



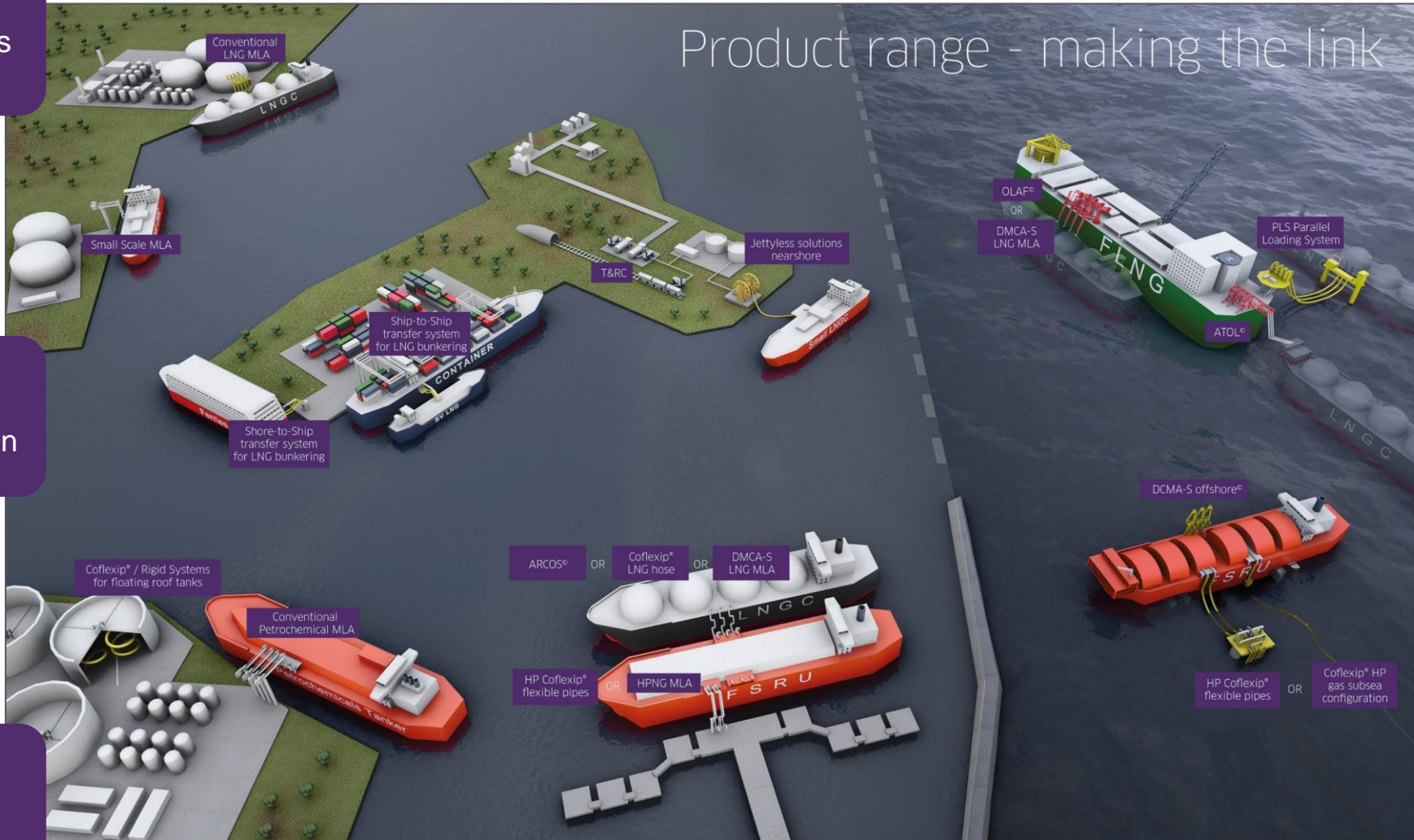
# ARCOS

Advancing Ship-To-Ship LNG Transfer Solutions



# TechnipFMC Loading Systems in a nutshell

Over **10,000**  
Marine Loading Arms  
supplied worldwide



Over **500**  
LNG MLA in operation

**100 %** offshore  
FLNGs fitted with  
TechnipFMC's MLA

Temperatures:  
**Cryogenic**  
**Ambient**  
**High**

Pressures:  
**ANSI 150** to  
**ANSI 900**

Environments:  
**CALM**  
**MODERATE**  
**HARSH**

TechnipFMC Loading Systems' portfolio includes flexible hose and articulated rigid pipe based solutions

# STS LNG transfer solutions: state of the art

## Side-by-side


## Tandem/parallel

Offloading frequency


Daily

Weekly

Monthly



Conventional LNG MLA



Cryogenic hoses w/ ERS



DCMA-S w/ Targeting System<sup>®</sup>



OLAF<sup>®</sup> w/ Targeting System



HiLoad LNG Parallel Loading System



ATOL<sup>®</sup>

Calm

Moderate

Harsh

Offloading conditions

# Cryogenic hoses vs Marine Loading Arms

## Conventional MLA



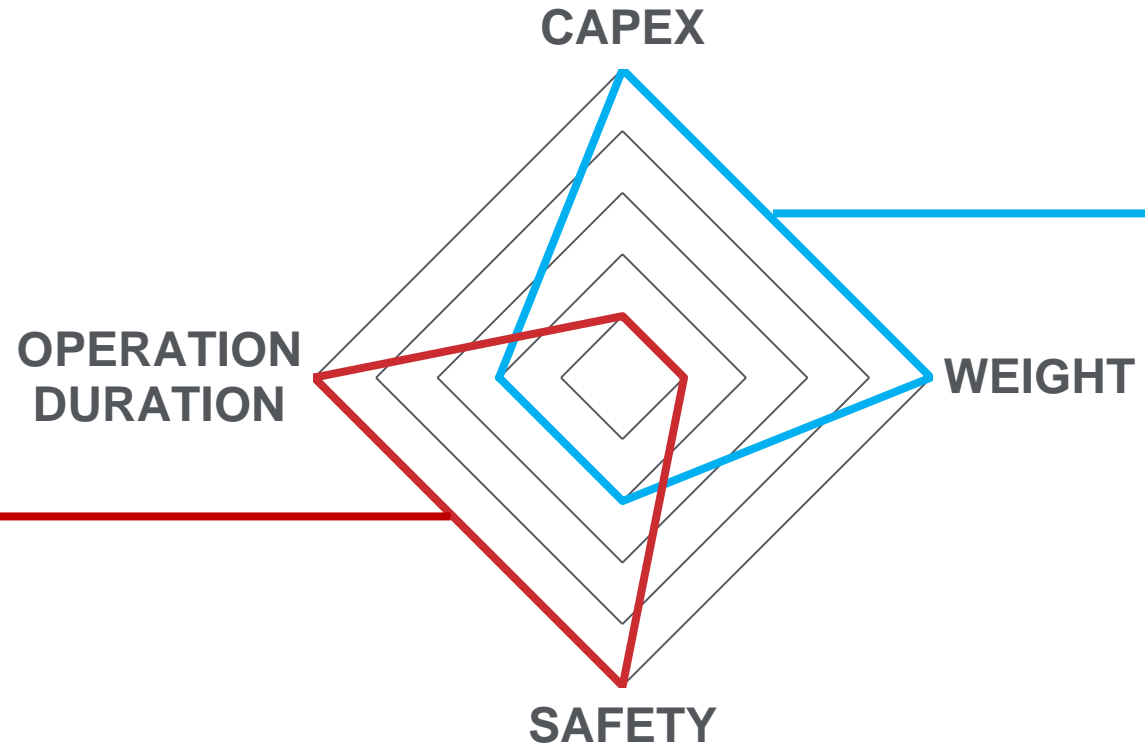
- + Low pressure drop/BoG
- + Fully powered/remote ops
- + 3 or 4 lines
- CAPEX
- Heavy
- Permanent installation

