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DYNAMIC POSITIONING CONFERENCE
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Risk

Analyzing Petrobras DP Incidents

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1- Introduction

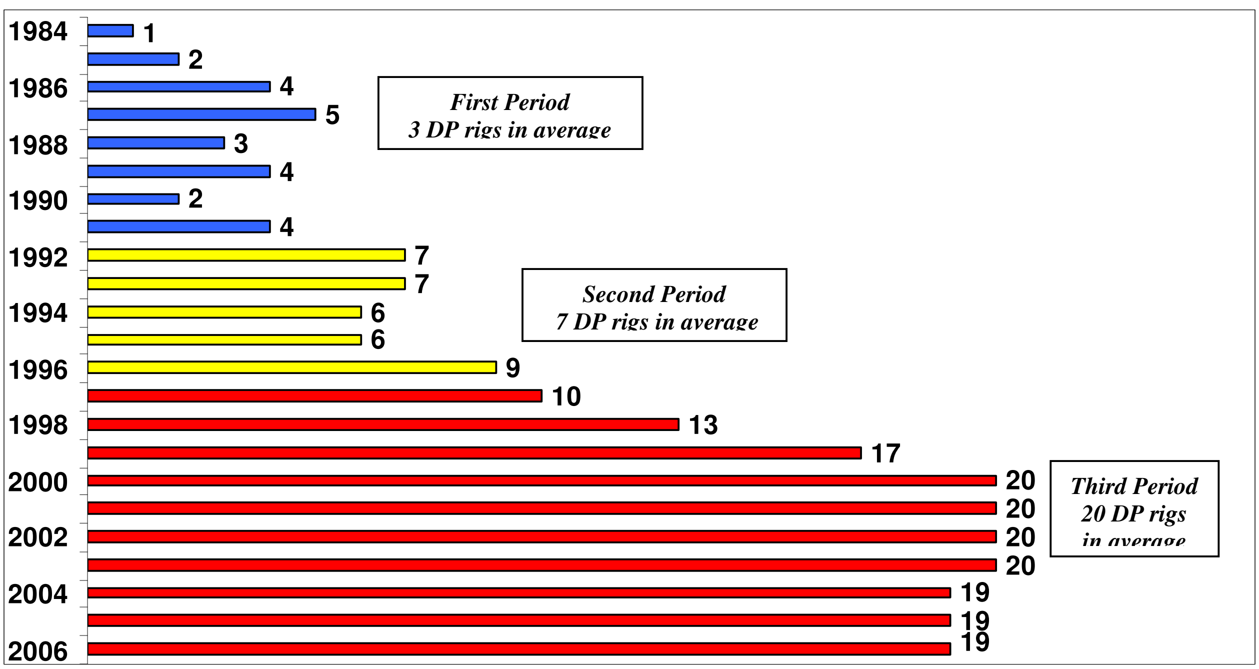
Petrobras in particular and the oil industry worldwide are moving into deeper water, where new demands on Dynamically Positioned vessels are required. Existing technology will be pushed to its limit; the deeper the water, the greater the variety and complexity of the challenges that must be met.

There is also a general need to improve the safety and reliability of DP vessels used in the offshore industry. This is because the tasks DP vessels are required to perform are becoming increasingly complex. Considering these kind of vessels, Petrobras has different operating scenarios: “old” wells workovers in shallow water (500 m), development of deepwater fields in crowded areas with close proximity to other vessels – DP or Moored, FPSO, Production Facilities, Special Vessels, and ultra deepwater exploration (up to 2750 m).

When Petrobras started using DP-operated vessels, the state-of-the-art technology had been developed for shallow water operations and was not necessarily appropriate to be used in deeper water. Before 1992, operations such as drilling, production, testing and well intervention have been done by vessels using mooring systems. In deeper water, however, purely DP-operated vessels have been proven to be the best alternative to that existing technology.

Regarding the challenges inherent to the utilization of dynamically positioned vessels, special cares always need to be taken since their characteristics of "intrinsically unsafe" and the risk of a positioning loss or a black out are always present, whose consequences are potentially catastrophic especially for the environment.

The first DP unit to work for Petrobras started her operations in 1984. Since then, the number of DP rigs has increased in three different periods, as shown in the graphic below:



Within the second period, challenging operational scenarios, such as operations in crowded areas, made Petrobras to develop a safety program called **DPPS (Dynamic Positioning – Programa de Segurança)**, composed by several projects to avoid incidents, if not, to minimize their consequences. Among them, a **DP Incidents Database** was created.

DPPS works in a proactive way to anticipate problems either by using newest technology or by pushing the industry to create particular solutions, and some of the objectives DPPS has to get reliability of DP operations are:

- to improve safety when using a DP-operated vessel for drilling, subsea installation, production, testing and well intervention;
- to minimize risks of incidents that could lead to “drift-off” or “drive-off”;
- to improve the performance of DP technology by developing systems with acceptable reliability for operation in remote areas and in deepwater.

2 - DP Incidents Database -BDIP

Looking for opportunities to improve the work quality, DPPS has developed a DP Incidents Database to storage complete incidents data. It is named BDIP (DP Incidents Database). By gathering available information related to the incidents, DPPS is able to analyze Potential Failure Modes on which their associated causes are identified, considered and addressed.

BDIP contains information gathered since 1984 when the first DP-operated vessel started working for Petrobras. By having more than 600 incidents on its databank, BDIP is one of the best tools DPPS has for both evaluating the rigs performance and avoiding repeating unwanted occurrences.

As a matter of definition, BDIP considers for analysis that DP Incidents are **any events that potentially can lead to an emergency disconnection**. So, every incident registered on BDIP is linked with an event described as one of the status as below:

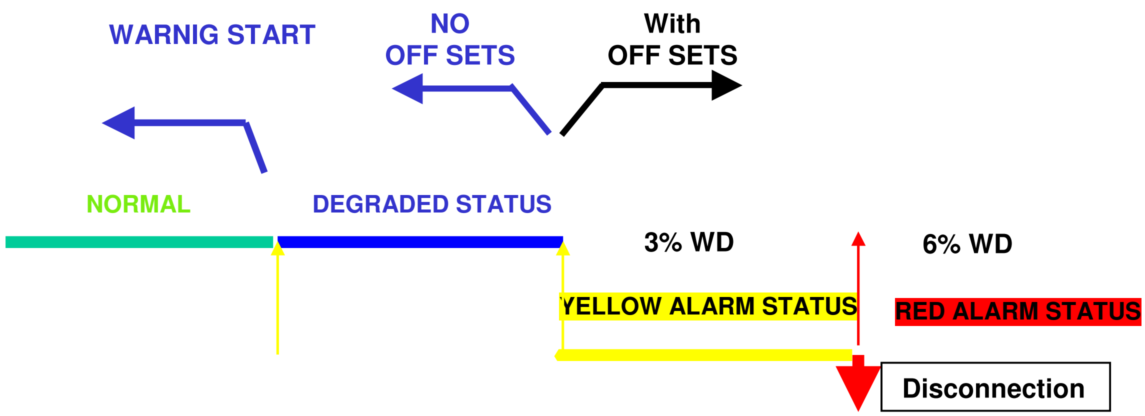
Degraded Operational Status - when the vessel, due to failures, malfunctions or high demand loses the minimum needed redundancy for DP System & Equipments to proceed safely with the operations and, consequently, loses the safe operational capacity of station keeping.

Yellow Alarm Status – when the vessel’s safe operational capacity is compromised since there is an offset related to the well and/or an abnormal LFJ deflection.

Red Alarm Status – when the vessel’s station keeping capacity is irreversibly lost, resulting in a high offset and a high LFJ deflection. In that situation the vessel must proceed with an emergency disconnection.

