DNV·GL

OIL & GAS

Offshore release data – trends in underlying causes

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24 May 2019

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DTU

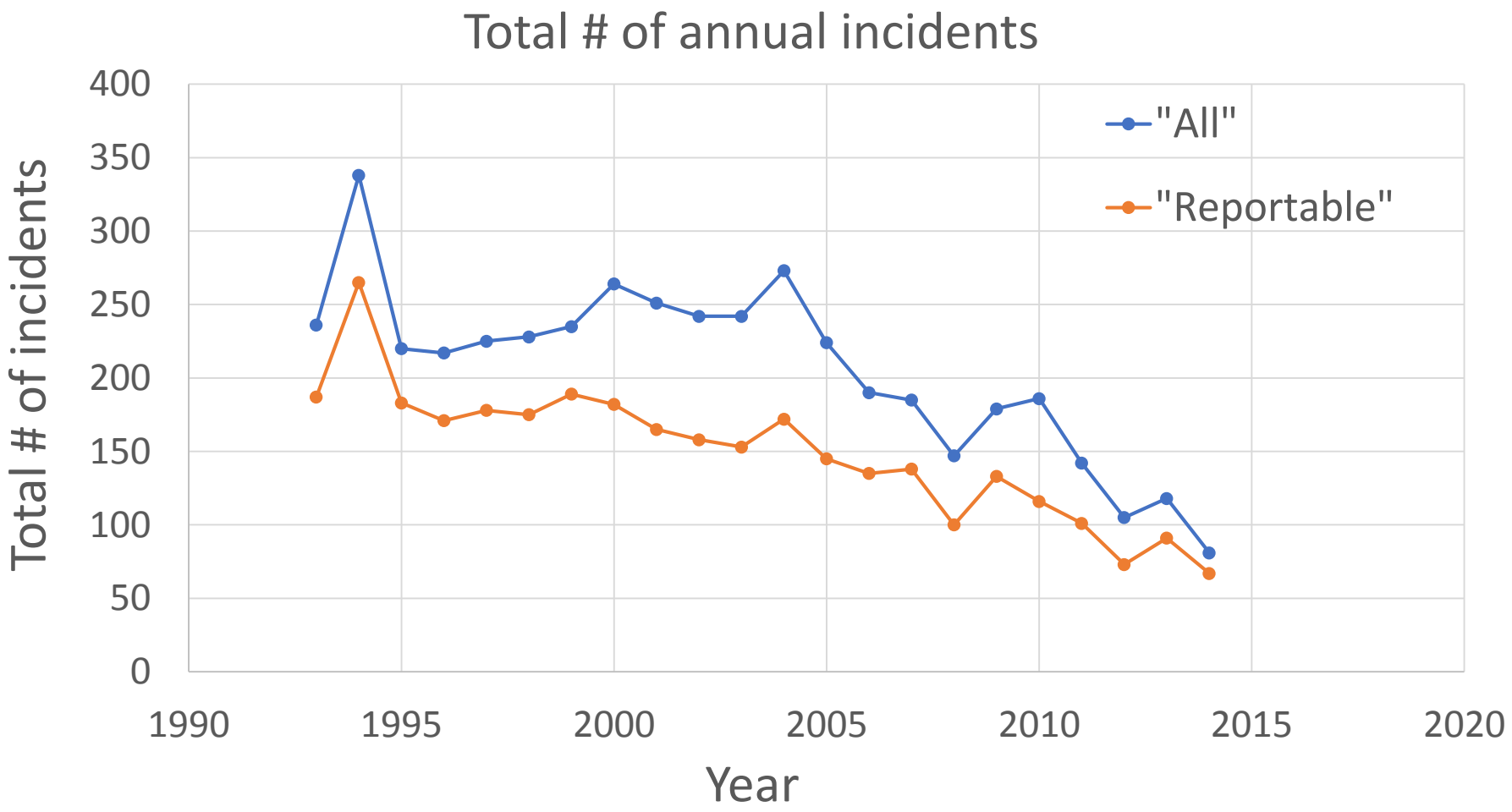
Introduction – reason for this study

- Offshore QRA use data on loss of containment
- Main source of data is the UK-HSE Hydrocarbon Release Database (HCRD)
- The HCRD contains data on incidents/accidents in the UK sector of the North Sea, split out per component, operation, etc.
- **In recent years the number of incidents is observed to decrease (while the number of installations has grown)**

- How shall the decrease in incidents be handled when performing QRA?
- May it be applied for old and new installations?
- What is the reason for the decrease?
- Do all causes show a decrease in the same proportion?

- Study was performed as a Master Thesis at the Technical University of Denmark DTU in cooperation with DNV GL

Decrease of the absolute number of reported incidents



Aim of the study

- The aim of the study was to investigate whether the decrease in the number of incidents depend on the cause:
  1. Causes that can be linked to mechanical integrity ("newer is better")
  2. Causes that can be linked to management (would apply to old as well as new installations)

Methodology

1. We made relative comparisons of number of incidents, not frequencies (there is also uncertainty in the population data)
   - The trend of the fraction of incidents caused by e.g. equipment failures as compared to the total number of incidents over the years
   - If this trend is decreasing (significantly), then (lack of) equipment failure would explain (part of) the decrease of all incidents
2. We did not distinguish between components
3. We needed to design a classification algorithm for how to interpret the reported data unambiguously into main causes

Ambiguity in the reporting form for “Cause of Leak”

- The reporter may provide input to different fields in the reporting form for the “Cause of Leak”:
  - Design
  - Equipment
  - Operation
  - Procedural
- When input is present in more than one field, the “real” cause may become ambiguous, so a classification algorithm was needed to get a clear classification of causes

Reporting Form

CAUSE OF LEAK CHECK LIST (SEE "CAUSE OF LEAK". ITEM 13. ON PAGE 3)

(Please indicate those items which come nearest to identifying the cause of the leak)
(Choose one parameter from each of the following categories, and tick appropriate boxes)

(a) DESIGN:

