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We put you first.
And keep you ahead.

Subsea Electric Systems Enter a New Era

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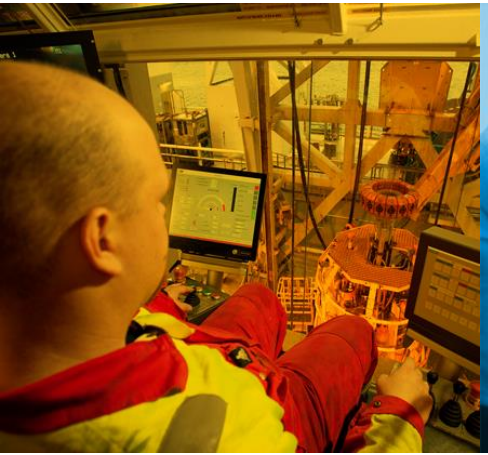
Subsea Controls Down Under, Perth, WA- Oct 2016

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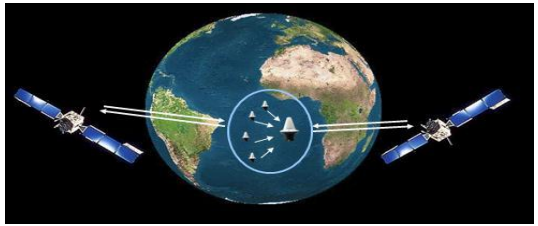
Subsea Electric Solutions

Significant benefits subsea:

- **HSE;** no high pressure, no fluid discharge, no chemical exposure
- **Functionality;** speed, accuracy, retrievability, diagnostics
- **Cost;** standard units, no piping or cleanliness issues, no hydraulic fluid consumption
- **Field Upgrade;** Electric actuators may be retrofit subsea

General industry trend offers core technology:

Electrical Ferry (Norled)

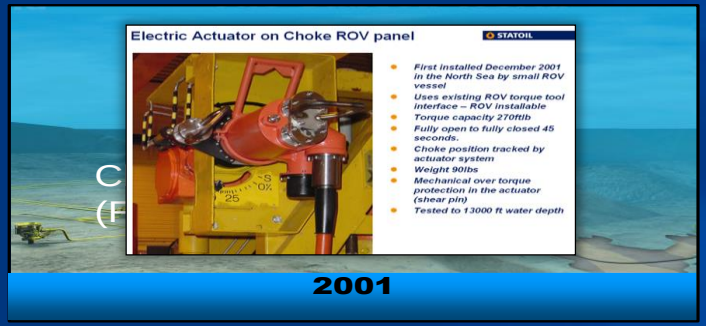


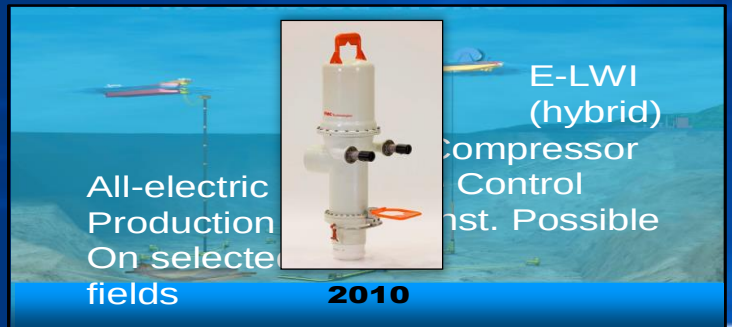
Satellite (Inmarsat)

Electrical ROV (Sperre)

Yr. 2001 FMC Vision: "Components to Systems"

Vision: Electric actuator applications





Expansion of product portfolio from field proven system

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Application History

2001-2015, Total Units Sold:
- **205 eActuators**
- **38 eSCMs**

Main applications have been manifolds, chokes and flow modules.
Some project are:

