Novel technologies to boost the shipyard industry

Robotic Underwater Repair

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ORGANIZED BY THE EU HORIZON 2020 PROJECTS:

30th and 31st May 2023, RTD Innovation Dock, Rotterdam

These projects have received funding from the European Union's Horizon 2020 research and innovation programme under grant agreements n° 101006860 (FIBRE4YARDS), n° 101007005 (RESURGAM), and n° 101006798 (Mari4_YARD).

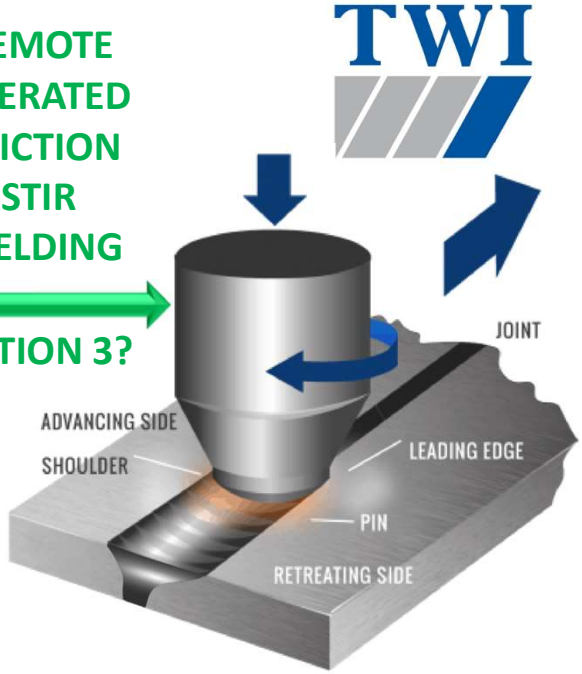
The Resurgam Project

OPTION 1

DIVER REPAIR

REMOTE OPERATED FRICTION STIR WELDING

OPTION 3?

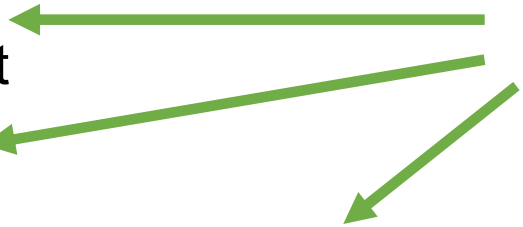


OPTION 2

DOCK REPAIR

The Challenge

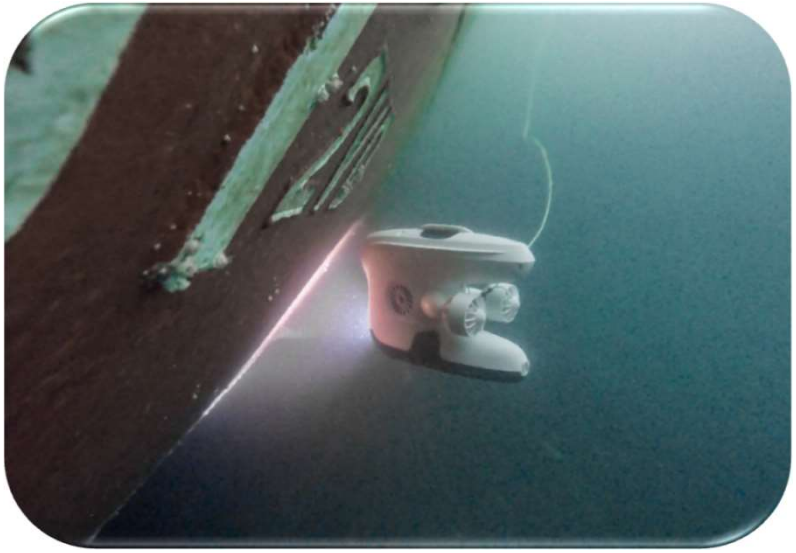
Develop a Process that can:



- Inspect ship defect
- Clean ship defect
- Scan ship defect (to allow suitable repair patch to be manufactured)
- Friction Stir Weld a repair patch onto the side of a ship
- All remotely operated underwater (J4IC) – Full presentation to follow

