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Reduction of Microplastic Emission through System Optimisation of Feed Pellet Conveying Pipelines

Jana Chladek, Chandana Ratnayake, Huaitian Bu - SINTEF,
Andy Booth – SINTEF Ocean & Alessio Gomiero – NORCE

Online webinar: Microplastics occurrence in fisheries and aquaculture
21st April, 2021

The project has received funding from FHF under the project number 901658.

Background for project

- FHF November 2020 call

  "Tiltak for å redusere utslipp av både makro- og mikroplast fra sjømatnæringen

  ➢ Delmål 3: Fremskaffe kunnskap om tiltak og beste praksis som næringen kan iverksette for **å redusere utslipp av nano- og mikroplast fra fôrslanger**"

- Budget: 2 000 000 NOK
- Project duration: 15.01.2021 – 31.12.2022
- Partners:

SINTEF — SINTEF Tel-Tek; Materials & Nanotechnology

NORCE

SINTEF OCEAN

- Project manager: SINTEF

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Research topic

- Erosion of plastic pipes due to abrasion by fish feed pellets => release of microplastics into environment

- Pneumatic conveying systems often suboptimal => too high air velocities leading to:

Pipe erosion

+

Pellet degradation

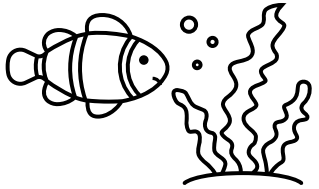
=>

Increased cost

NOK

+

Environment issue



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Objectives

Primary Objective

- optimise the feed pellet conveying systems, technology and costs in fish farms to minimise microplastic emissions and maximise pipeline lifetime and pellet integrity

Sub-objectives

A. Evaluate the effect of air velocity and pipeline configuration (bend radius) on pipe wall erosion for selected fish feed qualities **– WP1 (pneumatic conveying tests)**

B. Quantify the amount of micro- and nanoplastic (MNP) fragments from WP1 and characterize their physical properties (size, shape) **– WP2**

C. Map the erosion pattern and evaluate the evolution of erosion with application time **– WP3**

D. Implement the results in a simulation software for a selected industrial site to demonstrate how the feeding system can be optimized **– WP4**

E. Disseminate the learning from the project and present the methodology for optimization of the feed pellet conveying systems to the fish farming community **– WP4**

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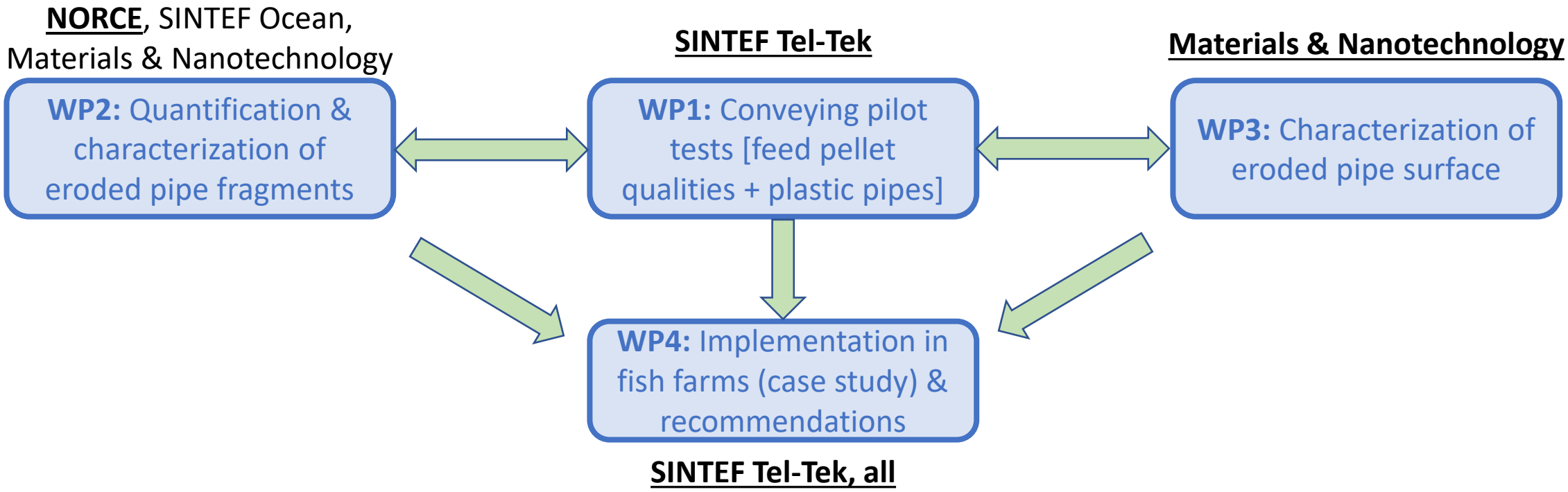
Work Package Structure