## Cryogenic hoses



Credits: Teekay LNG

- + Competitive CAPEX
- + Lean & light
- + Easily removable
- High pressure drop/BoG
- Numerous lifting & bolting ops
- 6 to 8 lines



# Cryogenic hoses vs Marine Loading Arms

## Conventional MLA

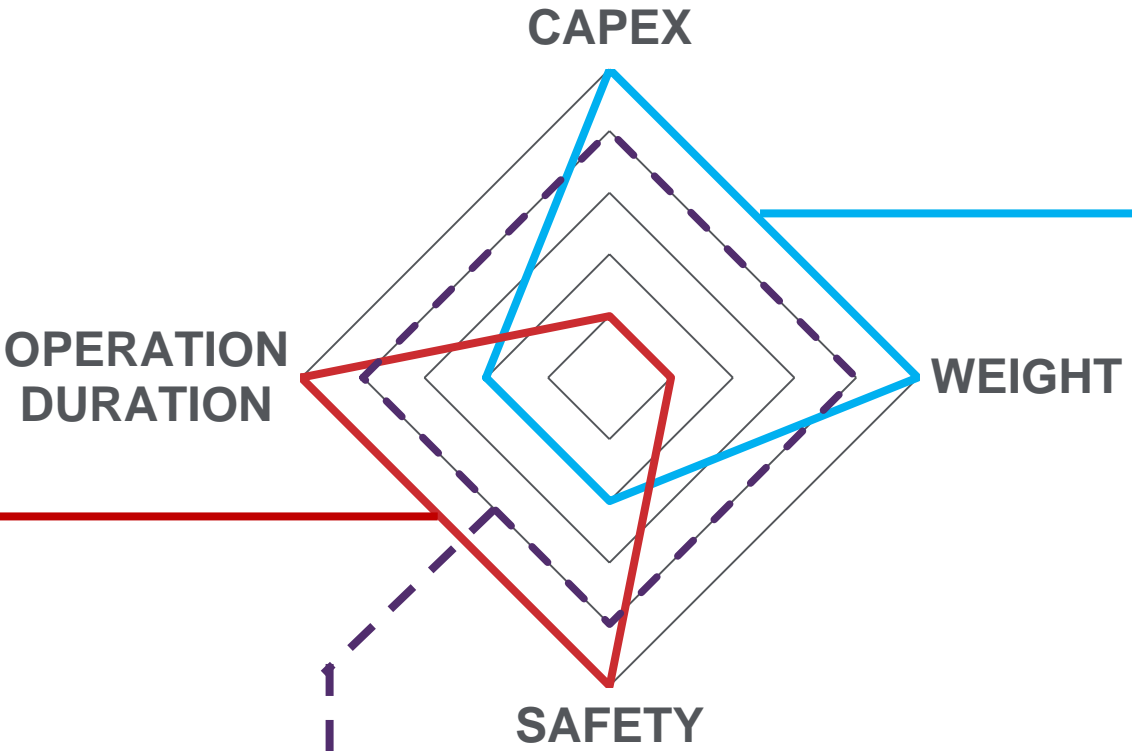


- + Low pressure drop/BoG
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- + 3 or 4 lines
  
- CAPEX
- Heavy
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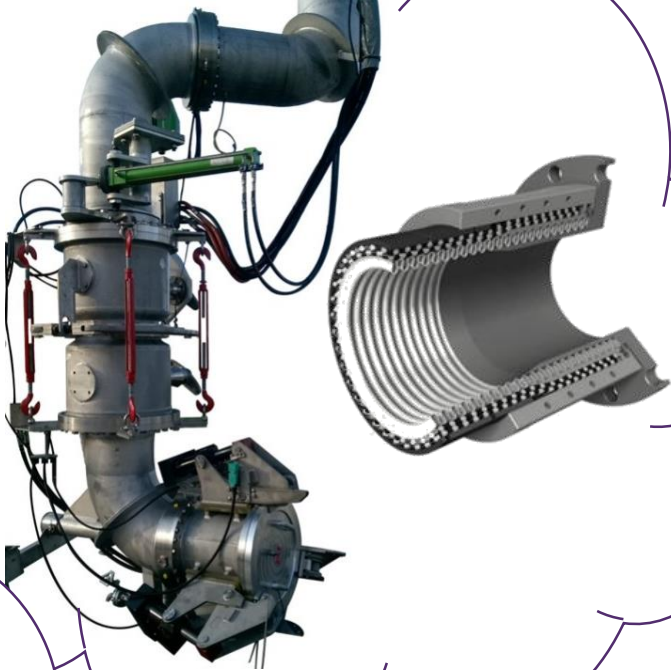
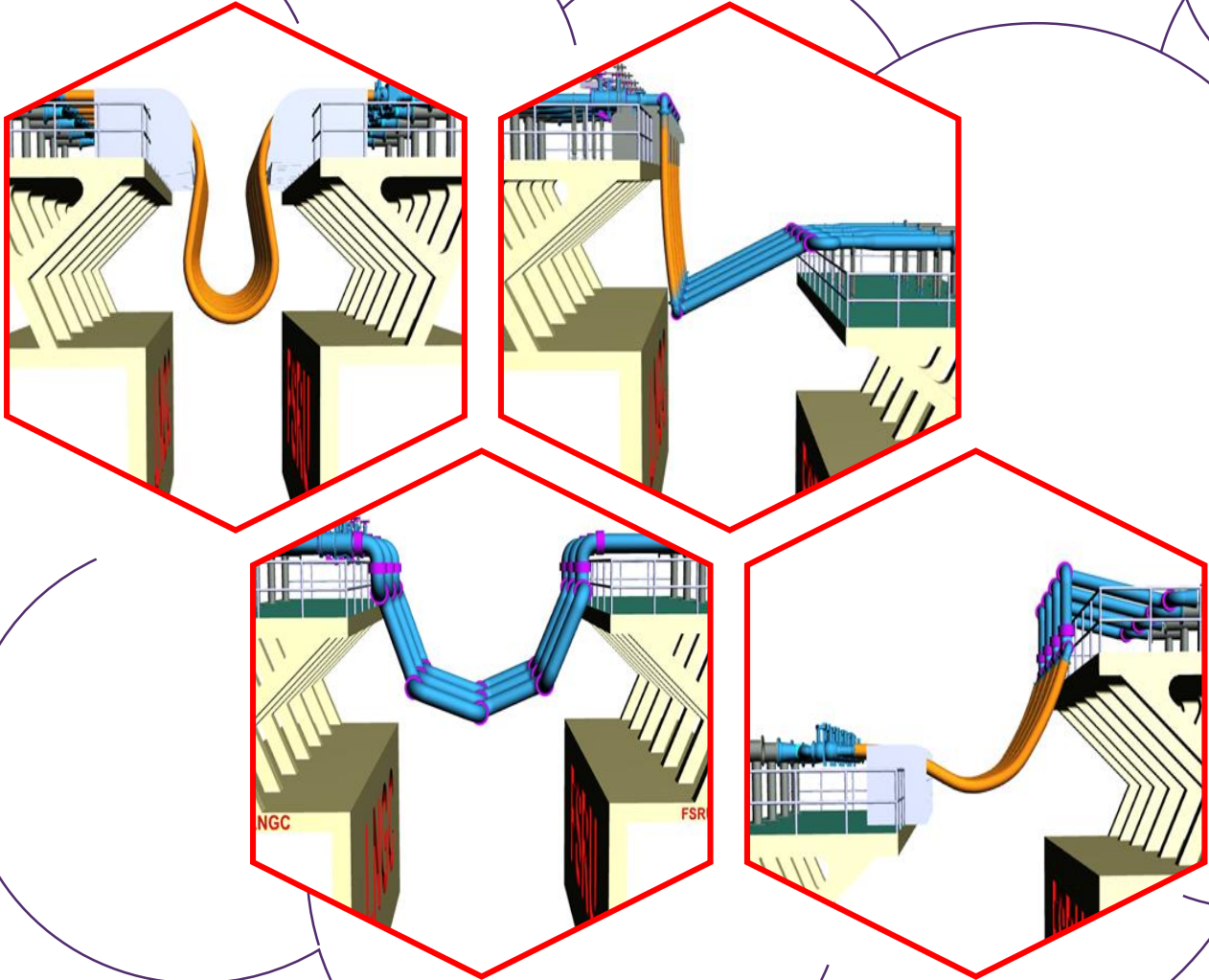
## Cryogenic hoses



