Looking Above the Water:
Rapid Delivery of Subsea Intervention Technologies

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16 June 2021

Rapid Delivery of Subsea Technologies

- How do we deliver faster and more reliably?
  - Process Driven Product Design
    - Understand the Problem
      Decompose and solve sub problems
    - Search Internally
      Does it already exist for subsea?
    - Search Externally
      Does it exist in another industry?
    - Explore and Reflect on the solutions

- Case Study: ROV Installable Ultrasonic Gas Flowmeter

Product to Market

Subsea Engineered Solutions

- <1-12 weeks to operating in field
- 1’s to 10’s of units
- Specialists in subsea, generalists otherwise
- Customers bring needs to you
- Testing conducted to the specific instance, analysis and conservatism for fatigue and cycling.
- Small group of users

Traditional Markets

- 2-5 years to market
- 1000’s to 1,000,000’s of units
- Many Specialized Roles such as injection molding experts
- Have to search for Unmet Customer Needs
- Long and expensive testing and development cycles depending on industry
- Broad group of users

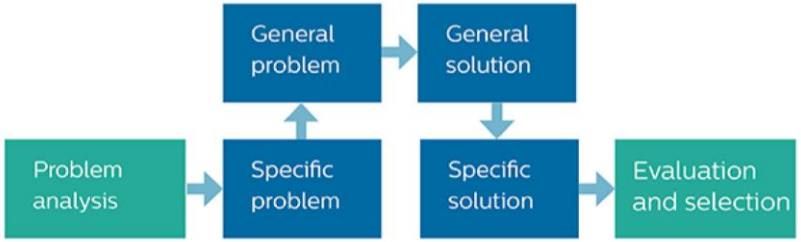
Benefit of looking at Analogous Fields

Why does size matter?

- Able to specialize in specific areas
- Larger Development Budgets
- Longer timeline for product development
- Competitive landscape where enhancements provide differentiation
- Product Lifecycle Management
- Economies of Scale
  - Engineering is diluted across millions of products
  - Spare parts are more readily available
  - More efficient manufacturing processes used for bulk manufacture
- All of these contribute to a cheaper, more reliable product.

How to look at analogous fields

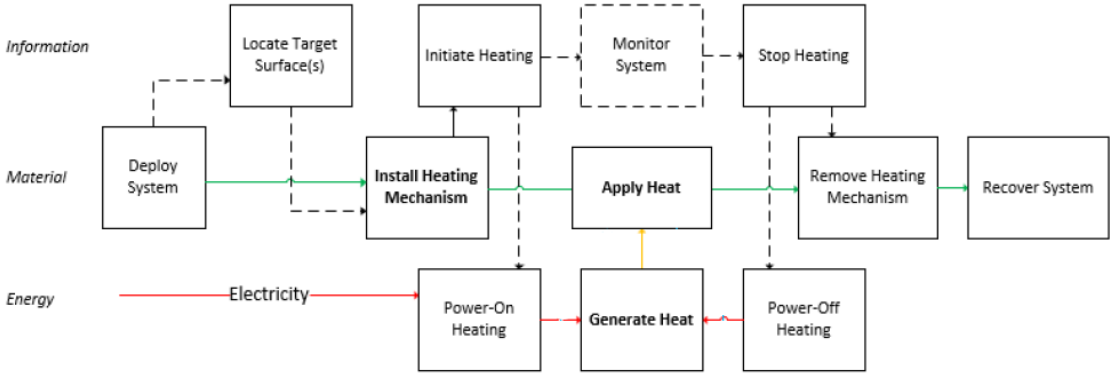
- Talk to suppliers with cross-industry coverage
- Trips to Bunnings
- Google! (especially image search)
- Pyramid Search
- Talk in a common language



Importance of Problem Decomposition

Why decompose problems?

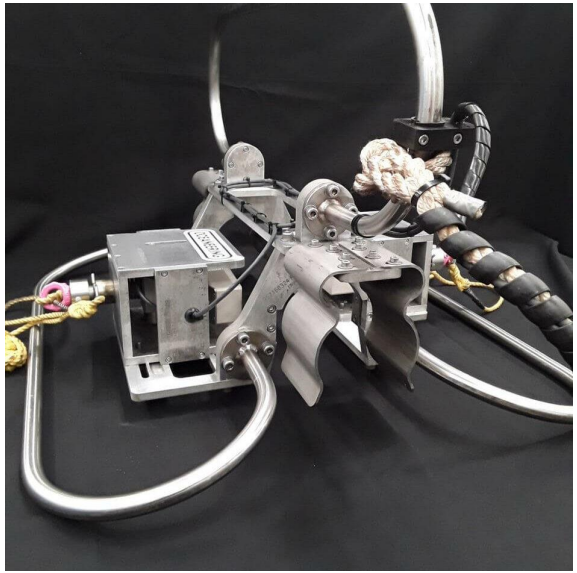
- It's easier to find solutions to individual sub problems that can later be combined into the final concept
- Enables engineer to search other industries
- Allows communication in a common language with other experts
- Allows stakeholders to digest and/or implement "radical ideas"