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WP1 – Conveying pilot tests

Chandana Ratnayake

Chief Scientist, SINTEF

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WP1- Objectives

- To carry out pneumatic conveying pilot-scale tests
- To collect data relevant to transport properties of feed pellets
- To quantify the weight loss in pipeline sections
- To provide pellet samples for the test under WP2
- To provide pipeline section for the test under WP3
- To formulate the calculation software for WP4

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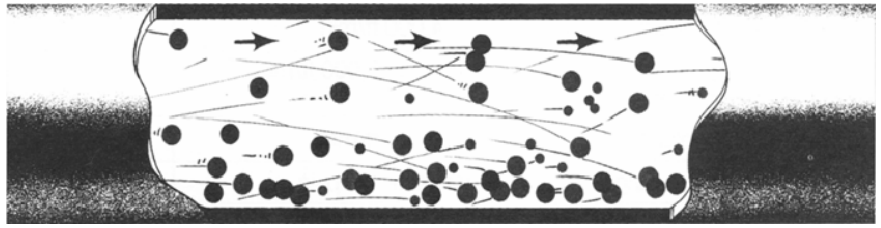
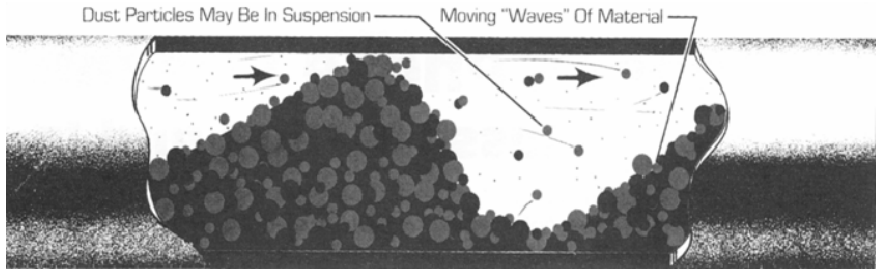
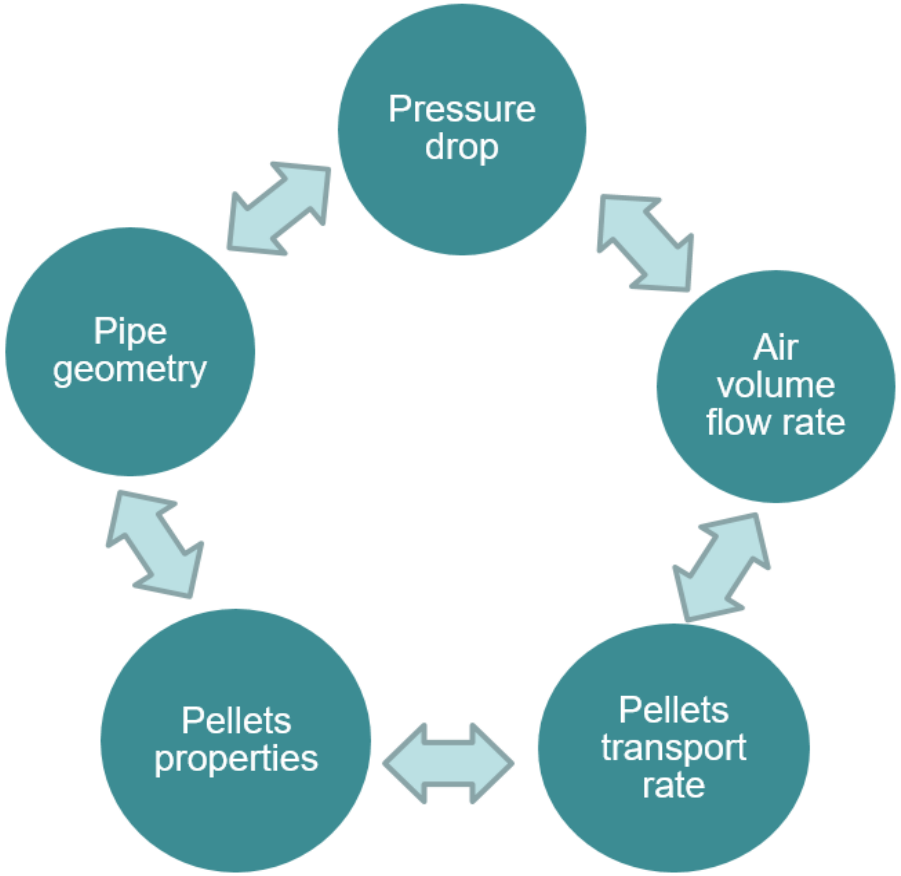
Pneumatic conveying of feed pellets



