DYNAMIC POSITIONING CONFERENCE
October 13-14, 2015

OPERATIONS

DP-3 Design Systems Based on Closed Bus-Ties

Aleks Karlsen
DNV GL

MARITIME

DP-3 systems based on closed bus-ties

DNV GL Offshore Technical Guidance:

DNVGL-OTG–10 DP classed vessels with closed bus-tie(s)

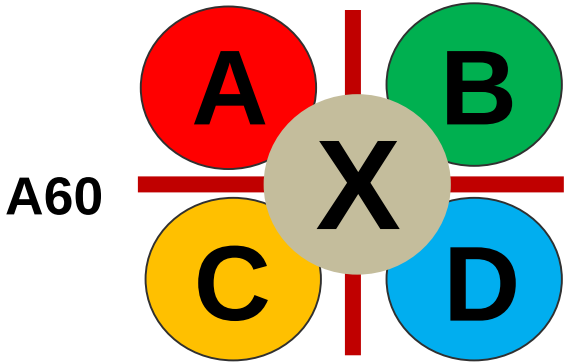
Aleks Karlsen

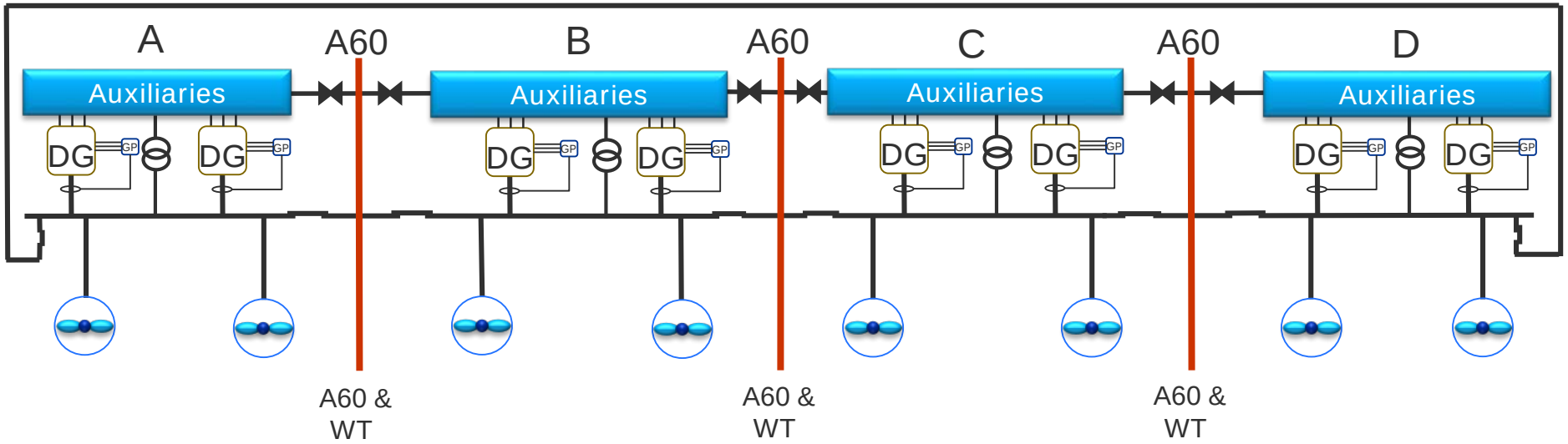
13 October 2015

Content

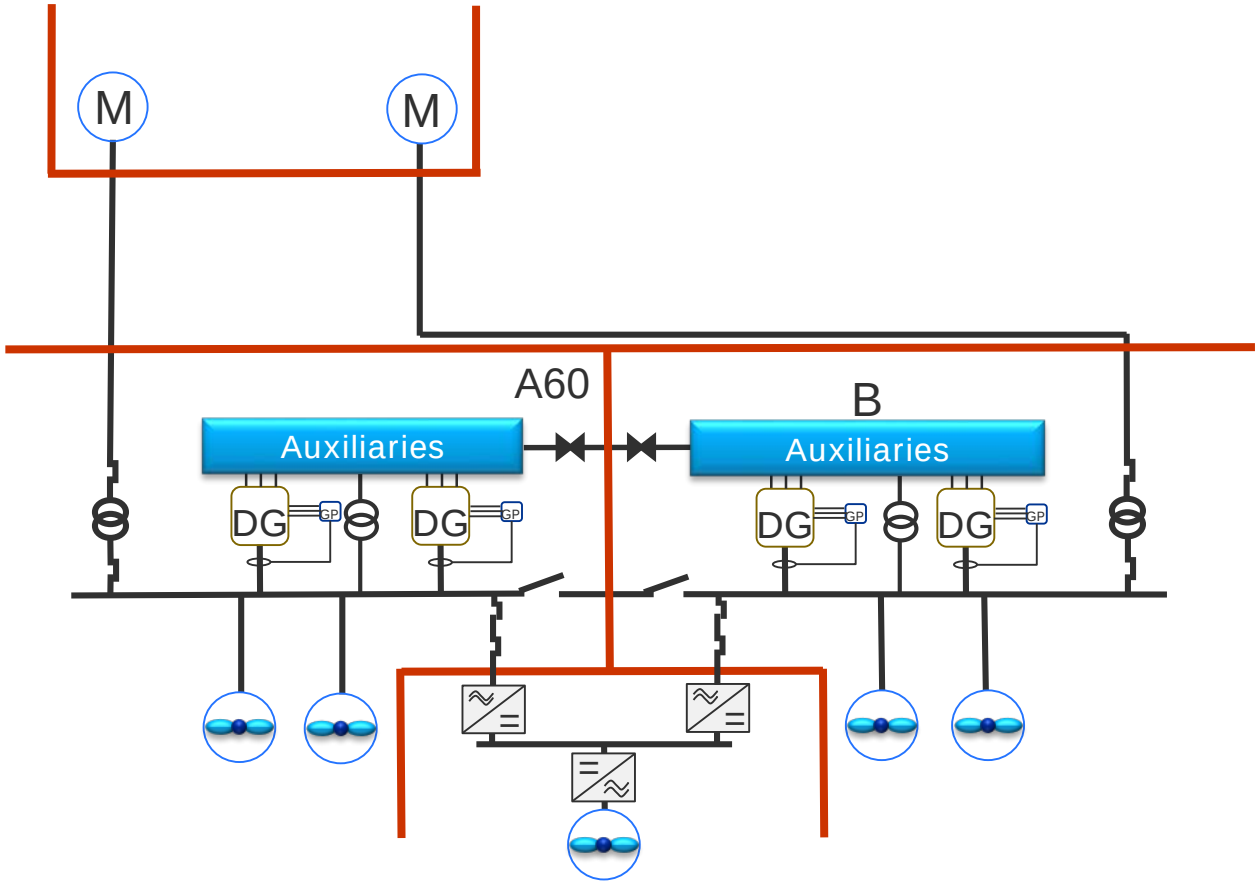
- DP-3 closed bus-ties (CB) designs
- CB pros and cons
- Verification of DP-3 CB
- Verification contribution by short circuit testing
- Evaluation of test result obtained by short circuit testing
- Experience gained
- DNV GL Offshore Technical Guidance: “*DP-classed vessels with closed bus-tie(s)*”
- Conclusions

Example 4 split closed bus-ties DP-3 notation





Dual feeding of thrusters and supply to industrial mission systems



Industry motivation for closed bus-ties

Pro:

- Less fuel consumption
- Lower environmental footprint
- Less spinning reserve
- Higher flexibility
- Less engine hours
- Less consequence for some failure modes
- Working environment
- …