Inspect/Clean/Scan Defect (UoL)

*Images shown are not of UoL's final products

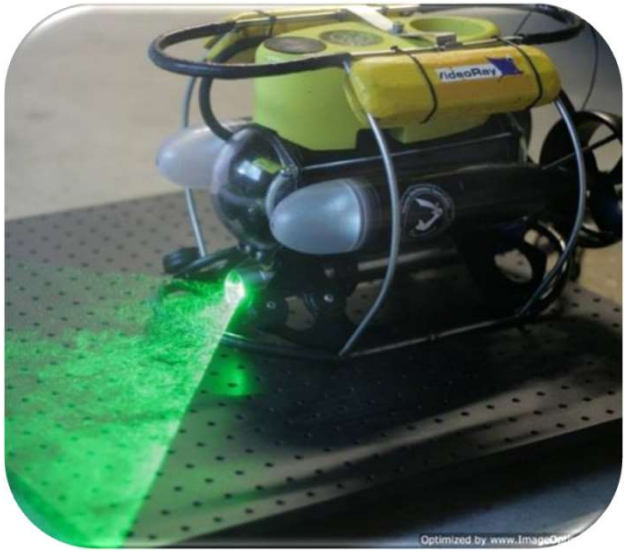


1 – Inspect Defect

To know extent of damage and require cleaning.

2 – Clean Defect

To allow accurate scanning.



3 – Scan Defect

To allow accurate manufacture of repair patch.

Scan – Development So Far (UoL)

FSW Repair Tool – Design Parameters

- TWI's testing enabled them to provide Forth with the necessary operating parameters the tool must work to:

4.6. DH36 steel welded in water. Lap weld geometry.

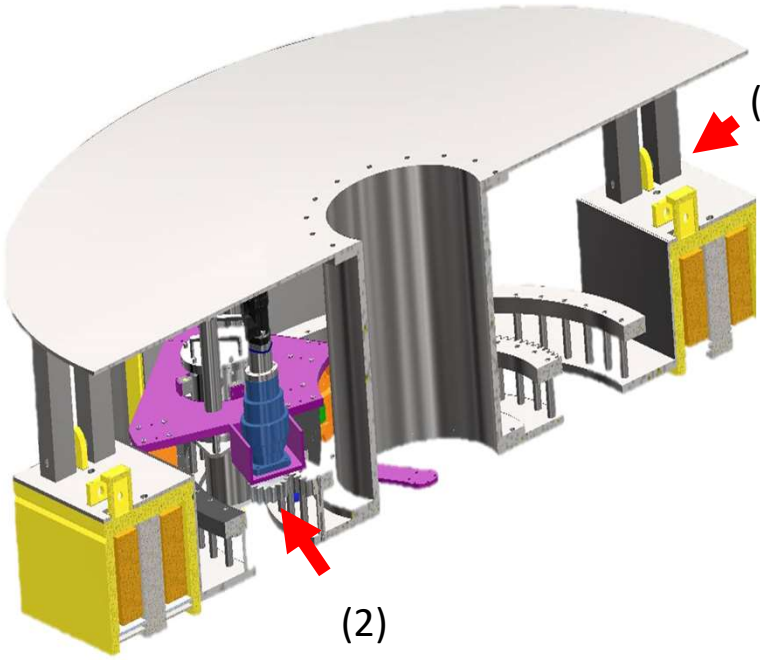
Steel thickness (mm)	Tool type	Control regimen	Tool rotation (RPM)	Welding speed (mm/min)	Tilt angle (degrees)	Measured forces (kN) *			Measured Torque * (Nm)	Calculated energy input kJ/mm	UTS (MPa)	Charpy Impact Joules at -XX C
						Fx	Fy	Fz				
4mm patch 15mm hull plate	Element Six 2188-4 6mm	Force at 30 kN	200	100	0	1	5	30	246	N/A	N/A	N/A
4mm patch 15mm hull plate	Element Six 2188-4 6mm	Force at 32.5 kN	200	100	0	2	4	32.5	253	N/A	N/A	N/A
4mm patch 15mm hull plate	Element Six 2188-4 6mm	Force at 35 kN	200	100	0	4	6	35	225	N/A	N/A	N/A
4mm patch 15mm hull plate	Element Six 2188-4 6mm	Force at 40 kN	200	100	0	4	6	40	212	N/A	N/A	N/A