Dilute Phase- *high velocity & low transport rate*



Dense Phase- *low velocity & high transport rate*



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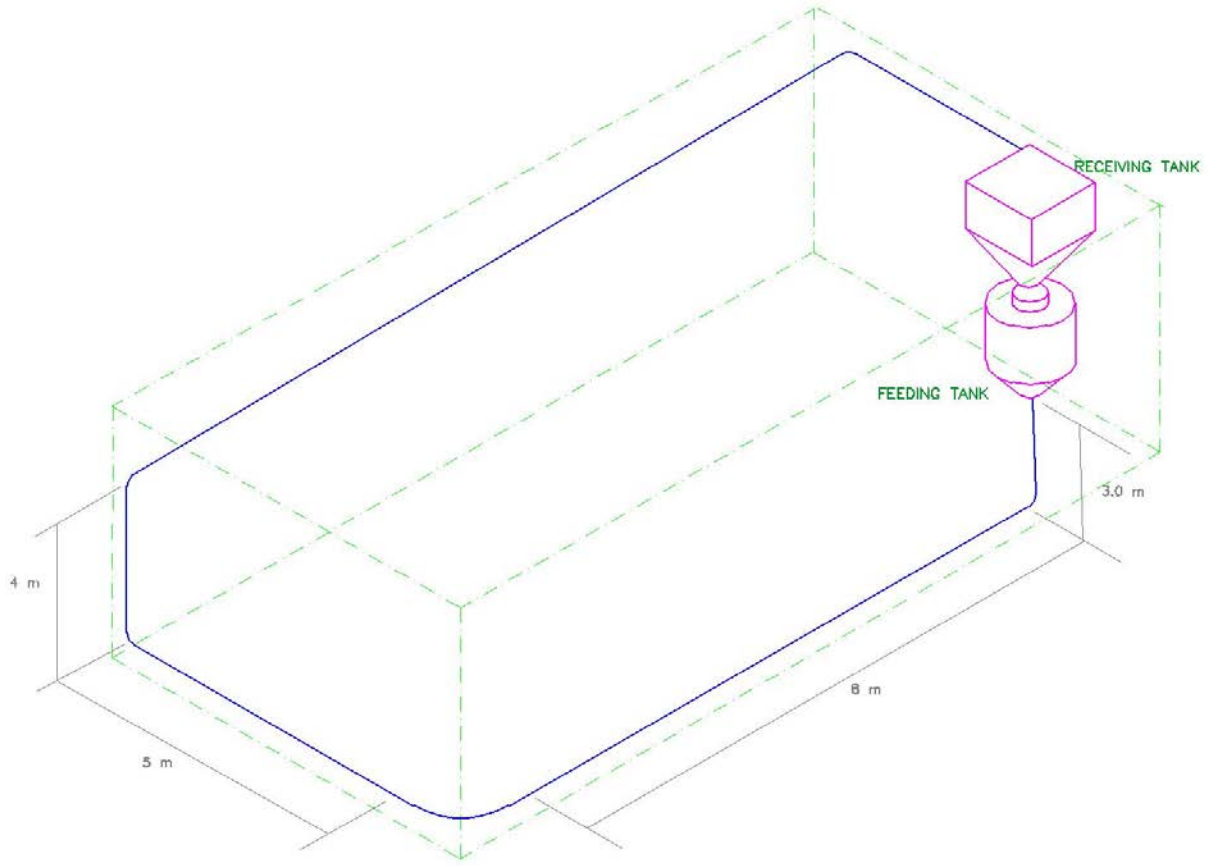
Infrastructure- Pilot conveying rig



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Conveying pilot test

- Select HDPE pipes & fish feed qualities
- Identify main pipeline components
- Setting up conveying pipeline
- Perform tests under different conveying parameters
- Collect data- feed transport rate, supply air pressure & volume flow (velocity), influence of pipe components