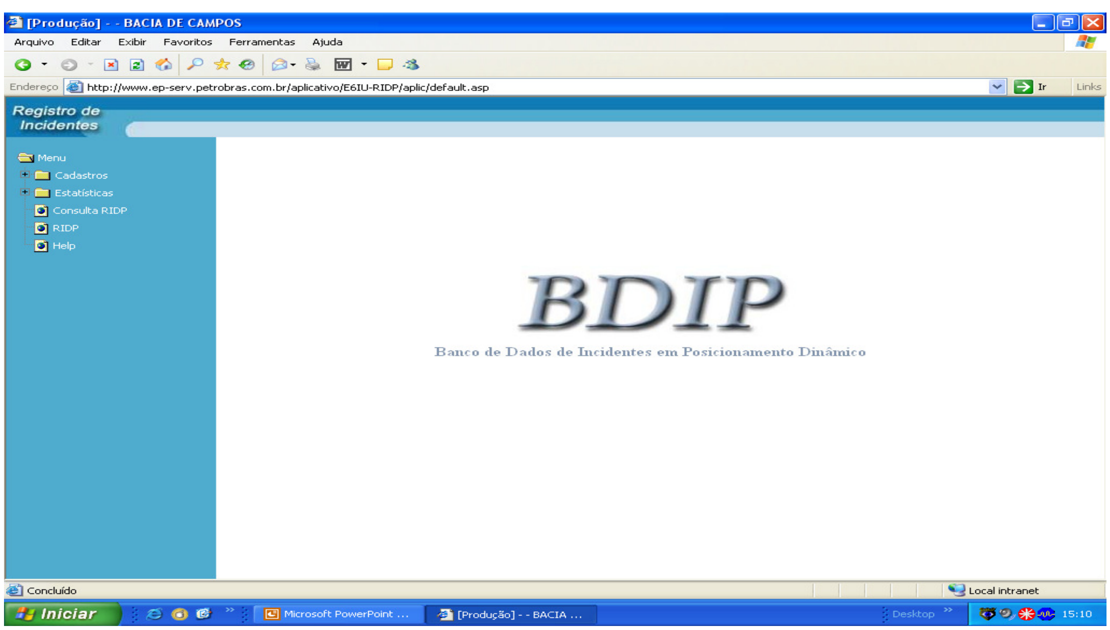
Straight Red Alarm Status – when the vessel suddenly loses the capacity of station keeping even if there is no offset or LFJ deflection. DPO must proceed with the emergency disconnection.

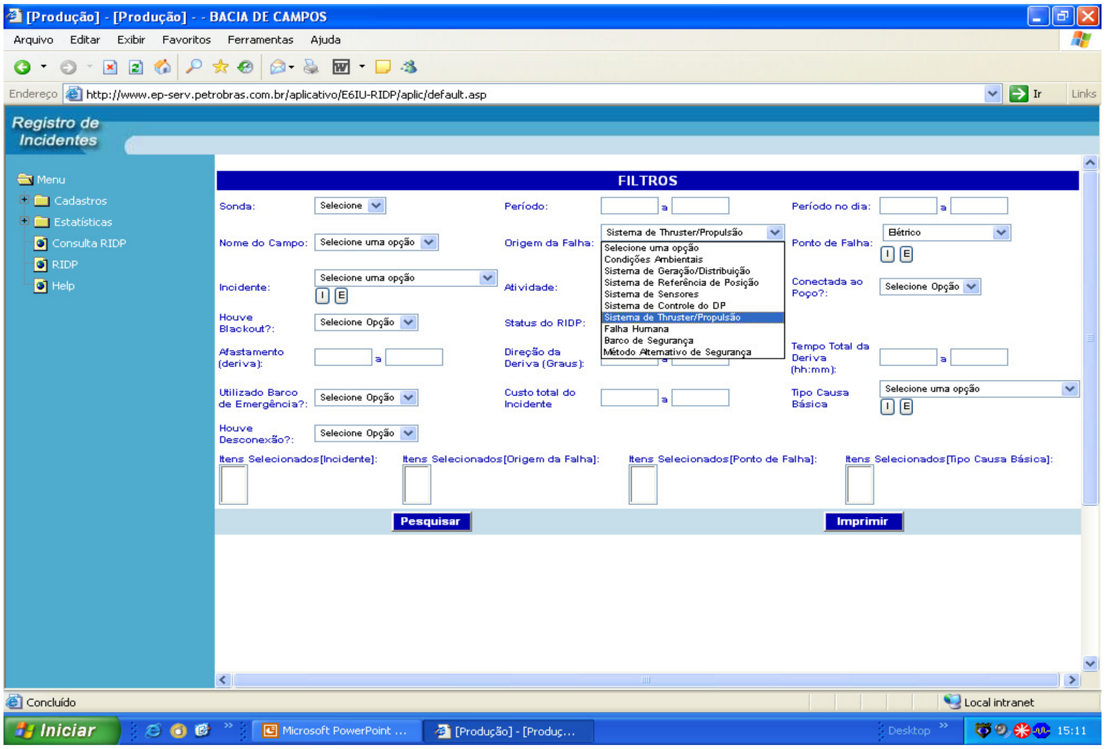
The following table summarizes the status above described:



CAUSE	EFFECT	CONSEQUENCE
Loss of Redundancy	Degraded	Without loss of position - Possible cease of operations (Critical Operation)
Progressive loss of station keeping capability	Yellow Alarm / Red Alarm	Loss of position with control – preparation for disconnection => disconnection
Sudden loss of station keeping capability (ex: black-out)	Straight Red Alarm	Loss of position without control => Immediate disconnection

BDIP also generates a considerable amount of data that allows DPPS improving “Restriction Diagrams”, operational procedures, vessel’s class comparisons, bids, analyses, statistics, updated surveys check-lists, etc. Below, as an example, its two first pages with the main menu and filters:





3 – Incidents

The purpose of this paper is to present an overview of DP incidents in units under contract with Petrobras and it is based on those three different periods previously mentioned.

In this analysis, no DP Class I vessels are included and, as per required by Petrobras' contract, DP Class III vessels work as Class II with the bus tie breaker closed, which means that only Class II vessels were considered here despite the fact that Class III vessels are expected to be safer than the others.

The first period between 1984 and 1992, despite working with few rigs, was characterized for a great number of DP incidents mainly due to the following reasons:

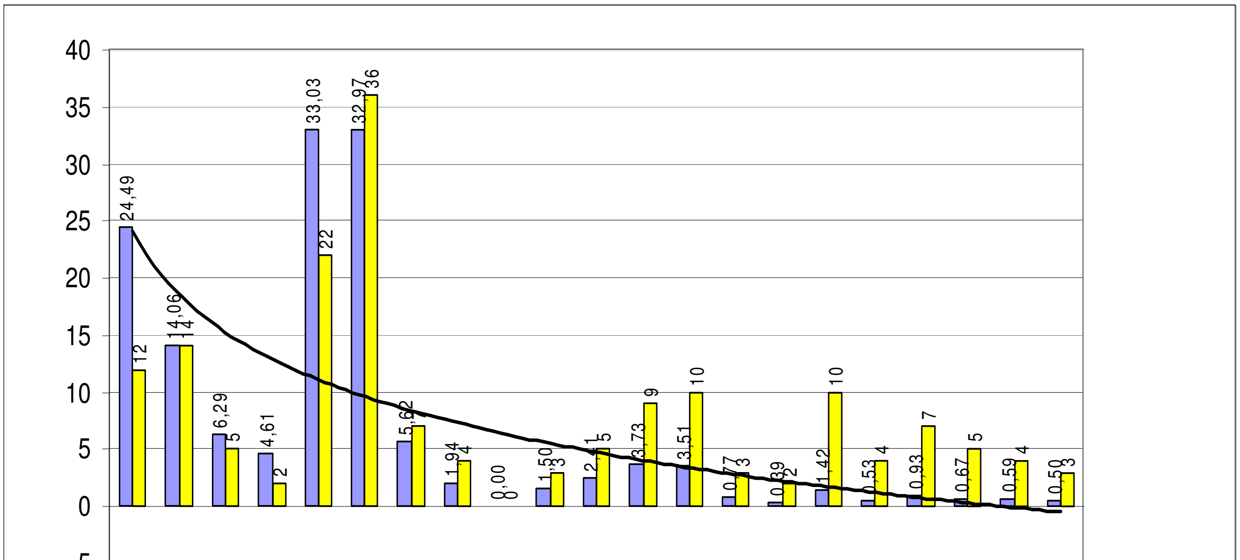
- Poor operational procedures and contingency plans;
- Lack on safe operational limits;
- Unfamiliarity of Petrobras Engineers with DP vessels' details.

