



Innovative CAFM solutions for the inspection and management of bridges

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- 3. An overview of innovative concept

► Part B.

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- 2. Platform
- 3. Mobile application





1. Background to the project idea

- 2011-2013: Irish Rail Bridge Scour Management Programme
 - Development of methodology for bridge scour inspection for Irish Rail
 - Bridge Scour Inspections for various bridges
 - Design of scour protection measures
- 2009-2014: Croatian Railways
 - Bridge collapse on the Sava River in 2009
 - Detailed inspections and recommendations
- 2009-2012: Irish Rail Malahide Viaduct Reinstatement
 - Investigation of a root cause of bridge collapse
 - Hydrology, Hydraulic, Morphology, Environment









Statistic of bridge failures in USA (Biezma 2007)

A 83% of all bridge collapses due to the natural causes.
 A 58% of failures due to bridge scour (flooding).



■ Hydraulics ■ Collision ■ Overload ■ Fire ■ Earthquake ■ Deterioration ■ Other June 16, 2021





Why such a large share?

- Bridge scour is complex issue (hydrology, hydraulics, sediments, geotechnics, construction, materials).
- Floods are low probability / high consequence events.
- ► Standards for bridge scour inspections:
 - Too little information (DANBRO = a single component) and no requirements for river surveys (underwater inspections)
 - Too much information (BA74/06 = requires foundation depth) to obtain scour condition rating (foundation info on cca 20% IE bridges)
- ▶ In-house (asset owners) expertise on scour is low.
- Aging infrastructure vs. climate change.
- ► Lower budgets for inspection, maintenance and management.

What is a key element for scour safer bridge?"



Efficient management of information! (our experience)



Elements of efficient information management

- A. Process of information collection (bridge inspection)
 - o not too many, not too little
- B. Quantitative rating
 - o less subjectivity, comparable
- C. Proactive maintenance
 - monitoring + flood early warning
- D. Efficient storage and information connectivity (database)
- E. Information presentation
 - o reporting, viewing, BIM





2. BRIDGE SMS project details

- "Intelligent Bridge Assessment Maintenance and Management System" is an EU Marie Curie FP7 project, under the Industry Academia Partnerships and Pathways (IAPP).
- ▶ Budget: € 1.418.821
- Project partners:





3. An overview of innovative concept





A. New Standardised Inspection and Evaluation of bridge scour

- Guidelines include
 - Optimised structural inspection
 - New scour inspection process
- Two types of bridge structures
 - Level 1, simple structures
 - Level 2, complex structures
- Two different Condition Rating
 Structural, StCR:0 to StCR:5
 - Scour, ScCR:0 to ScCR:5





B. New Mobile App for bridge inspection

- Structural and Scour Inspection.
- Evaluation of
 - Condition rating
 - Maintenance costs
 - Time to next inspection
- Photo documentation and notes.
- Syncronisation with database for storage and Inspection Report.







C. Flood and Scour Early Warning System

- A flood and scour forecasting system.
- Magnitudes and locations of floods up to 10-days in advance.
- Operational and fully automated forecasting system for bridges in the Bandon River catchment.
- Delft-FEWS platform on 94 subcatchments.
- ▶ Proactive approach.





Meelon bridge



Baxters bridge Ahakeera bridge



D. New real-time monitoring system

- Weather monitoring WILD device (rain, temperature, soil moisture).
- Water level monitoring BIRD device.
 - Atmel microcontrollers
 - Telemetry
 - $_{\circ}$ SD card module
 - RTC module
 - IP67 certified casing







E. Effective database and software platform

- The platform modules: bridge inventory, inspection module, maintenance, monitoring, flood forecasting and decision support.
- The platform can be easily integrated with other systems.
- Web-based access
- ► GIS and BIM support





IoT

- Hardware development universal data logger
- ► Limitations:
 - ► No budget for commercial solution
 - No knowledge / experience with IoT
 - Control over development / changes
- ► From 0 -> working solution:
 - ► 3 prototype stages