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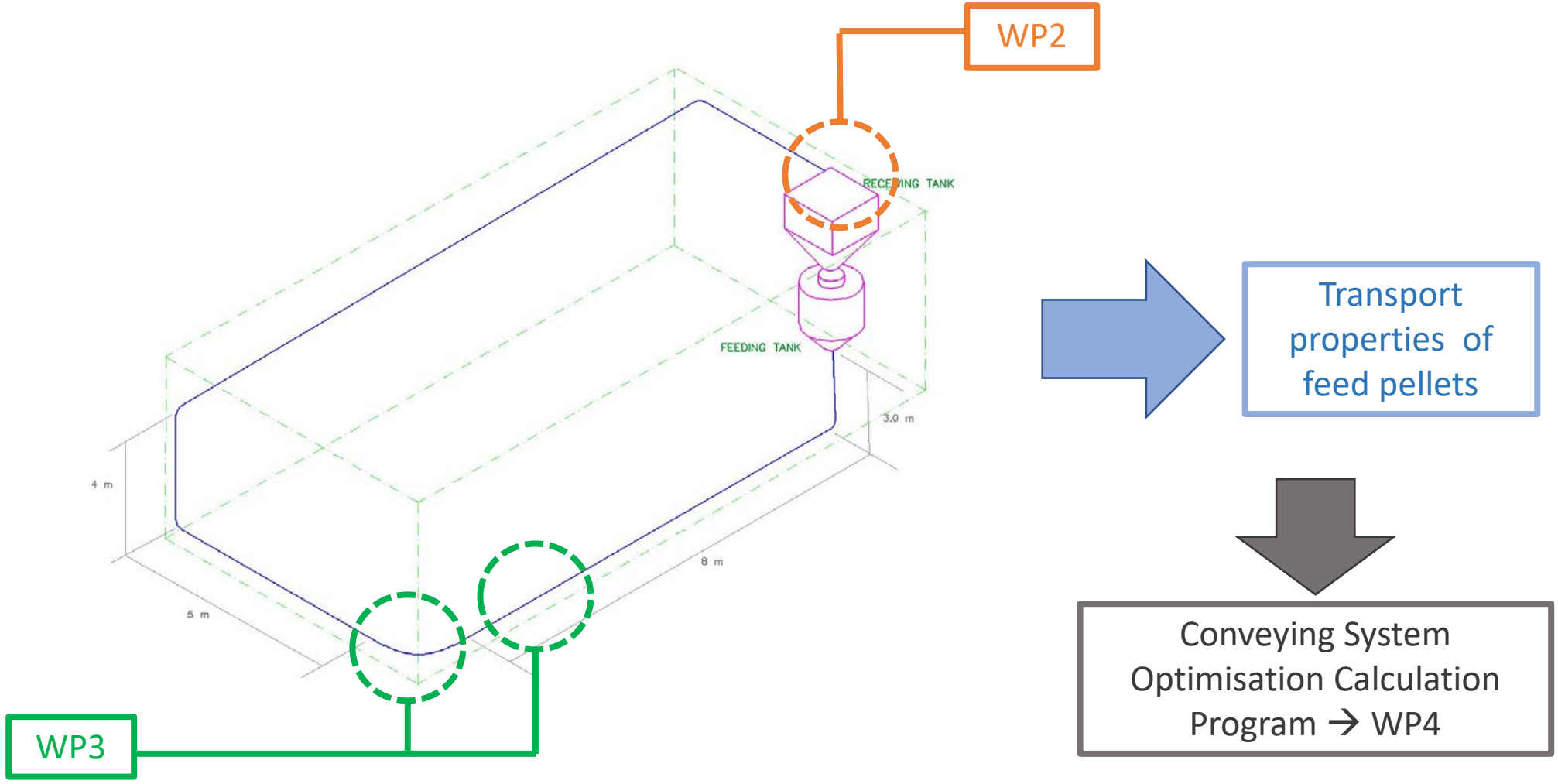
Test outcome



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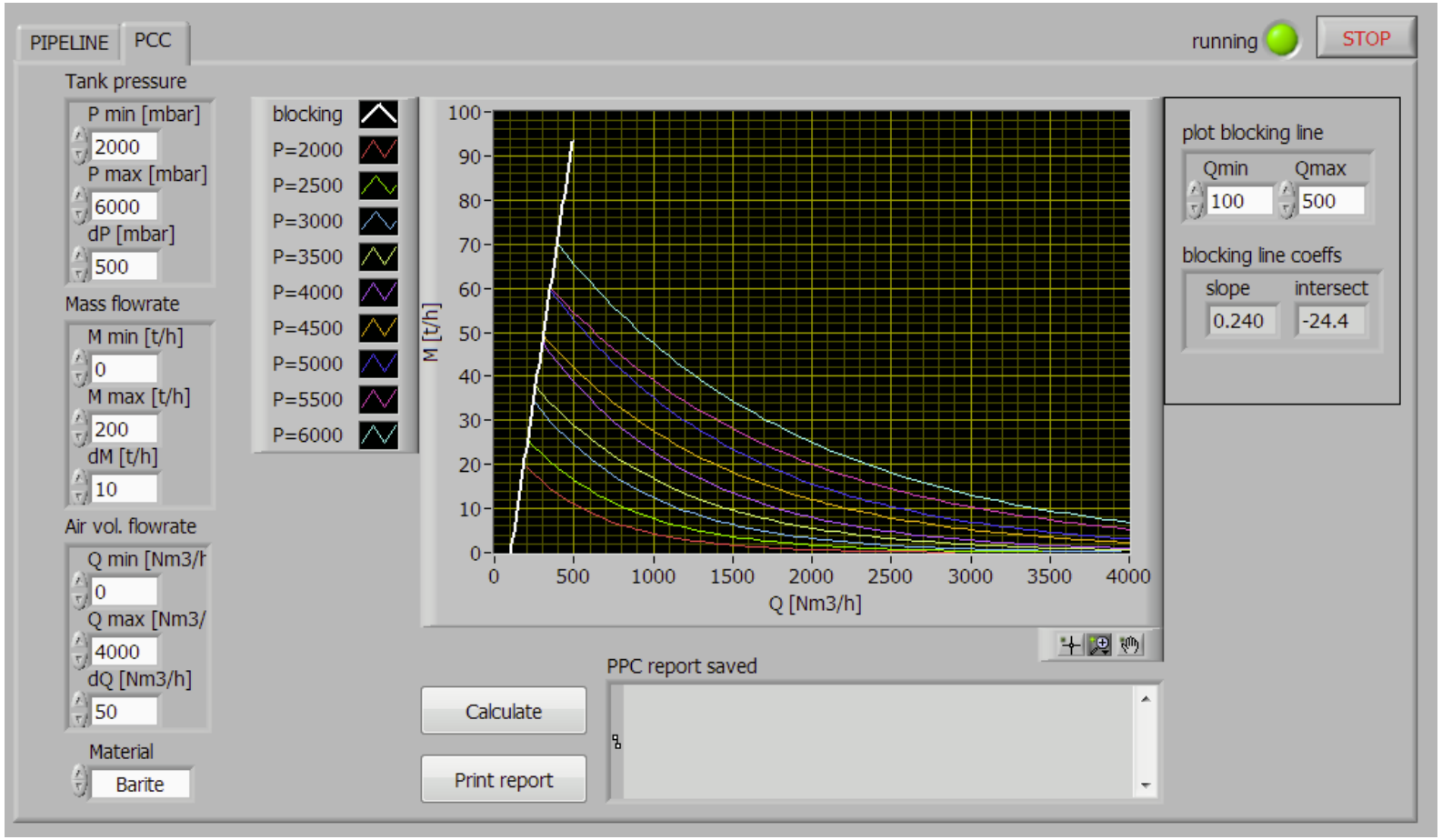
Calculation software