FSW Repair Tool - Concept Design

Design Split into 4 Main Sub-Assemblies:

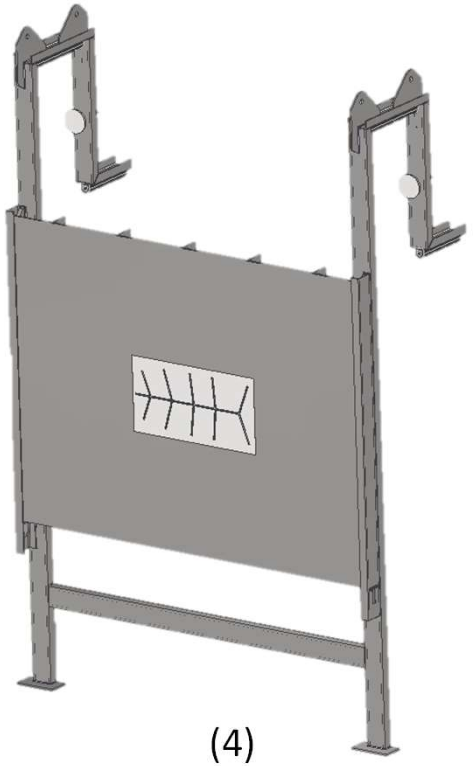
1. Operational Head
2. Track Drive System
3. Tool Magnet Frame
4. Ships Hull

(1)



(2)

(3)

