DEEP OFFSHORE WIND (DOW)

Malta Council for Science & Technology
R&I Programme - 2009
Project Number: R&I-2009-003

http://www.dow.edu.mt/

Presented by: Ing. Robert N. Farrugia

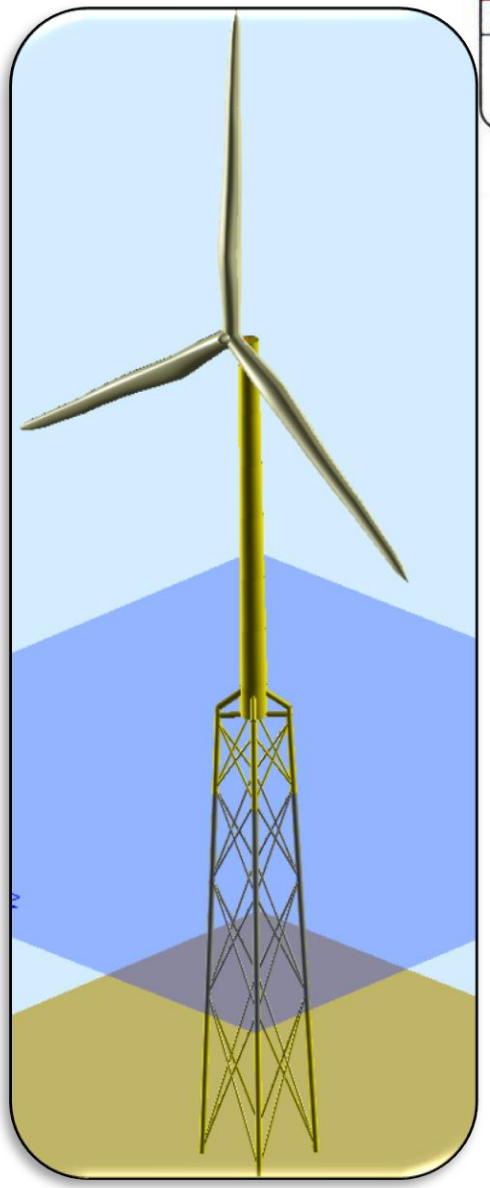
DEEP OFFSHORE WIND (DOW)
MCST (R&I – 2009)

Project Objectives:

- In-depth literature review of the technology status of deep offshore wind;
- Design of a novel jacket support structure to support a 5 Megawatt offshore wind turbine in Maltese waters up to 70 metres deep;
- A feasibility study with the local industry for constructing the proposed supporting structure design in Malta.

Participants:

- Department of Mechanical Engineering and the ISE, University of Malta (Coordinator);
- Global Renewable Energy Ltd. (GREEN Ltd.);
- Honeycomb Services Ltd.



Source: Offshore Wind Energy Research at the Institute for Sustainable Energy, Ghirlando, R., Farrugia, R.N. and Sant, T. MIEMA – 4POWER Consultation on Offshore Wind, Valletta, Malta, 23 November 2012.

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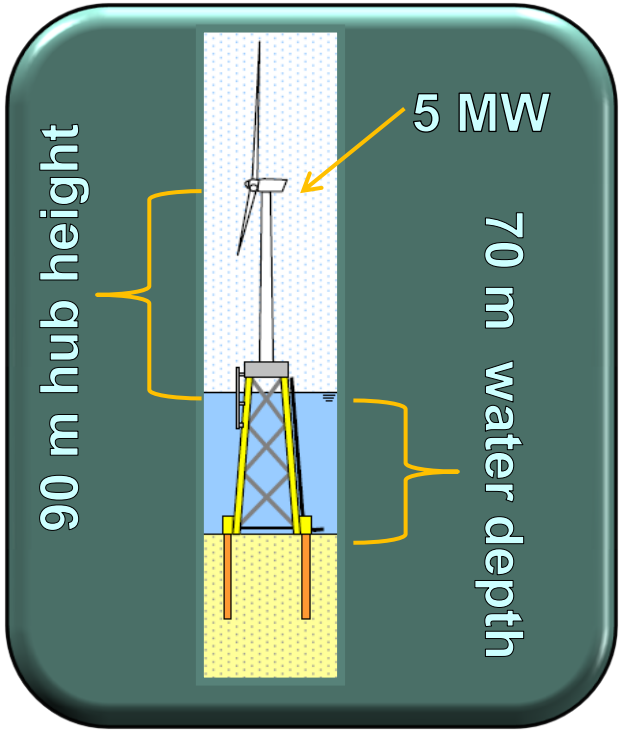
Sourced from: DOW Project, Photo showing the South East Offshore Zone (SEOZ) *(Image Source: Google Earth 2011 with additions by T. Sant 2011).*

