TU1406
COST ACTION

WG MEETINGS & WORKSHOP

An overview of Key Performance Indicators across Europe and Overseas
The main findings from WG1 and other contributions from WG2 and WG3

DEVELOPMENT OF THE BRIDGE MANAGEMENT SYSTEM UNDER THE PROJECT BRIDGE^{SMS}

http://www.bridgesms.eu/

Vikram Pakrashi - University College Cork, MaREI, Ireland
Eamon McKeogh - University College Cork, MaREI, Ireland
Igor Kerin - University College Cork, MaREI, Ireland **igor.kerin@ucc.ie**
Sean McAuliffe - University College Cork, MaREI, Ireland
Damir Bekić - University of Zagreb, Faculty of Civil Engineering, Croatia

UCC University College Cork, Ireland Coláiste na hOllscoile Corcaigh

Cork County Council Comhairle Contae Chorcaí

NIVAS®

Infraestruturas de Portugal Ligamos destinos

30th March - 1st April 2016
Belgrade, Serbia

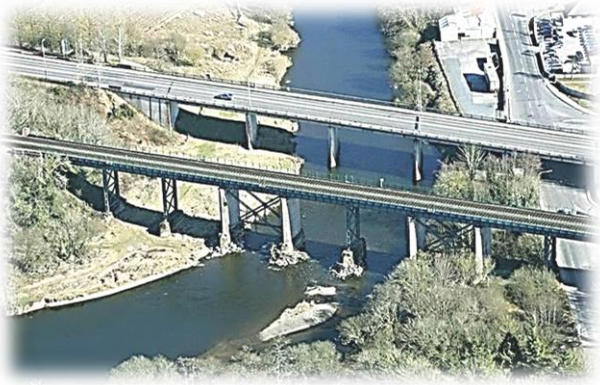
OVERVIEW

- Background
- Introduction
- Summary of Bridge SMS
- Methodology and Approach
- Innovative features
- Dissemination of the Bridge SMS

BACKROUND

Collaboration between UCC and UNIZAG evolved as a result of a major railway bridge collapse at Malahide on the main Dublin to Belfast line in August 2009 as a passenger service passed over the Malahide Viaduct.

UCC carried out inspections and assessments of more than 100 railway bridges in Ireland (Bekic et al., 2012) and have carried out inspection, testing and assessments for around 250 road bridges in Ireland working closely with the National Roads Authority and the County Councils



BACKROUND

bridge^{sms}
Intelligent Bridge Assessment Maintenance and Management System

- BridgeSMS Project partners

Project partners

UCC
University College Cork, Ireland
Coláiste na hOllscoile Corcaigh

Cork County Council
Comhairle Contae Chorcaí

NIVAS®

Infraestruturas de Portugal
Ligamos destinos

Supporting institutions

NRA
An tÚdarás um Bóithre Náisiúnta
National Roads Authority

Universidade do Minho
Instituto de Educação

Comhairle Contae Átha Cliath Theas
South Dublin County Council

Dublin City
Baile Átha Cliath

BACKROUND

bridge^{sms}
Intelligent Bridge Assessment Maintenance and Management System

End-User (CCC, INFPO) - Bridge owner and network operator
- Expertise in day to day management of bridge structures over rivers
- End User perspective
- Test-bed for new system development

UniZag - Academic Experts
- River hydraulics
- Computer simulations of river and bridge modelling
- Scour protection measures

Nivas - Software Developers
- Software platfrom experts
- New software system integration
- Open Source experts

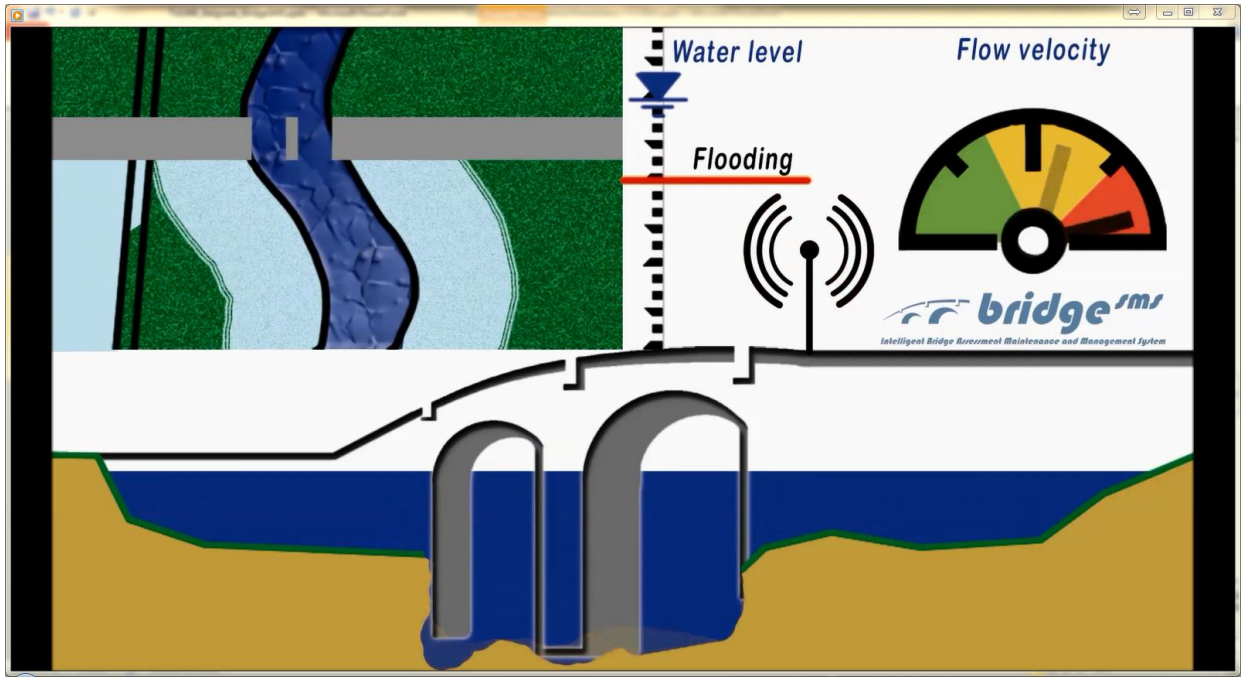
UCC - Academic Experts
- River hydrology & hydraulics
- River & bridge modelling (scaled physical modelling)
- Foundation engineering
- Scour protection design & installation
- Risk modelling and quantification
- Foundation and Structural Engineering