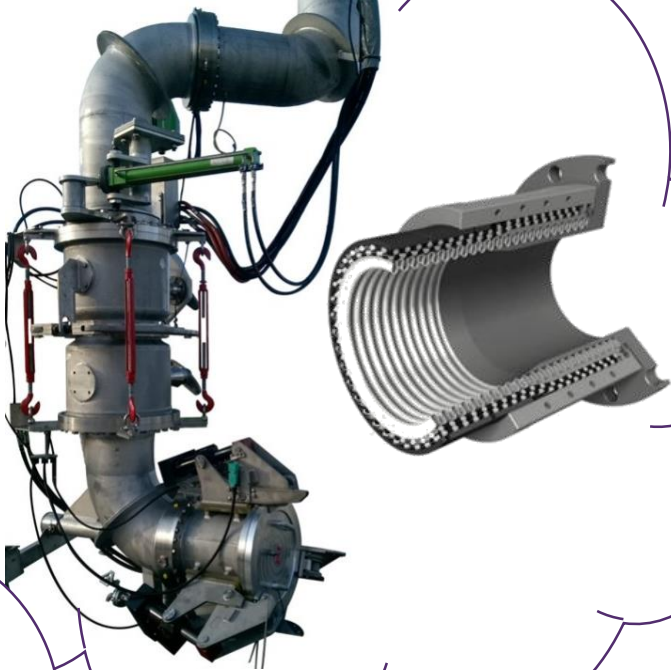
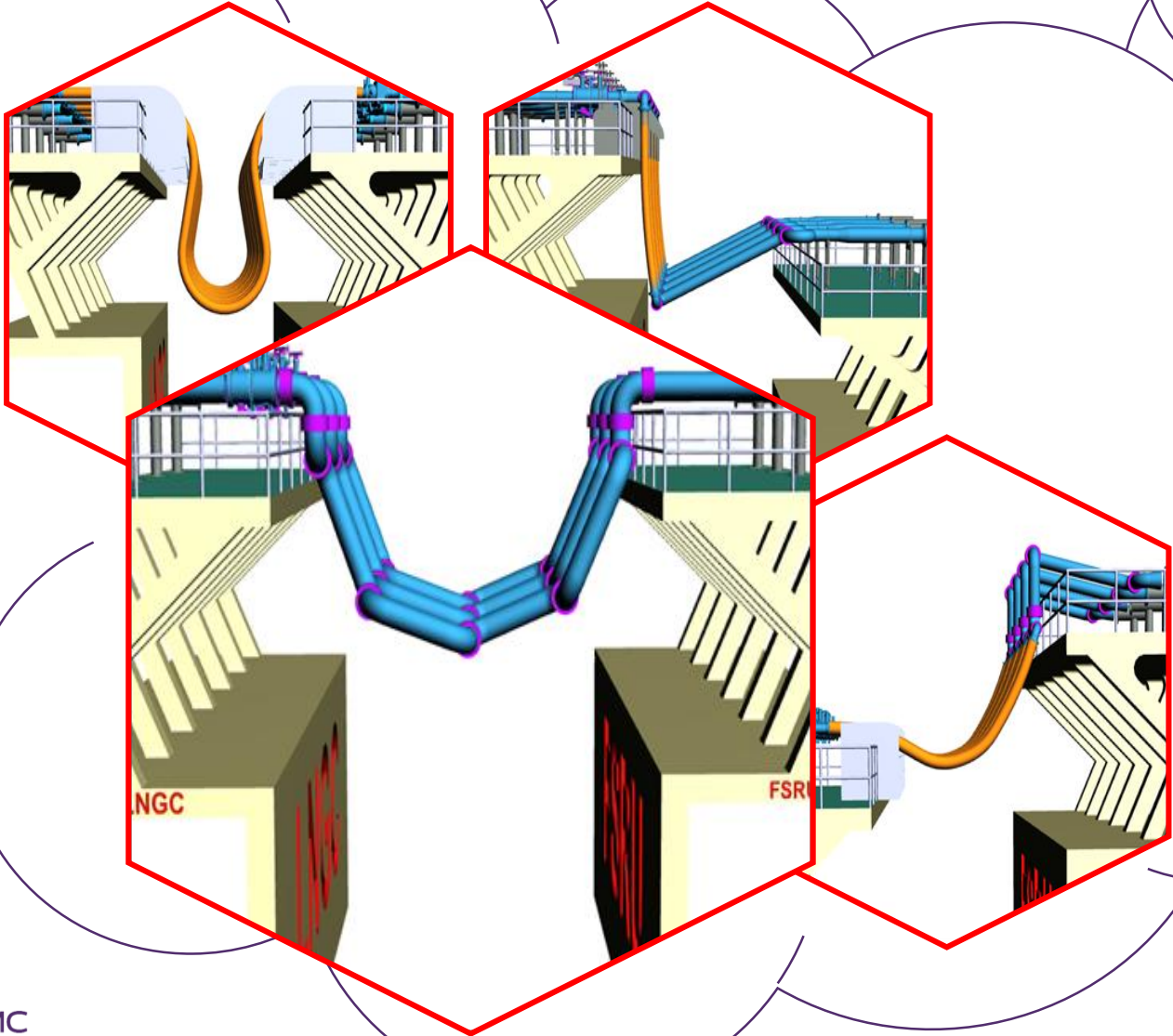
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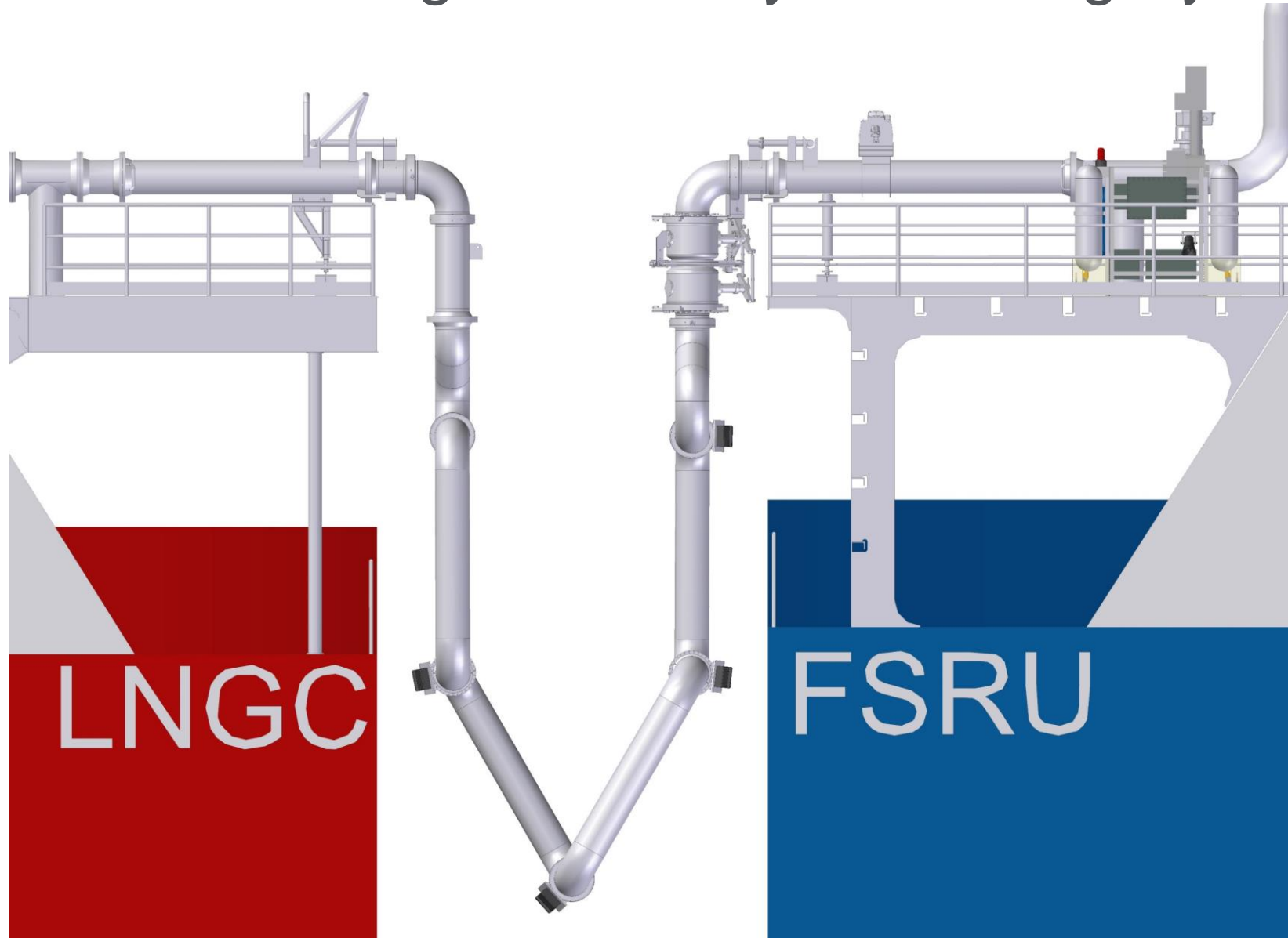
# ARCOS development