On the second period, between 1992 and 1996, when **DPPS (Dynamic Positioning – Programa de Segurança)** was created, we could see that the effort DPPS was making together with the Contractors is producing good results, based in the reduction of DP incidents.

Finally the last period started in 1996, we could notice the number of incidents rising up slowly from 1996 to 2000. It was because of the apprenticeship's curve due to the high number of DP-operated vessels on that period: from an average of seven to twenty by year. This tendency was interrupted in 2001 and, as a consequence, the number of incidents went down to a very low level.

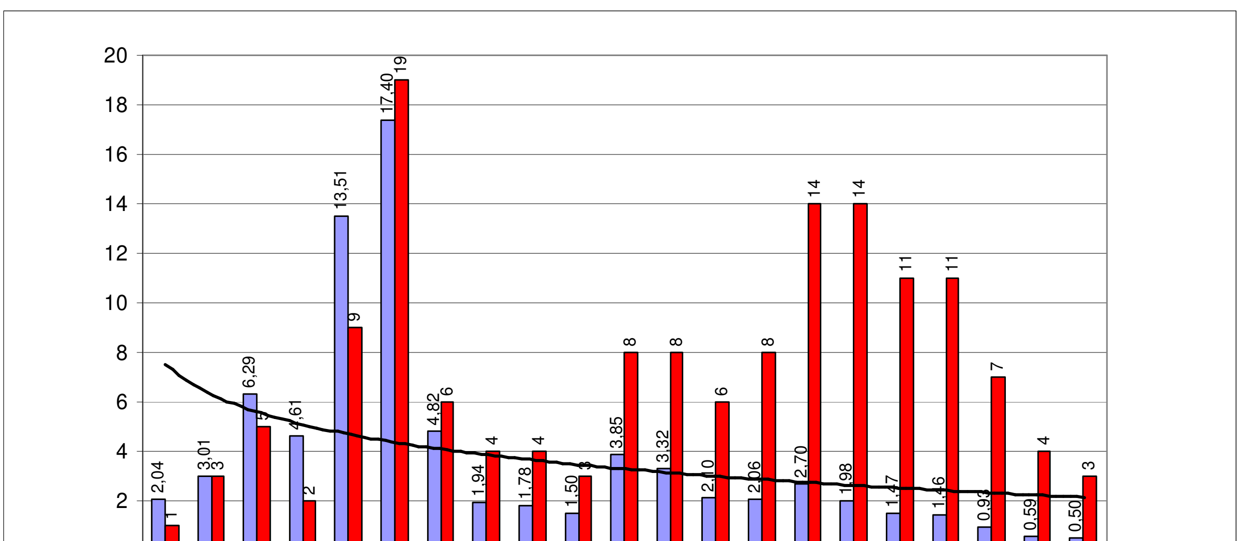
The following graphics show the evolution on the number of DP incidents since 1985. They show both the number of incidents by year and the incidents' rate by 1000 days of operations. Based on the incidents' classification adopted, this analysis was restricted to those incidents that had caused Yellow and Red Alarm lights to go off. Also, the number of blackouts and disconnections were analyzed too.

Yellow Alarm vs. Working Hours 1985-2005



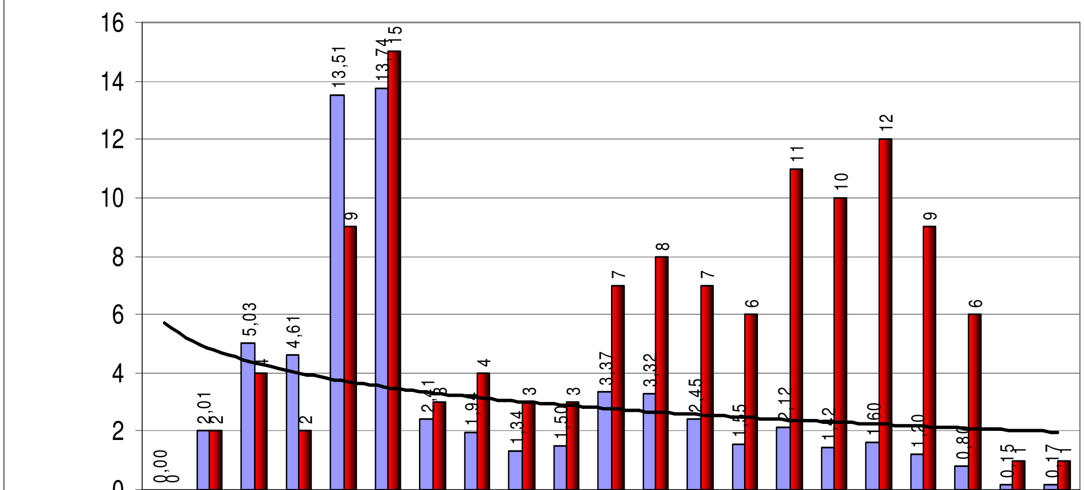
	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Rate	24,49	14,06	6,29	4,61	33,03	32,97	5,62	1,94	0,00	1,50	2,41	3,73	3,51	0,77	0,39	1,42	0,53	0,93	0,67	0,59	0,50
# Alarms	12	14	5	2	22	36	7	4	0	3	5	9	10	3	2	10	4	7	5	4	3

Red Alarm vs. Working Hours 1985-2005



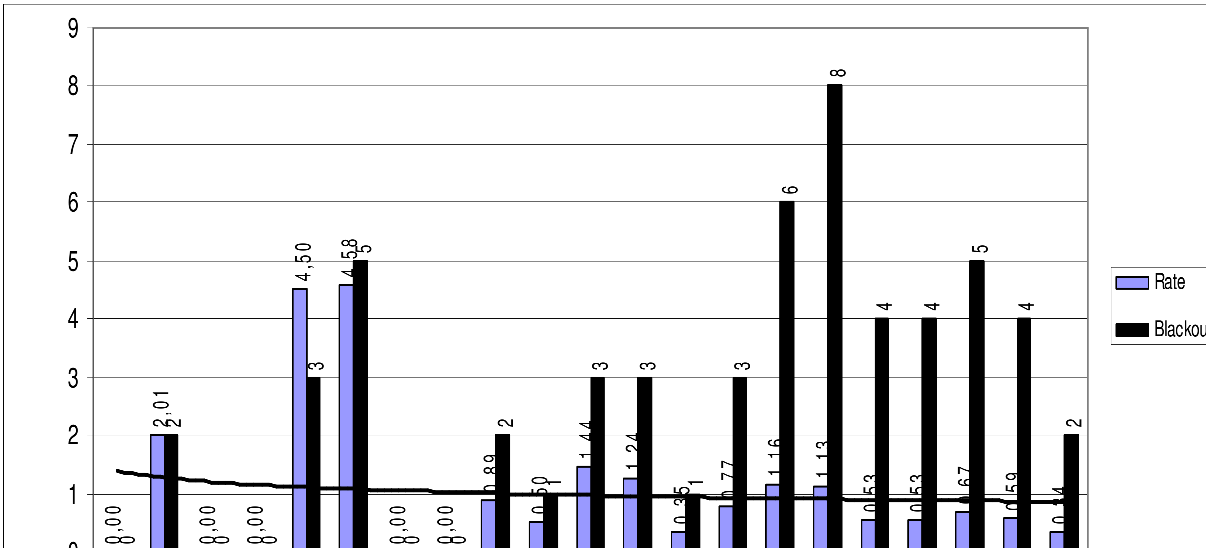
	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Rate	2,04	3,01	6,29	4,61	13,51	17,40	4,82	1,94	1,78	1,50	3,85	3,32	2,10	2,06	2,70	1,98	1,47	1,46	0,93	0,59	0,50
# Alarms	1	3	5	2	9	19	6	4	4	3	8	8	6	8	14	14	11	11	7	4	3