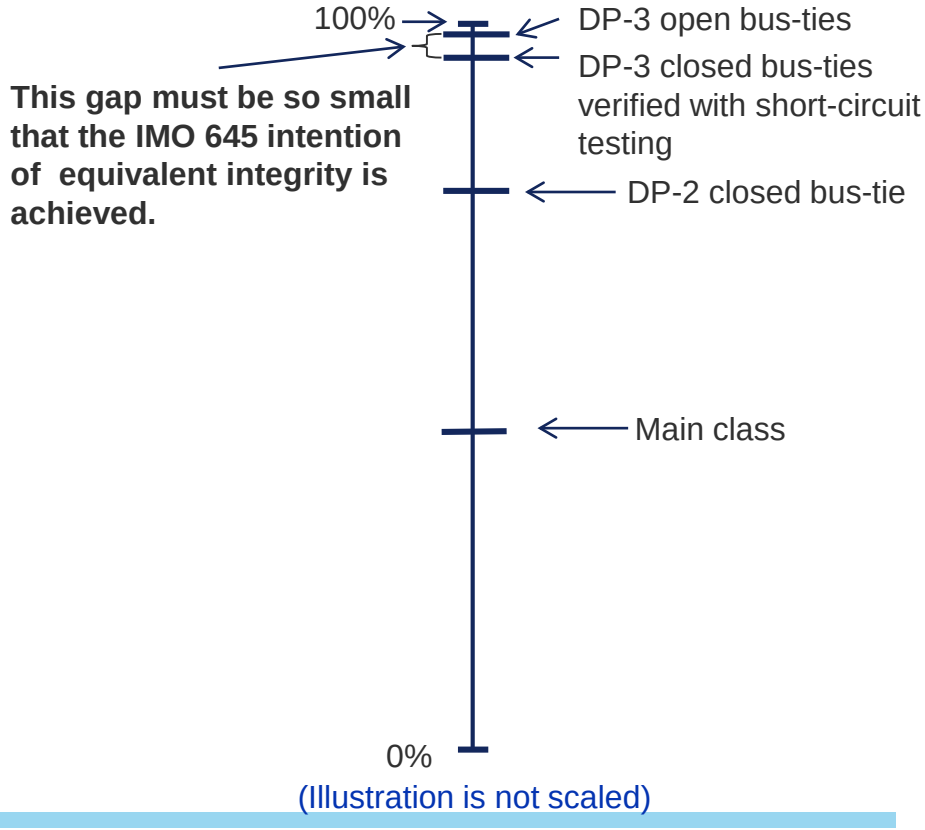
Con:

- Complexity
- More verification needed
- Higher demand for operational awareness
- …

Pros and cons needs to be considered towards the gain…

Closed bus power system integrity

- Integrity is based on **complex software based systems**
- Must **verify and demonstrate** that these systems maintain the **same safety level as the traditional open bus-ties systems**
- Challenging to:
  - design and build
  - **establish** a set of **uniform verification activities and methods** in order to reach and verify the required integrity level
  - maintain functionality during the vessel operational life



Some very important aspects

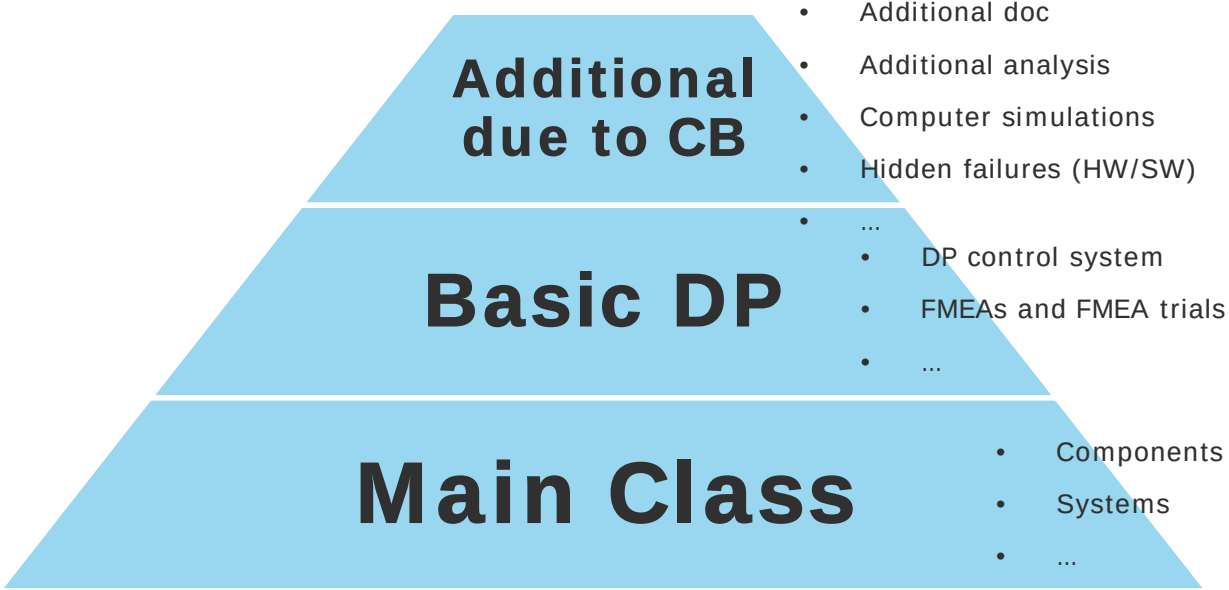
- **System design philosophy:**
  - Redundancy groups
  - WCFDI for all modes
- **Specification of technical system set-up for DP:**
  - All modes intended for DP
  - Owners involvement!
- **Integration on a system level:**
  - Competent management of functionality on a system level
- **Hidden failures and monitoring:**
  - Increased monitoring requirements to limit hidden failures
  - Two independent protective functions for each failure mode
- **Master Parameterization System:**
  - As part of a MOC process
  - Periodic check of all important set-point
- **Periodic testing and trials:**
  - Scope of annual and 5-yearly renewal trials

