2015 Japan Technology Summit
Yokohama, September 9-10

Game Changing Technologies & Trends in LNG Marine

David Higgins – Director Marine, HPS
Agenda

Experience in FLNG

• Projects
• Leveraging LNG Carrier technologies

Key Levers driving FLNG ROI

• Analysis of project metrics
• Impact of APC and OTS

LNG Carrier Solution Examples

• DFE
• MEGI
• Regas Vessels / FSRU
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Simulation on Shell FLNG

- Honeywell awarded by TECHNIP 2 contracts:
  - Dynamic Simulation Studies (Dec. 2011)
  - Operator Training Simulator (Jan. 2012)

- Unisim is used for
  - Validation and overall optimisation of process design
  - Developing operating best-practice strategies
  - Building and enhancing operator’s skills

Honeywell Performance Materials supplying 245FA Blowing Agent for the GTT Mk3 membrane insulation (low BOR), working now on Solstice LBA for ultra low BOR.
**Petronas PFLNG1**

- FLNG unit will be moored approximately 180km off the coast of Sarawak, Malaysia, and is designed to produce 1.2 million tons per year of liquefied natural gas.
- Honeywell’s UOP Amine Guard FS process to remove carbon dioxide and hydrogen sulfide from the liquefied natural gas feed streams.
- Storage 177,000CBM
- Size 360m x 60m
- Startup scheduled for end of 2015
UOP offers Amine-based and Solvent-Free Pretreatment Schemes
Exmar FLRSU Project

FLRSU : Floating Liquefaction Regas Storage Unit

- FLRSU Owner : Exmar Pte Ltd (operated by Exmar ship management)
- Gas Owner: Pacific Rubiales Energy
- Shipyards : Wison Shipyards, China
- Top Side Pre-treatment, Liquefaction technology : Black & Veatch
- ICSS Provider : Honeywell
Caribbean FLNG Project Details

- World’s first floating liquefaction
- Location: The Colombian Caribbean coast 4km offshore in 14m water depth.
- Pacific Rubiales Energy : Owner of Gas
- 15 years contract : Tolling Agreement
- FLSRU Storage Capacity : 16,100 m³ of LNG (Type-C Tanks) +FSU alongside
- Liquefaction Capacity : 0.6 MMTPA
- Length: 144m, Breadth: 32m, Depth: 20m
- Commercial Operations : Third quarter of 2015 (Estimated)
- As part of the project, PSE will build an 88 km, 18" diameter pipeline from its producing La Creciente Field to the Caribbean coast with an initial design transportation capacity of 100 MMcf/d.
Honeywell Scope of Supply

- ICSS based on Experion PKS
  - 3000 Hard I/O, 3000 serial
    - DCS – C300
    - SIS – Safety Manager
    - FGS – Safety Manager
    - HIPPS – Safety Manager
    - Hart Integration/Asset Management System using Field Device Manager
  - Digital Video Manager CCTV
  - Fire & Gas Detectors
  - Addressable Fire System for Accommodation
  - BV Certification
  - Project Management and System Engineering from our Tianjin Engineering and Customer Solution Centre
    - Dedicated team working with Wison design team in Shanghai and B&V design team in Kansas City
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Automation Technologies from LNGC applicable to FLNG

- Integrated Automation System, or ICSS
- Cargo ESD
- Cargo Tank Custody Transfer Systems (Fiscal metering by level)
- Ship Shore Link
- Gas Detection System – Sampling Type around Cargo Tanks
- Accommodation Fire Alarm System
- Dual Fuel Engine Control System
- Dynamic Positioning System
- Propulsion Control System
- Security/Surveillance Solutions – CCTV, Radar
- Generator Control
- Power Management System
- Gas Management System
- Loading Computer (vessel stability/stress calculations)
QFlex and QMax LNG Carriers
(with Re-liquefaction Plant onboard)
Reliquefaction experience

We have 27 vessels where we supplied the Reli Control System, including Control of Cold Box, Nitrogen Componders and BOG Compressors.