Disconnections vs. Working Hours 1985-2005



	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Taxa	0,00	2,01	5,03	4,61	13,51	13,74	2,41	1,94	1,34	1,50	3,37	3,32	2,45	1,55	2,12	1,42	1,60	1,20	0,80	0,15	0,17
Nº Desconexões	0	2	4	2	9	15	3	4	3	3	7	8	7	6	11	10	12	9	6	1	1

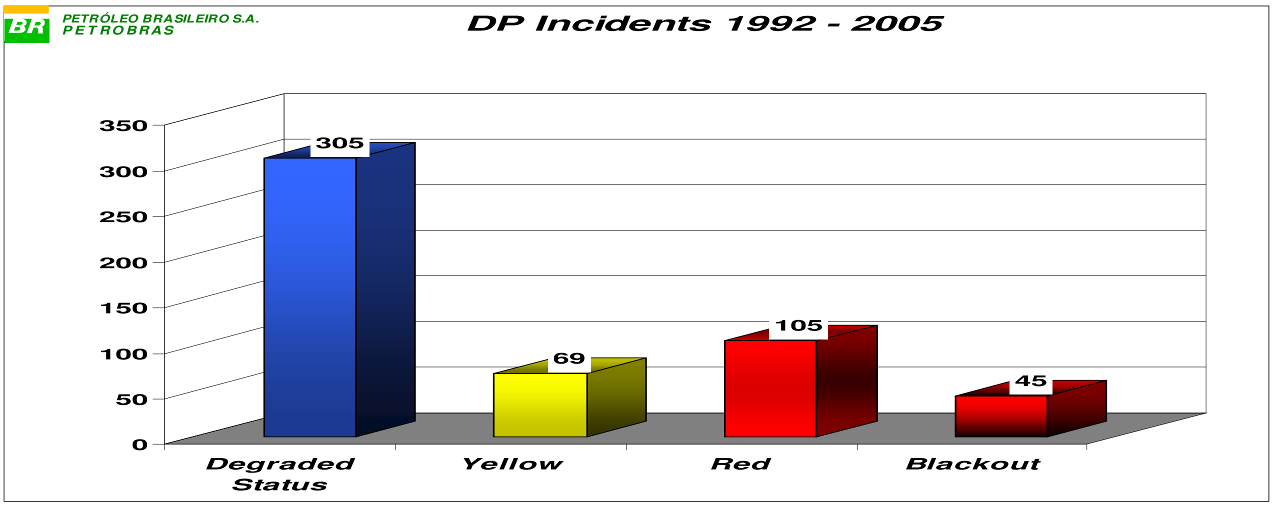
Blackout vs. Working Hours 1985-2005



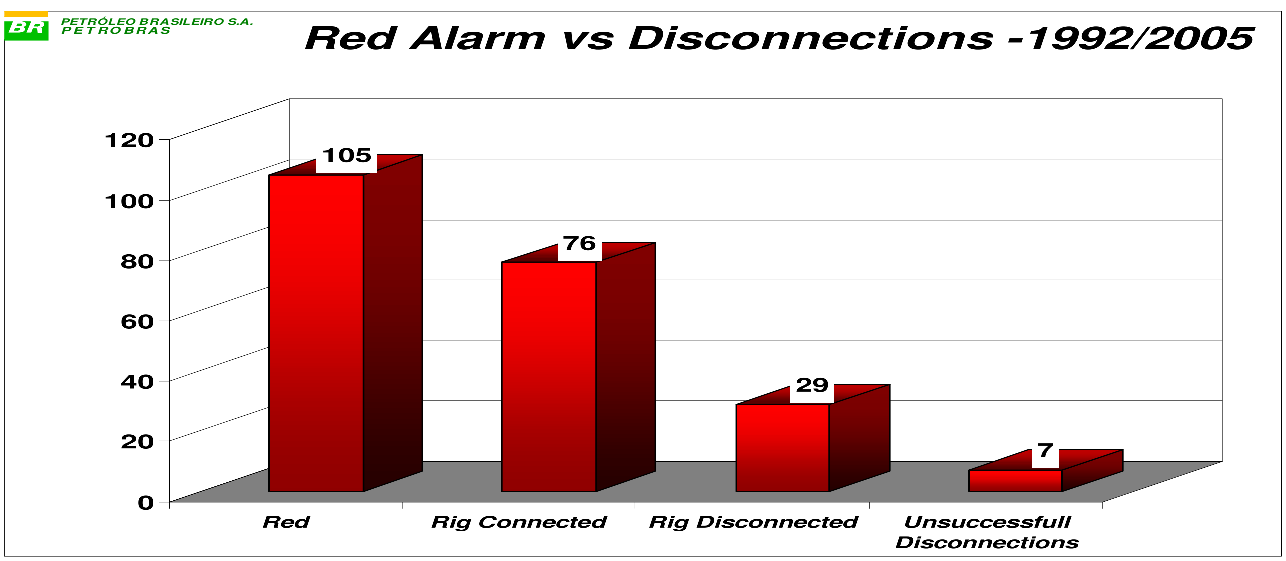
	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Rate	0,00	2,01	0,00	0,00	4,50	4,58	0,00	0,00	0,89	0,50	1,44	1,24	0,35	0,77	1,16	1,13	0,53	0,53	0,67	0,59	0,34
Blackout	0	2	0	0	3	5	0	0	2	1	3	3	1	3	6	8	4	4	5	4	2

4 – Analyses

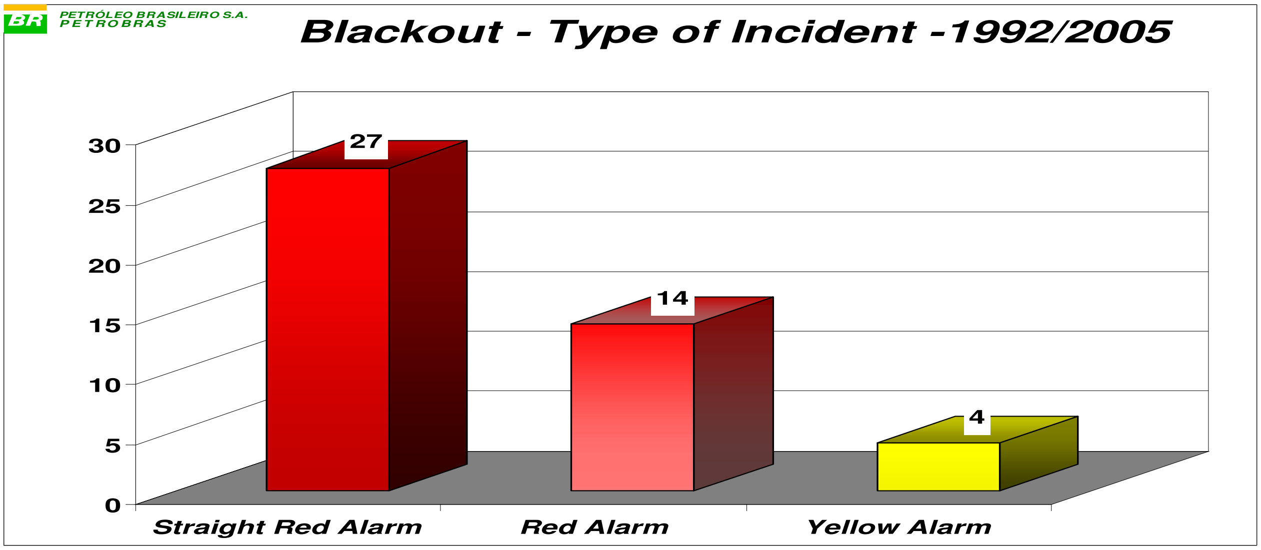
The next graphs present the incidents in the period after DPPS has been created. That was characterized for having more precise data being gathered from newly born standards that allowed us to make deeper analyses and to search for root causes in a much easier way. Within the period from 1992 to 1995 we had 479 incidents in total, according to that classification previously defined, and the graph below shows how incidents were distributed. The amount of 45 Black Out situations is shown only as extra information and it is included on the total of Red & Yellow alarms. Due to the time available for the presentation no further analysis will be made for Yellow Alarm Status.