To be used in WP4 to optimise full scale pellet conveying pipeline

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Previous works

Design & optimise pellet conveying pipelines of pellet carrier ships

- to minimise pellet degradation
- to increase transport capacity

Bulk ship “Eidsvaag Pioner”

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WP2 – Quantification and characterization of eroded pipe fragments

Alessio Gomiero, *Senior Researcher*, NORCE

&

Andrew Booth, *Research Manager*, SINTEF Ocean

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WP2 Objectives

- Visualize and mass estimate MP fragments generated during feeding pipes abrasion tests performed in WP1

- The quantification and characterization will support the implementation of the abrasion model (WP4) and will directly contribute to optimization of the feed hoses and feed delivery parameters to minimize particle generation and emissions in the aquaculture production process

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WP2 – Task activities

Task 2.1 – Sample's preparation to analysis targeting interferents removal, isolation, and fractionation

Samples provided by WP1 will be treated with surfactants in a water based dense solution to help extracting the plastic particles present in the fat layer present in the fish feed pellets. The obtained sample will be processed and split into microplastic and nanoplastic fractions prior to further dedicated sample preparation and analysis approaches. (D1 >300 µm, 300µm > D2 >20 µm, D3 <20 µm)

Task 2.2 – Quantification and characterization of eroded microplastic fragments

The micron-sized plastic particles subfraction will be characterized by:

D1 >300 µm = ATR FTIR

300µm > D2 >20 µm = µFTIR Imaging

Task 2.3 – Qualification of eroded nanoplastic fragments

There are currently no validated methods for the analysis of nanoplastic particles. An approach focused on using HDPE additive chemical markers will be performed

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WP3 – Characterization of eroded pipe surface

Huaitian Bu

Senior Scientist, SINTEF

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WP3- Objectives

- To visualize the erosion pattern of the pipeline under selected conveying conditions in WP1
- To provide information on the character of the surface damage on the pipe wall surface, thus complement the result on weight loss obtained in WP1 and quantification of MP in WP2
- To set up initial correlation between the conveying parameters and the evolution of erosion and physical steadiness of worn pipes in WP1

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WP3: Task activities

- Task 3.1 Surface detection of eroded pipeline:
  - The surface topography of the inner wall of the pipelines will be investigated by white-light interferometry (WLI) to **map the roughness and erosion pattern of pipeline surface**
  - Scanning electron microscopy (SEM) will be utilized to **examine the surface damage on the pipe wall surface** (e. g. depth of penetration, localized grooves or dispersed erosion) and thereby, complementing the results on weight loss obtained in WP1 and quantification of MP in WP2

- Task 3.2 Evolution of erosion in the pipelines:
  - The physical properties (e. g. tensile strength, elongation at break and impact strength) will be measured for both virgin and eroded pipelines to set up an initial correlation between the conveying parameters and the evolution of erosion and physical steadiness of worn pipes in WP1

The results of both tasks will feed directly into optimization of the fish feeding systems in WP 4.