DP-3 Closed bus-ties (CB) verification

Main Class

- Components
- Systems
- ...

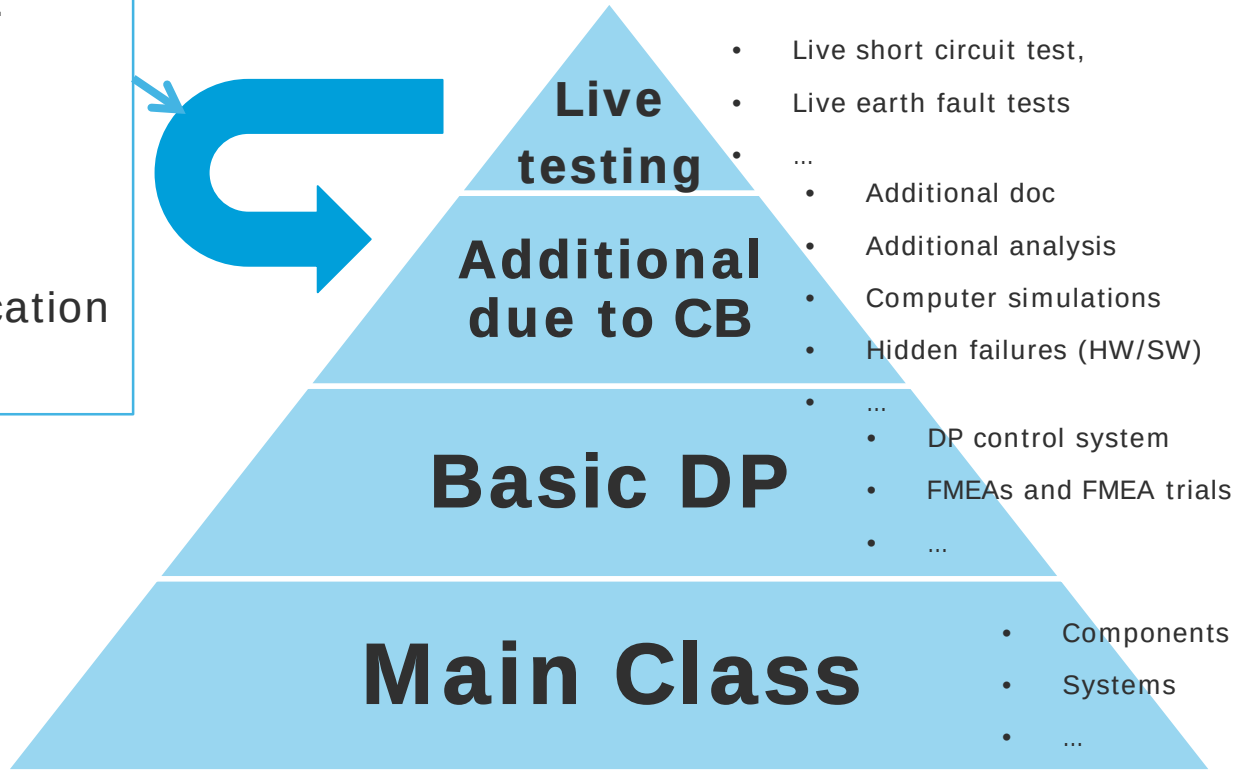
DP-3 Closed bus-ties (CB) verification



DP-3 Closed bus-ties (CB) verification

Evaluation of test results:

- Margins:
  - Predictability
  - Repeatability
- Model verification
- Parameterization verification
- Model/analysis update