By comparing the number of Red Alarm Status with the number of Disconnections, we can evaluate how critical was the incident. By far, the vessel was connected when the Red Alarm went off: 76 of 105 times. In another 29 times the red light came up but the vessel was not connected. From the total, we had 7 failed attempts to disconnect. It was due to wrong disconnection procedures or because the emergency disconnection sequence has failed.



Considering that, by definition, a blackout situation leds to a Straight Red Alarm, we had only 27 times out of 45 where the expected result was like that. However, we got a Red Alarm on 14 situations and 4 of them went off the Yellow light. The explanation is that, even being aware of the right procedure to follow, operators made a decision to not disconnect because the weather conditions were supporting that.

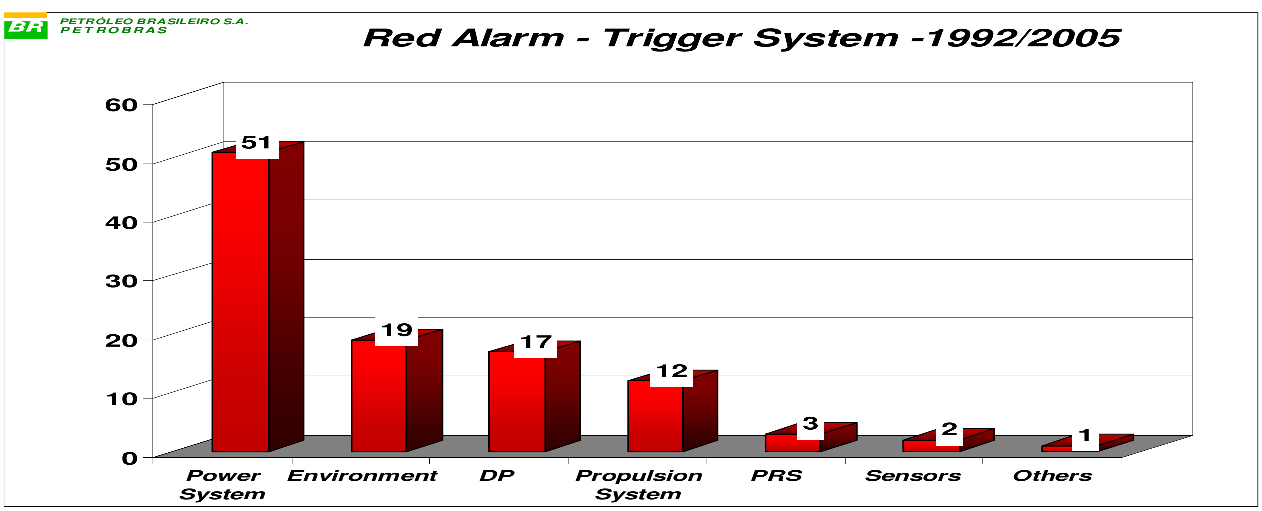


Root Causes, Trigger Systems and Points

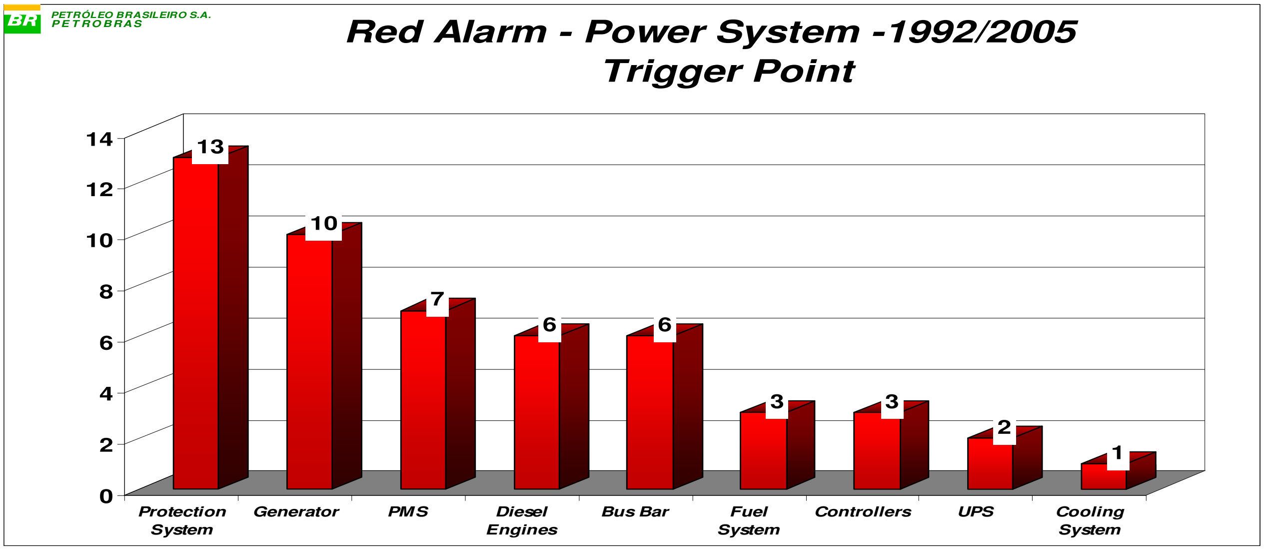
The incidents reported and the graphs on the presentation were categorized into Failure Root Causes (initiating events), identified as a fault that starts an event, which could cause a position loss; Trigger System, identified as a system or place where the event starts, and Trigger Point, identified as a point that, as part of the trigger system, was responsible for starting the event. The analysis was focused on the incidents classified as Red Alarm Status and the Blackout events because of their severity.

Red Alarms

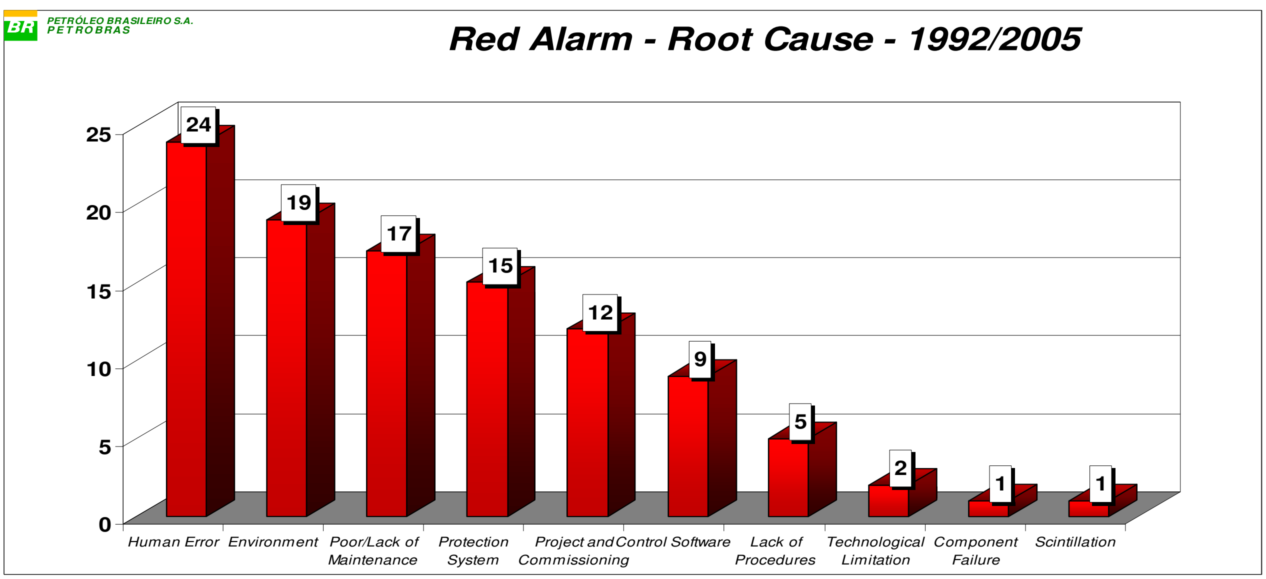
From 1992 to 2005, when considering the number of Red Alarms from the Trigger System's point of view, we found that the Power System was by far the main source of reports: 51 of 105.