- ☐ FAILURE RELATED TO DESIGN
- ☐ NO DESIGN FAILURE

(b) EQUIPMENT:

- ☐ CORROSION: INTERNAL ☐ EXTERNAL ☐
- ☐ MECHANICAL FAILURE FATIGUE ☐ WEAROUT ☐
- ☐ EROSION
- ☐ MATERIAL DEFECTS
- ☐ OTHER (Specify) _____
- ☐ NO FAILURE IN THE EQUIPMENT ITSELF

(c) OPERATION:

- ☐ INCORRECTLY FITTED
- ☐ IMPROPER MAINTENANCE INSPECTION ☐ TESTING ☐ OPERATION ☐
- ☐ DROPPED OBJECT OTHER IMPACT ☐
- ☐ LEFT OPEN
- ☐ OPENED WHEN CONTAINING HC
- ☐ OTHER (Specify) _____
- ☐ NO OPERATIONAL FAILURE

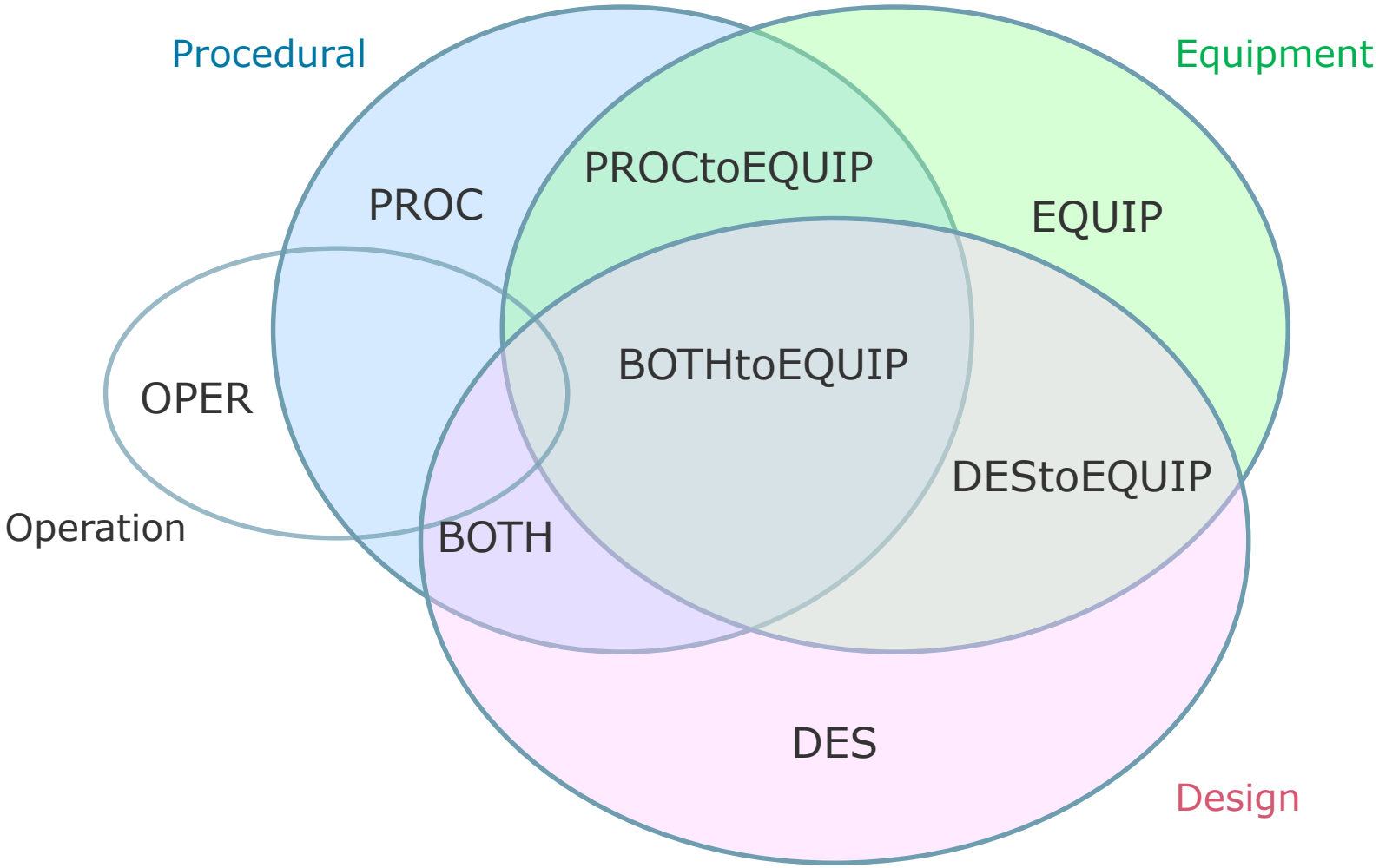
(d) PROCEDURAL:

- ☐ NON - COMPLIANCE WITH PROCEDURE PERMIT TO WORK ☐
- ☐ DEFICIENT PROCEDURE
- ☐ OTHER (Specify) _____
- ☐ NO PROCEDURAL FAILURE