2001 Statoil Statfjord SSP

16 eActuators and 4 eSCMs for choke actuation

2006 Statoil Åsgard

2 eActuators for manifold valve actuation

2006 Statoil Norne K

21 eActuators and 6 eSCMs for choke actuation

2008 Petrobras Albacora RWI

21 eActuators and 7 eSCMs for pump system valve actuation

2008 Woodside Pluto

1 eActuator and 1eSCM for pig valve actuation

2009 Statoil Gjøa

6 eActuators for choke actuation

2009 Statoil Norne M

2 eActuators and 2 eSCMs for pig valve actuation

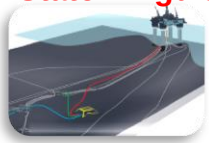
2010 Petrobras Roncador

6 eActuators for water injection choke actuation

2011 Statoil Smørbukk

2 eActuators and 2 eSCMs for choke actuation

2011 Statoil Vigdis NE



2 eActuators and 2 eSCMs for choke actuation

2011 Statoil Åsgard Gas Comp.

79 eActuators for choke and control valve actuation

2015 Statoil Johan Sverdrup

43 eActuators for choke and manifold valve operation

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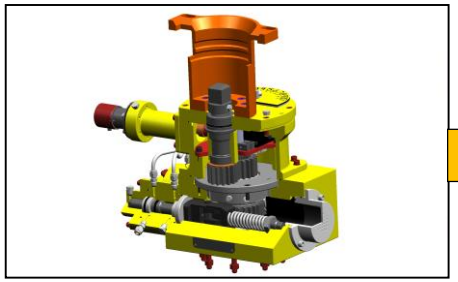
FMC Experiences – Electric Solutions

Electric Choke Actuation



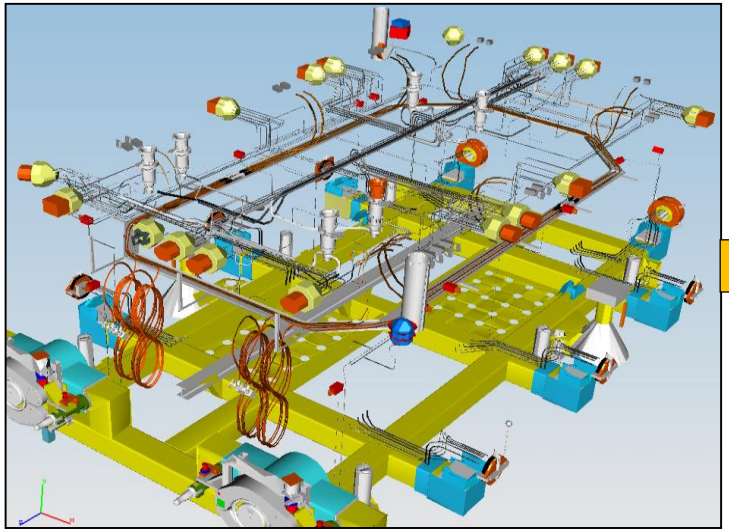
Hydraulic Stepping actuator

G2i Electric Actuator

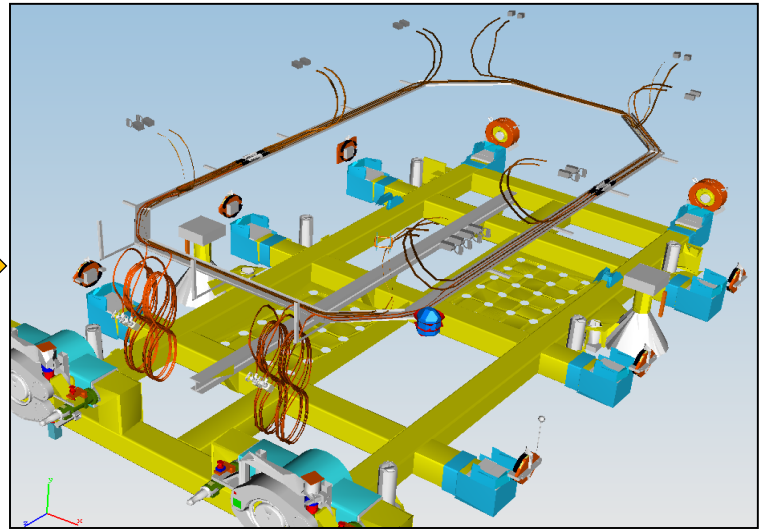
Electric choke valve control:

- Quick and accurate
- Choke vibration information and exact position available
- Actuator retrievable independent of choke
- Eliminates largest hydraulic fluid consumer

Manifold Valve Actuation – Distribution Simplified



Conventional Electro- Hydraulic Manifold



All Electric Manifold

Added functionality is not enough for easy sell…

«Cost of the choke and/or manifold control function needs to compete
with the traditional hydraulic solution»

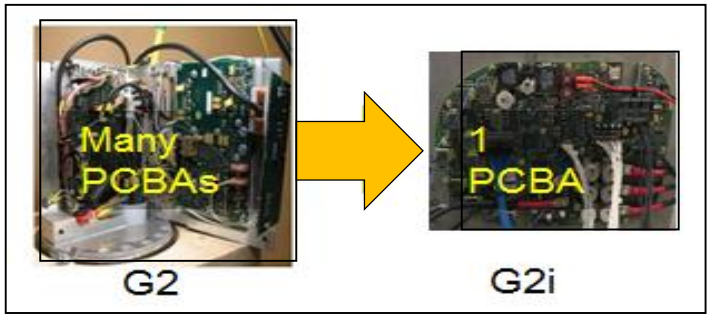
- Lean Engineering Principles adopted to solve the issue:
  - Cost simulation SW used during design of machined parts
  - Close collaboration with high end machine shop during development
  - Utilization of high end industrial components
  - In-house electronics development

G2 actuator (obsolete)

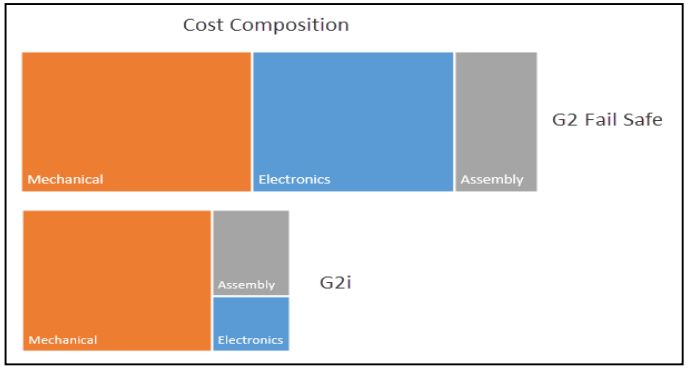
G2i actuator (current)

Lean Results – G2i actuator

Reduced number of parts
& Combined functionality



G2i less than 50% of G2 cost



G2i family of eActuators (Choke & Manifold Version)

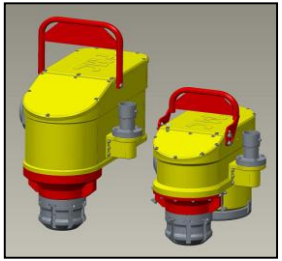
Electrically operated:

- Power & Communication via SCM
- Battery powered, trickle charged
- ROV installable
- Canbus SIIS Level 2 electrical interface
- API RP 17H / ISO 13628-8 mechanical interface
- High accuracy position and vibration monitoring
- Fail to position on loss of communication

Typical applications:

- Manifold Valves (5” - 22”)
- Choke Valves

G2i Actuator (HS version for choke)



G2i Actuator (HT and HS comparison)

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Subsea Processing Plants

- Statoil Åsgard Gas Compression fist user
- Statoil: All electric control an enabler
  - All electric a default – no hydraulics
- FMC Technologies chosen for largest contract ever for subsea electrical actuators
  - Field operating successfully

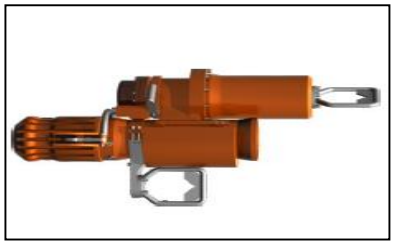
G3 eActuator (Processing Plants)