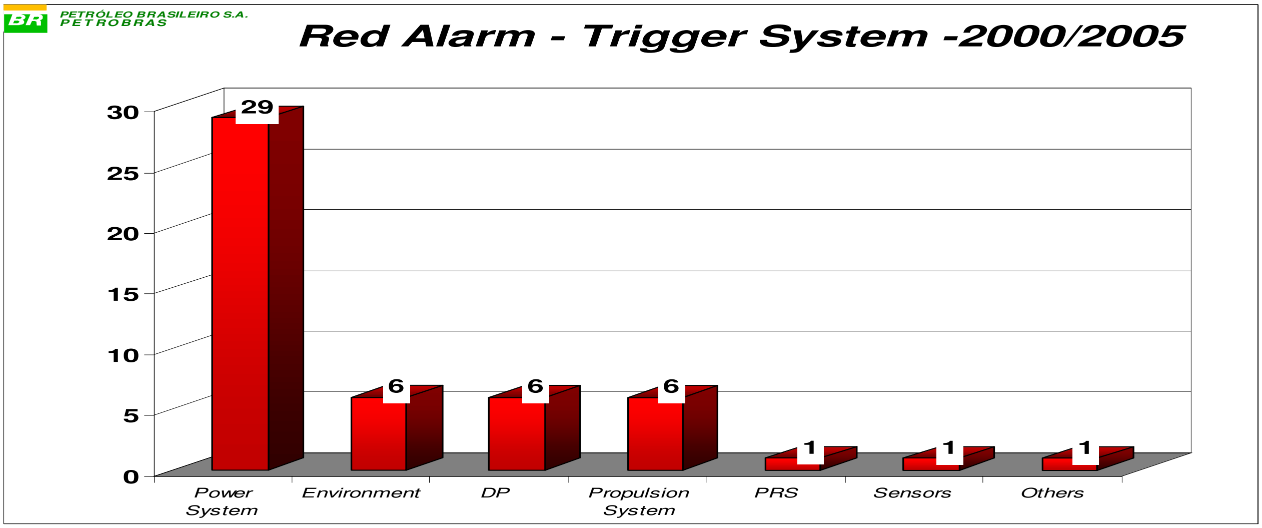
Going deeper with that analysis we noted that the Protection System, which includes not only the protective devices but also the Coordination & Selectivity Survey and its (wrong) calibration, was responsible for 13 reports followed by the Generators with 10 related incidents.



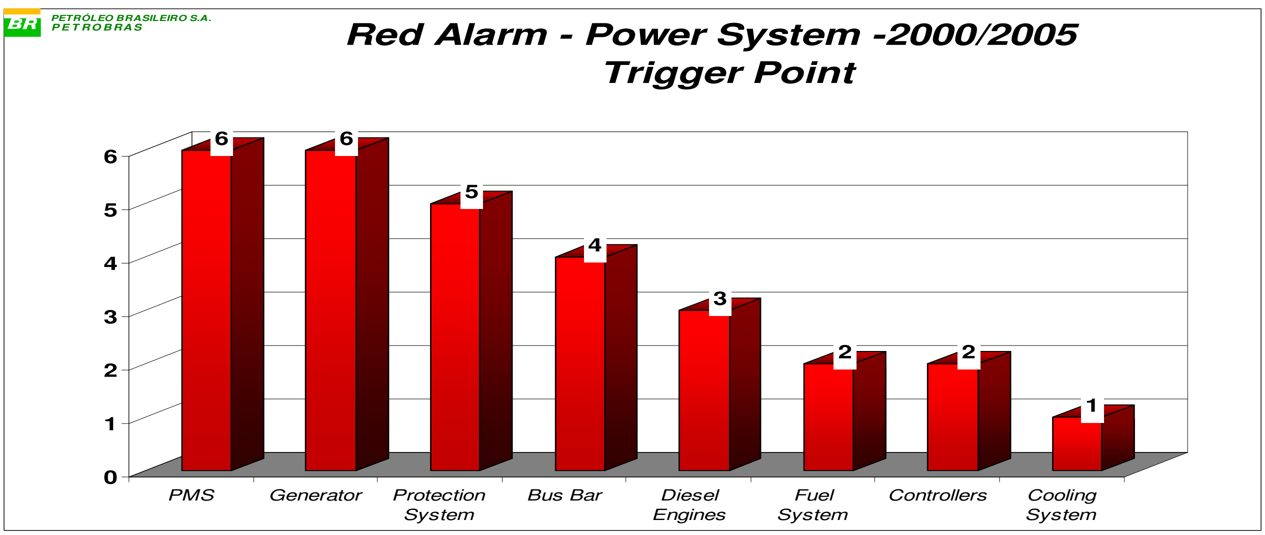
Still talking about Red Alarms on that period, what most called our attention was the fact that 24 incidents of 105 had their Root Cause in human error, which corresponds to 23% of the total. It was followed by Weather Conditions (19), Poor/Lack Maintenance (17) and the Protection System (15). The human factor here proved that something had to be done related to that matter. In the end of this paper, we will discuss more about that.



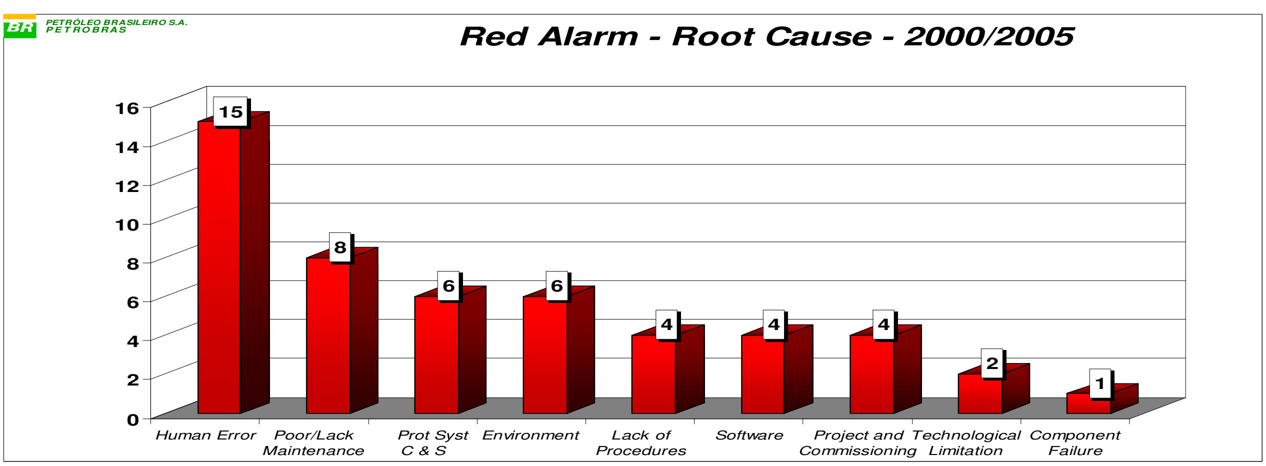
We got almost the same result when our focus is on the period from 2000 to 2005: 29 of 50 incidents were triggered by the Power System. No surprises since many vessels have been modified or upgraded in a hurry.