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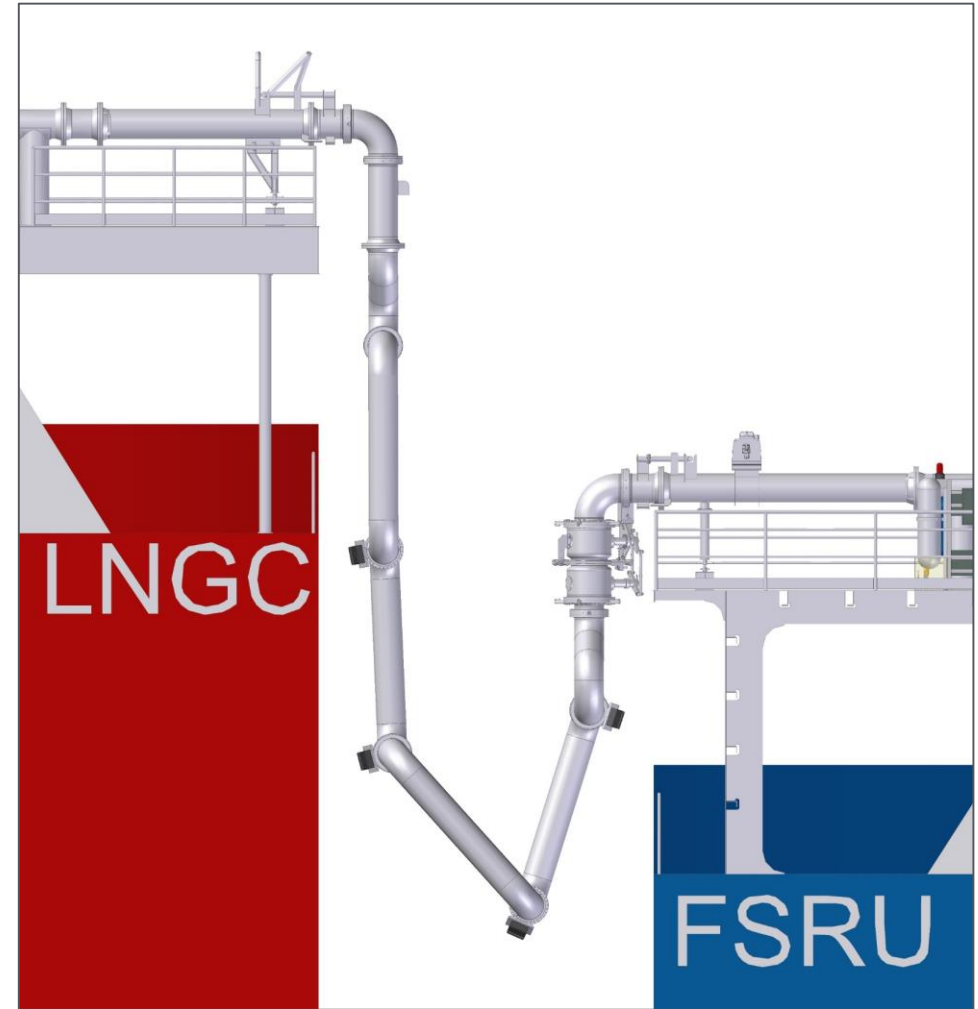
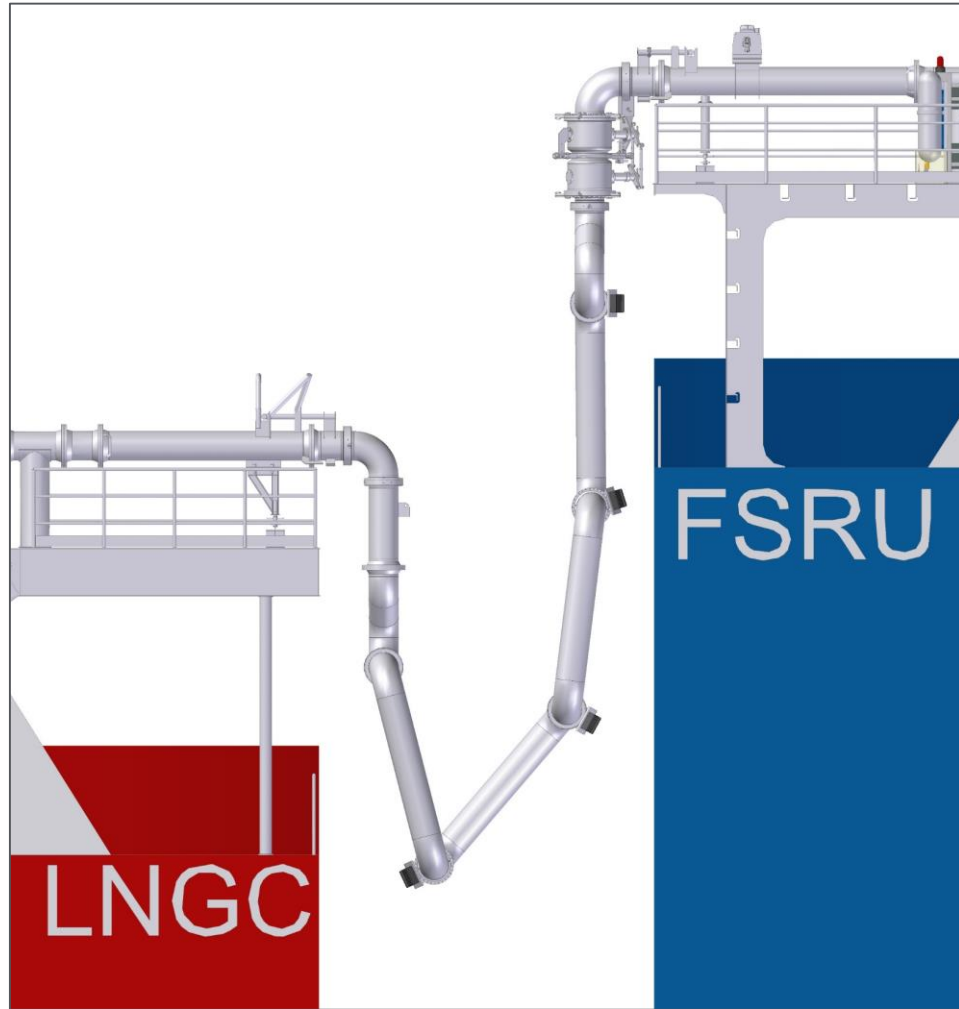