Case Study: ROV installable Ultrasonic Gas Flowmeter

Understand the Problem

- Non-intrusively measure gas injection rate to an individual well while adjusting the choke to optimize Sealtite injection during an ROV campaign
- Flowmeter should not damage pipeline
- Production System barrier cannot be breached
- Measurement within 50,000 scfd on between 250,000 to 1,000,000 scfd
- Line size – 101.6mm dia x 6.4 WT with 3LPP coating external (5mm WT)



- **Critical Sub-Problem:** Measurement Sensor

Case Study: ROV installable Ultrasonic Gas Flowmeter

Search Internally

- Review of engineering vaults found topside installed flowmeters and flow loops for measuring directly but no ultrasonic flowmeters
- Oceaneering has experience in ROV subsea ultrasonic testing of wall thickness and corrosion mapping and know that transducers can work up to a depth well beyond this requirement.
- Identified internal expertise in UT and PAUT NDT, electronics, and ROV communications

Search Externally

- Searched for manufacturers and vendors for ultrasonic flowmeters. Ultrasonic flowmeters extensively used topside but not subsea
- Found Flexim Clamp-On Flowmeters distributed by Aquip who understood needs of Oil and Gas and their product in detail.
- Consulted with Aquip and Flexim Engineering on failure modes, efficacy through coatings, general design of equipment, density of pipe contents
- Gathered information on ultrasonic measurement principle to better understand how it works

Case Study: ROV installable Ultrasonic Gas Flowmeter

Explore Systematically

Attach Sensor	Position Sensors against pipe	Measure Flow	Communicate back to Surface
~~• Clamp~~ • **Clip-On** ~~• Balance Frame~~	• **Spring** ~~• Lead Screw~~ ~~• Linkage~~	• **Ultrasonic**	• RS232 • **TCP/IP** ~~• FO~~

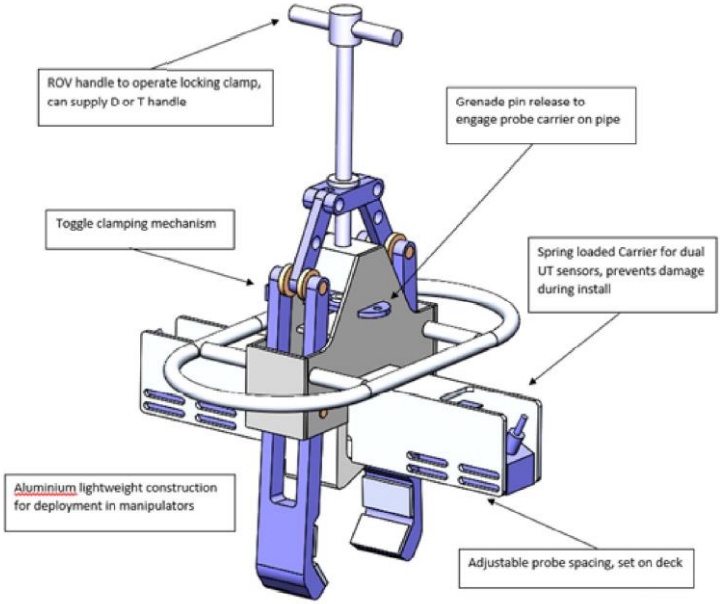
Case Study: ROV installable Ultrasonic Gas Flowmeter