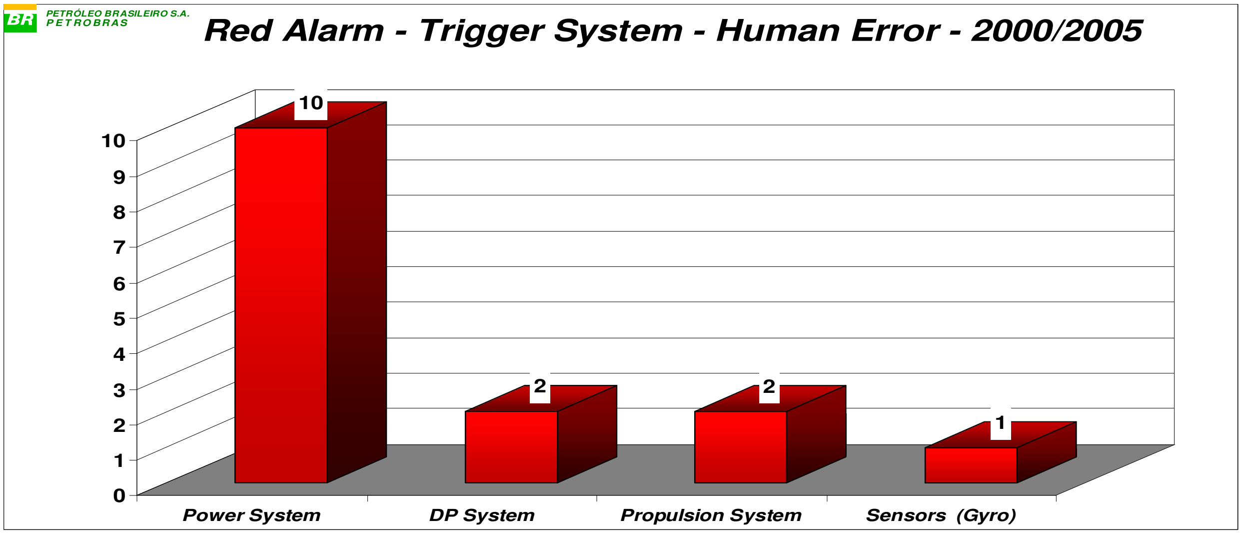
Again, we went deeper with that figure and we found now that 6 of them were triggered by the PMS and Generators being close followed by the Protection System with 5 reported incidents. Again, same reasons brought no surprises.



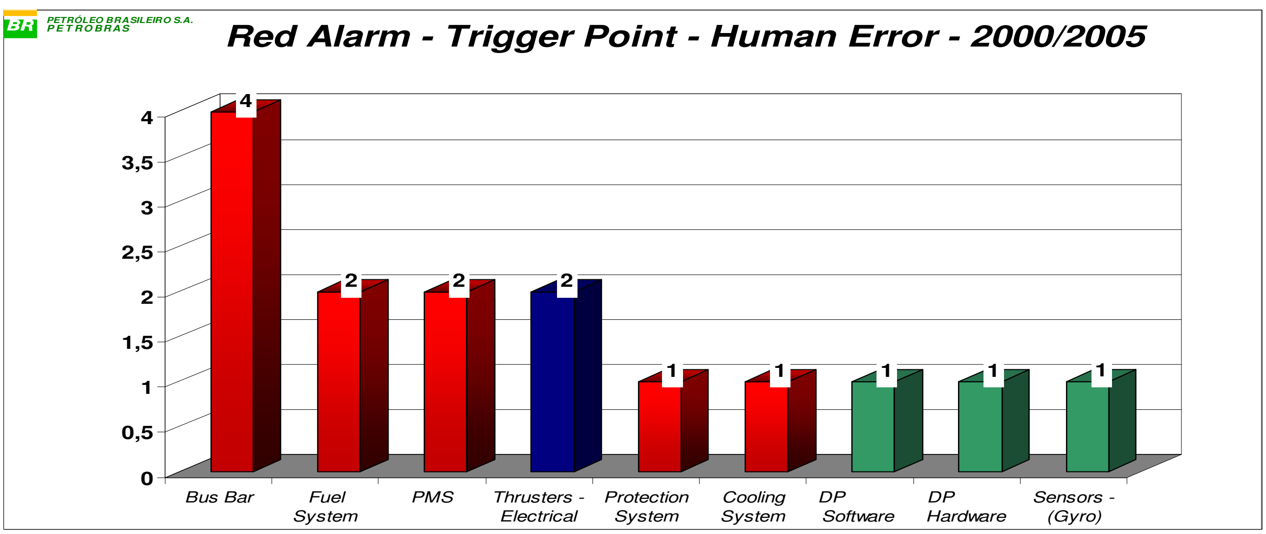
Analyzing the total of 50 incidents on this period we also verified that human error was the Root Cause in 15 of them, which corresponds to 30% of the causes and demonstrates a relatively larger number compared to the second period.



From those 15 incidents reported, 10 were related to the Power System while 2 were related to the DP System, 2 to the Propulsion System and 1 was related to Sensors (Gyro).

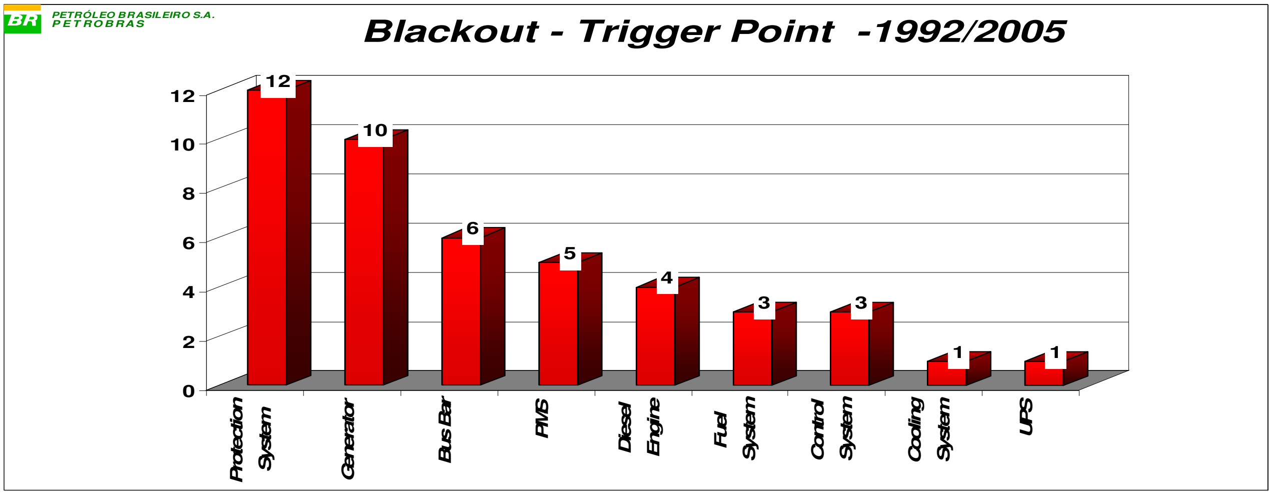


Going deeper on this analysis we got that the related trigger points were: Bus Bar (4), PMS (2), Fuel System (2), Thruster/Electrical (2), Protection Devices (1), Cooling System (1), DP Software (1), DP Hardware (1) and Sensors – Gyro (1).