LNG Carrier Procurement Projects by Qatar

<table>
<thead>
<tr>
<th>Project</th>
<th>Capacity (cu.m)</th>
<th>No. of Ships</th>
<th>Honeywell</th>
<th>Shipping Company / Shipbuilder</th>
<th>Market</th>
<th>Completion</th>
<th>QGTC’s share per ship</th>
</tr>
</thead>
</table>
| RasGas II              | 150,000         | 8            | 3         | Maran Gas: 4 (Daewoo)  
Teekay: 3 (Daewoo)  
Japan consortium: 1 (Samsung) | Europe       | 2006 - 2007 | 30%                                                |
| Qatargas II (Train A)  | 210,000         | 8            | 4         | Pronav: 4 (Daewoo)  
OSG: 4 (2 each by Hyundai and Samsung) | U.K.         | 2007 - 2008 | 50.1%                                              |
| RasGas III (Train A)   | 210,000         | 12           | 9         | Japan consortium: 8 (5 by Daewoo, 3 by Hyundai)  
Teekay: 4 (Samsung) | U.S.          | 2008        | 60%                                               |
| Qatargas II (Train B)  | 260,000         | 6            | 3         | QGTC (3 each 260,000 by Daewoo and Samsung) | Europe/U.S. | 2008 - 2009 | 100%                                              |
| Qatargas III           | 210,000  
260,000       | 10           | 3         | QGTC (3 260,000-cu.m and 1 210,000-cu.m by Samsung) | U.S.        | 2009        | 100%                                              |
| Qatargas IV            | 210,000  
260,000       | 8            | 4         | QGTC (4 210,000-cu.m by Daewoo,  
4 260,000-du.m by Samsung) | Europe/U.S. | 2009 - 2010 | 100%                                              |
| RasGas III (Train B)   | 260,000         | 4            | 4         | QGTC (all by Samsung) | U.S.        | 2009 - 2010 | 100%                                              |

56  30  <-includes 13 Qflex with HGS Reli and 14 Qmax with Cryostar Reli  
54%
Cargo Overview with Re-liquefaction System
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  • Regas Vessels / FSRU
## Advanced Application Benefits

### LNG Plant

<table>
<thead>
<tr>
<th>LNG Plant</th>
<th>Petronas FLNG2</th>
<th>Petronas FLNG1</th>
<th>Shell FLNG</th>
<th>Chevron Angola</th>
<th>Exxon PNG</th>
<th>Woodside Pluto</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nameplate Capacity</td>
<td>1,500,000</td>
<td>1,200,000</td>
<td>3,600,000</td>
<td>5,200,000</td>
<td>6,600,000</td>
<td>4,300,000</td>
<td>TPA</td>
</tr>
<tr>
<td>LNG Storage Capacity</td>
<td>177,000</td>
<td>177,000</td>
<td>220,000</td>
<td>318,000</td>
<td>320,000</td>
<td>240,000</td>
<td>m3</td>
</tr>
<tr>
<td>=</td>
<td>81420</td>
<td>81420</td>
<td>101200</td>
<td>146280</td>
<td>147200</td>
<td>110400</td>
<td>Tons</td>
</tr>
</tbody>
</table>

### Impact of APC

<table>
<thead>
<tr>
<th>APC benefit (increased throughput)</th>
<th>1.5%</th>
<th>1.5%</th>
<th>1.5%</th>
<th>1.5%</th>
<th>1.5%</th>
<th>1.5%</th>
</tr>
</thead>
<tbody>
<tr>
<td>=</td>
<td>22,500</td>
<td>18,000</td>
<td>54,000</td>
<td>78,000</td>
<td>99,000</td>
<td>64,500</td>
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<tr>
<td>=</td>
<td>48,913</td>
<td>39,130</td>
<td>117,391</td>
<td>169,565</td>
<td>215,217</td>
<td>140,217</td>
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<tr>
<td>=</td>
<td>1,176,750</td>
<td>941,400</td>
<td>2,824,200</td>
<td>4,079,400</td>
<td>5,177,700</td>
<td>3,373,350</td>
</tr>
</tbody>
</table>