Intelligent Bridge Management System

BRIDGE-SMS

INTRODUCTION

- Bridge scour



[Bridge SMS youtube channel]

https://www.youtube.com/watch?v=6GrFwF1rXEU

SUMMARY OF bridge sms

- What is Bridge^{SMS}?

bridge sms
Intelligent Bridge Assessment Maintenance and Management System

SEVENTH FRAMEWORK PROGRAMME
MARIE CURIE ACTIONS

- "Intelligent Bridge Assessment Maintenance and Management System" (Bridge SMS) (Grant no: 612517) is a European Commission, Marie Curie 7th Framework Programme funded Project, under the Industry Academia Partnerships and Pathways (IAPP) call: FP7-People-2013-IAPP.
- Bridge SMS is a software application that empowers engineers and key personnel to predict, identify and prepare for potentially destructive flood events. It is robust and efficient tool designed to lower maintenance/planning costs and to provide more secured bridge management/operation.
- Project length: 4 years
- Project start: January 2015

WP	Work package title
WP 1	WP 1 Management
WP 2	WP 2 Technical Research
WP 3	WP 3 Development of Bridge Scour Management System
WP 4	WP 4 Knowledge Transfer and Training
WP 5	WP 5 Dissemination and Commercialisation

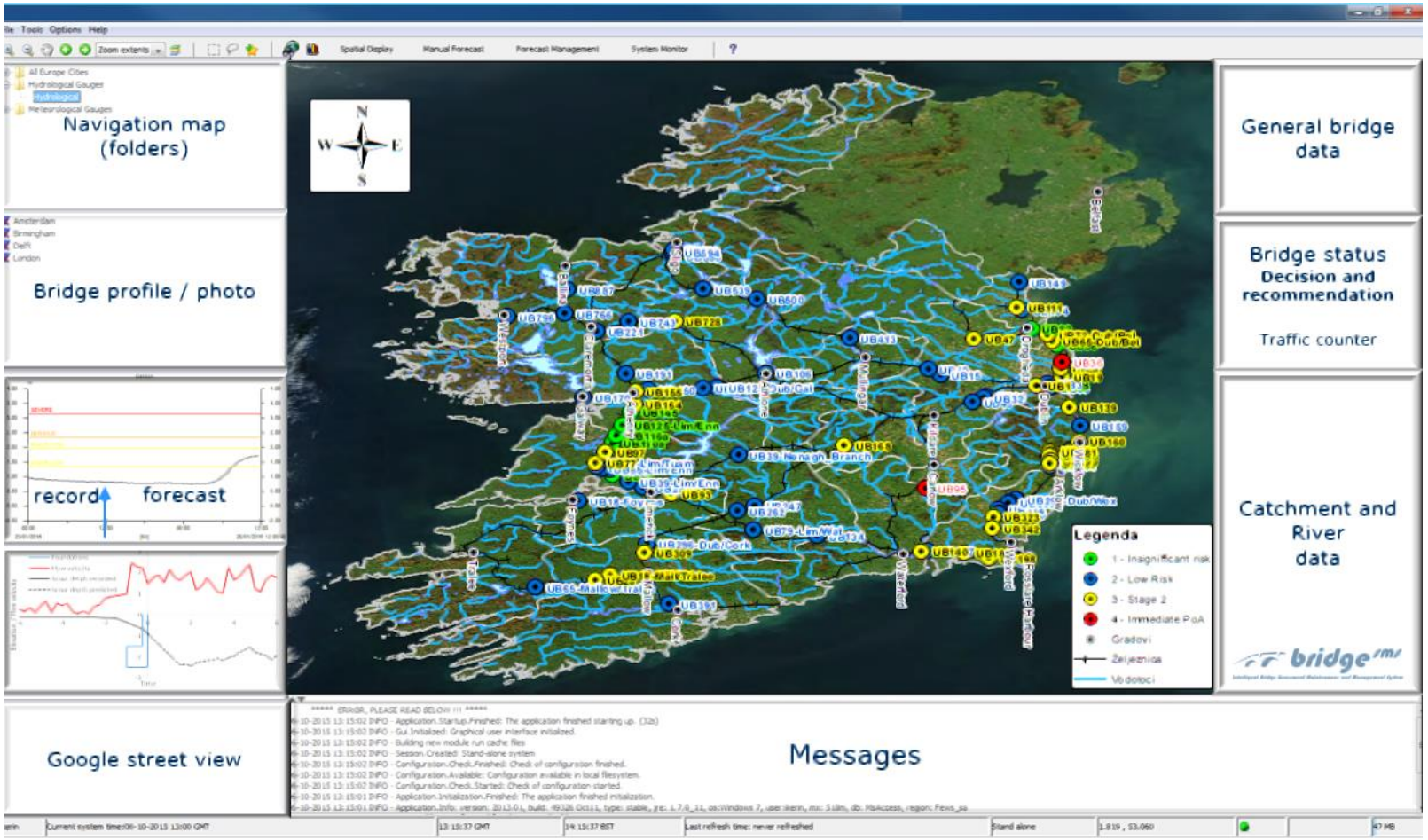
SUMMARY OF bridge sms

Bridge SMS uses structural engineering, geotechnics, hydraulics, hydrology, materials and transport management. Bridge SMS key goals:

1. To develop standardised methods for bridge scour inspection.
2. To develop standards for bridge assessment and management.
3. To calculate the risk of and manages the potential effects of flood events.
4. To develop a database framework which is designed for intuitive use, encouraging participation by personnel at all levels within management authorities.
5. To develop a system that
   - collects integrates and processes real-time data at regular intervals from weather and hydrologic sources, meters and gauges, and other sensing devices.
   - will rapidly notify based on in-built intelligence and decision-making processes, relevant personnel of possible maintenance and failure issues.
   - will advise in relation to current Scour Risk at bridge structures and prompt an appropriate Plan of Action (POA) which may involve various levels of maintenance and repair.
   - which will prioritize and optimize the operational and maintenance budget spend for infrastructure companies.
6. Maximum use of new Information and Communications Technology (ICT) hardware such as tablets and cloud-based systems for on-site rapid communications, etc.