# ARCOS: Articulated Rigid Catenary Offloading System

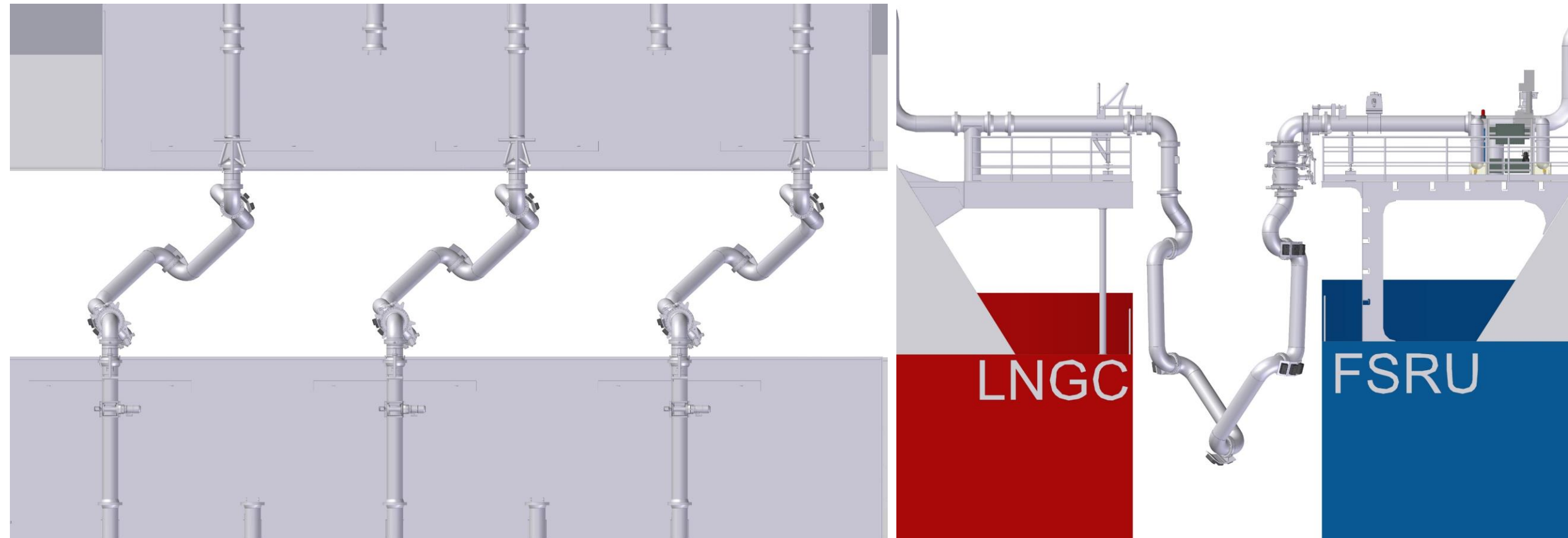




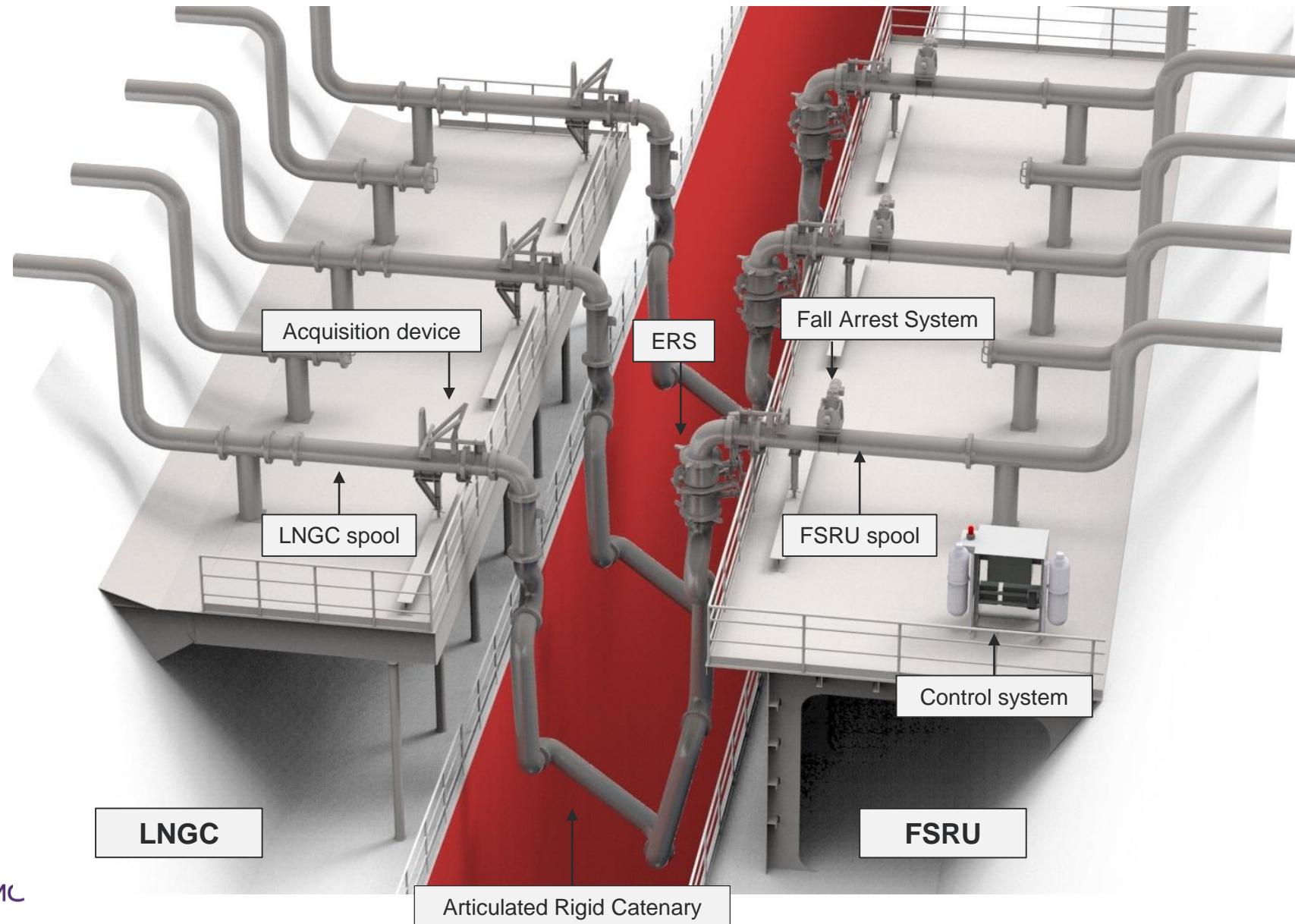
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