DES Japan/Korea Gas Price
- $18 per TPA
- $18 per m3
- $18 per mMBTU

Extra Revenue across the LNG Supply chain
- $21,181,500 per year

**Honeywell Products: APC (Advanced Process Control) for increased production**

### Impact of Uptime or Delays in Startup or Tanktops reached

<table>
<thead>
<tr>
<th>Impact of Uptime or Delays in Startup or Tanktops reached</th>
<th>Daily Production</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4,110</td>
</tr>
<tr>
<td></td>
<td>3,288</td>
</tr>
<tr>
<td></td>
<td>9,863</td>
</tr>
<tr>
<td></td>
<td>14,247</td>
</tr>
<tr>
<td></td>
<td>18,082</td>
</tr>
<tr>
<td></td>
<td>11,781</td>
</tr>
<tr>
<td>=</td>
<td>8,934</td>
</tr>
<tr>
<td>=</td>
<td>7,147</td>
</tr>
<tr>
<td>=</td>
<td>21,441</td>
</tr>
<tr>
<td>=</td>
<td>30,971</td>
</tr>
<tr>
<td>=</td>
<td>39,309</td>
</tr>
<tr>
<td>=</td>
<td>25,610</td>
</tr>
<tr>
<td>DES Japan/Korea Gas Price</td>
<td>$18</td>
</tr>
<tr>
<td></td>
<td>$18</td>
</tr>
<tr>
<td></td>
<td>$18</td>
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<tr>
<td></td>
<td>$18</td>
</tr>
<tr>
<td></td>
<td>$18</td>
</tr>
<tr>
<td>=</td>
<td>214,932</td>
</tr>
<tr>
<td>=</td>
<td>171,945</td>
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<tr>
<td>=</td>
<td>515,836</td>
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<tr>
<td>=</td>
<td>745,096</td>
</tr>
<tr>
<td>=</td>
<td>945,699</td>
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<tr>
<td>=</td>
<td>616,137</td>
</tr>
<tr>
<td>DES Japan/Korea Gas Price</td>
<td>$18</td>
</tr>
<tr>
<td></td>
<td>$18</td>
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<td></td>
<td>$18</td>
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<td></td>
<td>$18</td>
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<tr>
<td>=</td>
<td>8,934</td>
</tr>
<tr>
<td>=</td>
<td>7,147</td>
</tr>
<tr>
<td>=</td>
<td>21,441</td>
</tr>
<tr>
<td>=</td>
<td>30,971</td>
</tr>
<tr>
<td>=</td>
<td>39,309</td>
</tr>
<tr>
<td>=</td>
<td>25,610</td>
</tr>
<tr>
<td>Revenue lost in the LNG supply chain due to one day of outage</td>
<td>$3,868,767</td>
</tr>
<tr>
<td></td>
<td>$3,095,014</td>
</tr>
<tr>
<td></td>
<td>$9,285,041</td>
</tr>
<tr>
<td></td>
<td>$13,411,726</td>
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<td>$17,022,575</td>
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<td>$11,090,466</td>
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<td>$18</td>
</tr>
<tr>
<td>=</td>
<td>$18</td>
</tr>
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<td>$18</td>
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<td>$18</td>
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<td>=</td>
<td>$18</td>
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<tr>
<td>=</td>
<td>3,868,767</td>
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<td>3,095,014</td>
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<td>9,285,041</td>
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<td>13,411,726</td>
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<tr>
<td>=</td>
<td>17,022,575</td>
</tr>
<tr>
<td>=</td>
<td>11,090,466</td>
</tr>
</tbody>
</table>