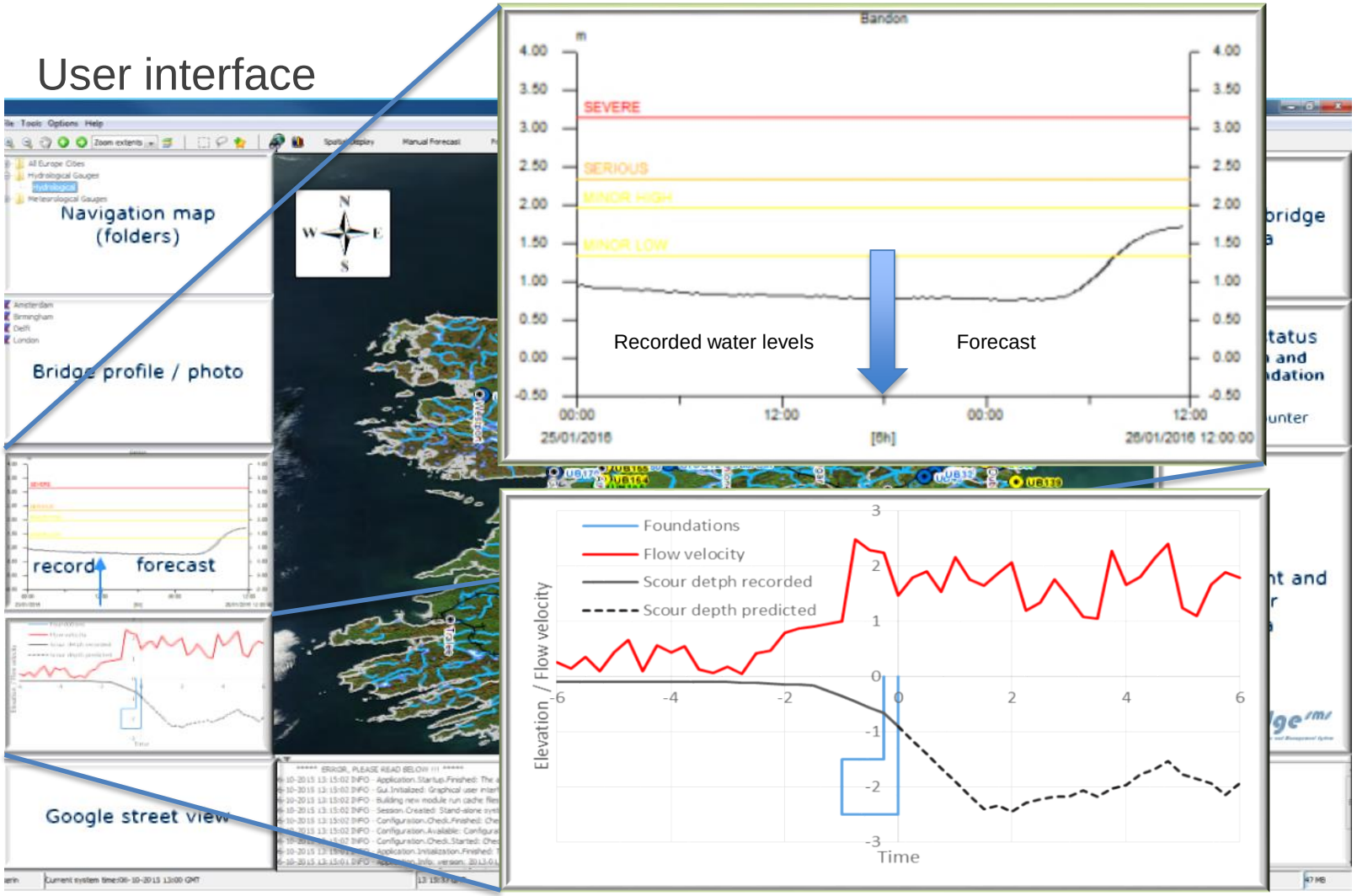
SUMMARY OF bridge sms

- User interface



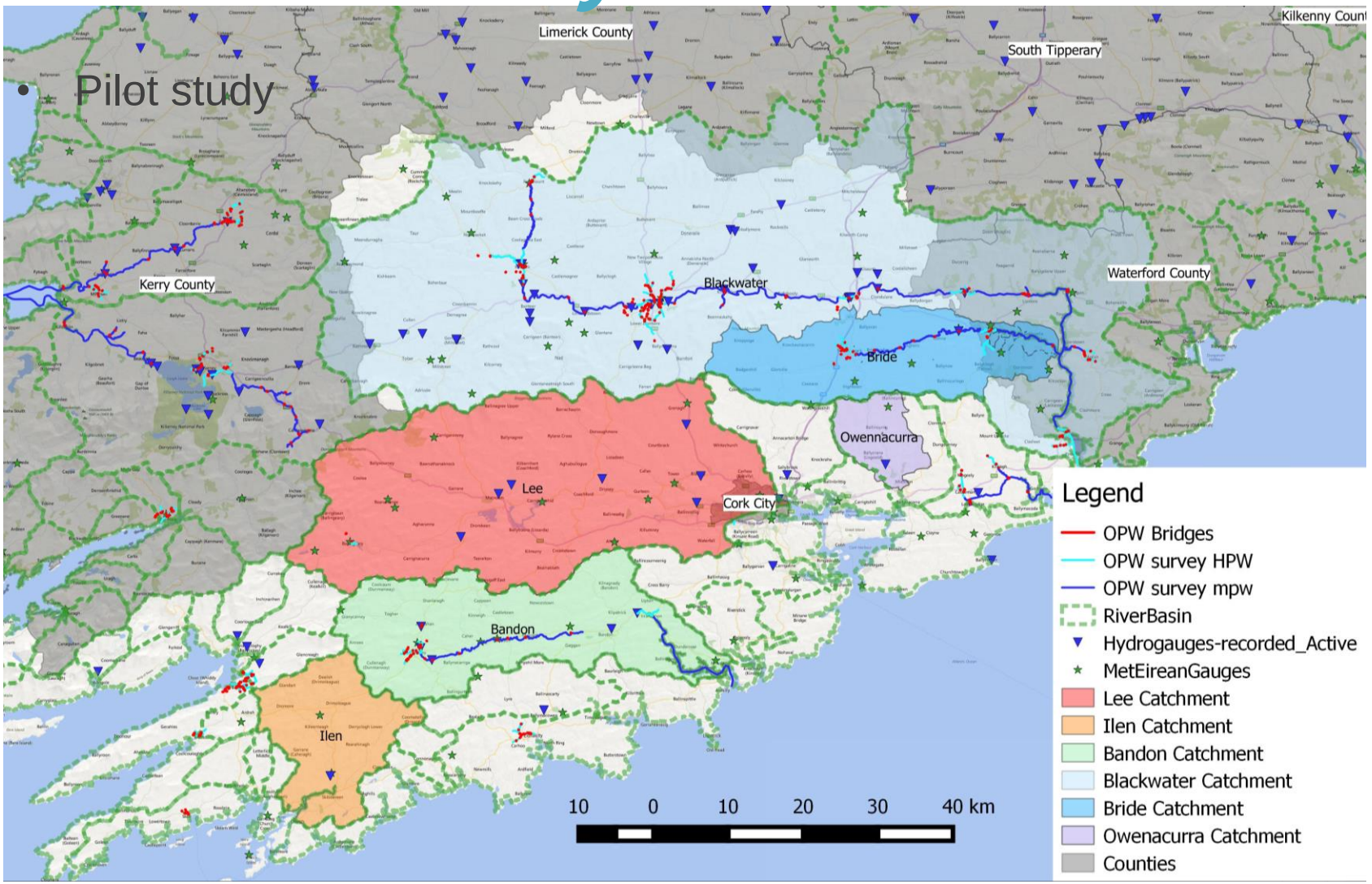
SUMMARY OF bridge sms

- User interface

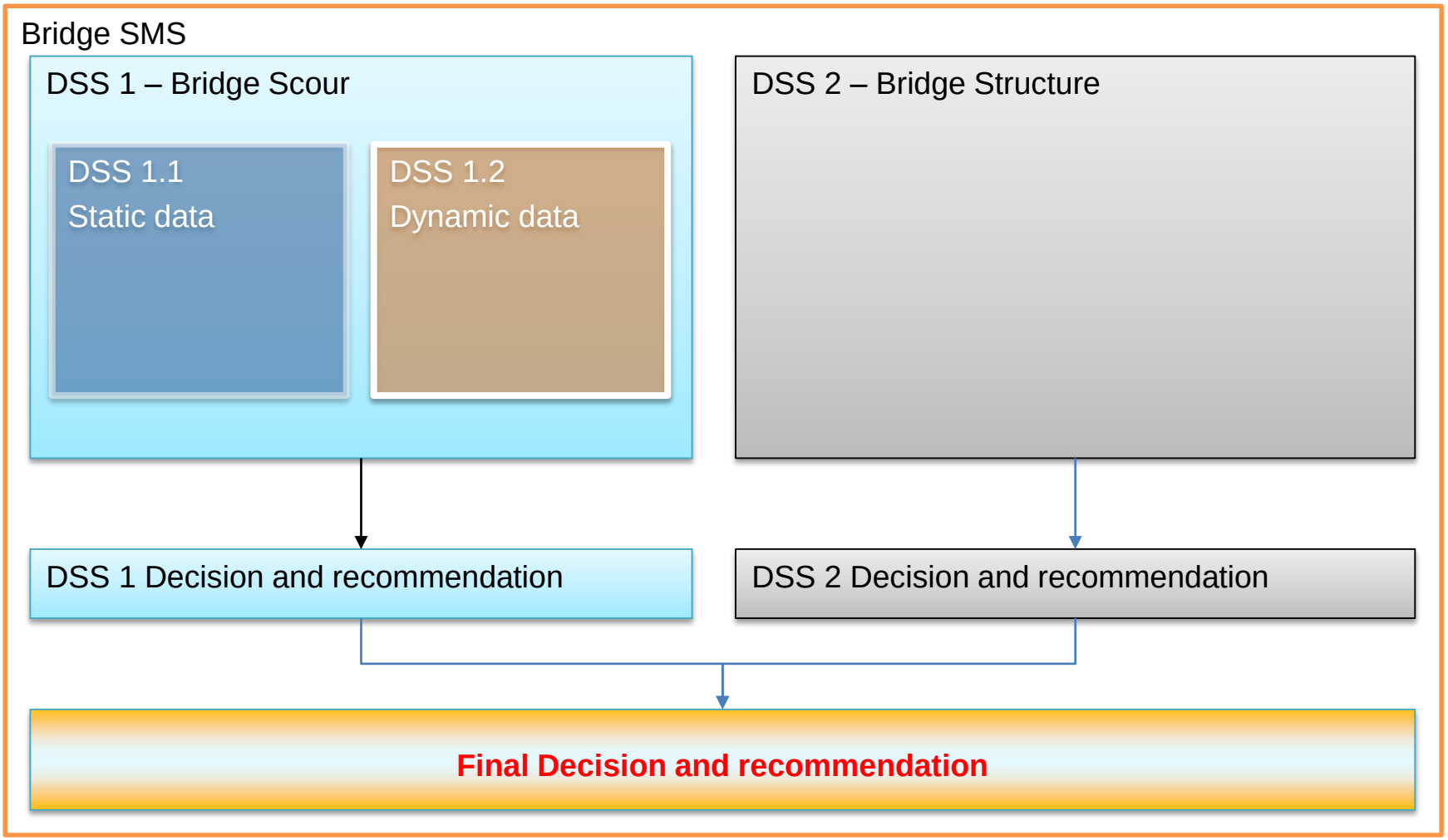


SUMMARY OF bridge sms

- Pilot study



METHODOLOGY AND APPROACH



APPROACH

a. QUALITATIVE scour risk QR

Derived from a qualitative risk matrix

Product of $QR = L \times S$

- L, *Likelihood of occurrence of hazardous event*
- S, *Severity of hazard consequence*

4 classes of scour risk

Likelihood (L) and Severity (S) are obtained from the HYRISK methodology in the NCHRP report.