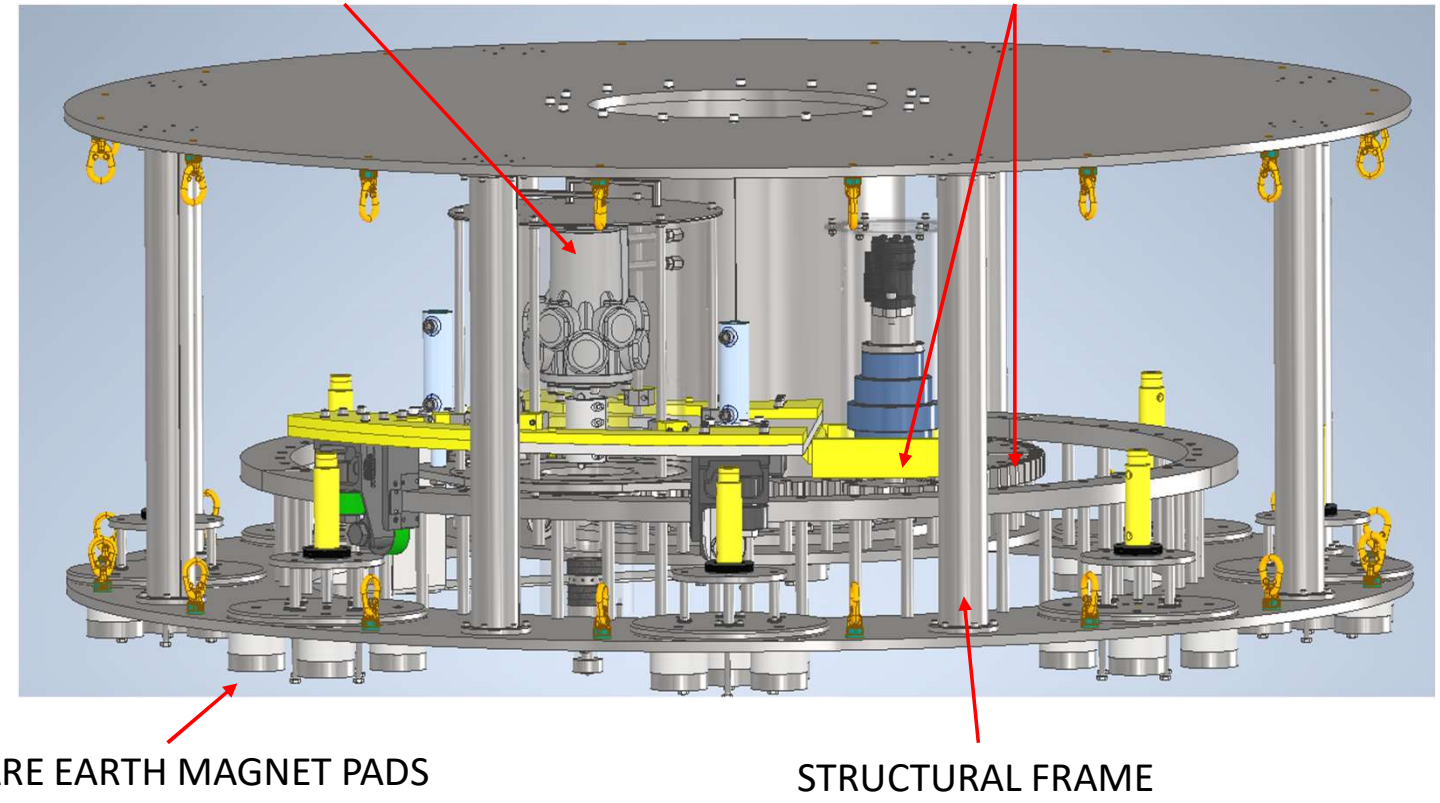


(4)