- 2 versions:
  - High Speed, for low torque valves
  - High Torque, for large bore valves
- Modular design
- Complete dual channel electronics
- Complete dual barrier oil system
- Weight for ROV installation
- 400V 3-phase 50Hz direct drive
- Power consumption 500W nom, max 1500W per channel
- Built in “flight recorder”

General Experience Summary (1) - Reliability

- Reliability has been good:
  - More than 8 million operating hours with FMC Technologies electric actuators with no significant issues reported

- Qualification processes including accelerated life testing tailored for “the electrics” proved to pay off:
  - Early detection of marginal seal solution (first generation)

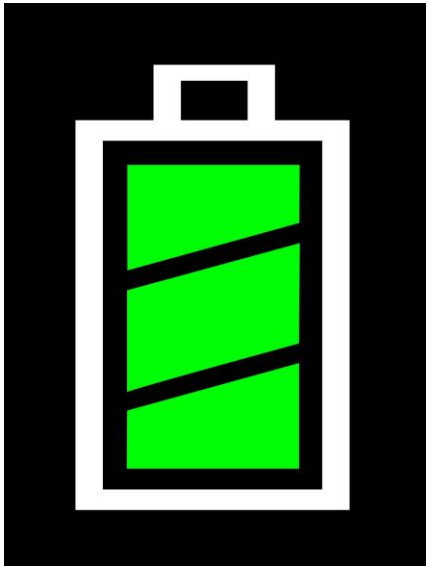


  - Voltage dependent motor wire compatibility detected before deployment (first process valve actuators)

General Experience Summary (2) - Batteries

- More than 100 of the electric actuators supplied have featured trickle charged batteries
- In operation, the experience with the batteries has been extremely good – exceeded expectations

- Batteries simplify the infrastructure and allow design for average, not peak power
- Batteries are enablers for eliminating springs as shut down power sources



General Experience Summary (3) - Framework

- Industry Standard specifications are not suited for the transition to electric systems. E.g.: September 2016 proposal for API 17D change :

Add to 7.10.1.1

Actuated tree valves inboard of the wing and including the wing shall be designed to fail closed upon loss of hydraulic supply.

- Implementing electric solutions in projects with a hydraulic biased framework requires flexibility!

Summary of Performance

	Advantage	Disadvantage
Hydraulic System	• Easy to create large forces for linear movements • Fail-to-position well established by spring return at power cut	• Two different “utilities” required for a subsea system, hydraulic and electrical • Complex rotational actuation • Issues with cleanliness and compatibility experienced • HSE issues; discharge, exposure
Electric System	• Well suited for rotational movements • High speed and accuracy of rotational movements • Easy to do self diagnostics	• Difficult to have a simple fail-to-position mechanism on power cut • Linear movements require some sort of transition mechanism

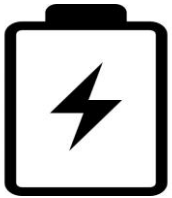
The new Era

Technology avenues

- Hybrid electrohydraulic systems needed going forward
  - Co-existence of electric and electrohydraulic functions

- Two options for safety (SIL) certified shut-down
  - Mechanical Spring
  - Electrochemical Spring (Battery)

vs.



eSpring - Electric fail safe actuator

- Electrically operated
  - No external hydraulic supply required
  - Features a small HPU per actuator

- For fail safe applications (SIL applications)
  - XT valves
  - For rising stem valves
  - Fail safe close by valve spring package
  - HIPPS

- ROV installable without need for buoyancy

eSping being installed on a subsea X-mas tree

Norwegian DEMO 2000 project with FMC Technologies, Total and Statoil – but open for additonal participants

The new Era

- Field cases show 10 - 30 % CAPEX cost benefit
- Unparalleled interest from Major Operators – Pull & Push market situation
- Batteries and DC motors have had a major technology leap in the past 15 years
- Industrialization of subsea electrical products ongoing
- Electric DHSV progressing
- More than 8 million operating hours of FMC electric actuators
  - The positive results have exceeded our expectations


Thank You!