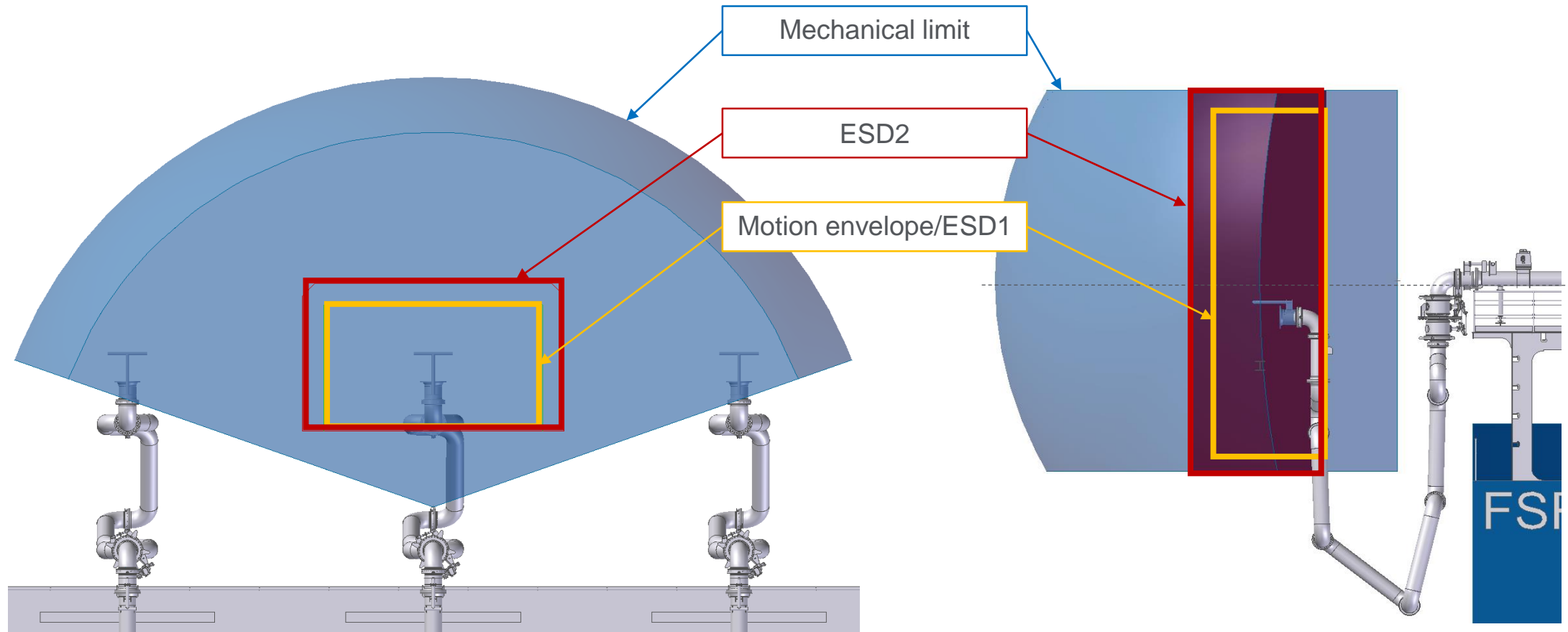


# ARCOS – Articulated Rigid Catenary Offloading System



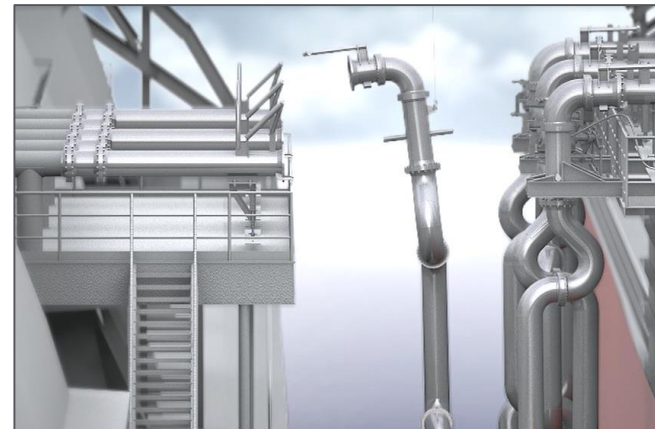
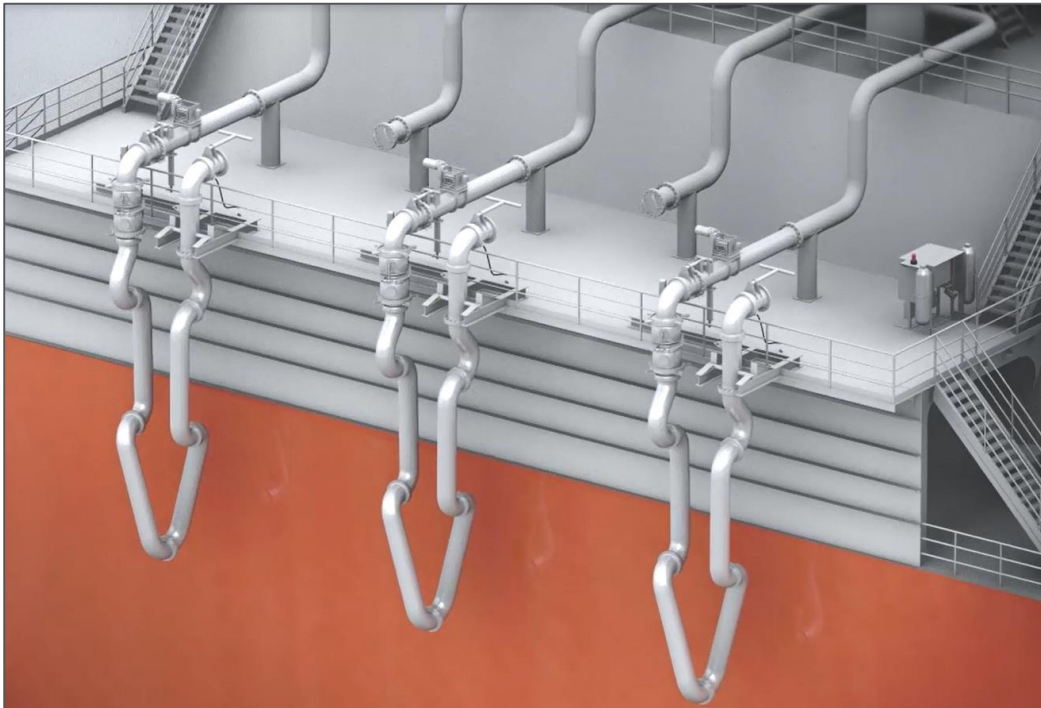
# Operating envelope