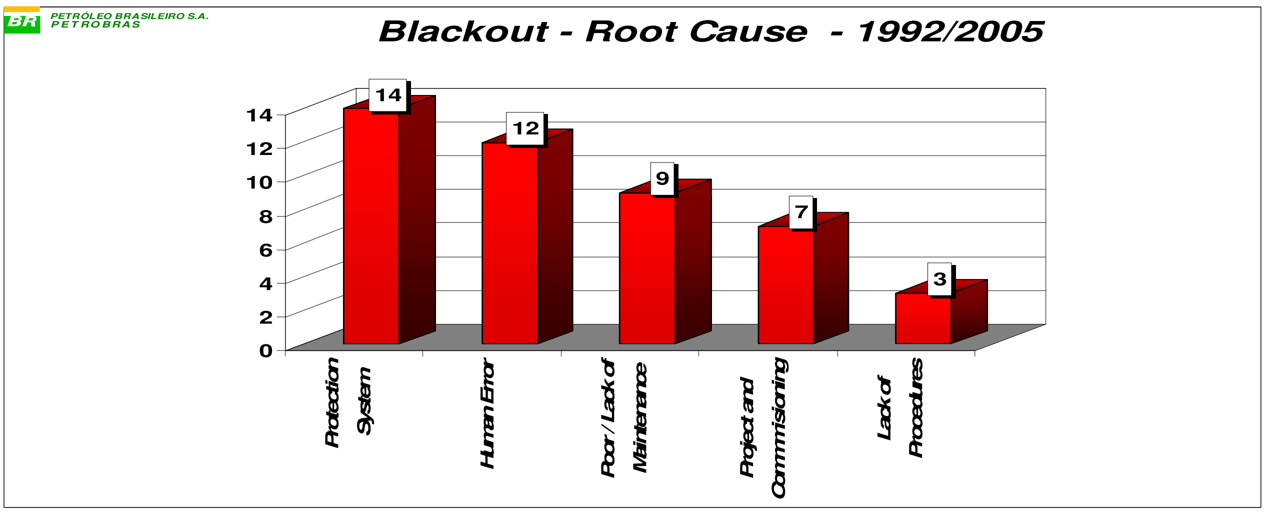


Blackout

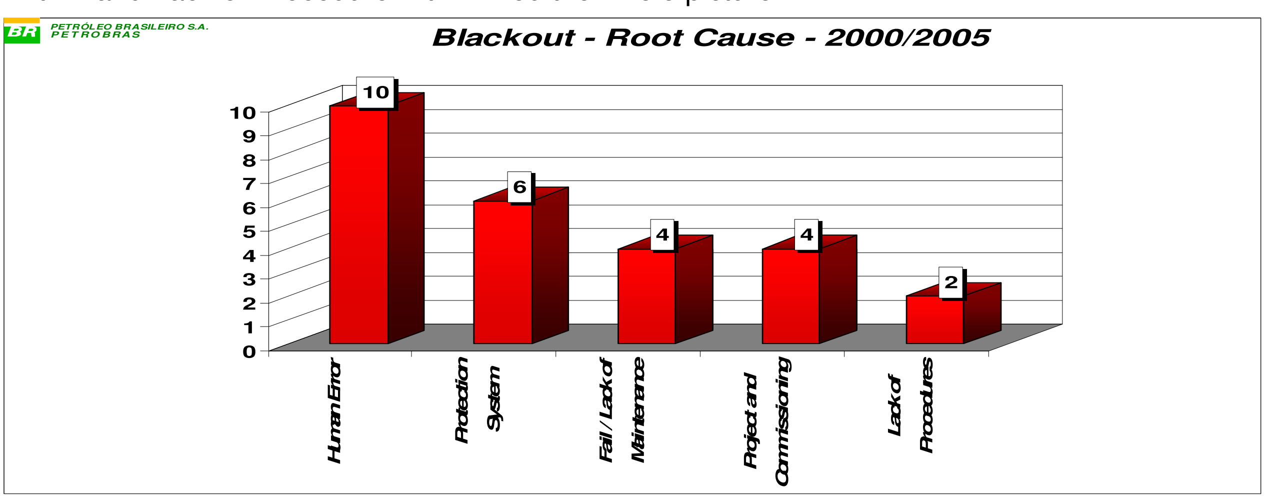
Another important scenario is related to the incidents that led to blackouts where, naturally, the main source is the Power System. From a total of 45 blackouts reported between 1992 and 2005, 12 were triggered by Protective Devices, close followed by the Generators with 10 occurrences. The other important reports were related to Bus Bar (6), PMS (5), Diesel Engines (4), Fuel System (3), Control System (3), Cooling System (1) and UPS (1).



When considering the root cause of incidents in that period we found that 14 out of 45 were triggered by the Protection System while 12 were by Human Error, 9 by Poor/Lack of Maintenance, 7 by Project and Commissioning and 3 by Lack of Procedure.



The scenario looks different when we focus the period of time between 2000 and 2005 where Human Error was the trigger point that most appeared: 10 times out of 26. The Protection System with 6 events, Poor/Lack of Maintenance with 4, Project and Commissioning with 4 and Lack of Procedure with 2 filled the whole picture.



5 – Human Error as Root Cause of DP Incidents

Concerned about this *Human Error* problem, DPPS was asked to join a workgroup especially dedicated to analyze the causes and propose solutions as an action plan to be put into practice. Also, the workgroup would be responsible to create new procedures for Straight Yellow and Red alarms.

As every major action from DPPS related to DP-operated vessels, this task was shared with Contractors and the result could not be better since fourteen causes were identified and twelve actions were proposed to be implemented by both Petrobras and Contractors as detailed below:

1. **Ineffectiveness of on-job-training for DPO / SDPO as well as for new DPO Certification.**

2. **High turnover among companies or even within the same company.**

3. **Few opportunities for practicing or not enough time to be familiar with the system.**

4. **Inadequate supervision.**

- Theoretical training for DP/ECR personnel:

  ✓ *By considering needed skills according to a training matrix developed together with the manufacturers.*

- Practical training on board for DP personnel:

  ✓ *By operating DP/ECR on manual whenever possible.*
  ✓ *By training manual blackouts recoveries with simulated failures whenever possible.*
  ✓ *By asking the supervisor to spend a time to familiarize new operators with their functions.*

- Training on simulators:

  ✓ *By installing DP/VMS simulators allowing DPO/ECRO to practice.*
  ✓ *By checking simulators functionality where already installed.*
  ✓ *By creating a training program for operators.*

- Make DP/ECR a worthy team:

  ✓ *By implementing a better HR policy to create a motivational perspective for operators allowing them to plan their careers.*

- DP personnel hiring as part of a bigger process:

  ✓ *By hiring skilled people or those who have a technical background ensuring they present the right profile to work on that environment.*

5. **Poor handover causing incidents due to the lack of details about ongoing operations.**

    - Improve handover:

        ✓ *By creating a specific procedure for handover, especially while/after testing, audits, and related to critical equipments.*
        ✓ *By reinforcing the need of Supervisor's presence on those moments.*

6. **Poor communication among departments (DP / Rig Floor and DP / ECR).**

    - Improve communication process among DP/ECR/RIG FLOOR:

        ✓ *By considering a cross training among the involved areas, that is, DP training for Engineers and so on.*
        ✓ *By checking the effectiveness of this making improvement when necessary.*

7. **Stressful situations caused by less experienced operators combined with more activities/responsibilities.**

8. **Long time in front of the console (DP, VMS, etc) affecting DPO psychological aspects.**

9. **High noise, lack of attention, amusement for chatting in close coffee shops (Bridge, ECR).**

    - Improve work conditions for DP/ECR personnel:

        ✓ *By asking, via Contract, the companies to follow IMCA recommendations related to the minimum number of DPO on duty.*
        ✓ *By keeping a number of technical POB to guarantee tasks are shared and being carried out without extra job.*
        ✓ *By changing existing procedures restricting DPO to contact Supply Boats and Choppers only when necessary.*
        ✓ *By creating procedures to avoid the presence of non-authorized people on Control Rooms asking the Supervisor to, personally, take care of this.*
        ✓ *By replacing the existing coffee shops that are located next to the Control Rooms.*

10. **Poor motivation or lack of attitude.**

11. **Experienced people's overconfidence.**

12. **Lack of specific procedures.**

    - Improve confidence/motivation:

        ✓ *By developing motivation programs and competences, creating a career plan and avoiding needless turnovers.*
        ✓ *By considering keeping DPO/ECRO for three years on the same position as a minimum time required.*

- ✓ *By considering moving DPO/ECRO to another vessel after a long time on the same position/vessel.*

- Create procedures making them available:

  - ✓ *By comparing existing procedures with international standards and manufacturers' recommendations improving them when necessary.*
  - ✓ *By creating internal mechanisms to demand even experienced operators to apply them.*

13. Poorness/Absence of manuals especially after upgrades.

- Organize and update technical documentation:

  - ✓ *By verifying the existence of technical documentation providing updates when necessary.*
  - ✓ *By keeping a specific and organized place to save technical documentation and manuals.*

14. Poor automation demanding human interference.

- Automate DP/ECR system:

  - ✓ *By asking manufacturers to improve automation on those systems that offer lower risk for operation, especially on the ECR. For those systems where the human interference is crucial, the present status will be kept.*

6 – Conclusion

The purpose of this paper was to present an overview of DP incidents in units under contract with Petrobras. The analysis presented data gathered since 1985 with a special highlight from the year 1992 on (when DPPS – Petrobras DP Safety Program was created) until 2005. It tried to show not only the number of DP incidents but also analytical data.

By using statistics, the presentation highlighted the significant reduction of DP incidents after the implementation of a program that allowed DPPS team to learn more about incidents and, as a result, to improve reliability on DP-operated vessels.

As a final point, it focused the last incidents caused by Human Error as our major concern at the moment by presenting some actions currently put into practice through a partnership between Petrobras and the Contractors.

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