Qualitative Risk Matrix

Likelihood of occurrence of hazardous event						
	Frequent The hazard will occur on a regular basis during the life of the asset / process / system / procedure. The hazard will be continually experienced	10	10 *Undesirable*	20 *Intolerable*	30 *Intolerable*	40 *Intolerable*
	Probable The hazard will occur several times during the life of the asset / process / system / procedure. – The hazard will occur often	7	7 Tolerable	14 *Undesirable*	21 *Intolerable*	28 *Intolerable*
	Occasional The hazard will occur a number of times during the life of the asset / process / system / procedure. – The hazard will occur infrequently	5	5 Tolerable	10 *Undesirable*	15 *Undesirable*	20 *Intolerable*
	Remote The hazard is likely to occur at some time during the life of the asset / process / system / procedure.	4	4 Negligible	8 Tolerable	12 *Undesirable*	16 *Intolerable*
	Improbable The hazard is unlikely to occur but possible at some time during the life of the asset / process / system / procedure– the hazard may occur in exceptional circumstances	2	2 Negligible	4 Negligible	6 Tolerable	8 Tolerable
	Incredible The hazard is extremely unlikely to occur during the life of the asset / process / system / procedure	1	1 Negligible	2 Negligible	3 Negligible	4 Negligible
			1	2	3	4
Severity of hazard consequenc	**Description**		**Insignificant**	**Marginal**	**Critical**	**Catastrophic**
	Consequence to persons		Possible minor injury	Minor injury	Single Fatality or severe injury	Fatalities or multiple severe injuries
	Property loss and environmental Consequence		€20k	€200k	€2m	€20m

METHODOLOGY AND APPROACH

- Likelihood of occurrence *L* depends on the *Lifetime Risk of Scour Failure* (P_{LT}).

- $P_{LT} = 1-[1-P_A]^{LT}$
  - P_A is annual probability of scour failure
  - LT is provisional life of a bridge (100 years)

- Annual probability *PA*
  - Function of Overtopping frequency and Scour vulnerability.

Lifetime Risk of Scour Failure P_{LT}	*Likelihood of occurrence of hazardous event L*
1	10
0.999 - 0.400	7
0.399 - 0.100	5
0.099 - 0.010	4
0.009 - 0.001	2
<0.001	1

Table 14. NBI Annual probability of scour failure P_A.

Scour Vulnerability *(from Table 14)*	**Overtopping Frequency**		
	Remote (R)	*Slight (S)*	*Occasional (O)*
(0) Failed	1	1	1
(1) Imminent failure	0.01	0.01	0.01
(2) Critical scour	0.005	0.006	0.008
(3) Serious scour	0.0011	0.0013	0.0016
(4) Advanced scour	0.0004	0.0005	0.0006
(5) Minor scour	0.000007	0.000008	0.00004
(6) Minor deterioration	0.00018	0.00025	0.0004
(7) Good condition	0.00018	0.00025	0.0004
(8) Very good condition	0.000004	0.000005	0.00002
(9) Excellent condition	0.0000025	0.000003	0.000004

METHODOLOGY AND APPROACH

- Presented as value of money in €.
- HYRISK equation the total cost of bridge failure

$$Cost = C_1 eWL + \left[C_2 \left(1 - \frac{T}{100} \right) + C_3 \frac{T}{100} \right] DAd + \left[C_4 O \left(1 - \frac{T}{100} \right) + C_5 \frac{T}{100} \right] \frac{DAd}{S}$$

–Cost - total cost of bridge failure (€)
–*C*- unit rebuilding cost from (€/m)
–*e* - cost multiplier for early replacement based on average daily traffic
–*W* - bridge width from NBI item 52 (m)
–*L* - bridge length from NBI item 49 (m)
–*C*- cost of running automobile from (i.e. €0.22/km)
–*C*- cost of running truck from (€1.02/km)
–*D* - detour length (km)
–*A* - average daily traffic (ADT) from NBI item 29
–*d* - duration of detour based on ADT from (days)
–*C*- value of time per adult in passenger car (€/h)
–*O* - average occupancy rate
–*T* - average daily truck traffic (ADTT) form NBI item 109 (10% of ADT)
–*C*- value of time for truck (€22.01/hr)
–*S* - average detour speed (typically 64 km/h)

METHODOLOGY AND APPROACH

b. QUANTITATIVE scour risk

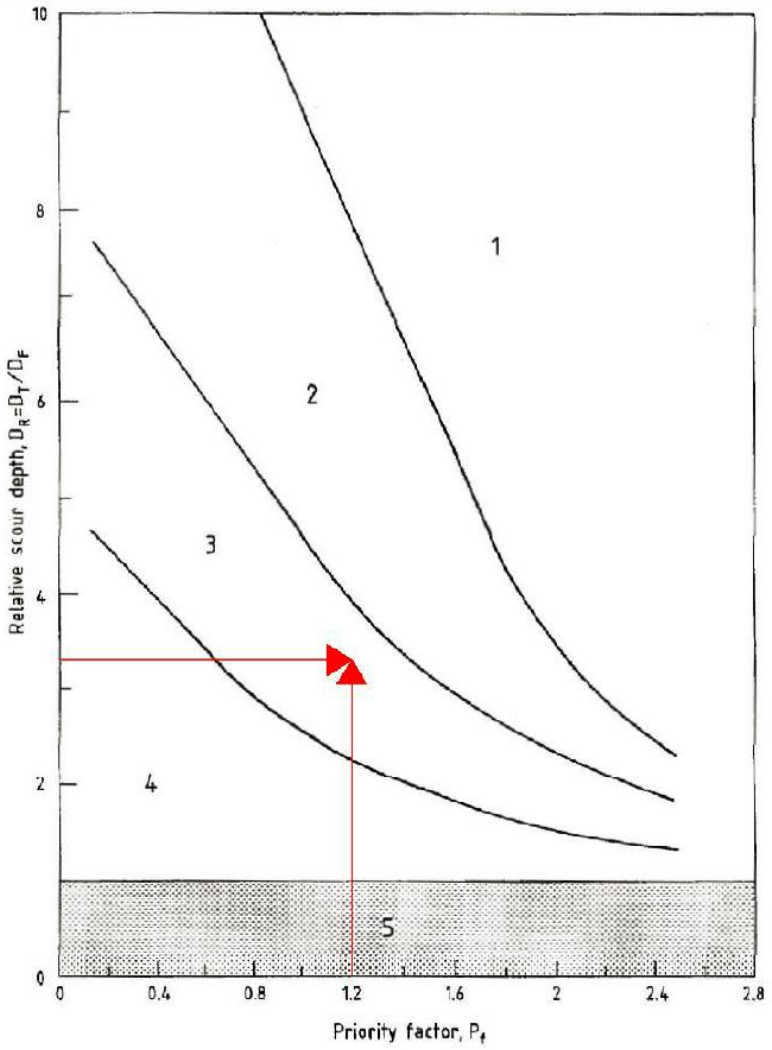
- PRIORITY RATING (PR)
- Relative scour depth

$$D_R = D_T / D_F$$

  - D_T = total depth of foundation
  - D_F = depth of foundation
- Priority factor

$$P_f = F \cdot H \cdot M \cdot T_R$$

  - foundation type factor F
  - history of scour problem factor H
  - foundation factor M
  - type of river factor T_R