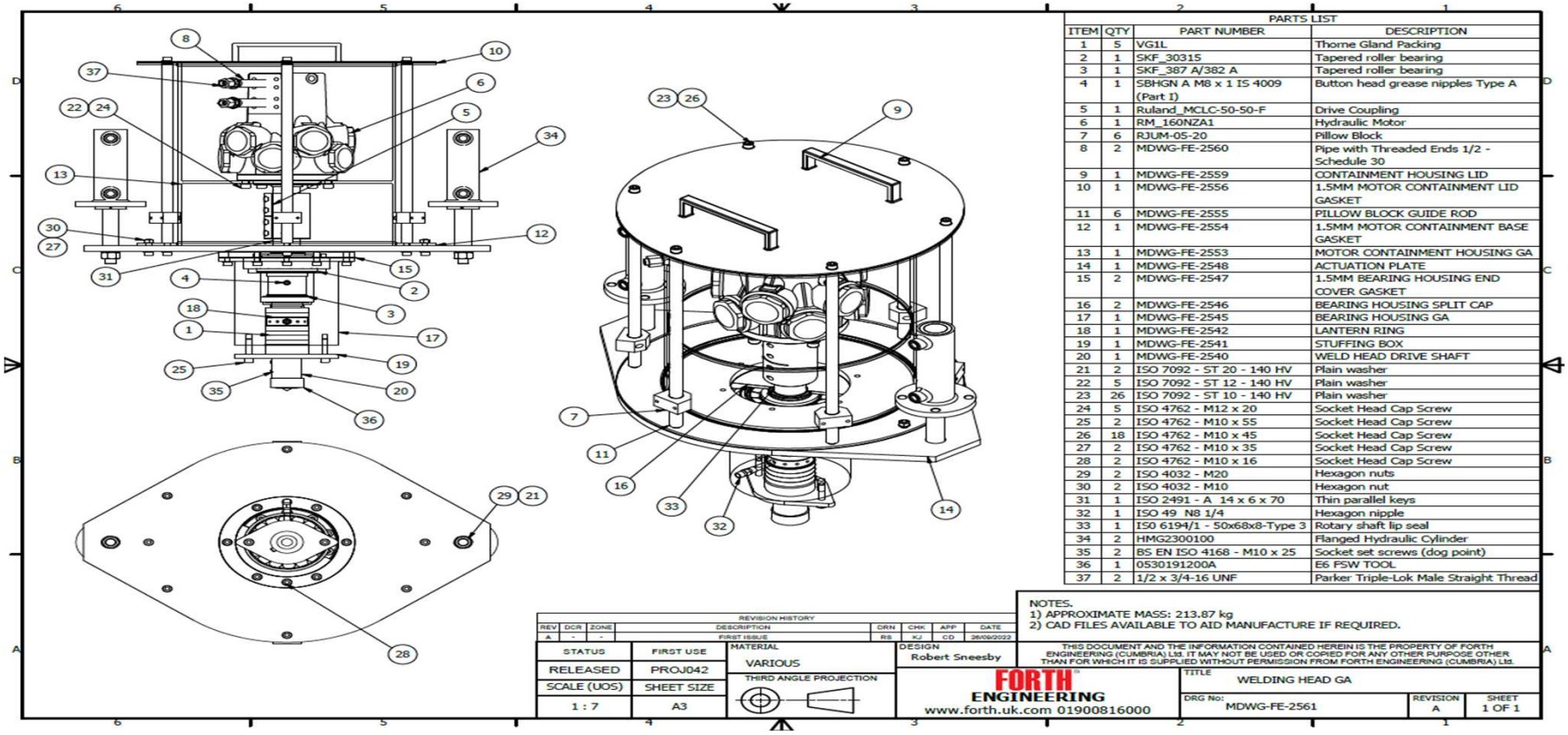
FSW Repair Tool - Detailed Design - GA

- The 4 Concept Design Subassemblies were assessed at Concept Design Stage Gate Review.

- The highlighted recommendations were taken forward into Detailed Design and combined into final design assembly.



Perform Friction Stir Weld - Detailed Design – Weld Head



PARTS LIST

ITEM	QTY	PART NUMBER	DESCRIPTION
1	5	VG1L	Thorne Gland Packing
2	1	SKF_30315	Tapered roller bearing
3	1	SKF_387 A/382 A	Tapered roller bearing
4	1	SBHGN A M8 x 1 IS 4009 (Part I)	Button head grease nipples Type A
5	1	Ruland_MCLC-50-50-F	Drive Coupling
6	1	RM_160NZA1	Hydraulic Motor
7	6	RJUM-05-20	Pillow Block
8	2	MDWG-FE-2560	Pipe with Threaded Ends 1/2 - Schedule 30
9	1	MDWG-FE-2559	CONTAINMENT HOUSING LID
10	1	MDWG-FE-2556	1.5MM MOTOR CONTAINMENT LID GASKET
11	6	MDWG-FE-2555	PILLOW BLOCK GUIDE ROD
12	1	MDWG-FE-2554	1.5MM MOTOR CONTAINMENT BASE GASKET
13	1	MDWG-FE-2553	MOTOR CONTAINMENT HOUSING GA
14	1	MDWG-FE-2548	ACTUATION PLATE
15	2	MDWG-FE-2547	1.5MM BEARING HOUSING END COVER GASKET
16	2	MDWG-FE-2546	BEARING HOUSING SPLIT CAP
