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CLIMATE RESILIENT COAST

GUIDANCE COMMITTEE CREST

15 January 2016, Oostende

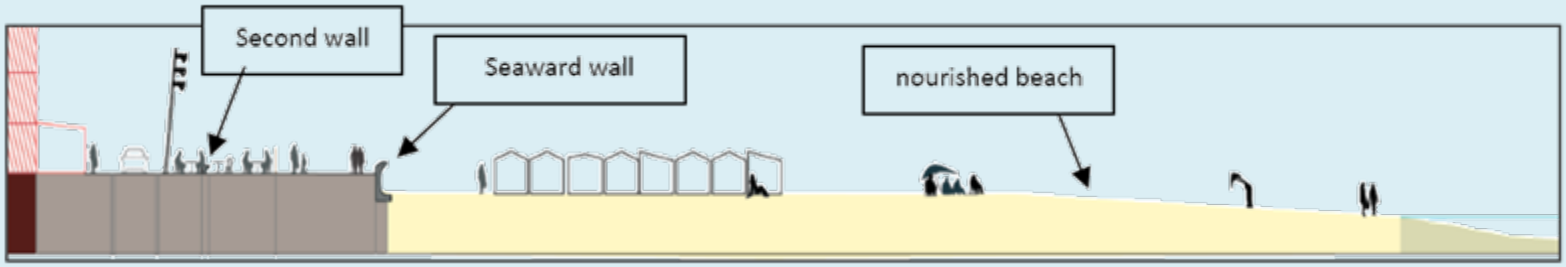
ACTIVITY 2:

Advanced modelling of overtopping risks in coastal urban areas

met de steun van

Overview ACT. 2

- **Knowledge gap** in the Integrated Master Plan for Coastal Safety
  - **typical Belgian sea defence system in urbanised coastal area** (*but wider applicable*): nourished beach in front of existing dike crest with buildings and/or storm wall(s)
  - **a more accurate tool to predict the wave induced overtopping and the wave loads on the structures** located on top of the crest of the sea dikes **is missing**.
    - coupling SWAN model + EurOtop formulae
    - no detailed info on individual overtopping volumes
    - out-of-range cross section for EurOtop overtopping manual
    - no effects of long waves, directional spreading, shallow water effects, wave obliqueness, dynamic beach profile during storm



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Overview ACT. 2

- **Knowledge gap** in the Integrated Master Plan for Coastal Safety
  - up to now, a **safety criterion** for overtopping is used, which can be significantly improved (q = 1 l/m/s) [requested by end-user government]
    - caused by inaccuracies in overtopping prediction (too conservative)
    - effect of individual overtopping volumes not included
  - assumptions regarding
    - **strength of (parts of) buildings on the sea dike and**
    - **behaviour of people inside these buildings**

    are not based on detailed modelling of wave-structure interactions, flow inside buildings, and risk for casualties in these extreme conditions.

- Improved understanding of the impact of overtopping discharges on buildings and existing infrastructure

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Objectives

- **General objective**
  - establish a prediction methodology for
    - wave overtopping,
    - wave impact forces for sea defences and
    - risk for casualties in buildings on the sea dike

    for the specific case of very shallow foreshores.

- **5 specific objectives**
  - WP1: A review of existing data and knowledge
  - WP2: Numerical modelling using a coupled CFD models approach
  - WP3: Validation using experimental model tests and using field measurements
  - WP4: Characterisation of the hydrodynamic forcing and the structural stability
  - WP5: Safety issues and socio-economic impact