Reflect on the Process

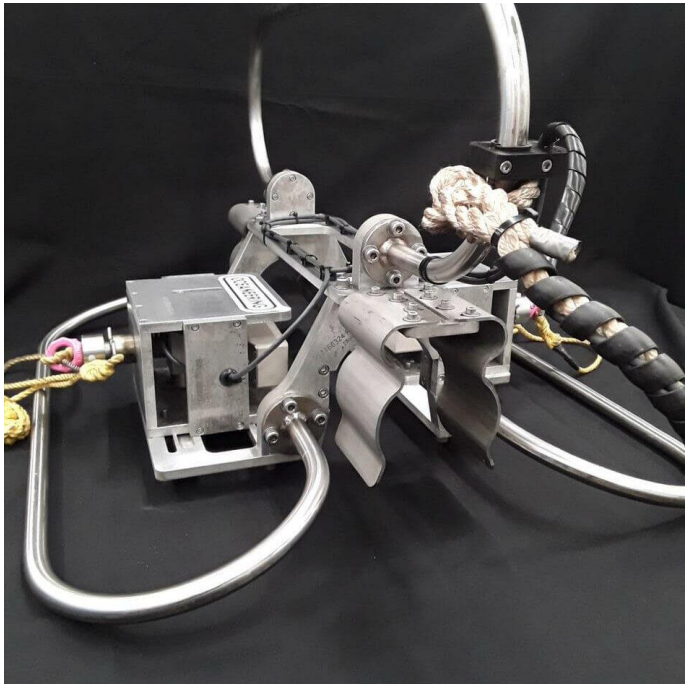
- Are we confident we have full explored the solution space?
- What risks are there technically and commercially?
  - Sensor is confirmed to have a hard failure in the sense that it will not communicate a flowrate unless it is properly setup and transducers talking properly (soft failure being that it communicated bad data and we didn't know)
  - Flexim have reviewed the parameters and specified a system that would normally work for this. The flowrates/temp/pressure are not extreme cases and have sufficient density for good measurement.
  - UT transducers are 0.5 MHz shear wave probes set at an angle
  - UT transducers are set up similar to TOFD (used successfully on Oceaneering Neptune and Trident systems)
  - Vendor (Aquip) will have an engineer/technician experienced with Flexim UT Gas flowmeters offshore with the system to ensure setup is correct and operate it

Case Study: ROV installable Ultrasonic Gas Flowmeter

Early Concept



Final Product



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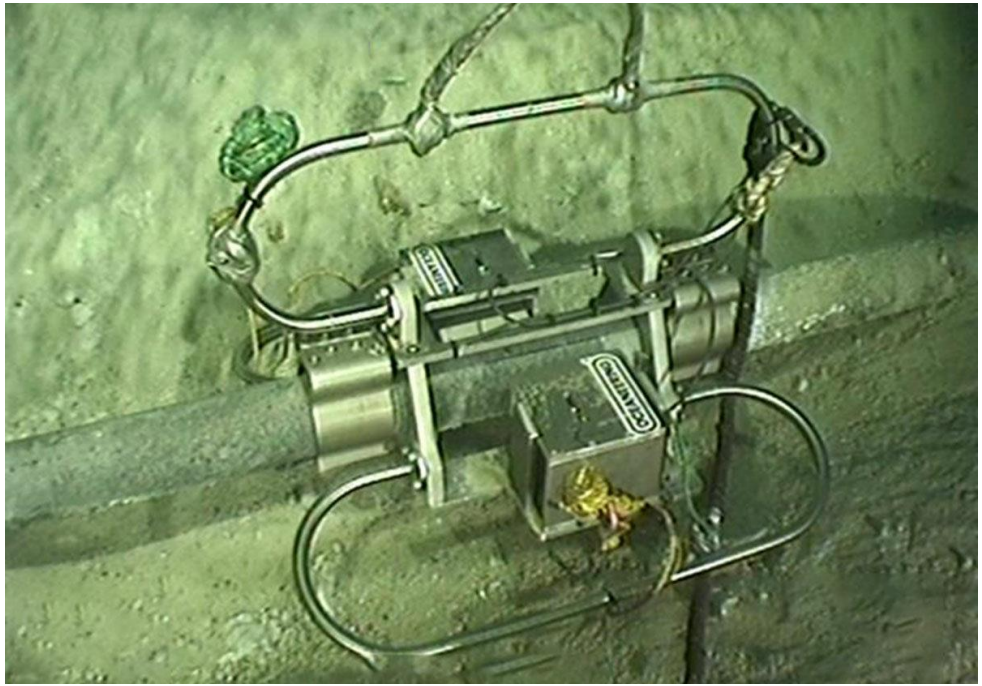
Results

- Worked first time offshore
- Identified the choke wasn’t fully closed and could be closed two further steps
- Provided valuable data
- Tool was easy to use by ROV
- Great Collaboration between Aquip, Flexim, and Oceaneering
- Winner of Oceaneering Chairman's’ New Product or Service Award



Conclusion

- Just because it’s not originally designed for subsea doesn’t mean it won’t work subsea
- Decomposition of Adjacent Technologies allows for rapid product development in the subsea industry for great reliability and fraction of the cost.

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