17	1	MDWG-FE-2545	BEARING HOUSING GA
18	1	MDWG-FE-2542	LANTERN RING
19	1	MDWG-FE-2541	STUFFING BOX
20	1	MDWG-FE-2540	WELD HEAD DRIVE SHAFT
21	2	ISO 7092 - ST 20 - 140 HV	Plain washer
22	5	ISO 7092 - ST 12 - 140 HV	Plain washer
23	26	ISO 7092 - ST 10 - 140 HV	Plain washer
24	5	ISO 4762 - M12 x 20	Socket Head Cap Screw
25	2	ISO 4762 - M10 x 55	Socket Head Cap Screw
26	18	ISO 4762 - M10 x 45	Socket Head Cap Screw
27	2	ISO 4762 - M10 x 35	Socket Head Cap Screw
28	2	ISO 4762 - M10 x 16	Socket Head Cap Screw
29	2	ISO 4032 - M20	Hexagon nuts
30	2	ISO 4032 - M10	Hexagon nut
31	1	ISO 2491 - A 14 x 6 x 70	Thin parallel keys
32	1	ISO 49 N8 1/4	Hexagon nipple
33	1	ISO 6194/1 - 50x68x8-Type 3	Rotary shaft lip seal
34	2	HMG2300100	Flanged Hydraulic Cylinder
35	2	BS EN ISO 4168 - M10 x 25	Socket set screws (dog point)
36	1	0530191200A	E6 FSW TOOL
37	2	1/2 x 3/4-16 UNF	Parker Triple-Lok Male Straight Thread

REVISION HISTORY

REV	DCR	ZONE	DESCRIPTION	DRN	CHK	APP	DATE
A	-	-	FIRST ISSUE	RS	KJ	CD	26/09/2022

NOTES.
1) APPROXIMATE MASS: 213.87 kg
2) CAD FILES AVAILABLE TO AID MANUFACTURE IF REQUIRED.

