page source

Checklists

class dtop_stagegate.business.checklists.ChecklistResults(*stage_gate_study_id*)

Bases: `object`

The main class for calculating the results of a Checklist Study.

The only required input argument is the ID of the Stage Gate study to be assessed.

property activity_schema

The initialised marshmallow schema for the Activity model

Return type: dtop_stagegate.business.schemas.ActivitySchema()

property eval_areas

List of all of the evaluation areas defined in the local database

Return type: list

property results

The list of calculated checklist results for the stage gate study

Return type: list

class dtop_stagegate.business.checklists.StageCategoryAssessment(*checklist_results, checklist_activities_list, stage_cat_type*)

Bases: `object`

A class for assessing the checklist results based on a stage *category*.

The category can be either *activity category* or *evaluation area*.

Public methods

- `assess()` - perform the selected categorisation assessment procedure

assess()

For each stage category; calculate the total number of activities and completed activities, percentages and list of outstanding activities.

Returns: list of dictionaries, with each item corresponding to an individual stage category and containing the summary results data

Return type: list

class dtop_stagegate.business.checklists.StageResults(*checklist_results, stage_name, activity_list*)

Bases: `object`

Calculate the results for a stage of a Stage Gate study based on the current state of the `ChecklistActivity` table.

For each category (activity category and evaluation area), creates an instance of `StageCategoryAssessment()` class.

property data

The results data dictionary for the stage

Return type: dict

dtop_stagegate.business.checklists.calculate_activity_totals(*activity_list*)

Function for calculating the activity totals and percentages complete based on a given list of checklist activities.

The number of activities that have been completed is divided by the total number of activities in the list. This value is multiplied by 100 and rounded to the nearest integer.

If the total number of activities is equal to zero, returns a dictionary with 'total', 'complete' and 'percent' values all set to 0. During development when a dummy set of activities were being used, there were several evaluation areas that had no corresponding activities. This if-block that returns a dictionary of zeros is not expected to be used when the final stage gate metrics framework is implemented.

CONTACT DETAILS

Mr. Pablo Ruiz-Minguela

Project Coordinator, TECNALIA

www.dtoceanplus.eu

Naval Energies terminated its participation on 31st August 2018 and
EDF terminated its participation on 31st January 2019.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 785921