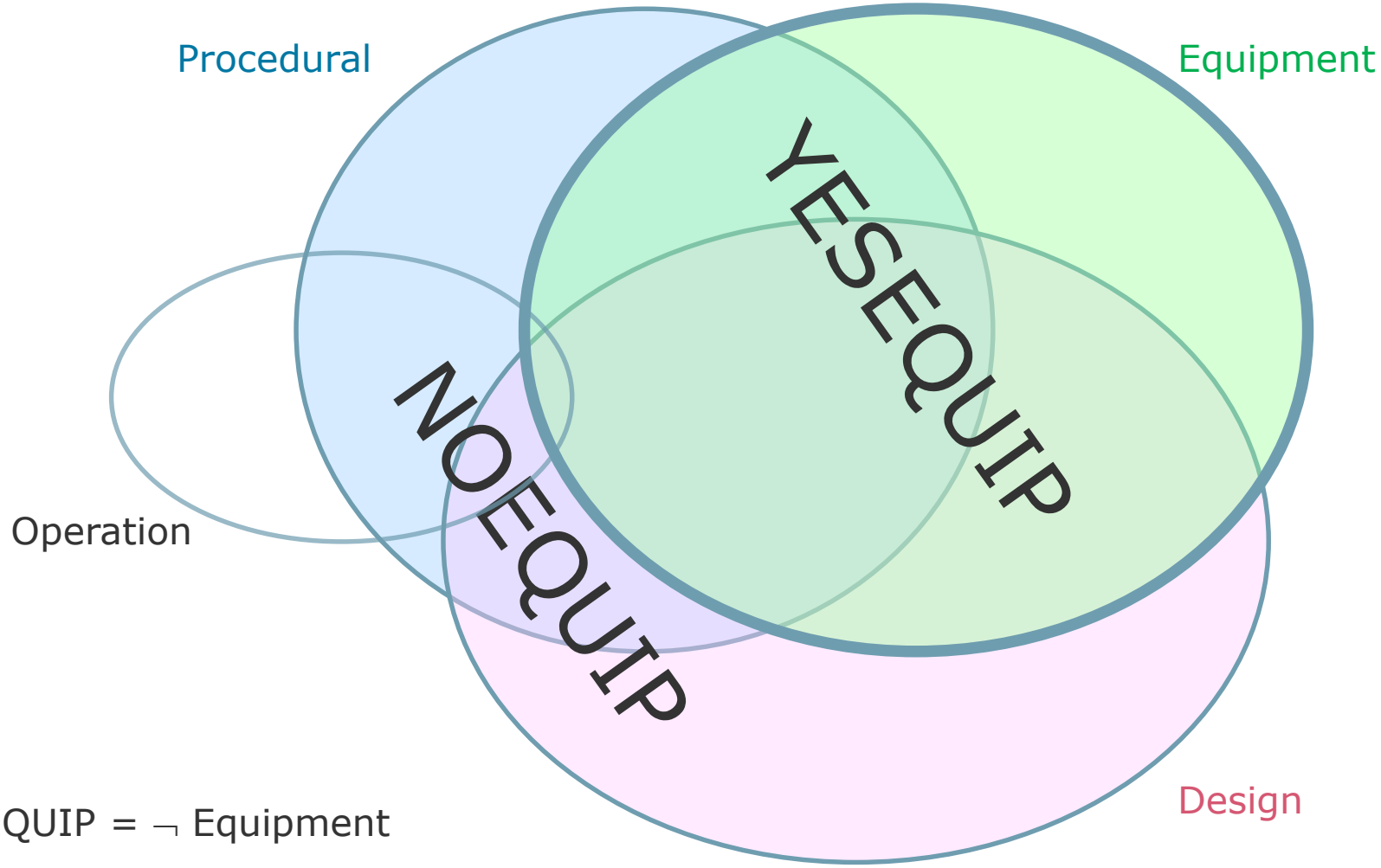
Classification

Meta-category	Category	Equipment	Design	Procedural	Operation
YESEQUIP	EQUIP	X	-	-	Disregarded
	DEStoEQUIP	X	X	-	Disregarded
	PROCtoEQUIP	X	-	X	Disregarded
	BOTHtoEQUIP	X	X	X	Disregarded
NOEQUIP	OPER	-	-	-	X
	DES	-	X	-	Disregarded
	PROC	-	-	X	Disregarded
	BOTH	-	X	X	Disregarded