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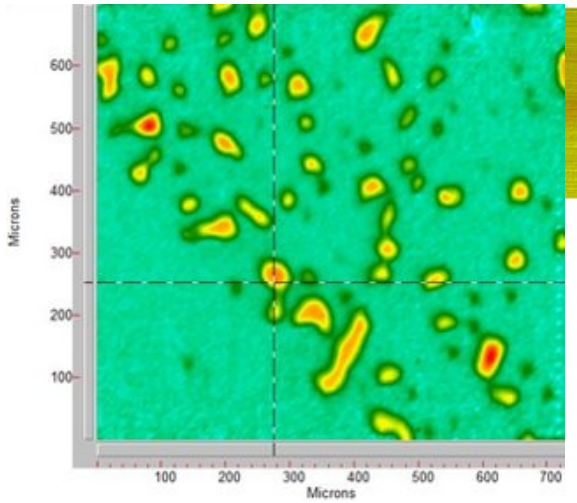
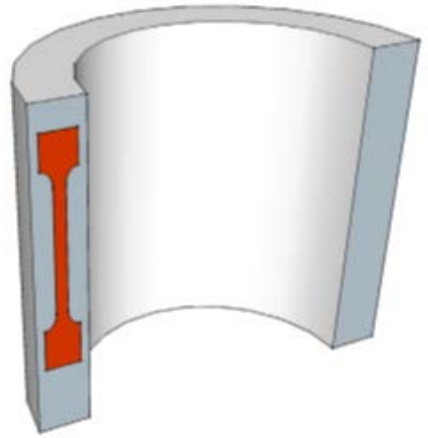
Relevant competence and facilities

- Surface topography
  - Optical microscopy
  - White-light interferometry (WLI)
  - Scanning electron microscopy (SEM)
- Mechanical tests
  - Tensile
  - Impact
- Chemical characterization
  - Fourier-transform infrared spectroscopy (FT-IR)
  - Nuclear magnetic resonance (NMR)





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WP4 – Implementation in fish farms (case study) & recommendations

Chandana Ratnayake

Chief Scientist, SINTEF

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WP4- Objectives

- To implement the results of simulation software in a selected fish farm (full scale conveying system) as a case study
- To arrange a workshop with the industrial stakeholders to transfer knowledge generated during the project

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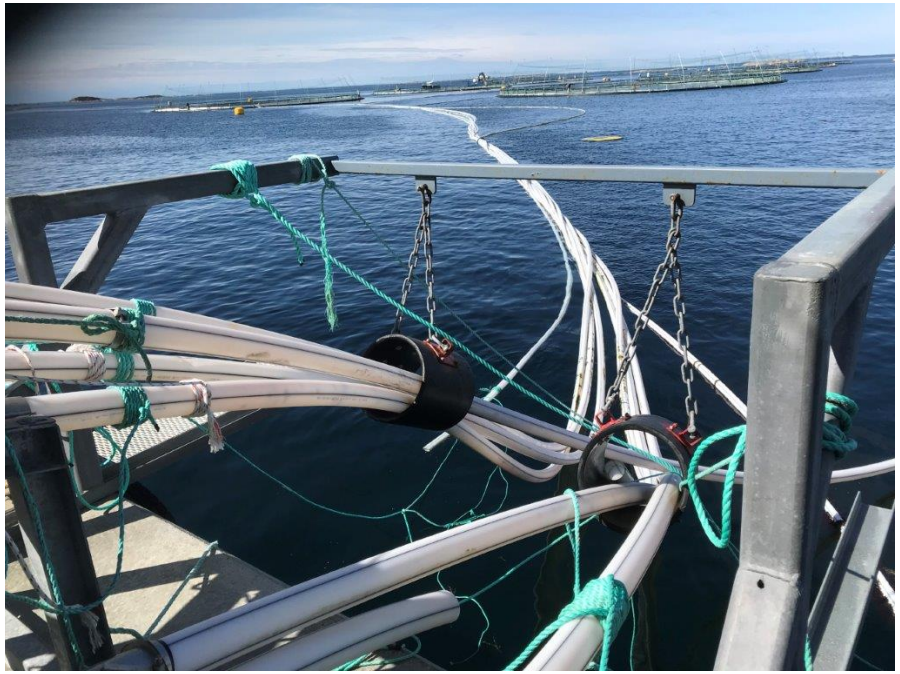
Full scale conveying plant- fish farm