METHODOLOGY AND APPROACH - Mitigation measures

1. Inspections

- Two frequencies of Bridge inspections: after major floods or regular re-inspections.

2. Maintenance

- Minor works at and around the bridge
- Further studies are not required.

3. Bridge monitoring

- Implementation of procedures and tools for detailed monitoring of scour at the bridge site.

4. Studies and investigations

- More detailed studies and investigations undertaken by engineers specialising in the study of river engineering and scour problems

5. Scour protection works

- Scour reduction measures to improve flow conditions at a structure (streamlining of piers, river training, etc)
- Structural measures to withstand the predicted depths of scour, (underpinning foundations, reinforcement and extension of foundations, sheet piling, etc)
- Scour protection measures (riprap, gabions, etc)

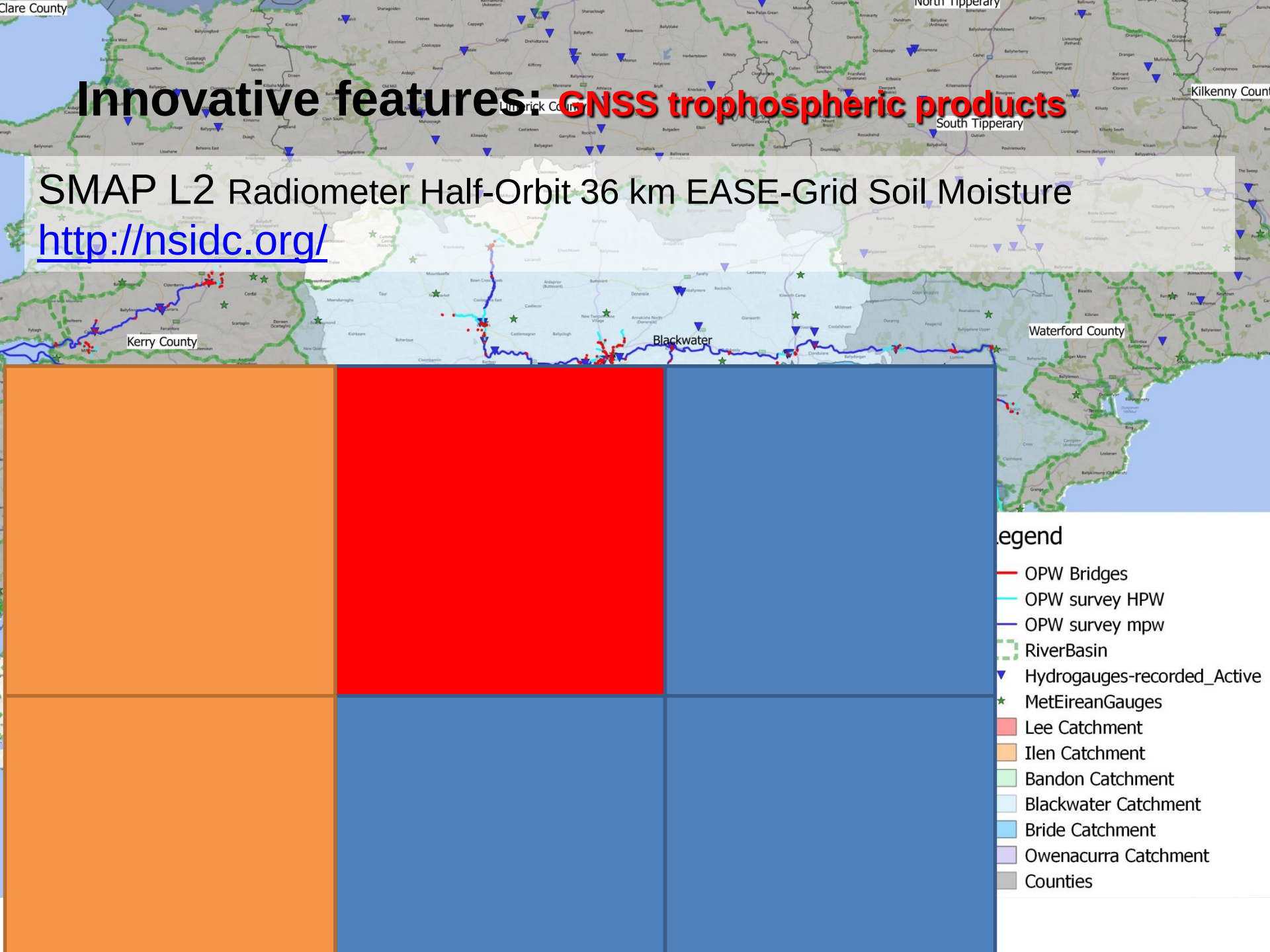
6.Bridge replacement works

- Significant works for partial or complete replacement of the bridge

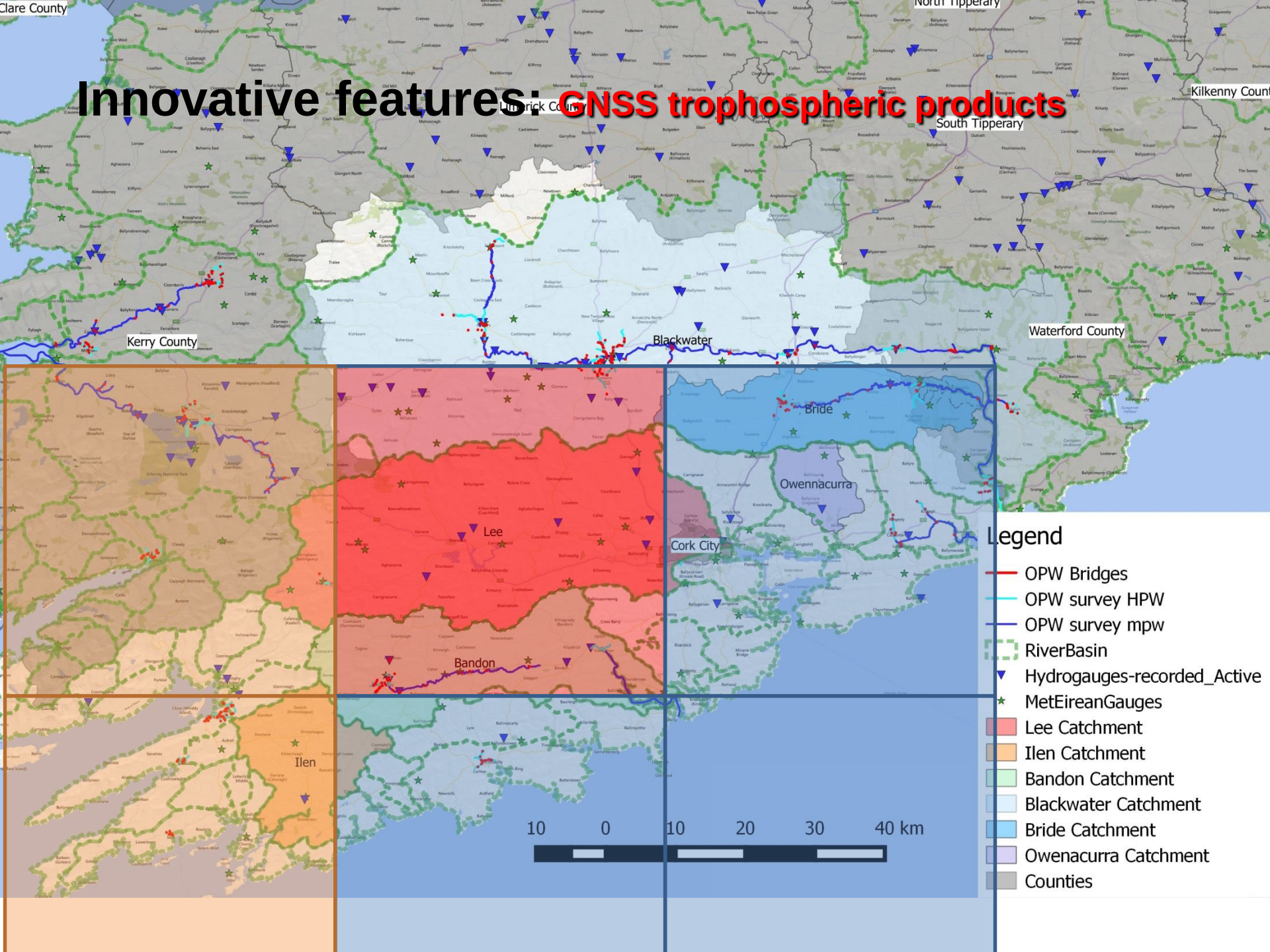
Innovative features: GNSS trophospheric products