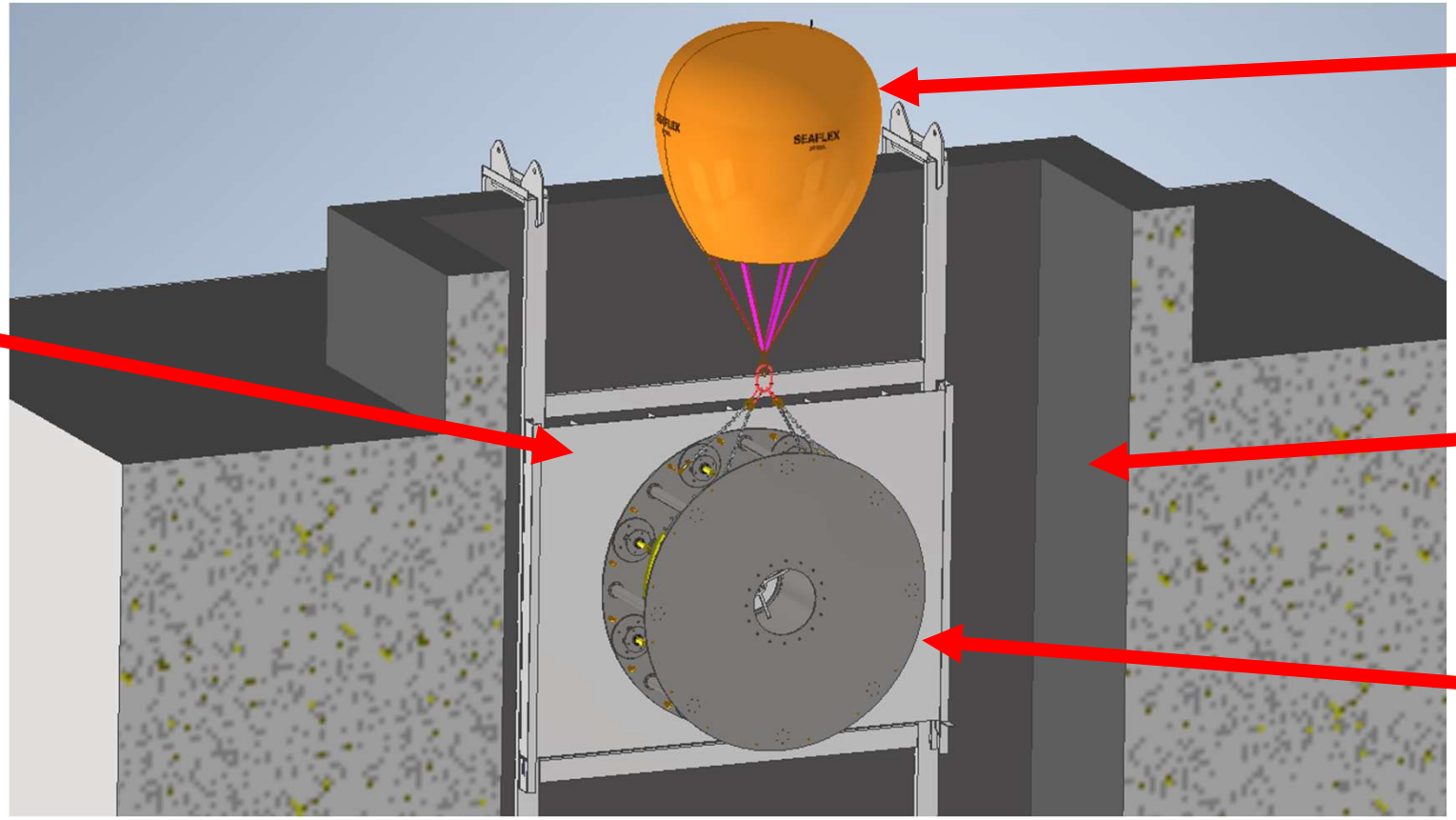
STATUS	FIRST USE
RELEASED	PROJ042
SCALE (UOS)	SHEET SIZE
1 : 7	A3

MATERIAL: VARIOUS
THIRD ANGLE PROJECTION
DESIGN: Robert Sneesby

FORTH ENGINEERING
www.forth.uk.com 01900816000

TITLE: WELDING HEAD GA
DRG No: MDWG-FE-2561
REVISION: A
SHEET: 1 OF 1

FSW Repair Tool - Detailed Design– Full Test GA



NEUTRAL BUOYANCY BALLOON

MOCK SHIP HULL

FORTH DRF TEST POND

TOOL GA

FSW Repair Tool - Manufacture – Progress So Far

- Once the Design Verification Checks had been completed and Detailed Design Stage Gate approved, the Project could then be taken into manufacture.

- These videos show the initial stages of the final build, allowing us to perform validating tests prior to full assembly.