**Honeywell Products: UniSim Simulation for Operator Startup training**

### Tanktops Analysis

<table>
<thead>
<tr>
<th>Tanktops Analysis</th>
<th>Daily Production</th>
<th>Storage Capacity</th>
<th>LNG Carrier Storage Capacity (assigned or available vessel)</th>
<th>Days between vessel</th>
<th>Days to tank tops from empty</th>
<th>Ship delay which will cause tanktops</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>8,934</td>
<td>177,000</td>
<td>155,000</td>
<td>17.35</td>
<td>19.81</td>
<td>2.46</td>
</tr>
<tr>
<td></td>
<td>7,147</td>
<td>177,000</td>
<td>155,000</td>
<td>21.69</td>
<td>24.77</td>
<td>3.08</td>
</tr>
<tr>
<td></td>
<td>21,441</td>
<td>220,000</td>
<td>155,000</td>
<td>7.23</td>
<td>10.26</td>
<td>3.03</td>
</tr>
<tr>
<td></td>
<td>30,971</td>
<td>318,000</td>
<td>160,000</td>
<td>5.17</td>
<td>10.27</td>
<td>5.10</td>
</tr>
<tr>
<td></td>
<td>39,309</td>
<td>320,000</td>
<td>172,000</td>
<td>4.38</td>
<td>8.14</td>
<td>3.77</td>
</tr>
<tr>
<td></td>
<td>25,610</td>
<td>240,000</td>
<td>147,210</td>
<td>5.75</td>
<td>9.37</td>
<td>3.62</td>
</tr>
</tbody>
</table>

**Honeywell Products: Production Planner, Capacity Distribution Planner**

### Multiple significant benefits at modest cost
Why APC? – Operating within Constraints

- APC Operating Region
- True Economic Optimum
- Profit Optimizer Operating Region

- Compressor Speed
- Pressure
- Temperature
- Valve Positions
- Purity

Need to Increase Operating Region

Operator's Preferred Operating Region

Why APC?
– Operating within Constraints
APC – Proven Benefits on LNG

• QatarGas Project Outcomes
  – 6.5% Increase in LNG Production (inc. tuning of loops)
  – 3.50% Reduction in Steam Usage

• Other LNG APC Experiences
  – LNG Train 1-3% increase in LNG Production
  – LPG Recovery improvement ~ 40%
  – Stabilisers 3% increase in Condensate Production
  – Additional LNG and LPG cargo per year at 1.7mpta rate
  – Stabilized production reduces process upsets and downtime
LNG end-to-end Optimisation

STABILITY

LIQUIFICATION

STORAGE

SHIPPING
Simulation Lifecycle Approach

The Simulation Lifecycle Approach

Plant Asset Lifecycle

- Concept Selection
- FEED
- Detailed Engineering
- Construction & Commissioning
- Operations

Main equipment items, P&ID connectivity, control system, pipeline - process interaction.

Extend the coarse model with vendor data, pipework details, ESD cause & effect functionality, advanced compressor control.

Initial Process Model

Detailed Process Model

Updated Process Model

Plant Simulator

- Operator Consoles
- Instructor Station
- OTS Gateway
  - Utility Models
  - DCS Emulation / Hardware
  - Training Exercises

Extensive IAS Verification

Expansion

Operations
ICSS Verification

Phase 1
Pre IAS Check-Out
- Develop/Verify Control Strategy and Design using Engineering Simulator (i.e. without DCS connected)

Phase 2
Initial Check-Out phase
- System connection / link connection
- IAS Integration
- IAS Commissioning
  Informal tests to make the simulator work

Phase 3
Formal Check-Out phase
- FAT for the IAS on the simulator
- Additional to the conventional FAT!

Phase 4
Operational Improvement
- Controller tuning
- Alarm system optimization
- HMI optimization

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- Regas Vessels / FSRU
Yamal ICE7 Class

- 15 vessels for three train Yamal LNG project
- Ice Class 7 LNGC, capable to break through 2 meters of ice in reverse with 3 propellers.
- Vessels will travel the Northern Sea route in Summer, and via Europe/Trans-shipment in Winter
- DSME Korea contracted for all vessels with one specification, driven by Yamal LNG (Novatek/Total)
- Sovcomflot signed contract for 1st vessel, with Teekay, MOL now participating
- DFE Design, 6 Generators
- First vessel Ice Trial 2016, Plant Startup 2017-2019
Electric Propulsion Block Diagram showing key interfaces
Gas Management System
## Interfaces to form an Integrated Automation System (DFE LNGC example)