Categories

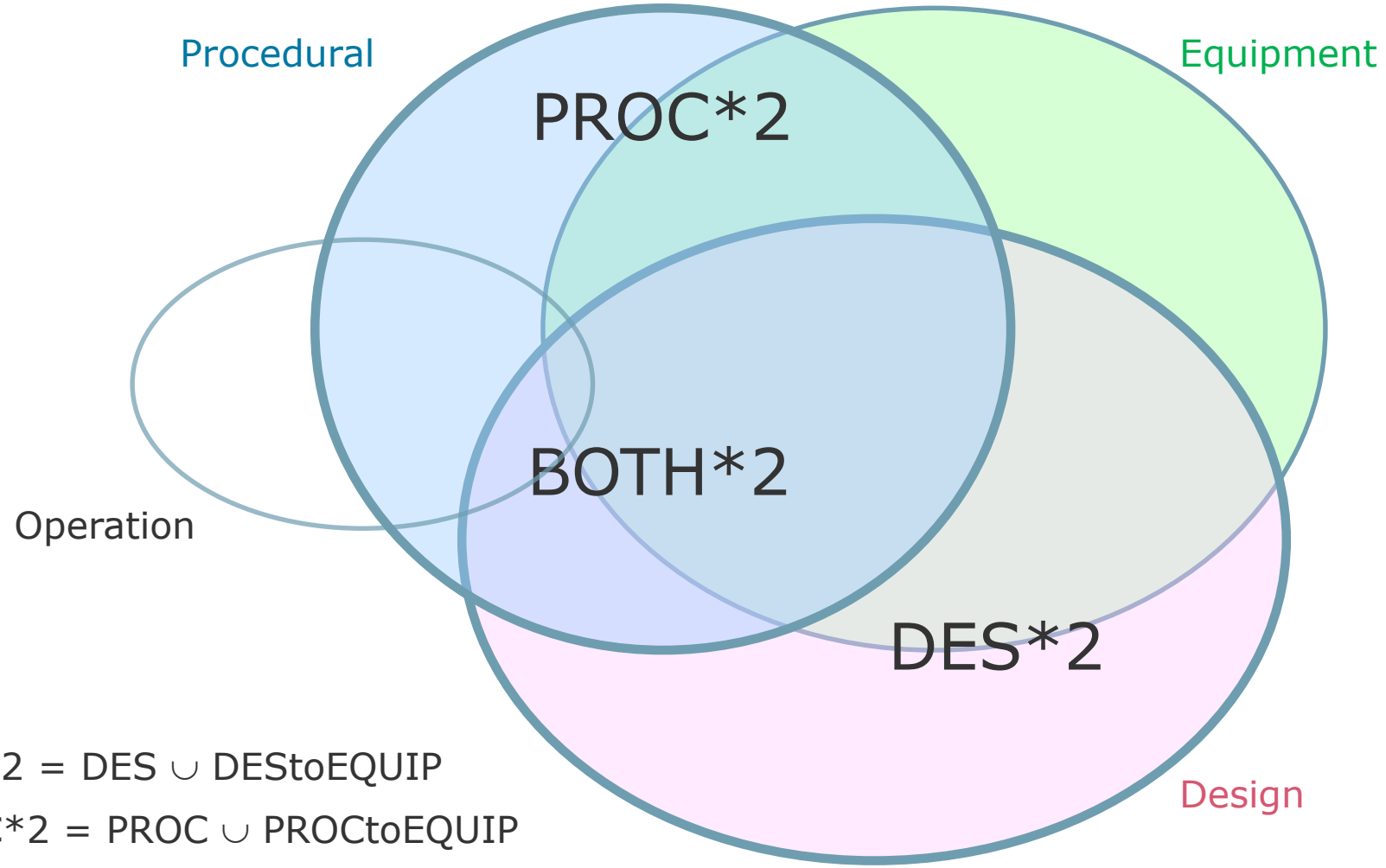

Procedural
Equipment
PROCtoEQUIP
PROC
EQUIP
BOTHtoEQUIP
OPER
DEStoEQUIP
Operation
BOTH
DES
Design

"Meta-categories"



NOEQUIP = ¬ Equipment

"Summed" (united) categories



DES*2 = DES ∪ DEStoEQUIP

PROC*2 = PROC ∪ PROCtoEQUIP

BOTH*2 = BOTH ∪ BOTHtoEQUIP

Classification algorithm

$EQUIP = B \wedge C \wedge H$

$DEStoEQUIP = A \wedge C \wedge H$

$PROCtoEQUIP = B \wedge C \wedge G$

$BOTHtoEQUIP = A \wedge C \wedge G$

$DES = A \wedge D \wedge H$

$PROC = B \wedge D \wedge G$

$BOTH = A \wedge D \wedge G$

$OPER = B \wedge D \wedge E \wedge H$

Failure related to design	**A**
No design failure	**B**
Corrosion internal	**C**
Corrosion external	
Mechanical failure	
Mechanical fatigue	
Mechanical wearout	
Erosion	
Material defects	
Other equipment failure	
No failure in the equipment itself	**D**
Incorrectly fitted	**E**
Improper maintenance	
Improper inspection	
Improper testing	
Improper operation	
Dropped object	
Other impact	
Left open	
Opened when containing HC	
Other operational failure	
No operational failure	**F**
Non-compliance with procedure	**G**
Non-compliance with permit to work	
Deficient procedure	
Other – Quality control	
Other procedural failure	
No procedural failure	**H**

Analysis & results

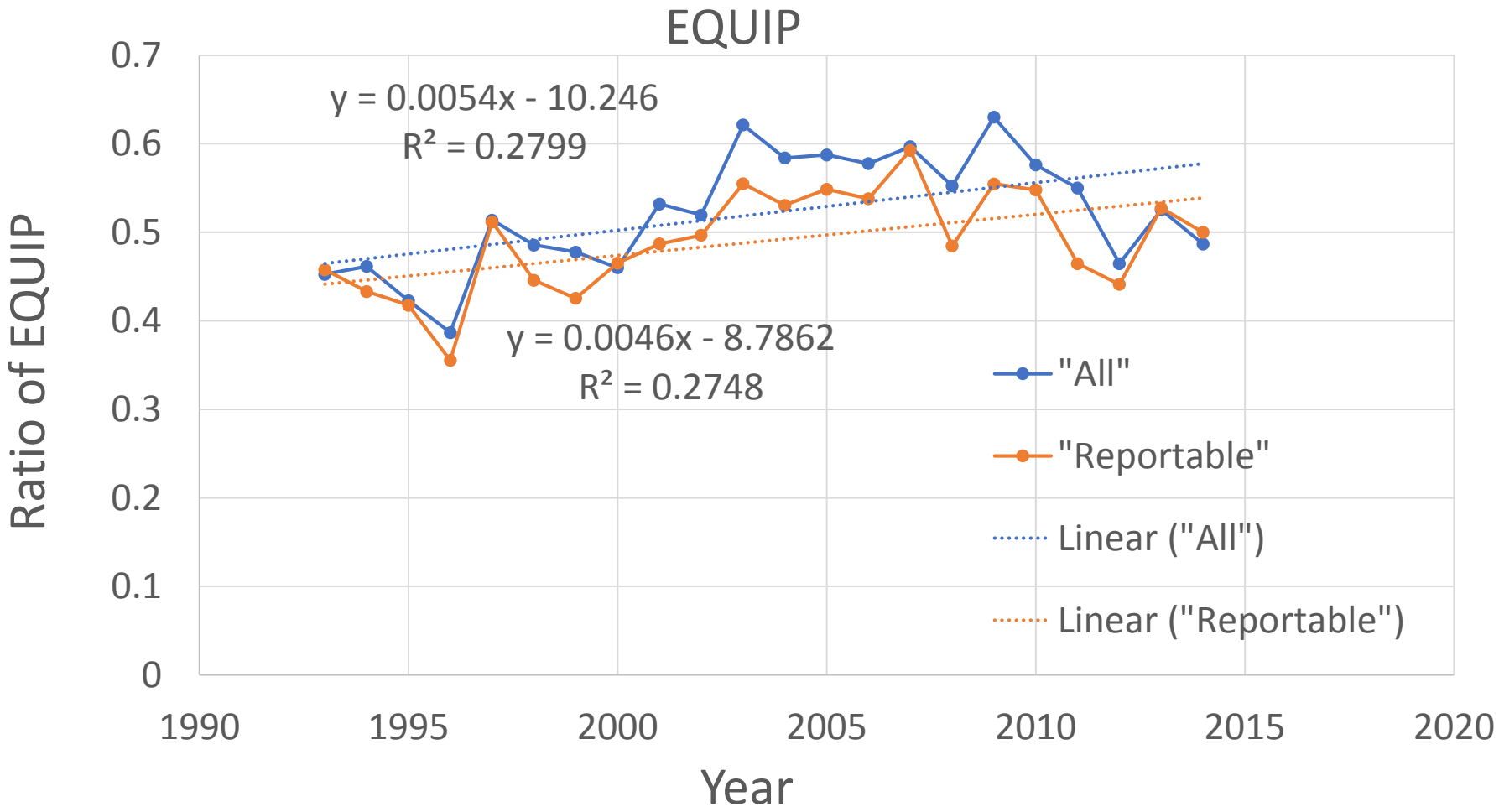
- Plot the ratio for each category:

$$\frac{number\ of\ incidents\ in\ category\ \ in\ (year)}{Total\ number\ of\ incidents\ in\ (year)}$$

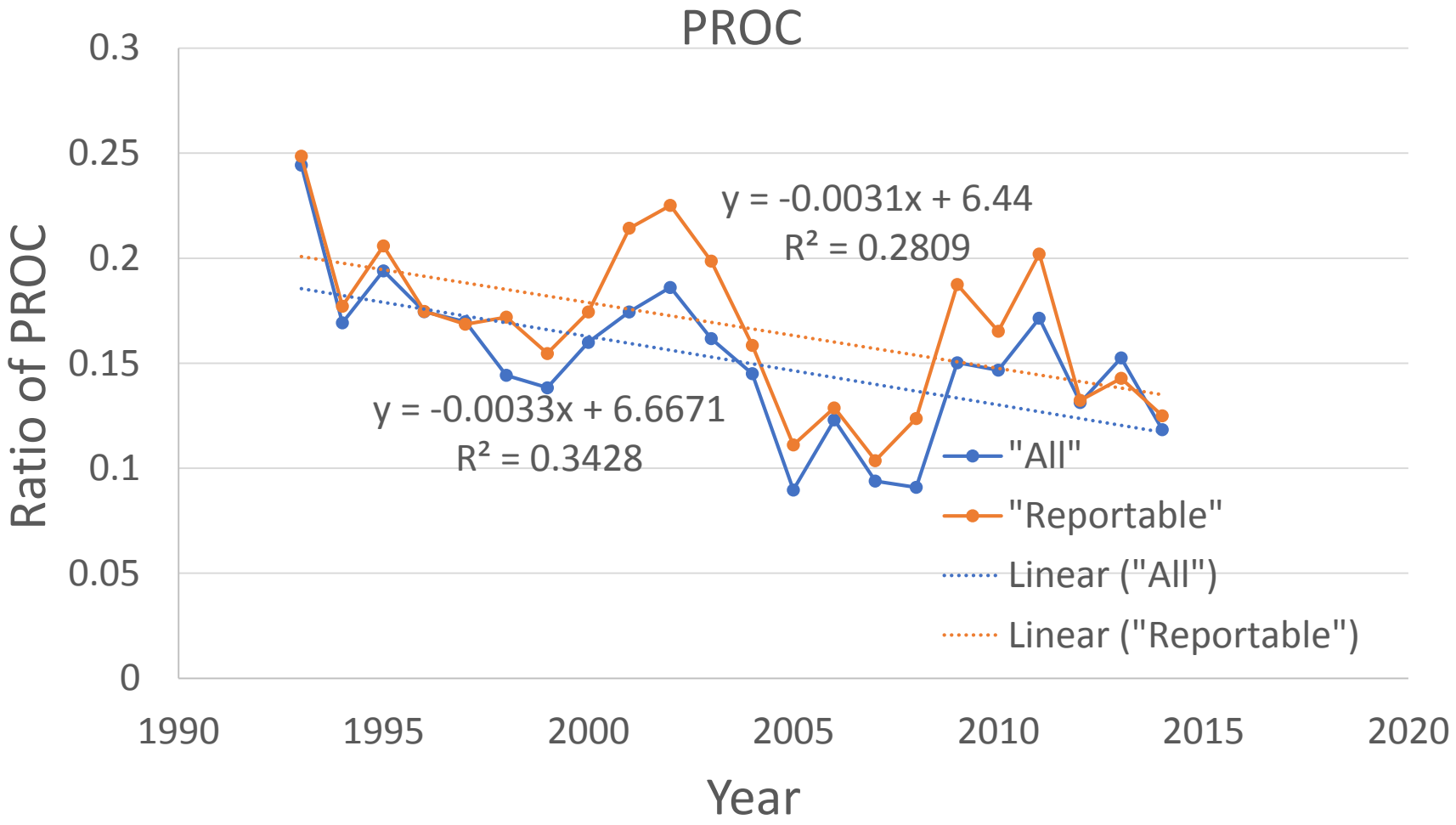
- Linear regression analysis for these ratios per year from 1993 to and including 2014

- Significance of the trend based on a two-sided *t*-test of the slope of the trend. The P-value expresses the probability that the slope is zero (neither positive nor negative): if P is small (<5%) the slope is deemed significantly different from zero.