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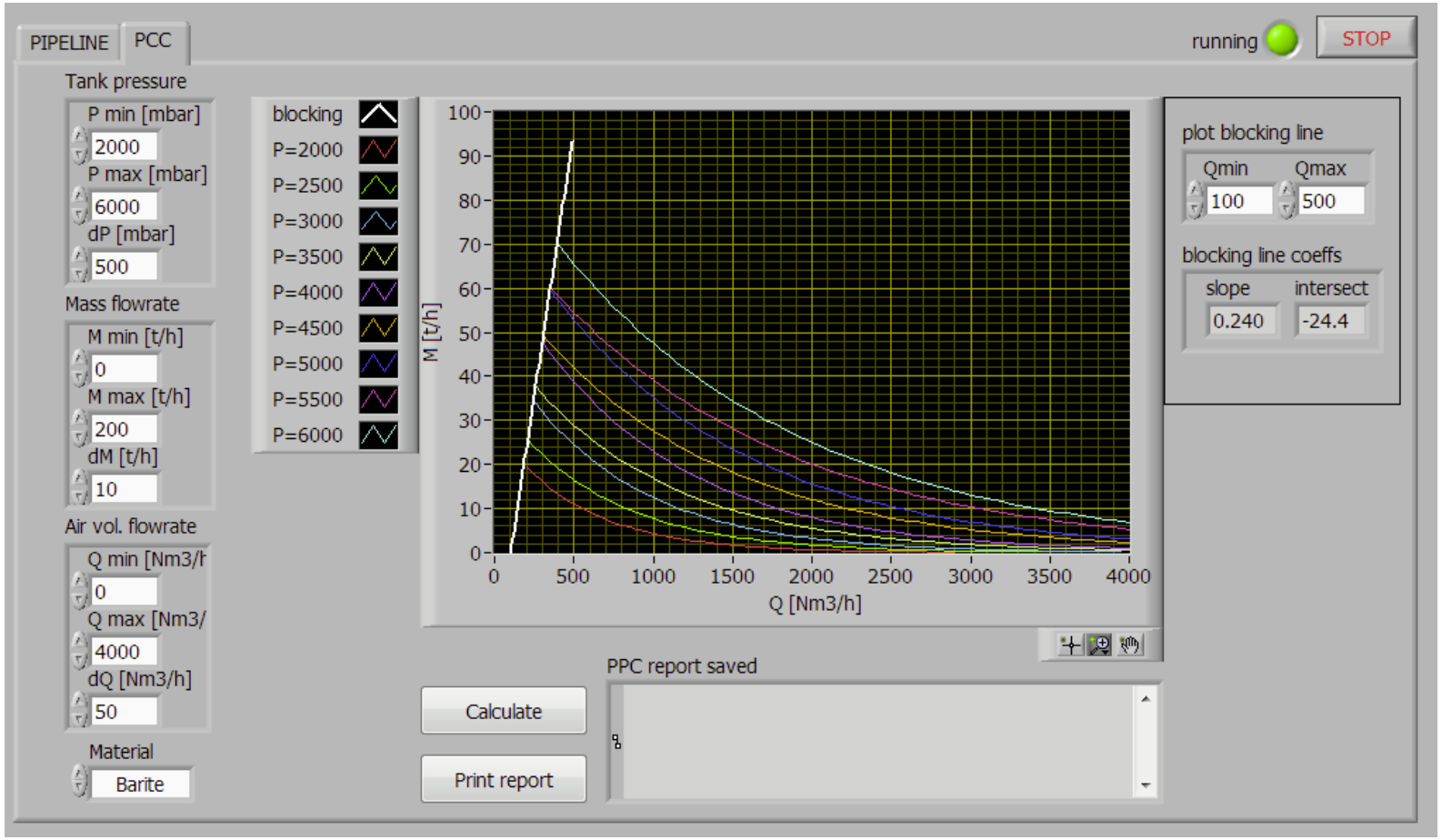
Calculation software



Optimise conveying parameters (air volume flow, system pressures, +++)

Define operating parameters to minimise MP generation

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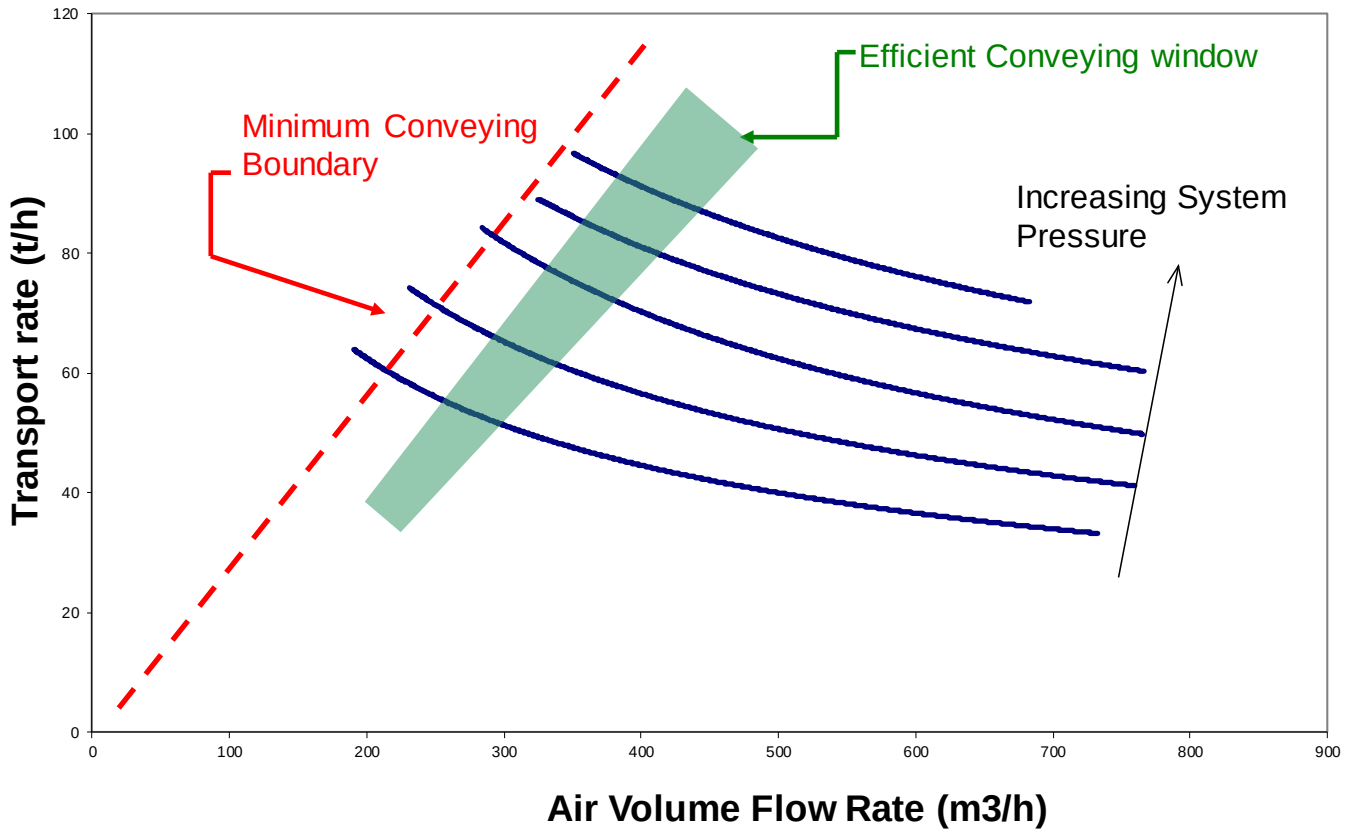
Conveying System Optimisation