<table>
<thead>
<tr>
<th>IAS Subsystem</th>
<th>Vessel System</th>
<th>Major Suppliers</th>
<th>Integration Experience</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cargo</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Compressors</td>
<td></td>
<td>CRYOSTAR</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ATLAS COPCO</td>
<td>✓</td>
</tr>
<tr>
<td>Reli (if fitted)</td>
<td></td>
<td>CRYOSTAR</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td></td>
<td>HGS</td>
<td>✓</td>
</tr>
<tr>
<td>GCU</td>
<td></td>
<td>CRYOSTAR</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td></td>
<td>HAMWORTHY COMBUSTION</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SAACKE</td>
<td>✓</td>
</tr>
<tr>
<td>CTS(Custody Transfer System)</td>
<td></td>
<td>SAAB</td>
<td>✓</td>
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<tr>
<td></td>
<td></td>
<td>AUTRONICA</td>
<td>✓</td>
</tr>
<tr>
<td>N2 Generator</td>
<td></td>
<td>UNITOR</td>
<td>✓</td>
</tr>
<tr>
<td>Level Gauging System</td>
<td></td>
<td>HOPPE</td>
<td>✓</td>
</tr>
<tr>
<td>LC(Loading Computer)</td>
<td></td>
<td>NAPA</td>
<td>✓</td>
</tr>
<tr>
<td>IGG</td>
<td></td>
<td>AALBORG</td>
<td>✓</td>
</tr>
<tr>
<td>FLG(Floating Level Gauge)</td>
<td></td>
<td>HENRI</td>
<td>✓</td>
</tr>
<tr>
<td>Gas Detection System</td>
<td></td>
<td>KOMYO</td>
<td>✓</td>
</tr>
<tr>
<td>NO.2 W/H G.P</td>
<td></td>
<td>FURUNO</td>
<td>✓</td>
</tr>
<tr>
<td>Machinery</td>
<td></td>
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</tr>
<tr>
<td>Dual/Triple Fuel Engine/Generator</td>
<td></td>
<td>WARTSILÄ</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td></td>
<td>MAN</td>
<td>✓</td>
</tr>
<tr>
<td>Propulsion System/Motor</td>
<td></td>
<td>ABB</td>
<td>✓</td>
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<tr>
<td>Switchboards</td>
<td></td>
<td>ABB</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>Terasaki</td>
<td>✓</td>
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<tr>
<td>SMS(Shipboard Management System)</td>
<td></td>
<td>-</td>
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</tr>
<tr>
<td>Service Air Compressor</td>
<td></td>
<td>ATLAS</td>
<td>✓</td>
</tr>
<tr>
<td>SPM(Ship Performance Monitor)</td>
<td></td>
<td>KYMA</td>
<td>✓</td>
</tr>
<tr>
<td>VDR(Voyage Data Record System)</td>
<td></td>
<td>SAMSUNG</td>
<td>✓</td>
</tr>
<tr>
<td>Control Air Compressor</td>
<td></td>
<td>ATLAS</td>
<td>✓</td>
</tr>
<tr>
<td>OMD(Oil Mist detector)</td>
<td></td>
<td>SPECS</td>
<td>✓</td>
</tr>
</tbody>
</table>

Honeywell has extensive experience with all key equipment makers
# Example Fuel Operating Modes

<table>
<thead>
<tr>
<th>Mode</th>
<th>IAS Input</th>
<th>IAS Output</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Gas Only Modes</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NBO</td>
<td>Tank Pressure</td>
<td>None</td>
</tr>
<tr>
<td>NBO + FBO</td>
<td>Tank Pressure &amp; Ships Speed (Power Demand)</td>
<td>Forcing Vaporiser</td>
</tr>
<tr>
<td>Cruise Control</td>
<td>Tank Pressure</td>
<td>Speed/Power Offset (+/-5%)</td>
</tr>
<tr>
<td><strong>Mixed Fuel Modes</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NBO + HFO (Oil Priority) inc. FSM</td>
<td>Tank Pressure &amp; Ships Speed (Power Demand)</td>
<td>Oil Demand</td>
</tr>
<tr>
<td>NBO + FBO + HFO (Gas Priority)</td>
<td>Tank Pressure &amp; Ships Speed (Power Demand)</td>
<td>Forcing Vaporiser</td>
</tr>
<tr>
<td><strong>Oil Only</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MDO/HFO</td>
<td>Ships Speed (Power Demand)</td>
<td>Oil Demand</td>
</tr>
</tbody>
</table>
Market leading Provider of Blowing Agent for LNG Tank Insulation