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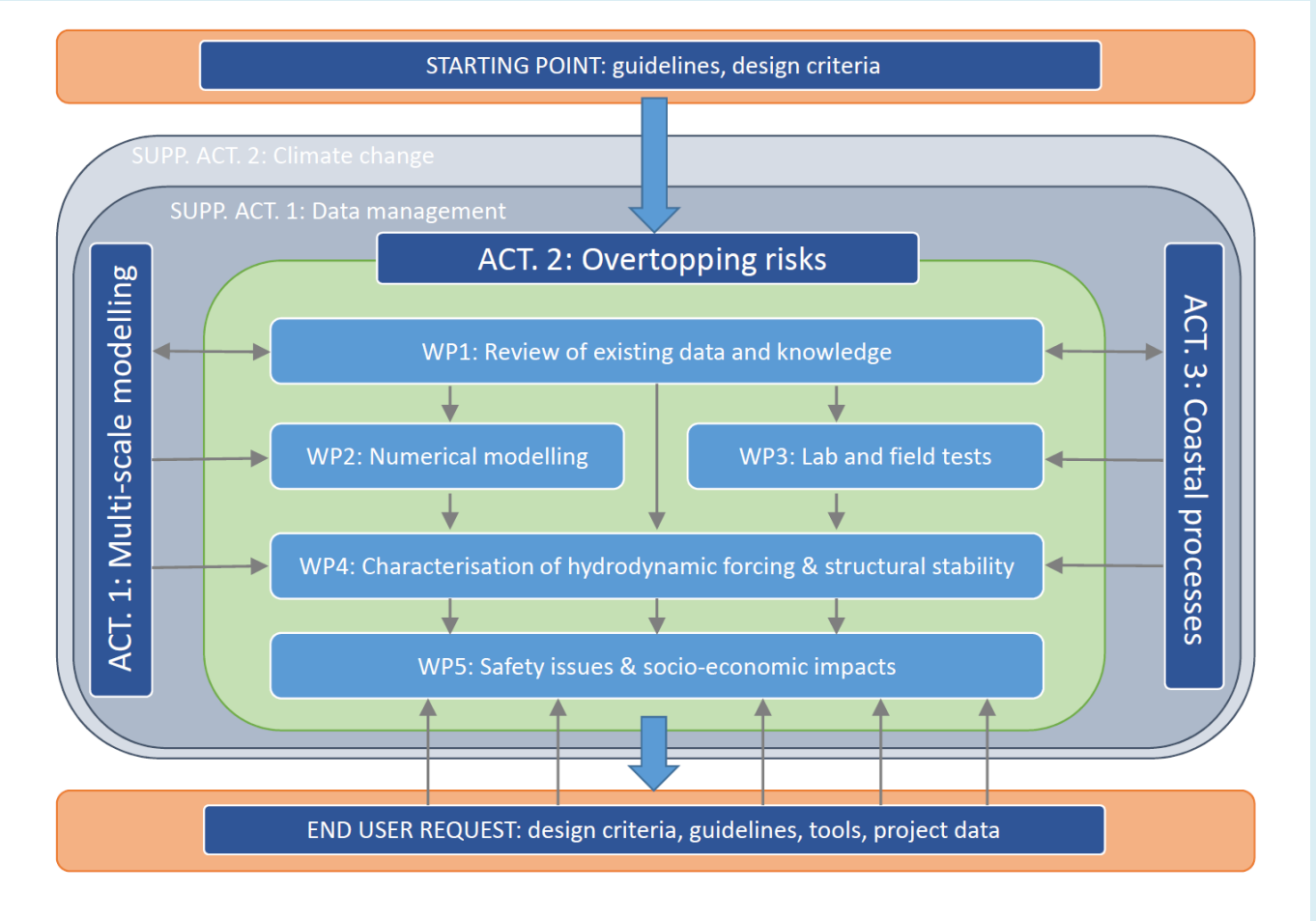
Workpackages ACT. 2



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Research questions (1)

- **WP1: Review of existing data and knowledge**
  - Task 1.1: REVIEW OF AVAILABLE PHYSICAL MODEL AND FIELD DATA SETS
    - physical (small and large scale) model tests and a field test (in Tielrode) **data**, available at Flanders Hydraulics and UGent, and used only in an ad-hoc design situation, **will be reviewed in the framework of the new approach**.
    - review of existing available numerical modelling tools for overtopping loads
  - Task 1.2: INTEGRATION OF COASTAL DIVISION EXPERT GROUP RESULTS AND ROADMAP
    - Coastal Division expert group has been investigating the existing knowledge of **wave-induced loading** and **structural resistance of existing buildings** for various overtopping volumes, with the objective to use these results in the upcoming review of the Master Plan Coastal Safety in 2015.
    - Coastal Division expert group will define a road map with their insights and ideas for this project. There results will be integrated in the project

END USER DELIVERABLE:
- insight in data sets and numerical models
- insight in physical processes
- integration of earlier work

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Research questions (2)

- **WP2: Numerical modelling using a coupled CFD models approach**
  - Task 2.1: **COUPLING** OF THE NUMERICAL MODELS WITH SWAN AND TELEMAC
    - **OpenFOAM**, **SWASH** and **DualSPHysics** will be coupled to **SWAN** at a location offshore, to provide the wave run-up and overtopping simulations over the beach profile towards the crest of the sea defence, delivering hydrodynamic parameters like surface elevations, layer thicknesses, flow velocities and pressure fields
    - in 2nd phase, **SWAN** will be replaced by **TELEMAC** developed in from Activity 1
  - Task 2.2: **VALIDATION** OF THE COUPLED CFD MODELS APPROACH (using data from literature and experimental tests in CREST project)
  - Task 2.3: **APPLICATION** OF THE COUPLED MODELS AND GUIDANCE ON THE MODEL SELECTION (← end user input on usage and act. 3 suggested scenarios)
  - Task 2.4: DEVELOPMENT OF **SEDIMENT TRANSPORT MODULE** IN OPENFOAM SOLVER
    - funding outside the SBO project