Site Conditions:

- South East Offshore Zone (SEOZ) off the East coast of Malta;
- Central Mediterranean weather conditions;
- Water depths of 70 m.

Tailored jacket design for:

- 70 m water depth;
- 5 MW wind turbine;
- 90 m wind turbine hub height.
- Design according to:
  - Des Norske Veritas (DNV);
  - International Electrotechnical Commission (IEC).



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Main Deliverable: Steel jacket structure design optimised for Central Mediterranean Conditions.

- Although depths at SEOZ are larger than in the North Sea, the more benign climatic conditions will result in material savings, and hence also reduced costs.

	SEOZ (Malta)	Moray Firth (Scotland)
Annual average wind speed 90 m above sea level	7.4 m/s	8.99 m/s
10 minute average extreme wind speed	37.5 m/s	50.0 m/s
Maximum 50 year extreme wind speed	52.5 m/s	70.0 m/s
50 year extreme significant wave height	6.8 m	8.4 m
50 year extreme max. wave height	12.6 m	15.6 m

Source: Offshore Wind Energy Research at the Institute for Sustainable Energy, Ghirlando, R., Farrugia, R.N. and Sant, T. MIEMA – 4POWER Consultation on Offshore Wind, Valletta, Malta, 23 November 2012.

Excerpts from the report:

Re-evaluation of Wind Conditions and Estimates of Turbine Performance at the South East Offshore Zone (SEOZ)

Robert N. Farrugia & Tonio Sant

Malta Council for Science & Technology R&I Programme - 2009
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WHY ARE LONGER-TERM WIND MEASUREMENTS IMPORTANT?

- **REDUCE** the uncertainty in wind resource projections;
- **ENABLE** more accurate estimates of wind turbine energy yield;
- But **EXTEND** waiting times before actual project fruition.

CHALLENGE

MEASURE-CORRELATE-PREDICT (MCP) TECHNIQUES BUILD A RELATIONSHIP BETWEEN:

CANDIDATE SITE - where only short-term measurements are available.

REFERENCE SITE – having a longer-term historic wind database [1].

SOLUTION STEP 1

COMPUTATIONAL FLUID DYNAMICS (CFD) MODELLING

Long-term wind resources time series is fed into a CFD software that is used to project long-term wind resources **AT** and **AROUND** the **CANDIDATE** site.