- Typical range of LNG carriers: 130,000 – 170,000 m<sup>3</sup>
- Same operating envelope as a 18 m hose
- Envelope continuous monitoring and ESD triggering using sensors



# Parking & handling

- **Parking position alongside floating unit**
- **Handling w/ FSRU crane**
- **Acquisition device for safe connection/disconnection with relative motions**

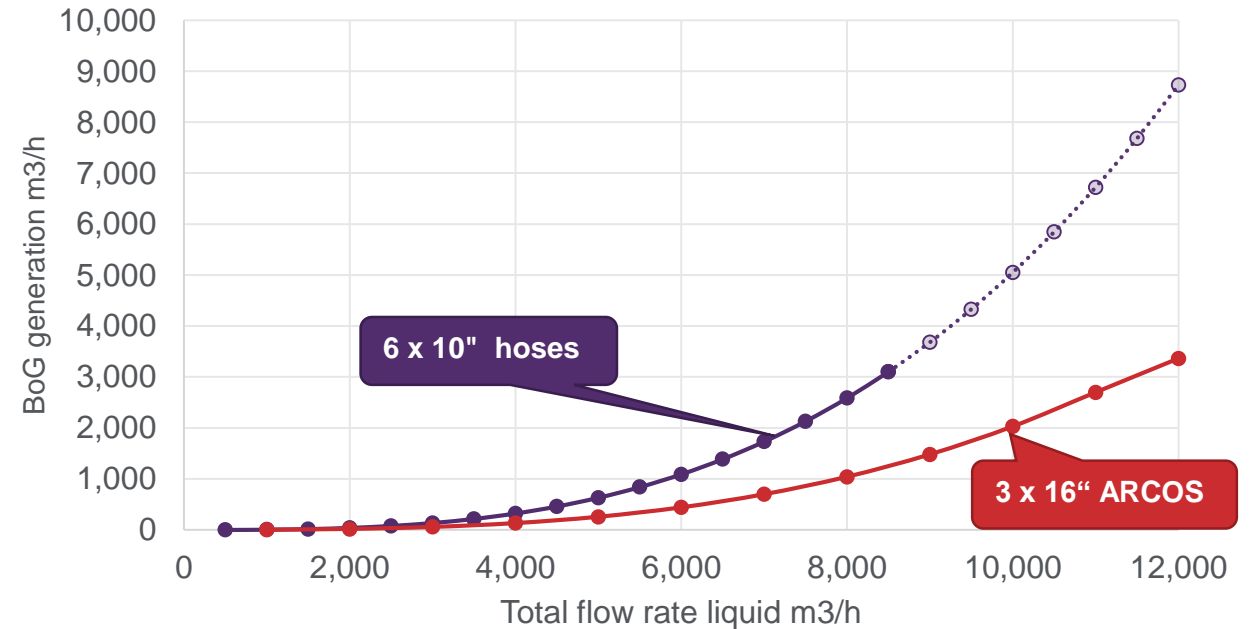


# Process performances

	ARCOS	
PRODUCT LINE	LNG	NG
LINE	2 x 16"	1 x 16"
NOMINAL FLOW RATE	10,000 m <sup>3</sup> /h @ 12 m/s	28 t/h @ 45 m/s
PRESSURE DROP	1.4 barg	0.1 barg
DESIGN PRESSURE	19 barg	

High transfer rate using 16" FB rigid pipes  
 Far lower pressure drop thanks to smooth inner bore  
 2.5 times lower BoG generation at high flow rate

BoG generation due to pressure drop



## Significant savings on:

- Recondenser
- Compressor unit
- Gas consumption unit

ARCOS is a great fit for high gas send out capacity installations

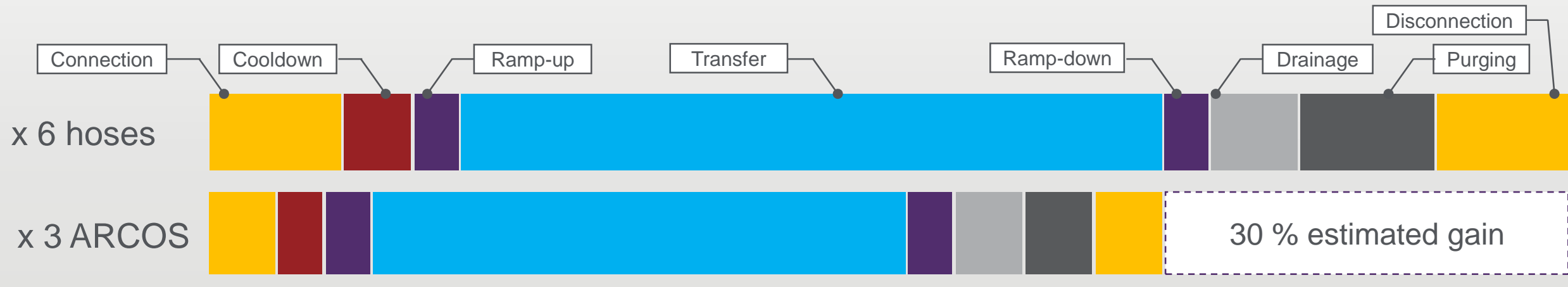
# Optimizing STS operation time

## Mechanical operations

- 12 lifting operations vs 36 with hoses
- Eliminate up to 112 bolting operations
- Only 3 ERS tests to be done
- Improved connection procedure with acquisition device