- ► First prototype unit in the making
- based on Arduino Mega board
- ▶ 3D printed housing
- External battery module
- ► Too much wiring
- not waterproof (seals)
- Insufficient battery









Prototype unit 1 mounted at Quarry, Ireland







Prototype unit 2 during development

- Custom and hand made PCB
- Based on Atmega microcontroller
- Less wiring
- First attempt to make a custom solution







Prototype unit 3 during development

- After confirming that the hand made PU2 was working
- PCB design was sent to a PCB manufacturer for production
- Optimised power consumption
- Optimised modules







- Working prototype data logger
- ► Characteristics:
- Based on Atmel microcontrollers
- Using GSM network for data transmission on servers
- ► Using SD card for data storage
- Internal clock for time management
- ► IP67 protection
- PCB designed in-house / professionally manufactured
- MQTT protocol





WILD - Weather Information Logging Device

IoT

- ► Characteristics:
- ► Air temperature measurement
- ► Air moisture measurement
- Soil moisture measurement
- Rainfall measurement
- 5V power source (smartphone charger)
- ▶ Reserve battery for 10 days









- WILD mounted in a IP67 case during testing (on the right is the temperature/air moisture sensor in its housing)
- IP67 sealed connectors (below)











IoT





BIRD – Bridge Information Recording Device

IoT

- ► Characteristics:
- Water level measurement
- Ultrasonic sensor for water level detection
- Contactless measurement
- Solar panel power management
- Accu battery for 30 days of work



IoT

- Prototype unit 1 during development
- ► First prototype
- Based on Arduino Mini board
- ► No 3G connectivity
- No SD card
- Proof of concept









- Prototype unit 2 during development
- Based on Atmega microcontroller
- Hand wired
- Includes all the features of a final product
- Includes 3 sonar sensors for accuracy testing at Faculty of Civil Engineering University of Zagreb



IoT



Prototype unit 3 during development

 Board assembled after PCB manufacturing









- Prototype unit 3 during development
- Assembled IP67 casing containing:
 - ▶ BIRD3 board
 - ► Solar battery
 - ► Solar regulator



















Bridge SMS platform





Modules, functionalities, technologies



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Intelligent Bridge Assessment Ma

Geographical hierarchyInfrastructure assets



June 16, 2021

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Intelligent Bridge Assessment I



► Bridge inventory

Structural / hydrological elements

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Requests / Surveys / Inspection history

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C06	
C07	
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Monitoring data

 Information from WILD / BIRD

- Analysis
- ► FEWS

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WILD - Informations from sensors						⊠Ă
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ForecastingFEWS





Mobile app

► Inspections application

Connection to the platform (RESTful api)

RIDGE OVERVIEW BRIDGE QUESTIONNAIR	GENERAL BRIDGE INFORMATION STRUCTURAL INVENTORY
Bridge Name	County
bridge	County Cork
PP Bridge Over Water?	Maintaining Agent
Yes	Cork County Council
Latitude	Infrastructure Label
51.876404	L4234
Longitude	Structure ID
-8.470124	CC-L4234-999.99
Region	
Munster	
Bridge Elevation Image	Bridge structure identification



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Mobile app

- Inventory / Inspections module
- Structural
- ► Scour



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L1 Scour Inspection				
PHOTO DOCUMENTATION	COMPONENT INFO	MAINTENA	NCE COST	SCOUR SUMMARY
Component		s	tate	
River bed material	А	В	С	
Debris accumulation potential	А	В	С	
Embankment fill state	А	В	С	D
Scour state at the bridge	А	В	С	D
Protection state at the bridge	Α	В	С	D
Scour state away from the bridge	Α	В	С	D
Protection state away from the bridge	А	В	С	D





Mobile app

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- Summary / Report
- ► Bridge questionnaire

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C03 Deck / Slab /	Arch Barrel		
CO6 Walls			
C07 Abutments			
C06 Walls C07 Abutments			





THANK YOU FOR YOUR ATTENTION!

www.bridgesms.eu

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