- **Enovate 245fa** provides the lowest BOR for LNG carrier Cargo Containment Systems
  - Mark III Flex 0.09%/day
  - NO96-LO3 0.108%/day

- Environmentally friendly - non-ozone depleting blowing agent

---

Honeywell 245fa is the Best Choice for LNG Vessel Containment System
Mixed Mode Fuel Efficiency

Fuel Use (kJ/kWh)

Boil Off Rate (kg/h)

- Efficiency
- GM

0.15% BOR
0.10% BOR
NCR
### Fuel Sharing Mode Control Principle

- **Interacting GMS/PMS Controls**
  - Fuel Gas Use adjusted to meet Tank Pressure Control Requirements (Calculation of Recommended Gas Load)
  - Fuel Oil Load adjusted according to Power Demand

- **Compare this to vessel without FSM and decoupled control**
  - Engines set to Gas by PMS
  - Forcing Vaporiser operation by GMS (but has minimum 1500kg/h turndown)
  - Possibility that GCU is also then operating to consume excess FBOG

### Fuel Sharing Mode Control Principle

<table>
<thead>
<tr>
<th>Power Demand</th>
<th>Recommended Gas Load</th>
<th>Fuel Oil Load</th>
</tr>
</thead>
<tbody>
<tr>
<td>N_{\text{gas}}</td>
<td>Gas Mode DFE</td>
<td>Fuel Gas</td>
</tr>
<tr>
<td>N_{\text{fsm}}</td>
<td>FSM DFE</td>
<td>Fuel Oil</td>
</tr>
<tr>
<td>N_{\text{oil}}</td>
<td>Oil Mode DFE</td>
<td></td>
</tr>
</tbody>
</table>

\[
0 < N_{\text{gas}} < 5; \quad N_{\text{fsm}} = 1; \quad 0 \leq N_{\text{oil}} \leq 1
\]
Management of FSM Engine Constraints

- Operator Initial operating point inside Light Blue zone
- Track NBOG requires adjustment of FSM Operating point to avoid SACOS engine trip to Oil (Red Line)
  - B1-B3 (Left Side)
    - Increase Gas % on FSM
    - Increase Load on FSM
    - Decrease Load (and unfortunately the efficiency) on GasOnly Engines
  - C1-C3 (Right Side)
    - C1: 87%GF x 60%L is same Gas Flow for C3: 80%GF x 65%L
    - Need to decrease Oil Engine Load
  - B4 or C4...better efficiency..but should the crew switch to FO or GM and allow the Tank Pressure to vary (not preferred close to discharge port)
**DF Engine Efficiency with Fuel Sharing Mode (e.g. Man)**

- Huge opportunity to influence Fuel Usage (and therefore Cost) by managing fuel selection and engine loading
- Highest efficiency when on Gas Only
- Highest efficiency when engine load is higher
- Asym Load Sharing will drive the highest efficiency since more engines can operate closer to their highest efficiency point

### DF Engine Efficiency with Fuel Sharing Mode (e.g. Man)

#### Symm Case

<table>
<thead>
<tr>
<th></th>
<th>DF1</th>
<th>DF2</th>
<th>DF3</th>
<th>DF4</th>
<th>DF5</th>
<th>Average</th>
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<tbody>
<tr>
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<td>Gas</td>
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<td>Gas</td>
<td>FSM</td>
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<tr>
<td>Load%</td>
<td>90%</td>
<td>90%</td>
<td>90%</td>
<td>90%</td>
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<tr>
<td>Gas%</td>
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#### Asym Case

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<tr>
<td>Gas%</td>
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<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>50%</td>
<td>90%</td>
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<tr>
<td>Asym Fuel Use</td>
<td>95</td>
<td>95</td>
<td>95</td>
<td>95</td>
<td>113</td>
<td>98.6</td>
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</table>