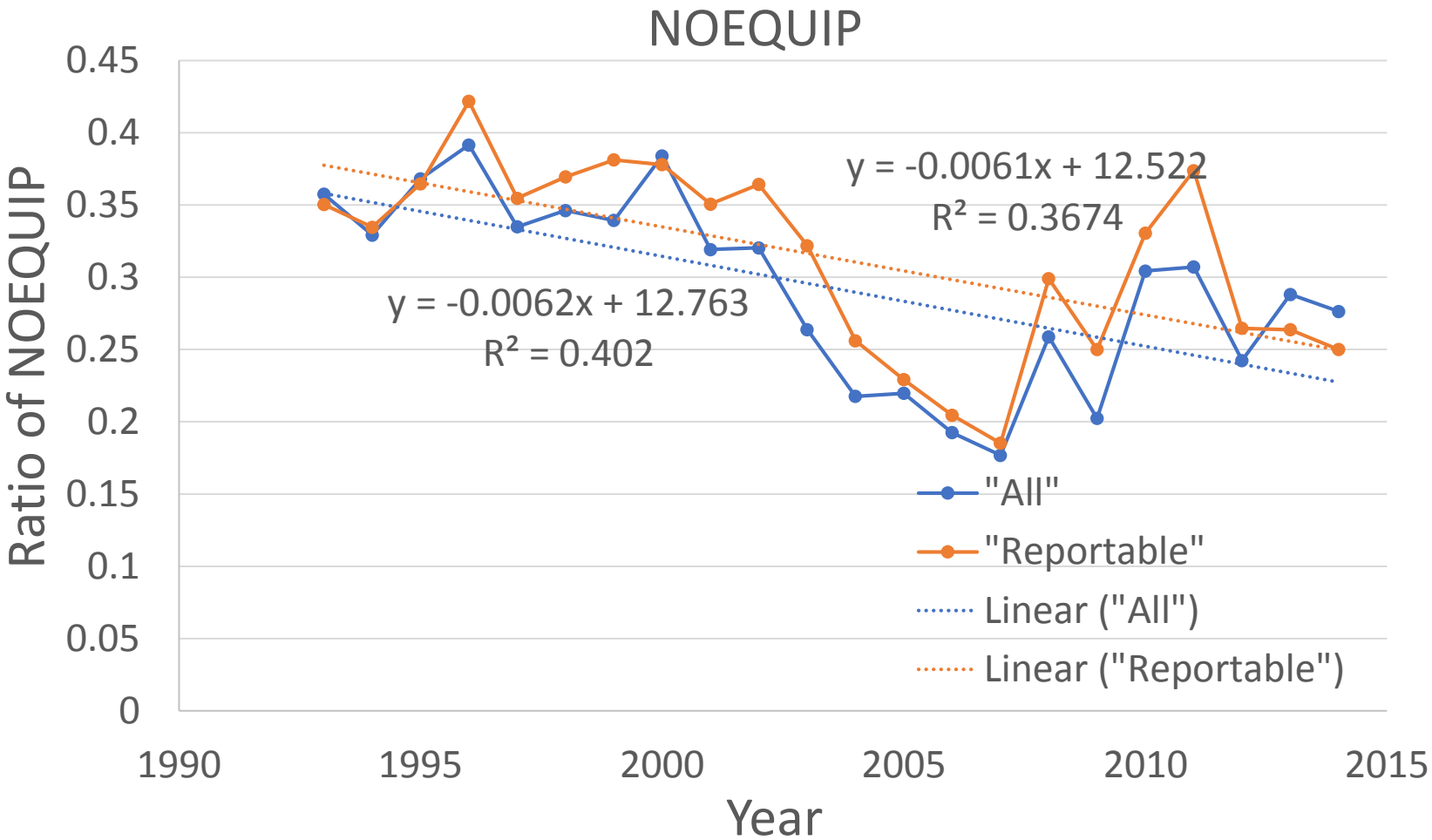
Ratio of EQUIP category to total number of incidents



Ratio of PROC category to total number of incidents



Ratio of NOEQUIP category to total number of incidents



Significant results (P-value less than 0.05)

	"All"		"Reportable"	
	Slope, α_1	P-value	Slope, α_1	P-value
EQUIP	0.005374	0.011356	0.004630	0.012265
DEStoEQUIP	-0.001967	0.030511	-0.001784	0.096914
PROCtoEQUIP	0.002868	0.026325	0.002956	0.024801
BOTHtoEQUIP	-0.000050	0.870171	0.000291	0.493067
PROC	-0.003252	0.004199	-0.003131	0.011182
DES	-0.000556	0.208004	-0.000617	0.171864
BOTH	0.000264	0.499732	0.000568	0.237311
OPER	-0.002680	0.041183	-0.002914	0.040824
DES*2	-0.002523	0.013301	-0.002401	0.040969
PROC*2	-0.000384	0.804649	-0.000174	0.907996
BOTH*2	0.000213	0.688165	0.000859	0.215147
YESEQUIP	0.006224	0.001532	0.006094	0.002789
NOEQUIP	-0.006224	0.001532	-0.006094	0.002789