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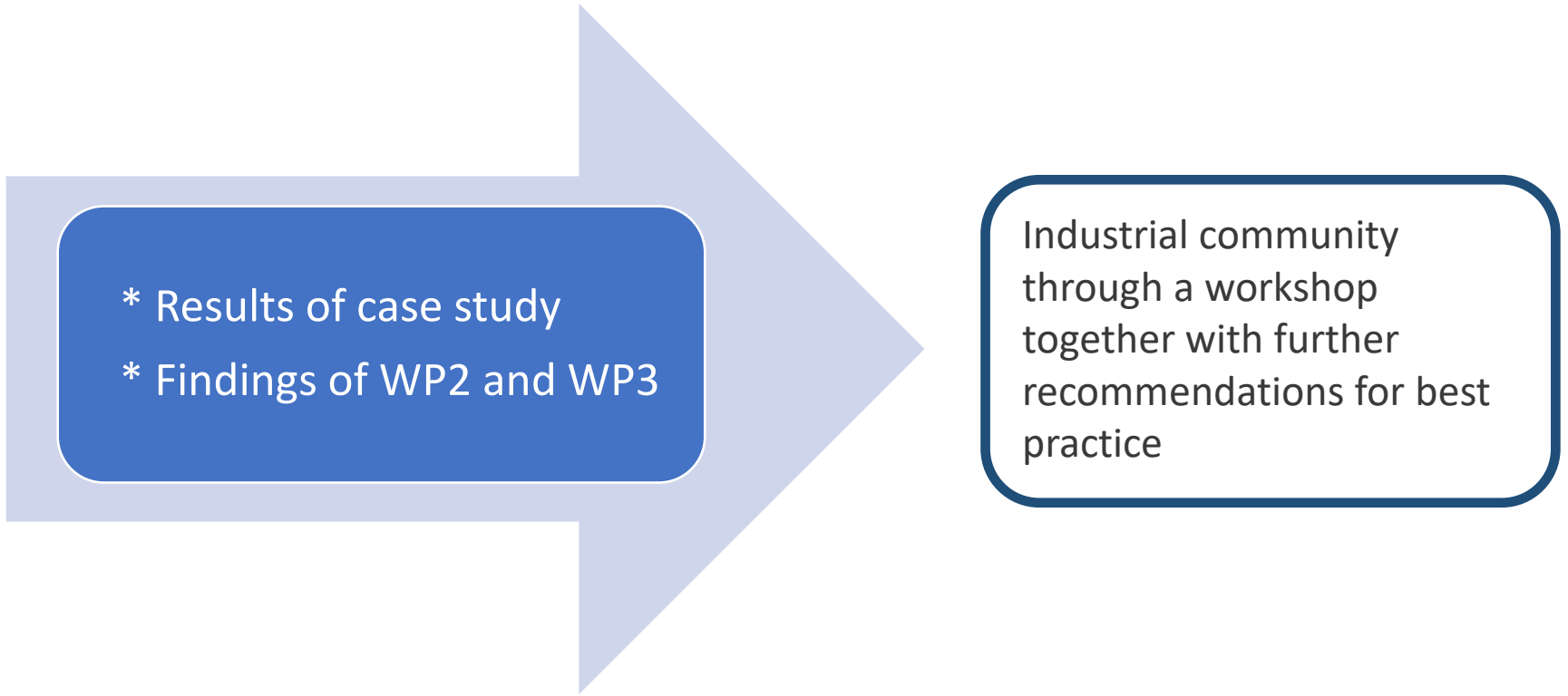
Outcome



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Thank you for your attention!

For more information about the project, please contact:

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