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**Workboats**

# Stability Management for DP Platform Supply Vessels

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# "Stability Management for DP Platform Supply Vessels"


## Abstract:

This paper attempts to explore some of the more pertinent issues surrounding the topic of "*Stability Management for DP Platform Supply Vessels*". "Stability Management" for our purposes here is generally defined as:

- *"The effective monitoring and control of a vessel's hydrostatic stability properties under changing loading and environmental conditions"*. (Rohr)

Looking at a tactical level, "*managing stability*" can also be defined as a "best practice". We refined the general definition above in an attempt to expose detailed elements of Stability Management for it's various key stakeholders:

- *"The application of certain predetermined specialized skills, tools, and procedures, that bring about courses of action that when applied to a given floating body, produces or returns the floating body to it's best state of stability for a given scenario of external and internal applied forces"*. (Rohr)

The format for this paper is divided into specific sections. Each section is designed to illuminate the subject in a meaningful way. Basic stability formulae and theory has not been restated as this information is easily found in textbooks on the subject. Instead we have focused on specific issues and topics relating to People, Processes and Technology as they apply to the ***management of stability*** under the definitions given above. We also felt that exposure of the more important interrelationships between these topics is required with specific attention to the DP Platform Supply Vessel in its' operating environment.

We feel this paper is addressed to all DP Platform Supply Vessel stakeholders. We understand this list to include key stakeholders such as the builder, owner, operator, underwriter, vessel master and crew. This is only a partial list and is conditioned on how a company is organized and the degree of involvement by external entities. Each stakeholder has, (or should have), a serious interest in the subject of Stability Management for these vessels and how it applies to the overall management of asset value. The information presented here applies equally well to other floating body designs such as Semi-Submersibles, TLPs, Jack-Ups or SPARs since this paper defines a generic best practice called "Stability Management".

## Stability Management Protects Asset Value:

Stability Management protects asset value by reducing the potential for major or catastrophic risks associated with a loss of vessel stability. We have listed only some of the more important risks worthy of consideration by a loss of vessel stability:

- Lost Time
- Lost Revenues
- Lost Vessel Performance
- Lost Cargo
- Lost Clients
- Lost Vessel
- Lost Lives

Each risk identified above clearly represents a serious impact on vessel stakeholders. *Managing Vessel Stability* is essential because in any given stability loss situation both human life and higher value assets are in play. “Stability Management” protects asset and operational value and protects human life by reducing the likelihood of occurrence (or) serves to mitigate the impact of the occurrence once a stability event occurs.

## Why Is Stability Management Important to a DP Platform Supply Vessel?

The simple answer is because Managing Stability saves useful assets and lives. Loss of intact stability (the inability of the vessel to return to an upright condition after being influenced by some external factor, e.g. wind, waves, force) is a leading cause of total vessel loss. Even a partial loss of stability affects onboard crewmembers in a dramatic and sometimes life threatening way. A listing 240’ PSV ship operating offshore in rough seas is a significant risk to the vessel asset and crew. Under these conditions when other fixed or floating structures are nearby, further risk is present from secondary impact.

Specification growth for today’s deep water DP Platform Supply Vessels is in direct response to new requirements of oil field owners and operators striving to explore, locate, drill and produce petroleum products from deep ocean outer shelf locations thought impossible only a few years ago. As activity moved further and further offshore, physical vessel size and enhanced capabilities were needed to keep pace with the more demanding operating conditions typical to this new offshore operating environment. Deep water drilling and production is now a viable solution and examples continuing to expand in areas such as North Sea, Africa, Alaska Coast or Gulf of Mexico to name a few regions.

Today’s specifications for large DP Platform Supply Vessels define a vessel with almost three (3) times greater loading capacity than vessels previously built during the 1976-84 era. No longer are DP Platform Supply Vessels a 150-170 foot coastal vessel serving a “near shore” fixed oil platform in moderate wind and sea conditions carrying loads far less than the total capacity of the vessel. Present generation new build DP Platform Supply Vessels are highly sophisticated medium sized multi-tasking ships of 240-290 feet in length delivering everything an operating

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platform needs from fresh bread on the galley table, to drill cements used down hole. Costs for new generation vessels are approaching 30 Million U.S.D depending on features and service classifications of this ship. Charles Fabrikant, Chairman and CEO of Seacor Schmit recently stated in his presentation to investors summarized here, “Larger DP2 Platform Supply Vessels approaching 320 feet is on the planning stages with costs exceeding 30 Million USD”.[1] The horizon for PSV’s is simply a move towards larger and more sophisticated vessels. It should also be noted that great attention is being paid to Environmental awareness and zero discharge profiles of these vessels demonstrating a stronger move towards environmental responsibility.