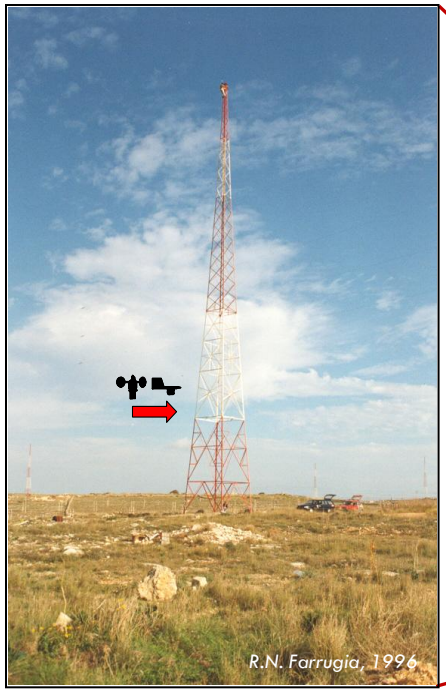
SOLUTION STEP 2

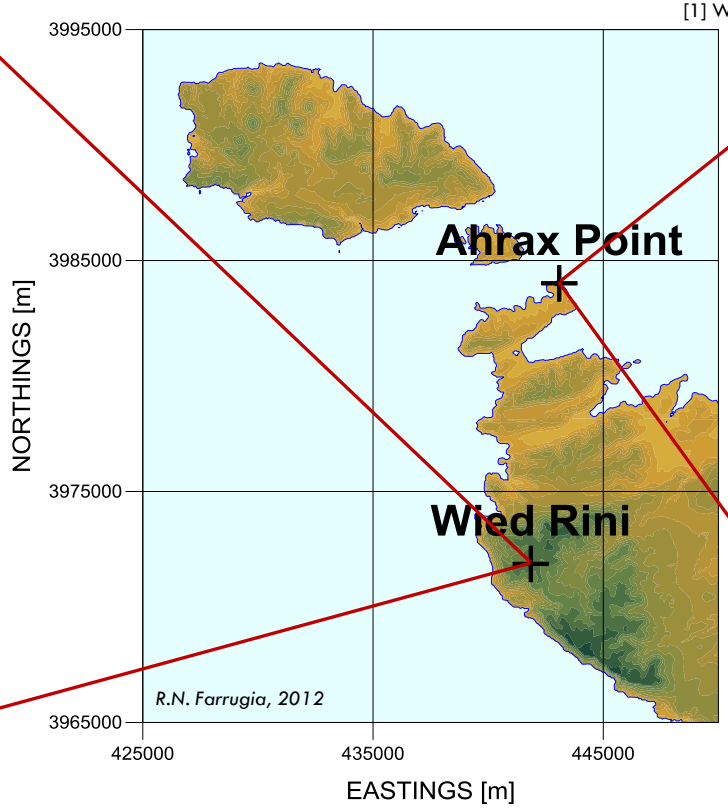
[1] Burton, T., Sharpe, D., Jenkins, N. and Bossanyi, E. (2004). Wind Energy Handbook, John Wiley & Sons Ltd., U.K. ISBN 0471489972.

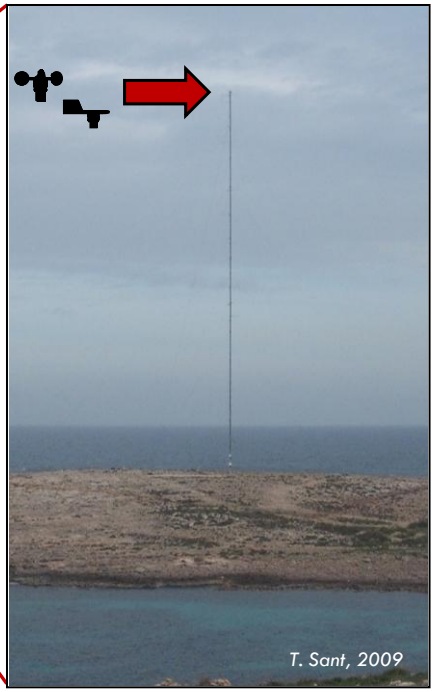
STEP 1: MCP ROUTINES

MCPs routines were conducted between the **Wied Rini** (**REFERENCE**) and **Ahrax Point** (**CANDIDATE**) sites to generate a long-term wind climatology at the latter station. The WindPRO [1] software facilitated this process.
The Wied Rini station supplied the 10 minute average wind speed and direction records.

[1] WindPRO Ver. 2.7, EMD International A/S, Aalborg, Denmark.







Source: Re-evaluation of Wind Conditions and Estimates of Turbine Performance at the South East Offshore Zone (SEOZ), R. N. Farrugia & T. Sant, R&I Project: Deep Offshore Wind, (DOW), Project Number: R&I – 2009-003, October 2012.

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Step 1: FROM MCP TO CFD

Long-term wind parameters time series generated for Ahrax Point (December 1996 to December 2011).

Long-term time-series used as climatological input to the CFD models. CFD is being used to tackle complex fluid flow problems. WindSim [1] is one such software.

CFD modelling was articulated by means of a large domain covering the archipelago and surrounding marine space.

[1] WindSim Ver. 5.0.1. WindSim AS, Tønsberg, Norway.