SMAP L2 Radiometer Half-Orbit 36 km EASE-Grid Soil Moisture

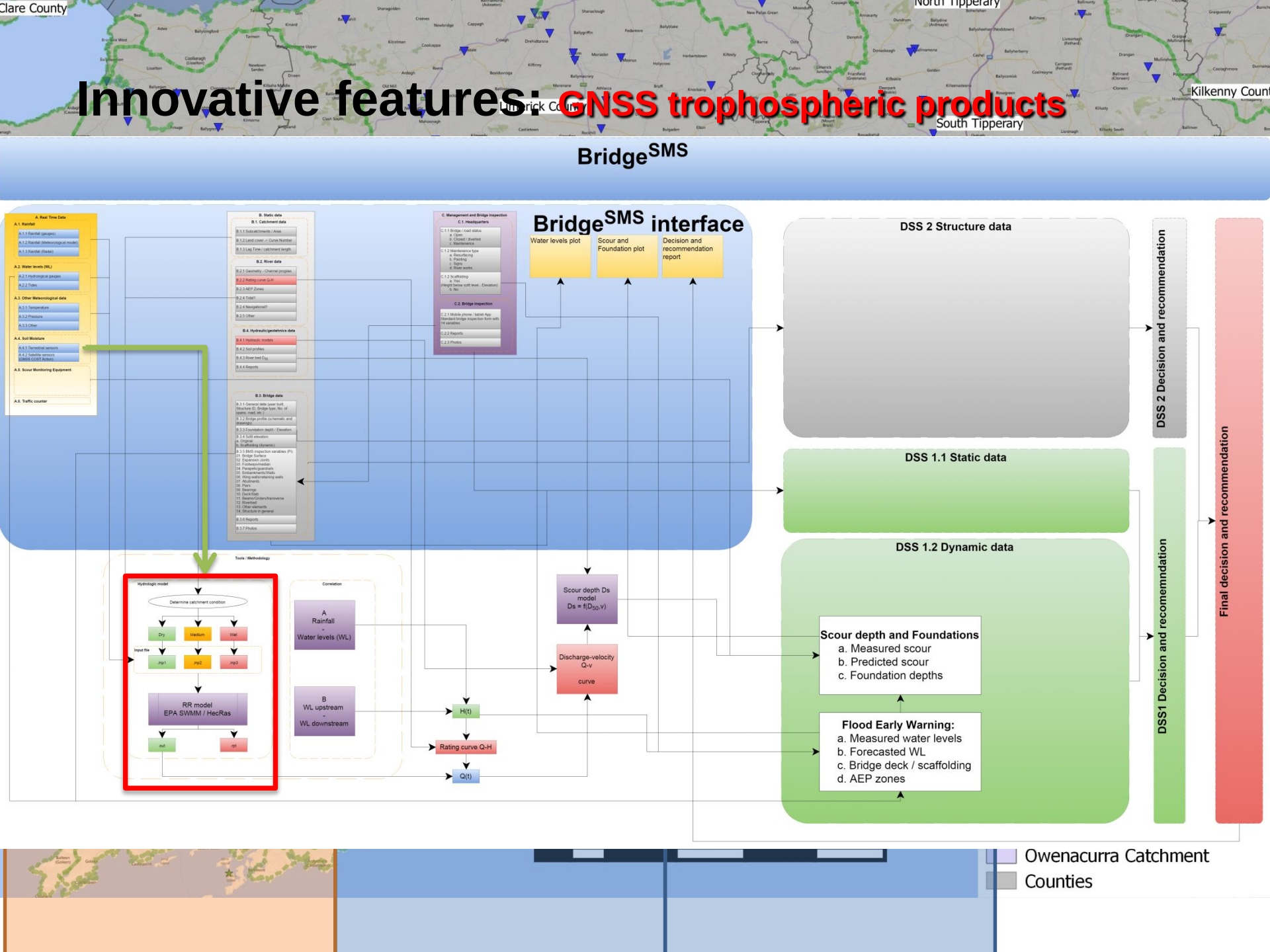
http://nsidc.org/



Innovative features: GNSS trophospheric products

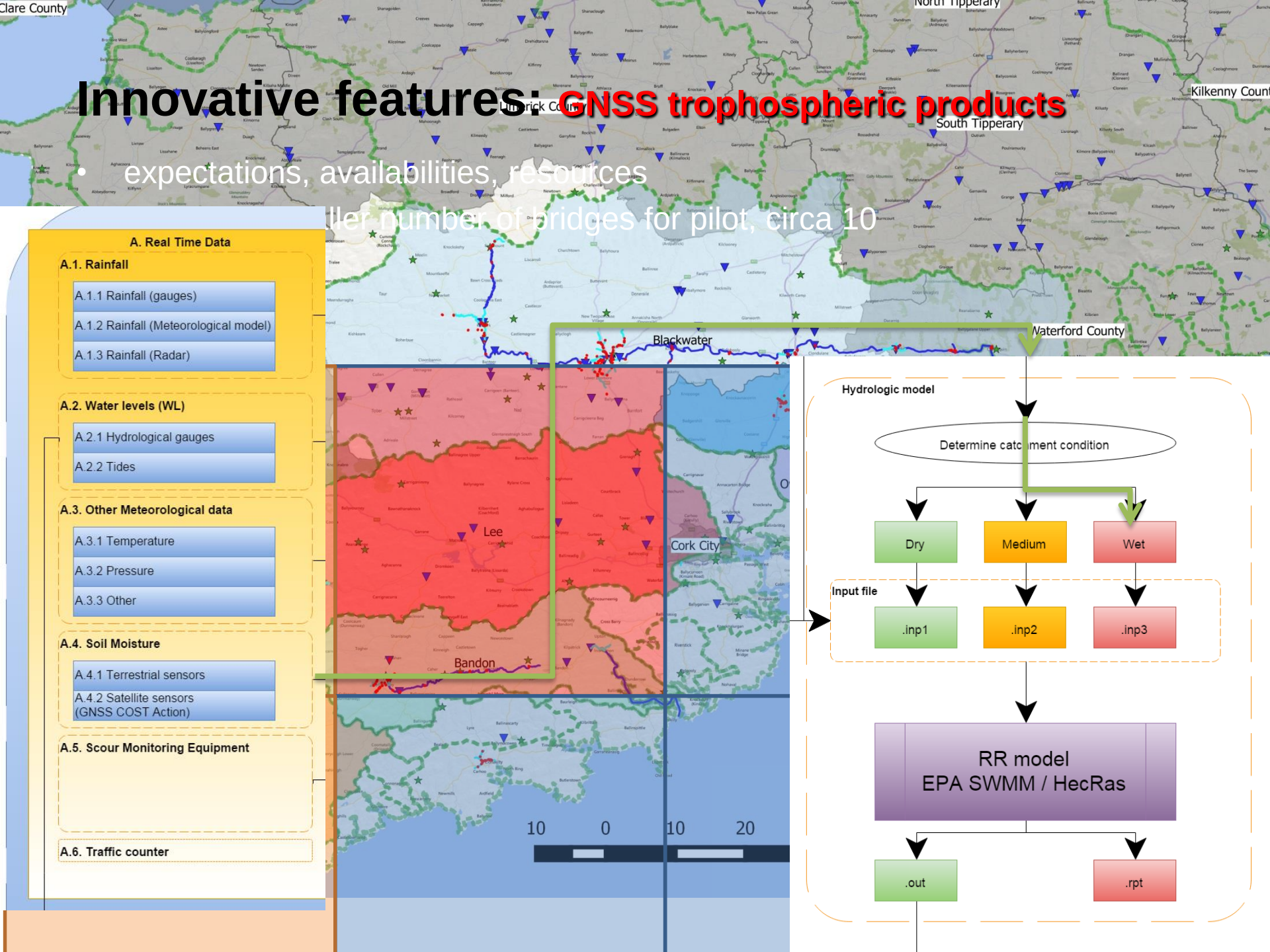


Innovative features: GNSS trophospheric products



Innovative features: GNSS trophospheric products

- expectations, availabilities, resources
- ller number of bridges for pilot, circa 10



Innovative features: GNSS trophospheric products

- ex

A. Re
A.1. Rainfall
A.1.1 Rainfall (g
A.1.2 Rainfall (M
A.1.3 Rainfall (R
A.2. Water levels
A.2.1 Hydrologi
A.2.2 Tides
A.3. Other Meteor
A.3.1 Temperat
A.3.2 Pressure
A.3.3 Other
A.4. Soil Moisture
A.4.1 Terrestria
A.4.2 Satellite s
(GNSS COST A
A.5. Scour Monito
A.6. Traffic counter
Wet
.inp3
.out
.rpt

Dissemination

- **Website** http://www.bridgesms.eu/
- **Twitter** @BRIDGESMS_MaREI https://twitter.com/BRIDGESMS_MaREI
- **Facebook** https://www.facebook.com/Bridge-SMS-1603198356632504/timeline/?ref=hl
- **Linkedin** https://www.linkedin.com/grp/home?gid=8337384&trk=my_groups-tile-grp
- **Youtube** https://www.youtube.com/channel/UCPAMvdlzSwQrpBfPQXcqvTA

TU1406
COST ACTION

Questions:
igor.kerin@ucc.ie

Thank you for your atention!
Hvala na pažnji!