END USER DELIVERABLE:
- validated individual models and coupled model chain
- guidance on model selection
- model application to real test case

Research questions (3)

- **WP3: Validation using experimental model tests and using field measurements**
  - Task 3.1 VALIDATION BY EXPERIMENTAL TESTS IN 2D AND 3D
    - a limited set of small scale model tests will be carried out, with **focus on:**
      - **specific areas**: in the shallow water in front of the structure toe and near the crest of the coastal defence where the largest modelling inaccuracies are present
      - **unexplored effects** of long waves, directional spreading, wave obliqueness and shallow water effects
      - **only relevant tests** will be carried out, based on the outcome of the review from Task 1.1 (avoid overlapping tests).
  - TASK 3.2 VALIDATION BY FIELD MEASUREMENTS
    - Broersbank location near Koksijde will be shared with activity 1 and activity 3
    - artificial dike crest to increase (measurement of) overtopping frequency
    - installed and operated in close co-operation with the Vlaamse Baaien project
    - (re-)activate the **Oostende and Zeebrugge wave overtopping field measurements**
    - Supporting activity of Data Management

END USER DELIVERABLE:
- new data sets (2D & 3D model + field)
- new insight on unexplored effects
- field set-up usable for awareness campaigns

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Research questions (4)

- **WP4: Characterisation of the hydrodynamic forcing and the structural stability**
  - Task 4.1: CHARACTERISATION OF THE HYDRODYNAMIC FORCING
    - realise **synergy** between WP1-2-3 and activity 1-3 (using developed numerical tools)
    - description of (individual) wave overtopping volume(s)
    - description of layer thickness and velocities on the crest
    - determination of pressure distributions at and forces on storm walls
    - development of prediction tool for hydrodynamic forcing (← FOCUS here)
  - Task 4.2: CHARACTERISATION OF THE STRUCTURAL STABILITY
    - analysis of structural response due to wave overtopping AND a simple model for structural failure prediction
    - organisation of mid-term international expert workshop on structural failure issues to discuss the obtained results on overtopping and loading up to this date
    - use results from Task 1.2 (national expert group) and 4.2 (international expert group) to establish impact research plan (aiming at acquiring multi-disciplinary fundamental research funding and partners in longer term)

END USER DELIVERABLE:
- insight in processes
- prediction tool for wave impact and for structural response
- tool to support coastal planning issues

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Research questions (5)

- **WP5: Safety issues and socio-economic impact**
  - Task 5.1: SAFETY OF PEOPLE / CASUALTIES UNDER EXTREME OVERTOPPING
    - desk study on safety of people inside buildings on sea dikes in overtopping and flow conditions
    - detailed CFD modelling of the flow inside the building
    - detailed characterisation of the behaviour of persons residing in these buildings
    - investigate scenarios of flooding by overtopping
    - proposal for a revised technical standard based on the policy standard of the Flemish Government to not allow casualties in coastal towns under conditions of extreme overtopping caused by a 1000y superstorm
  - Task 5.2: *next slide*

Research questions (5)

- **WP5: Safety issues and socio-economic impact**
  - Task 5.2: RISK MODELLING OF SOCIO-ECONOMIC IMPACT OF COST OF FLOODING ON THE FIRST BUILDING BLOCKS LINE

    objective:
    - **developing** damage and risk **prediction model of flooding** for the first urban construction line
    - **taking in account effects** such as macro 3D building models, water depth/height models, hydraulic data, detailed socio-economic data …
    - using **3 test sites**, selected together with stakeholders from the Belgian coastal communities and the project partners

(1) **analysis** of building interiors in a hydrodynamic context in connection with socio-economic aspects (construction typology as f(*hydrodynamic response*), functions, occupation type and characteristics, time dependency, …);

(2) **conceptual model** for calculation of (maximum) damage 'maps' and risk 'maps' (including analysis of uncertainty);

(3) **developing methodology** for functional classification of the coast line building blocks.

covering whole range between offshore and buildings on crest to support the safety criterion evaluation

END USER DELIVERABLE:
- tool for socio economic impact assessment
- support for risk modelling
- support/basis for safety criterion evaluation and/or optimisation
- guidance for building construction and evacuation

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Impact

- Acknowledged **optimization of the current policy** on coastal defense measures

- These models will facilitate **the development of better criteria** (now q = 1 l/s/m is used) for coastal safety in case of a 1000yr superstorm, given the requirement no casualties are acceptable (norm in Masterplan Kustveiligheid).

- Facilitate the development of **additional measures for flood risk management**:
  - evaluating the **failure risk of buildings** as part of the sea defence,
  - the **evacuation of persons staying in the buildings** on top of the sea defences,
  - establishing **specifications on building regulations** to make buildings on top of sea defences more resistant to overtopping waves and/or regulate the use, especially for ground floors / cellars

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