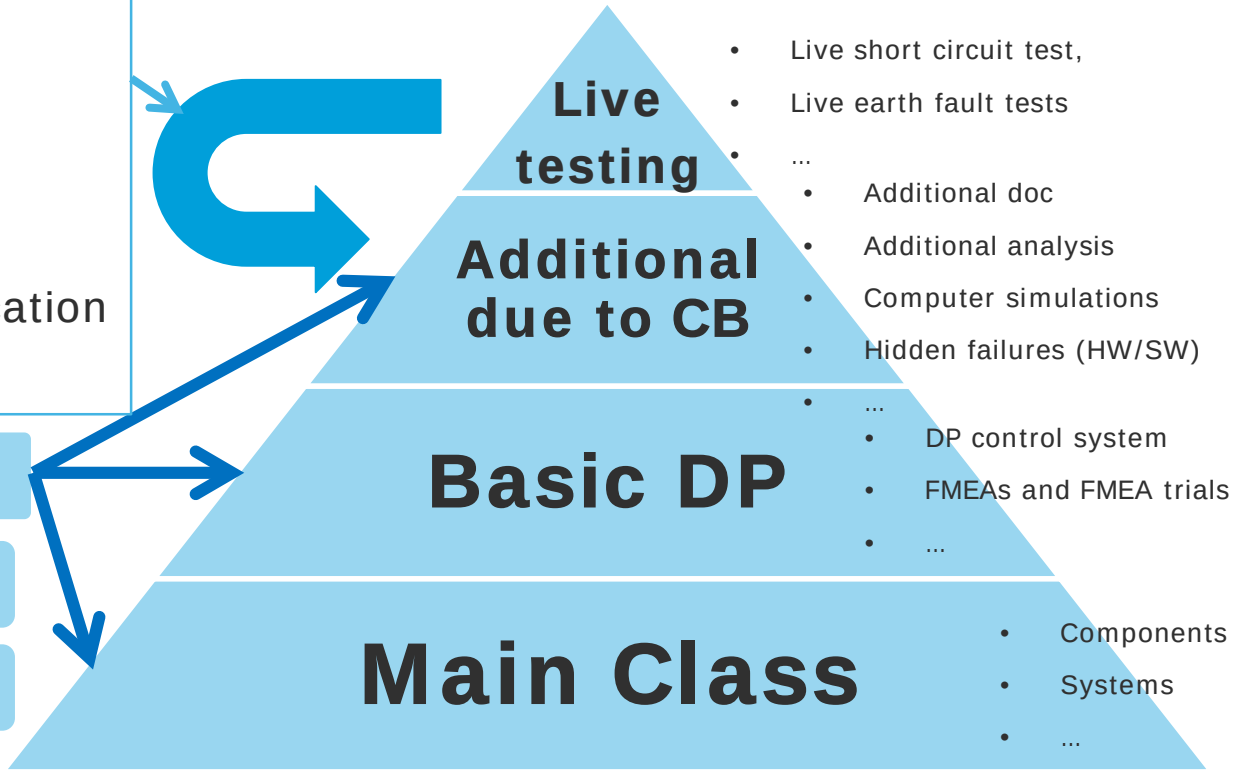
Additional verification methods

Evaluation of test results:

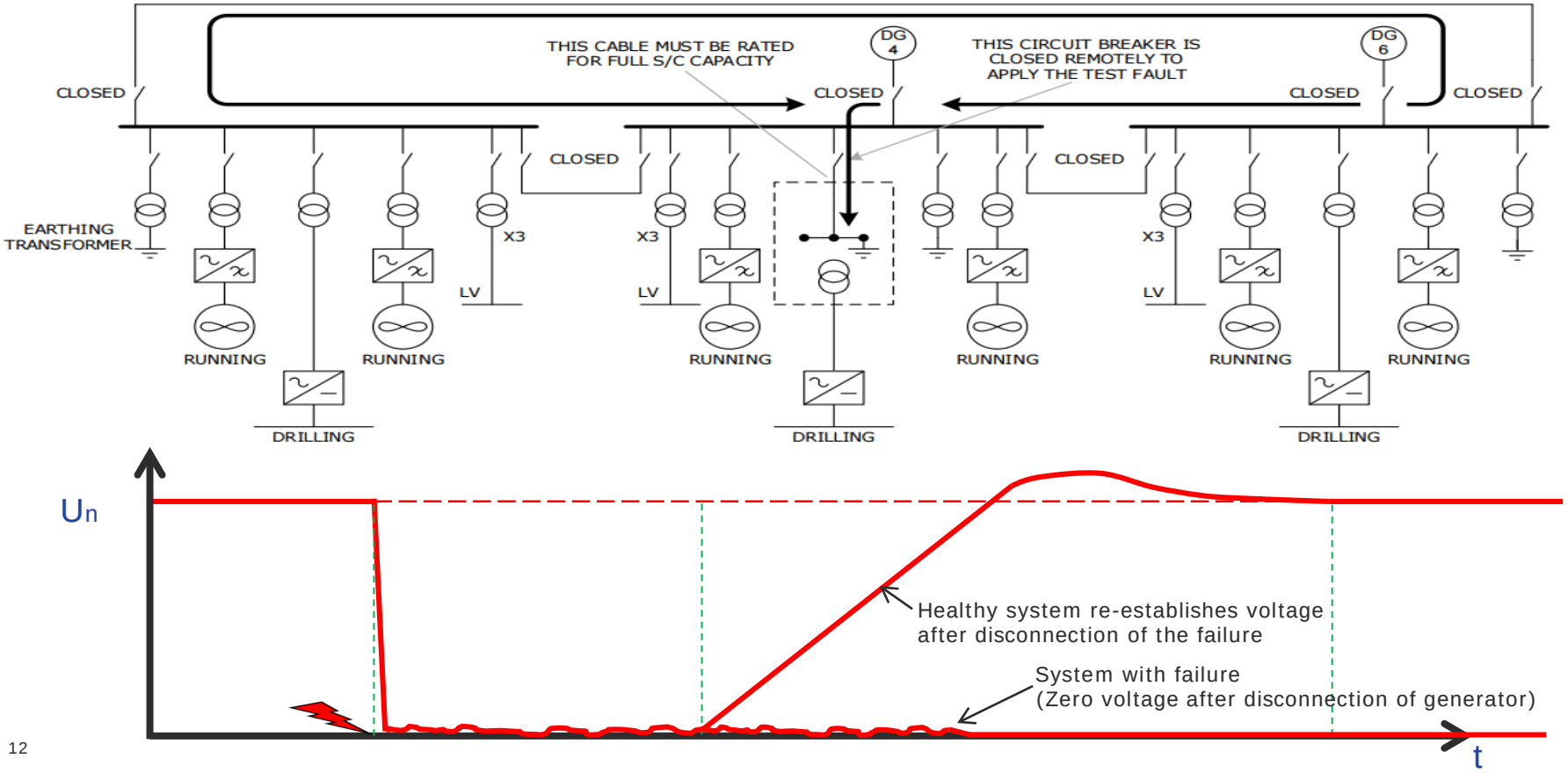
- Margins:
  - Predictability
  - Repeatability
- Model verification
- Parameterization verification
- Model/analysis update

Enhanced System verification

- HIL
- ISDS



Industry guidelines on how to do ride through testing



Verification gained from live short circuit testing

- **Demonstrating that the protective system works**
- Did the protection system operate with **sufficient margins**. Are the results **consistent and repeatable**?
- Demonstrating that the redundancy groups which shall continue to run after the failure is discriminated will be **able to ride through the period that they are affected by the fault**, and that they will re-establish and continue to run as required after the failure is removed
- **Disclosing possible design or installation failures**. This goes for **hidden failures** in HW (e.g. loose wires) insufficiencies in equipment (e.g. measuring equipment not being able to measure extreme values with sufficient accuracy)… and SW (e.g. parameterization, calibration etc…),…
- **Verification of equipment properties** like e.g. generators ability to provide short circuit current
- **Extensive logging is required** during testing. The logged data should be used to verify and improve the dynamic computer models. This should contribute to the development of more sophisticated simulators for future projects

Don’t forget the other challenges….

- Over/under/unstable voltage
- Over/under/unstable frequency
- Overload and over current
- Severe line current imbalance
- Earth failures
- Active power imbalance
- Reactive power imbalance
- Crash synchronization - inadvertent connection
- PMS control of generator fuel and excitation
- Harmonic distortion
- …

Verification and handling of the above failure modes represents a bigger challenge than passing the short circuit and earth fault testing!