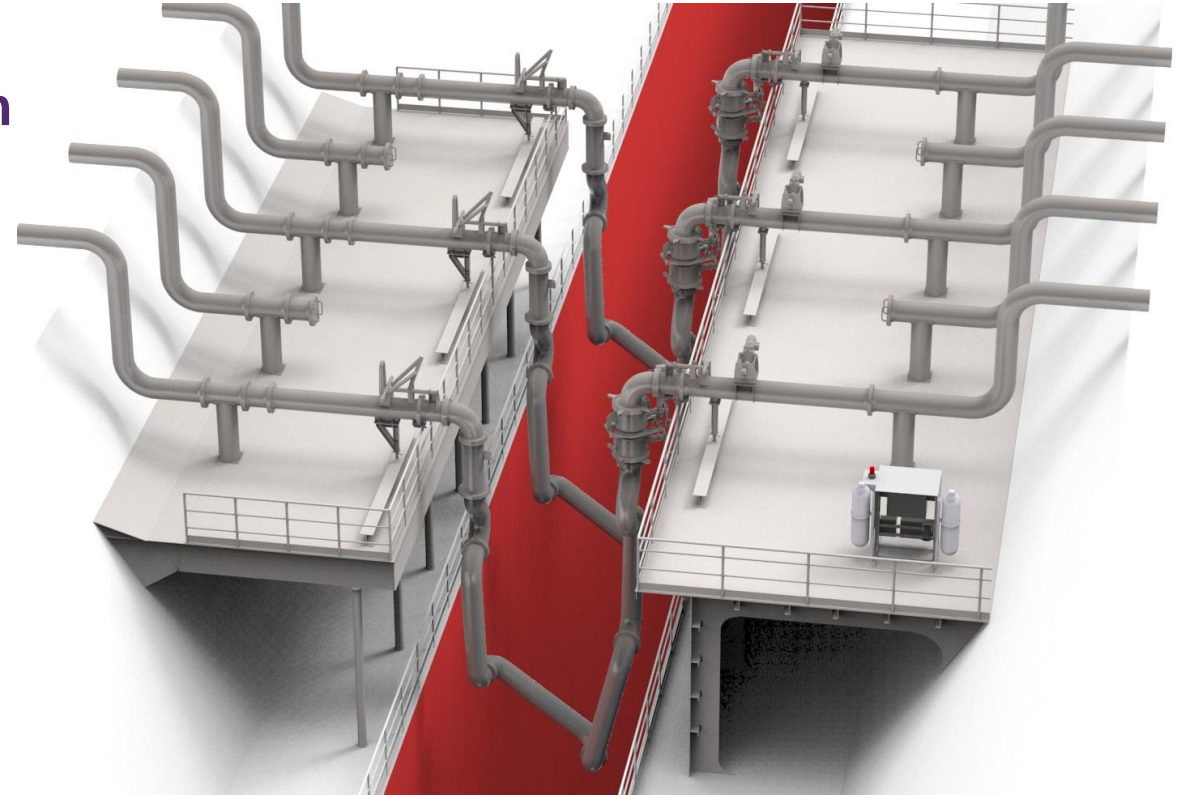
## Process operations

- 30 % faster cool down time
- 20 % higher transfer rate / 45 % lower pressure drop
- Ease LNG sampling for custody transfer
- Faster drainage thanks to higher conductivity of steel pipes vs composite hoses
- No methane bleed-off after drainage



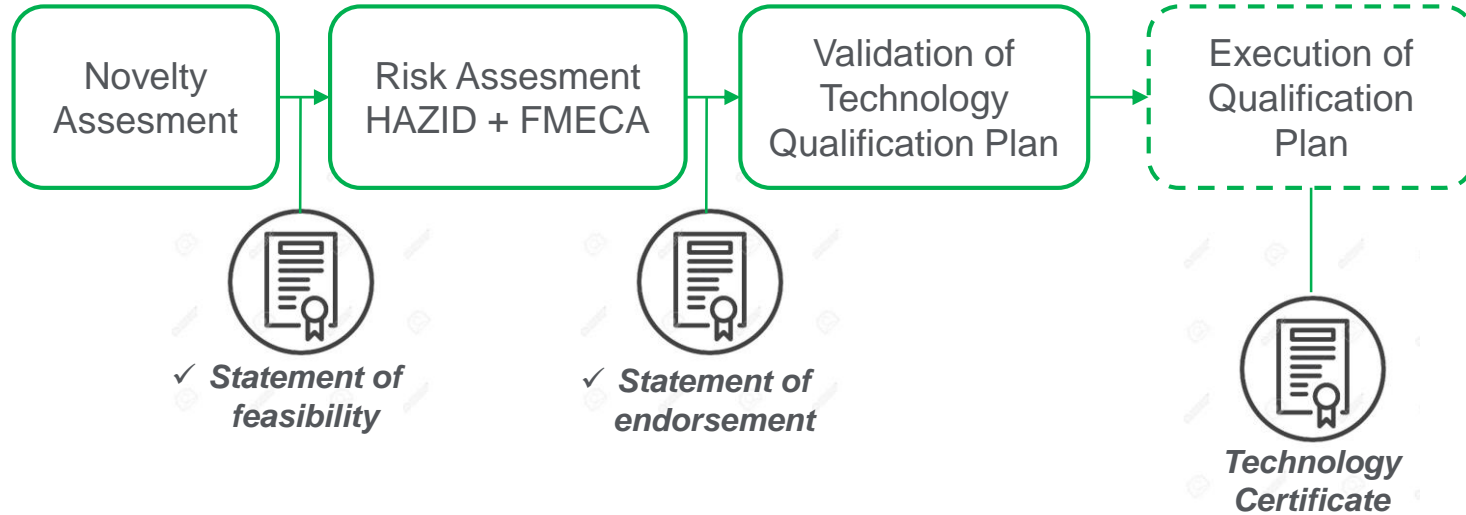
# Safety enhancement

- Less congestion on manifold working platform
- Significantly reduce hand crush risk
- Fewer ERS units to check & maintain
- Enhanced drift detection accuracy & reliability with sensors on lines
- Use of inherent fire safe materials
- Compliant with industry standards: SIGGTO, EN1474-3, ISO16904





# Technology qualification



## Main activities already performed:

- Novelty assessment: use of field proven components
- HAZID & FMECA
- ARCOS structural integrity in all operational modes
- LNG carrier platform and manifold integrity
- Operation procedures

**STATEMENT OF ENDORSEMENT**

**DNV-GL**

**This is to state:**  
that qualification of the

**ARCOS**

has been conducted in accordance with DNV RP-A203 Qualification Procedures for New Technology /1/ Sections 5, 6 and 7 as reported in DNV GL Technical Report <Report Number> /3/. DNV GL has found that the technology can be proven Fit for Service, as defined in /2/, through the remaining planned qualification activities.

Technology owner: **FMC Technologies SAS**

Name of Technology: **ARCOS - Articulated Rigid Catenary Offloading System**

Description: **LNG offloading system composed of at least 3 (2 liquid + 1 vapour) 16" free-hanging articulated lines, with ERS, fall arrest system, connection spools and control system**

Application: **Ship-To-Ship (STS) LNG transfer**

Involvement: **DNVGL has reviewed the Technology Qualification Plan issued by FMC**

Limitations: **Flow 5000 m3/h per liquid line - Hs max 2.5 m - FSRU / LNGC geometrical data: see ref. [3]**

Reference documents: **/1/ DNVGL-RP-A203 - Recommended Practice, Technology Qualification (June 2017)  
/2/ DNVGL-SE-0160 - Service Specification, Technology Qualification Management and Verification (Feb. 2018)  
/3/ DNVGL Technical Report ref. 11954J11-5 rev.0, Technology Qualification Plan Endorsement Report**

DNV GL shall not be responsible for not having identified failure modes or causes that has resulted in loss or damage or for not having prescribed the qualification activities necessary to avoid the loss or damage.

Issued at **Paris** on **2018-08-24**

Digitally signed by **Bruno Declerck**, Head of Department, Location DNV GL, Paris, France

for DNV GL  
**Pierre-André Kohn**, Project Manager

**Bruno Declerck**  
Head of Department

**Pierre-André Kohn**  
Project Manager

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# ARCOS: Key Take Away

## SIMPLE

- 3 lines/3 ERS
- Lightweight & removable
- Transport in 40-ft containers

## SAFE

- Minimum lifting & bolting operations
- Enhanced connection
- Field proven components
- SIL 2 ERS

## COST EFFECTIVE

- Competitive CAPEX & OPEX
- Reduced STS operation time

ARCOS combines the best of the MLA technology and of the hose based solution