STEP 1: MCP ROUTINES

SHORT-TERM CONCURRENT DATASETS

REFERENCE_ST
10 m

Nov. 2009 - Oct. 2011

CANDIDATE_ST
80 m

Nov. 2009 - Oct. 2011

LONG-TERM DATASET

REFERENCE_LT
10 m

Dec. 1996 - Dec. 2011

MEASURE-CORRELATE-PREDICT TECHNIQUES BETWEEN SITES USING WINDPRO

GENERATION OF HISTORICAL WIND SPEED TIMESERIES FOR 80 m at CANDIDATE_LT (Dec. 1996 - Dec. 2011)

WINDSIM RUNS WITH 80 m CANDIDATE_LT AS CLIMATOLOGY (Dec. 1996 - Dec. 2011)

WIND RESOURCE MAP GENERATED AT WIND TURBINE HUB HEIGHT (90 m) WITHIN THE EXTENDED DOMAIN

Source: Re-evaluation of Wind Conditions and Estimates of Turbine Performance at the South East Offshore Zone (SEOZ), R. N. Farrugia & T. Sant, R&I Project: Deep Offshore Wind, (DOW), Project Number: R&I – 2009-003, October 2012.

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STEP 2: MODELLING WIND TURBINE PERFORMANCE

WindSim [1] screenshot showing a perspective view of the Maltese Islands with the CANDIDATE site station at top left corner. The wind turbine array positions within the SEOZ are shown on the right hand side.

Source: Re-evaluation of Wind Conditions and Estimates of Turbine Performance at the South East Offshore Zone (SEOZ), R. N. Farrugia & T. Sant, R&I Project: Deep Offshore Wind, (DOW), Project Number: R&I – 2009-003, October 2012.

[1] WindSim Ver. 5.0.1. WindSim AS, Tønsberg, Norway.

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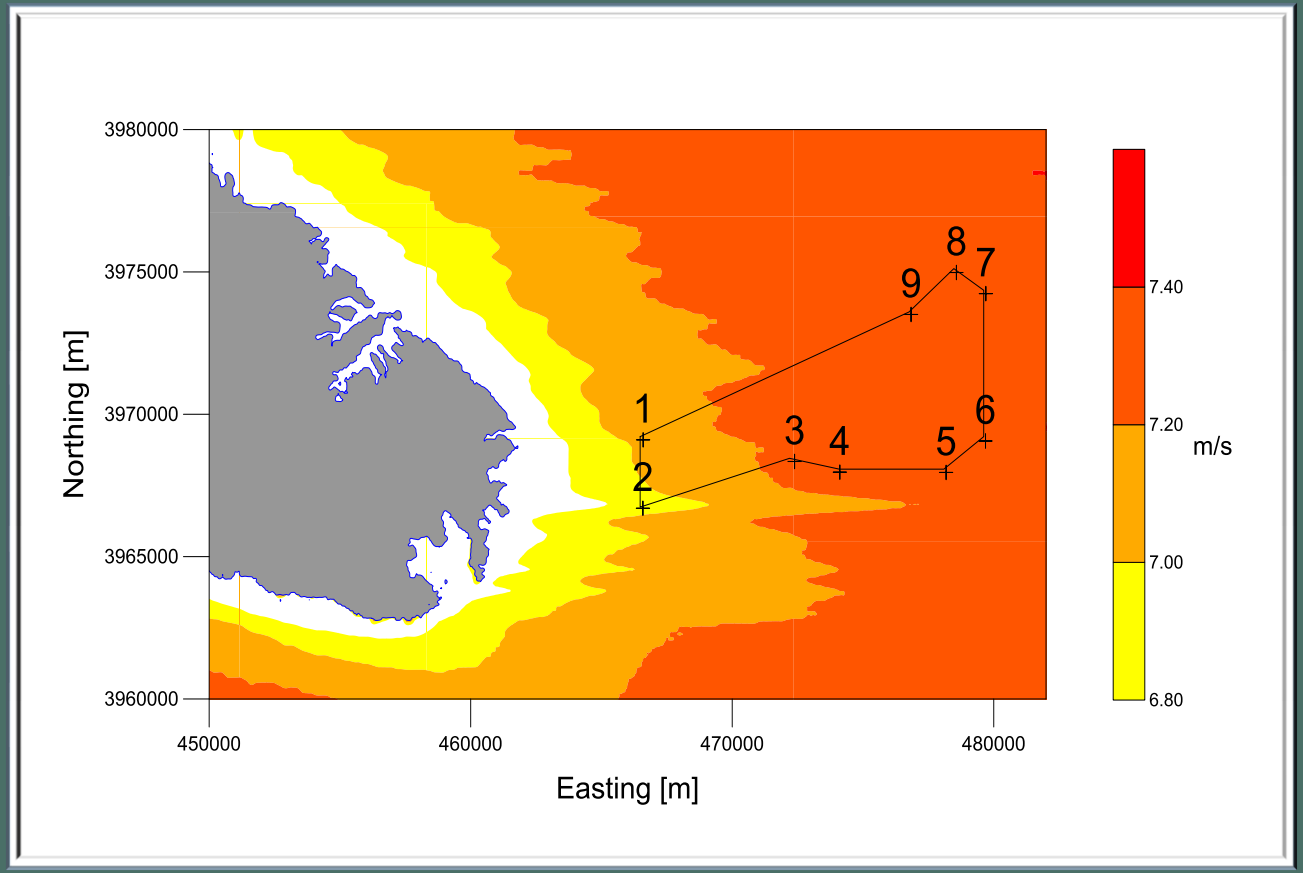
STEP 2: CFD – WIND RESOURCES IN THE SEOZ