Experience from completed and ongoing projects

Collective experience from:

- DNV GL DP-3 and closed bus-ties: 4 completed vessels, more than 10 ongoing
- Several projects with enhanced reliability notations
- Valuable experience is also gained from projects where DNV GL is not directly involved
- From vessels (with or without DP class notations) which have been operating with closed bus-ties for many, many years
- Cooperation with all the major system vendors and other industry players

Experience with bolted short circuit testing:

- There has been some concern in the industry related to safety of personnel and equipment. The use of the term “short circuit testing” may contribute to this
- When the testing is properly planned and executed there is a fundamental difference from a typical “in operation” short circuit. I.e. when the properly bolted short circuit is connected for test purposes there is no arc and no significant release of energy
- So far the tests have not caused any damage to equipment
- Important findings have been done and valuable knowledge and experience have been gained

Learning from completed and ongoing projects

Major learning points:

- Traditional marine power system design is not sufficient for DP-3 closed bus-ties
- The closed bus-ties mode provides more efficiency gain for larger 3 and 4 split systems
- Additional protective functions (HW and SW) needs to be arranged
- Important to coordinate the system integration through a system responsible
- Verification based on **paper analysis and computer simulations is not sufficient** for DP class 3 integrity levels
- **When live short circuit testing is performed on systems designed for CB the first tests normally fails, even when all involved parties have used extensive recourses (meaning a lot more than traditionally) to prepare for the testing**
- The system typically needs adjustments (HW/SW) before a successful test can be completed
- The systems **must be covered by the vessel change management system**. There should be a systematic periodic check of all set points and the **operability of the system needs to be demonstrated** during commissioning, testing and through the vessel operational life
- **DP-3 closed bus-integrity can not be verified without the contribution from live short circuit and live earth fault testing**

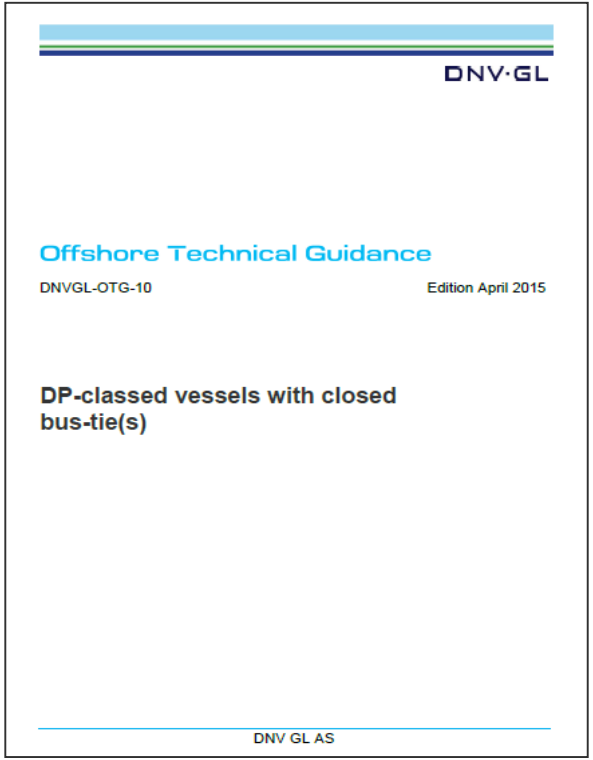
New DNV GL Offshore Technical Guidance

Content:

1. Introduction
2. General principles
3. DPS 2 and DYNPOS-AUTR
4. DYNPOS-E and DYNPOS-ER
5. DPS 3 and DYNPOS-AUTRO
6. Documentation requirements

Objective:

- Discuss important basics related to CB
- Explain the DNV GL approach
- Give guidance on design
- Describe additional technical measures
- Clarify documentation, verification and testing requirements



Concluding remarks and conclusions

- **Neither IMO guidelines nor class rules guides the operations** or differentiates between vessel types or operations
- The approved **FMEA states the verified modes** (owners should be actively involved)
- **Class is not requiring any closed mode(s)** for DP-3 systems
- It should be understood that **there will always be a residual probability for failure propagation**
- For operations where loss of position may result in unacceptable consequences, **risk considerations must be performed** in order to evaluate the technical systems operational modes, including open or closed bus-ties. This principles is valid for all DP notations and system. The **responsibility for this lays with the owner and the operator**
- The new **DNV GL OTG provides guidelines to the industry on design and verification** of high integrity DP closed bus-ties systems

DP-3 systems based on closed bus-ties

Aleks Karlsen
Aleks.karlsen@dnvgl.com

www.dnvgl.com

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