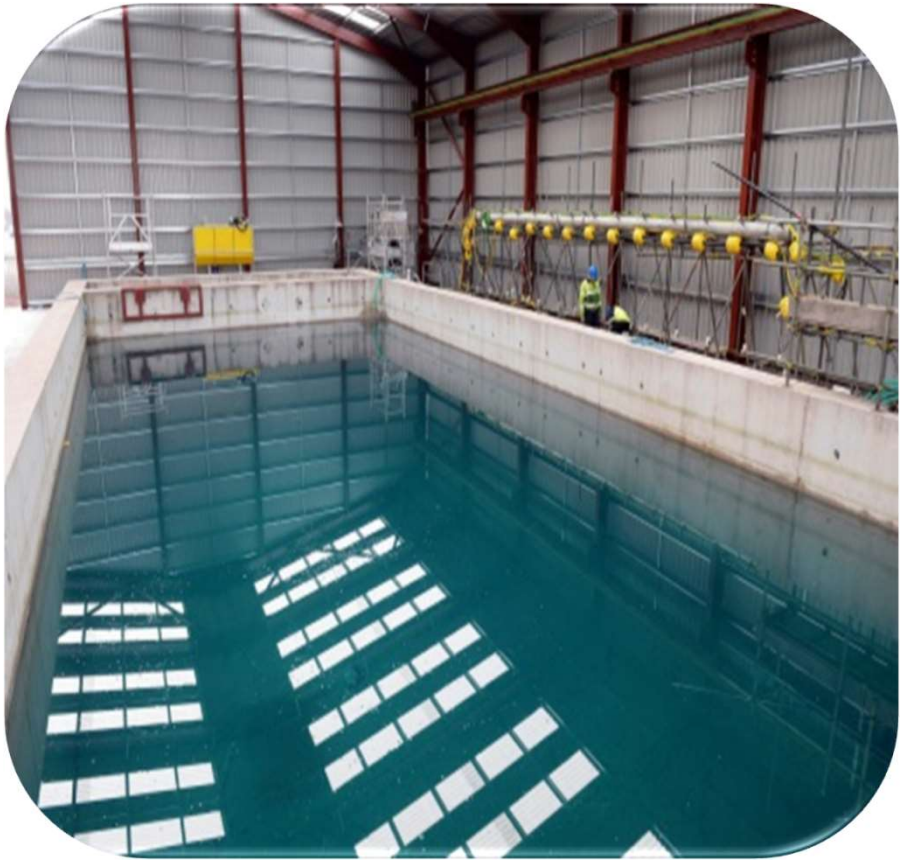
FSW Repair Tool – Remaining Actions

Implementation

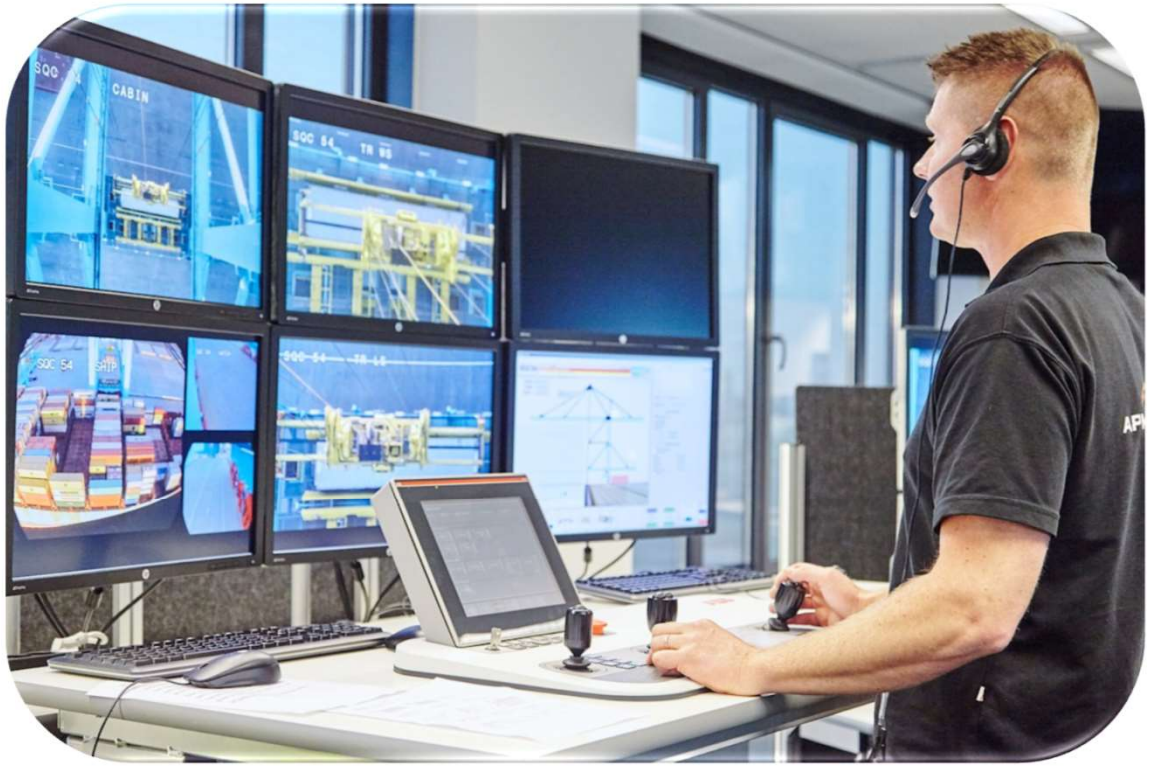
1. Delivery of remaining Parts and Material
2. Fabricate Frame and Ships Hull
3. Assemble Tool GA
4. Dry Weld Test (Facing Flat)
5. Wet Weld Test (Internal Factory Acceptance Test (FAT 1))

Handover

1. Demonstration Day Wet Weld Test (Site Acceptance Test (FAT 2))



Remote Control of ROVs and FSW Tool



J4IC
Joining 4.0 Innovation Centre

Further Potential Uses

Manless Storage Tank Repairs

In Situ Wind Turbine Tower Repairs

Underwater External Pipe Repairs

FSW Repair Tool - Challenges So Far (And Opportunities)

- Significant staff turnover.
- Electromagnets major risk due to required economic investment and likely electromagnetic interference – Suction Cups reviewed and discounted, progressing with electromagnets.
- Final Deflection of Frame, was not suitable for Carriage bearings, will require a large Strong Back beam in final construction.
- Falling GBP/Exchange Rate against original budget & Ongoing Import/Export Issues

Opportunities Realised

- Moving to a fixed track design over full 3D router, meant the elimination of risk of positioning errors. The track design also makes the tool much more easily scaled for different sized repairs.
- Suitability of rare earth magnets

FSW Repair Tool - Frequently Asked Questions (FAQs)

- This prototype and mock hull are flat, but it won't be like that on the boat needing repair?

- How is the patch deployed on the ship?

- Any other questions?

THANKS
FOR YOUR ATTENTION

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