Wind speed map for 90 m hub height in the SEOZ generated using a combination of long-term high-level wind measurements and CFD.



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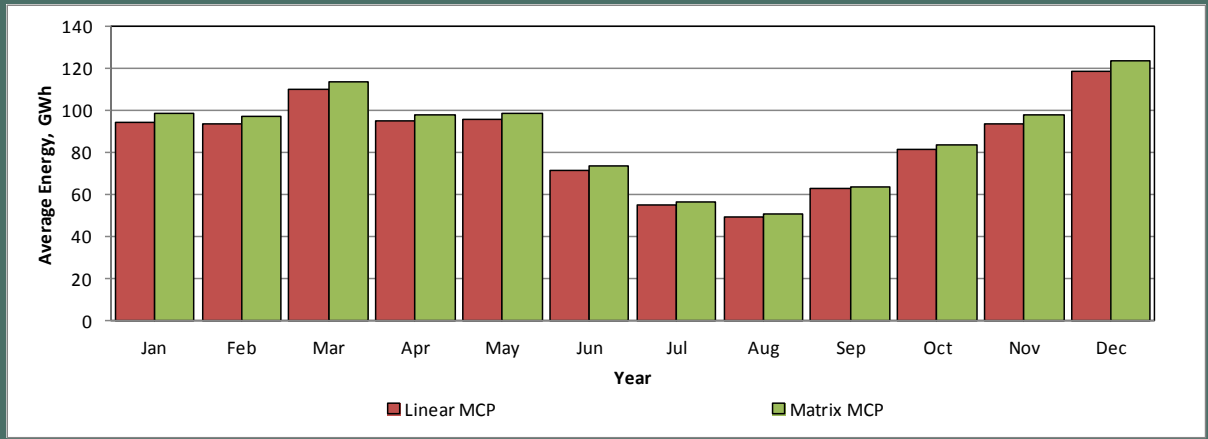

Wind turbine array theoretical average monthly energy yield (GWh) using results from two MCP methods.

Source: Re-evaluation of Wind Conditions and Estimates of Turbine Performance at the South East Offshore Zone (SEOZ), R. N. Farrugia & T. Sant, R&I Project: Deep Offshore Wind, (DOW), Project Number: R&I – 2009-003, October 2012.