1. Asym Case: 1.0% fuel saving by operating Gas Engines on High Load and FSM engine on low load
# Asym/Symm efficiency Comparison

<table>
<thead>
<tr>
<th>Engine Load</th>
<th>100</th>
<th>85</th>
<th>75</th>
<th>50</th>
<th>25</th>
<th>g/kWh</th>
<th>51/60DF Project Guide, Section 2.14.1 Table 23</th>
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<tbody>
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<td>Liquid Fuel</td>
<td>183.5</td>
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<td>Liquid Fuel</td>
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<table>
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<th>DF2</th>
<th>DF3</th>
<th>DF4</th>
<th>DF5</th>
<th>Weighted Average</th>
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<td>70</td>
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<td>70.0</td>
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<td>kJ/kWh</td>
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<td>kJ/kWh</td>
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<td>kJ/kWh</td>
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<td>9279</td>
<td>7579</td>
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</table>

* Fuel Saving based on 150 days Laden voyage per year with $100k fuel per day

**Below 80% Load, it is more efficient to operate in Asym Load Sharing.**

**below 75%, more efficient to stop one engine**
# Asym/Symm Comparison

<table>
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<tr>
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<td>kJ/kWh</td>
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<td>kJ/kWh</td>
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<td>7479</td>
<td>7988</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **Fuel Saving based on 150 days Laden voyage per year with $100k fuel per day**

- **Above 80% Load, it is more efficient to operate in Symmetric Load Sharing**
Experience in FLNG
• Projects
• Leveraging LNG Carrier technologies

Key Levers driving FLNG ROI
• Analysis of project metrics
• Impact of APC and OTS

LNG Carrier Solution Examples
• DFE
• MEGI
• Regas Vessels / FSRU
MEGI Experience – the journey so far

• Honeywell has IAS on 27 QFlex and QMax vessels fitted with MAN MEGI-Capable Main Engines (2008-10)

• MAN Slow Speed Diesel Copenhagen Engine Test (May 2011 and 2012) – Honeywell supplies Fuel Gas Supply Control System

• MEGI-Rel Test Facility

• MEGI Container Ship - General Dynamics NASSCO and TOTE to Build the First LNG-Powered Containerships in the World
  – two 3,100 TEU LNG-powered containerships (+3 options), designated Marlin Class
  – 900,000 Liters of LNG Fuel
  – Design by DSEC (DSME)
  – Constructed in NASSCO shipyard in San Diego
  – First ship delivery Q4, 2015, second in Q1, 2016
  – IAS and FGS Controls by Honeywell

• MEGI Conversion for QMax LNGC (TGE)
  – FGS Controls and integration to Honeywell IAS
  – ‘Rasheeda’ Drydock Q2, 2015
QMax LNGC Conversion

• 266,000 CBM LNG Carrier ‘Rasheeda’ with 2x MAN DIESEL TURBO Main Engines

• Conversion to run on LNG.

• TGE built Fuel Gas System
  – HP Pump/Vaporiser Skids
  – Buffer tank fed from Reliq plant condensate or Cargo Tank

• Drydock in April 2015 at Nakilat Keppel Offshore & Marine (NKOM) facilities in Qatar

• Honeywell Scope
  – Upgrade of vessel IAS
  – Expansion of IAS to include Fuel Gas Supply System Controls
    • New C300 controller
    • New Skid mounted LCP’s with Remote IO

First LNG Carrier to have ME-GI
QMax MEGI FAT Overview

- **NOW**: March 10-12 Software FAT in Choenan
- **Unisim Process Model** connected to IAS for closed loop testing and pre-tuning of
HI-VAR Control Scheme and Overall Integration

**MCC & VFD**
- Glycol water pump start/stop
- Glycol water pump emergency stop
- Glycol water electric heater control
- HP pump speed control
- HP pump emergency stop

**IAS**
- Suction drum control
- HP pump control
- HP vaporizer control
- Fuel gas line N2 purge control
- Safety functions
- Glycol water control
- Blow down