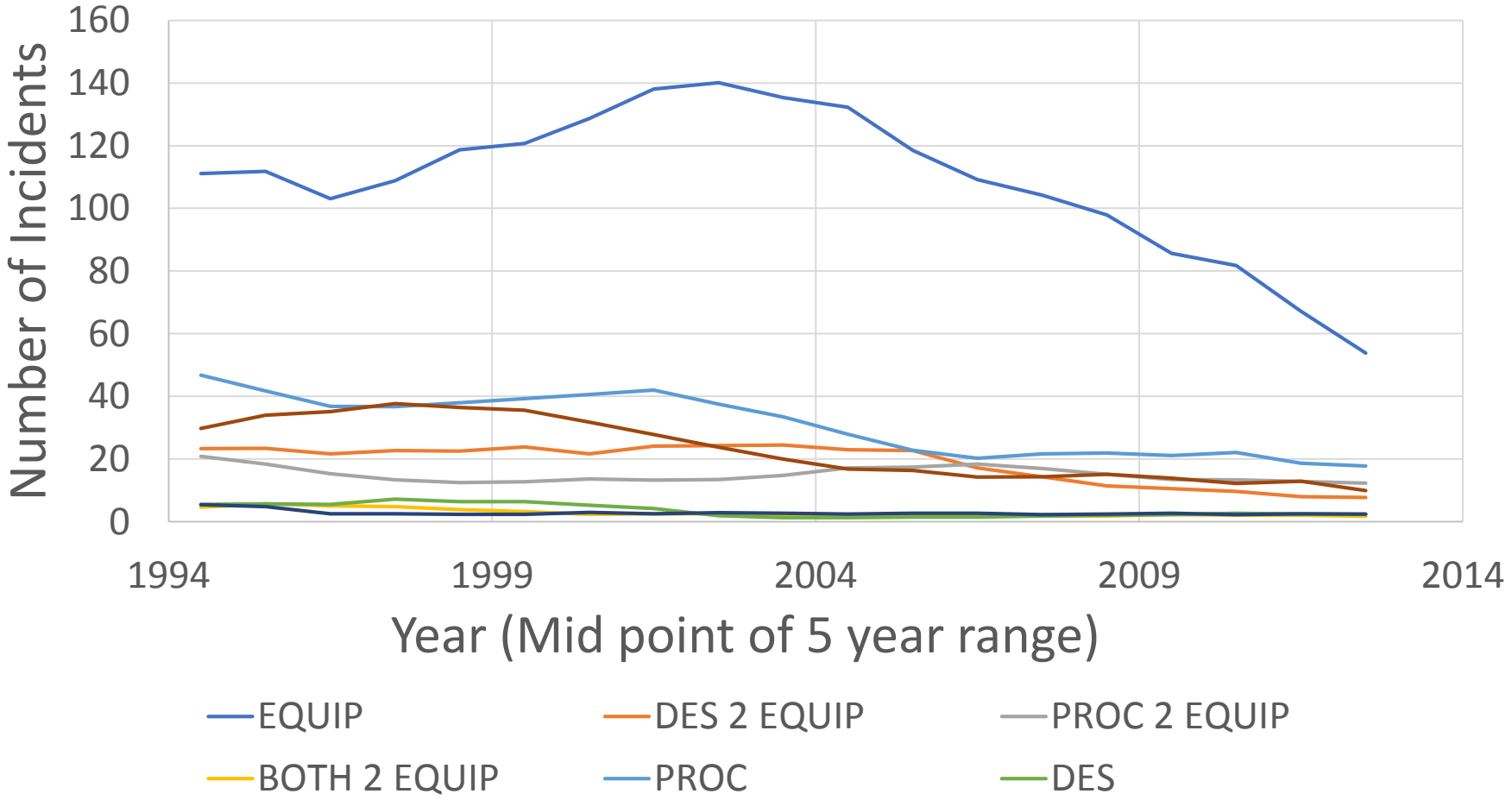
Conclusion from the linear regression

- The decrease of Loss of Containment events from 1993 to 2014 appears to be mainly driven by improvement in procedures, hence general management of the offshore platforms.
- Design also contributes to the decrease, although at a slower rate.

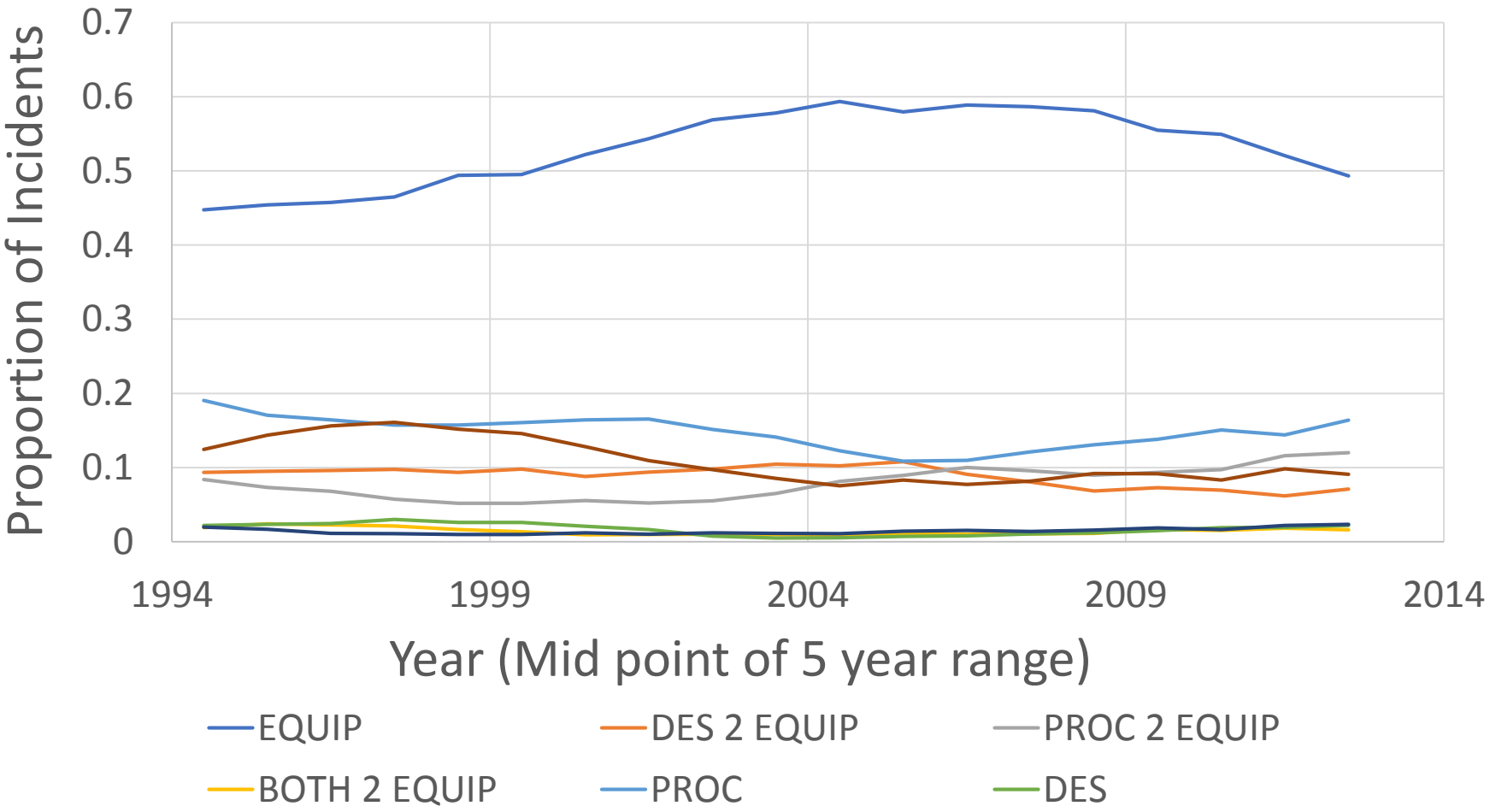
Alternative analysis using Running Averages