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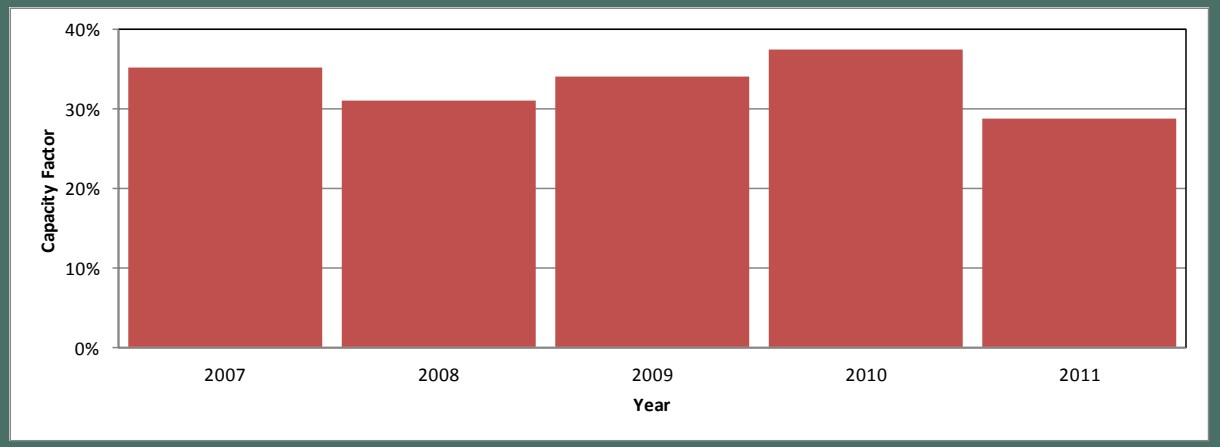
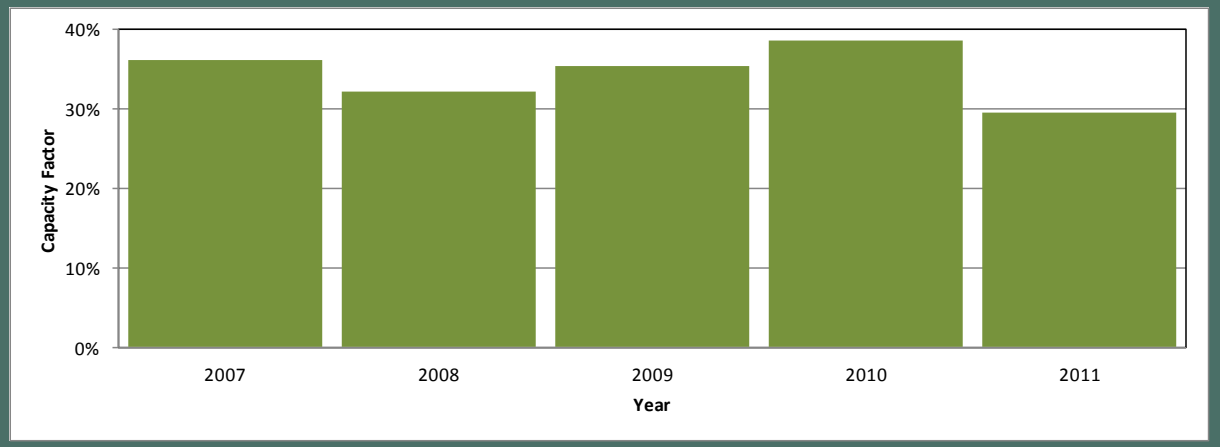
STEP 2: MODELLING WIND TURBINE PERFORMANCE





Wind turbine array theoretical average annual Capacity Factors (%) using results from two MCP methods.

Source: Re-evaluation of Wind Conditions and Estimates of Turbine Performance at the South East Offshore Zone (SEOZ), R. N. Farrugia & T. Sant, R&I Project: Deep Offshore Wind, (DOW), Project Number: R&I – 2009-003, October 2012.

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OVERVIEW AND FUTURE WORK

MCP techniques between **Candidate** and **Reference** sites enabled the generation of a long-term historical speed and direction time series at the Candidate site.

The Candidate site's long-term time series was used as a climatology input to a CFD programme. A map of wind resources at and around the Candidate site was produced.

Preliminary results indicate that the combined MCP-CFD Technique is capable of generating reasonable estimates for wind resources [1].

The methodology will be extended to other areas on and around the Maltese islands.

[1] Mediterranean Inshore Wind Resources: Combining MCPs and CFD for Marine Resources Quantification. R.N. Farrugia and T. Sant, OWEMES 2012, Rome, Italy, 5-7 September 2012

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- *Malta Resources Authority.*