**GI-ECS**
- Gas Pressure Monitoring (P2)
- Gas Pressure Monitoring (P9)
- Gas Pressure Set Point (P2-Set)
- Actual Engine Load
- DSME FGS System Run Indicator
- Gas Flow Indicator

Diagram:
- LNG Tank
- Gasoline Water Tank
- MAN B&W MEGET ENGINE
- GW Electric Heater
- GW Pump
MEGI LNGC Simulator and Test Plant
MEGI-PRS Simulation

- MEGI-PRS has DSME Patent
- Co-work with DSME R&D Center
- Honeywell UniSim Design Process Simulation Engine provide dynamic model of the Process Design
- Experion PKS with Graphics and Control Logic connected in closed loop to the UniSim model
- Enables testing of various operating Modes
  - HiCOM
  - HiVAR
  - Changeover between above two parallel operations
- Used for Plant design
- Enables Pre-tuning of loops to facilitate faster commissioning/startup
- Can be used for LNG Carrier Crew Training
MEGI-REL Test Skid

- Proof of concept, ready for trials
- IAS with Turck RIO in Zone 1
- Redundant Profibus DP connection
Agenda

Experience in FLNG
• Projects
• Leveraging LNG Carrier technologies

Key Levers driving FLNG ROI
• Analysis of project metrics
• Impact of APC and OTS

LNG Carrier Solution Examples
• DFE
• MEGI
• Regas Vessels / FSRU
LNG Regas Vessels

Exmar Excelsior (the first Regas Vessel)
Experience

- Honeywell is the leading Control System supplier with onboard Regas experience
  - All 8 vessels from Excelerate Energy/Exmar/DSME
    - Vessels were delivered with flowrates exceeding design capacity (up to 690 MMcf/day)
  - 1 conversion project with Golar (LNGC -> FSRU)
  - Completed 1 FSRU for Excelerate Energy/DSME, destination Rio, Brazil (up to 800 MMcf/day)
  - Currently implementing MOL/DSME Uruguay FSRU 260k
  - A total of 11 Floating Regas projects are using Honeywell Integrated Automation System

- Technology from our onshore LNG Terminal experience was transferred to meet the onboard requirements
  - Full Marine approved system
  - Additional Design considerations
Burckhardt HP Send Out Compressor

- 2 x HP Compressors 40-110 Bar Send Out to Pipeline
- 5.5 Bar Side Stream for Generators
- Similar design to MEGI-PRS
- Honeywell provides integrated Controls and Local Control Panels/RIO on the skids
FSRU Example Architecture
FSRU Jetty Integration
Training Systems

Industry Trend –

• Suit various environment
• Portability
• Latest technology
• Realistic simulation

Honeywell offers simulation to meet specific requirement -

<table>
<thead>
<tr>
<th>Sim 1</th>
<th>Sim 2</th>
<th>Sim 3</th>
<th>Sim 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single Laptop, suitable for:</td>
<td>Multiple PC’s each with dual screens and membrane operator keyboard; Suitable for</td>
<td>Console with actual Process Controller hardware and some field equipment.</td>
<td>Honeywell UniSim Dynamic Process Model, high fidelity realistic plant response;</td>
</tr>
<tr>
<td>• Temporary onboard training by Honeywell</td>
<td>• Honeywell training courses</td>
<td>• Extension of Sim 2 to facilitate hardware maintenance training</td>
<td>• Shipyards on new designs</td>
</tr>
<tr>
<td>• Ship-owner training manager</td>
<td>• Ship-owner HQ or Maritime Academy deployment</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Summary

- Strong global company with process control background
- Project Methodology and delivery to meet ISO marine standards
- Alignment with shipowner expectations through many previous projects
- Most experienced vendor for onshore LNG, FPSO & High Technology Vessels
- Large local presence Globally
- Large resources – over US$30B per annum listed on the NYSE
- Professionally managed support program - Worldwide Support in over 100 countries (same system hardware and software for onshore and marine)

All over the world, Offshore and LNG Marine operators trust Honeywell for their automation requirements
Thank You!