- An alternative way of viewing trends is to use running averages.
- The number or proportion of incidents is averaged over a number of years in order to smooth out the stochastic variation in the number of incidents reported in a given year and reveal the general trend.
- This is a less precise mathematical treatment but has the advantage of showing whether changes in the rate of incidents occurring have been consistent over the period or have themselves varied with time.
- In this study an averaging period of 5 years was considered appropriate for this purpose.

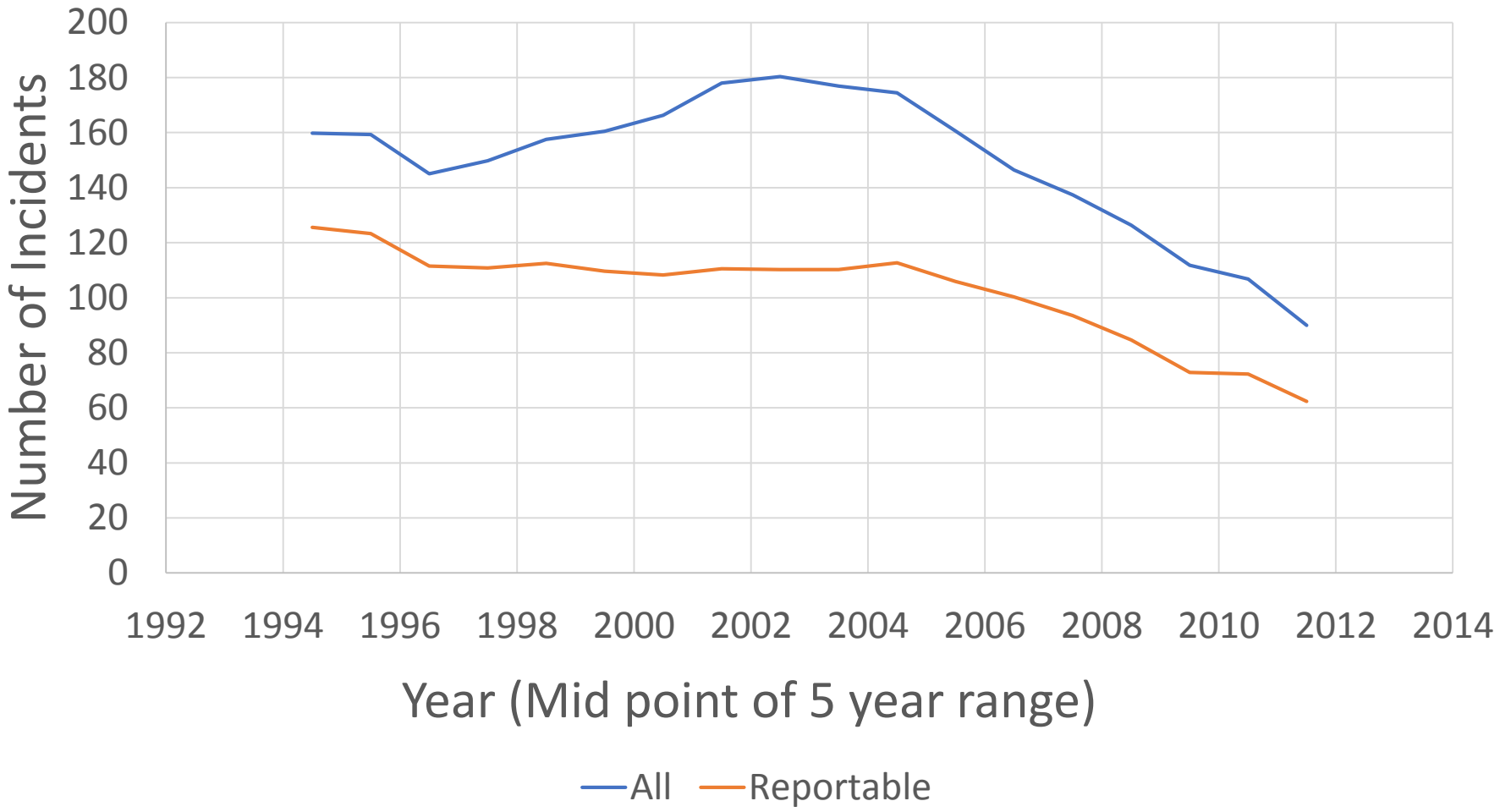
5-year running average number of incidents by category



5-year running average proportion of incidents by category



5-year running average of estimated number of YESEQUIP incidents



Observations

- Sensitivity - the study was performed with slight variations in the algorithm for the classification, among others how to deal with “unknown” or incomplete records. This had only a minor effect on the linear regression results
- The study only addressed relative trends – not absolute frequencies (no population data was included). Analysis of incident frequencies might show improvement for all causes in absolute terms.
- The study did not address whether some types of components “behave” in a different way as compared to the average over all components.

Overall conclusion

- The decrease of Loss of Containment events from 1993 to 2014 appears to be mainly driven by improvement in procedures, hence general management of the offshore platforms.
- Design also contributes to the decrease, although at a slower rate.
- Equipment failures decrease at the slowest rate, if at all, until 2003. Since then, the equipment too has been improving at a significant rate.
- The fact that procedural factors seem a driving factor for the decrease of incidents can be used as an argument that the newer data may apply to older platforms, managed in a modern way.
- The conclusions may be sharpened if the population data is included in the analysis, that is that absolute frequencies can be used rather than relative trends.

Thank you for your attention

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