Deep-water oilfield locations demand larger seagoing support vessels. New technologies have also influenced greater capacities, higher levels of control, added crew comfort and best of all, safer procedures and equipment. Today, almost everything can be run from the wheelhouse and engine control rooms on these vessels, driving a move towards reduced manning levels. We feel the current trend towards lower manning reduces vessel safety and ultimately will cost vessel asset value, if not from a given stability event than certainly over the vessel’s life cycle in reduced maintenance routines. Balancing technology and manning has always been the responsibility of the Owners and Operators of these vessels. Our view is when things go wrong offshore and it does with unplanned frequency, ultimately the combined DP Platform Supply Vessel’s crew skill, experience, training and procedures will correct the problem, not technology. It is a proven fact that “as complexity increases the failure rate of the system increases exponentially”.[2]

## Vessel Asset Risk Management:

“Vessel Asset Risk Management” is a set of actions commonly applied by prudent vessel owners and crews who consider all operational risks for the vessel. This consideration in our mind naturally includes all risks associated with the loss of vessel stability. Loss of a PSV or other floating structure in deep water would be a negative impact on any corporation’s balance sheet. Loss of life and the impact felt is a potential unacceptable result of poor stability management.

Next generation DP Platform Supply Vessels include significant technical advancements and sophisticated features that rival larger ships four to five (4-5) times their physical size thus raising the significance of the DP Platform Supply Vessel asset for the owner and chartering party.

When we discuss “vessel asset management as it relates to stability” the following questions come to our mind…

- How does the ship operator manage the critical risk called “vessel stability” in all the phases of asset life?
- How do the vessel specifications formally and specifically address the matter of stability on people, process and technology?

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[1] Lehman Brothers CEO Energy Conference, September 4, 2002: Charles Fabrikant, Chairman and CEO, Seacor Schmit Inc.
[2] Augustine’s Laws: Norman R. Augustine 1987

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- What constitutes an unstable vessel for the given environmental area and operational profile?
- What technology and operating procedures are in place to manage stability onboard in real time?
- What quantity and quality of Stability Management training do an operating crew and management receive in support of this vessel?

Answers to these question rests with every stakeholder charged with design, operation and management of the PSV asset. If questions such as these are not being asked than how is this important risk mitigated. We feel the approach taken to reduction in stability risk is the difference between "riding on luck" and "execution of maritime skill". Perhaps you will agree that some of the answers to these questions have been addressed in this paper.

### DP Systems Are No Longer An Option On Today's Larger Offshore Supply Vessels:

A noteworthy area of technical and physical achievement in Platform Supply Vessel control systems is the addition of Dynamic Positioning or (DP) systems. DP systems affect Stability Management by increasing the vessel's operational envelope. Added capability increases the demands placed on vessel stability management. DP systems when installed and operating correctly, allow vessel operators to safely maneuver, position and hold a ship or floating structure on location in dynamic environmental conditions over longer sustained periods of time. The ability of a well-designed DP system to maneuver, position and hold a ship in extremes of weather and current is simply a technical marvel of computers, propulsion systems, and machines all working in harmony with the vessel operators' intent. Naturally this capability comes with higher demands on people, processes and technology associated with today's DP Platform Supply Vessel. These are complex and interconnected groups of advanced software, hardware, machinery controls, heavy machinery and human interface elements.

DP systems are no longer an elective option in new build specifications for deepwater operations…they are a given requirement. The type of DP classification whether generically DP1, 2 or 3, is dependent on the level of operational risk usually a charter client feels is present for a given work region and activity. Today, DP1 is almost a standard for new builds and DP2 and DP3 reserved for higher reliability and special case scenarios. The higher numbers (DPX) signifies greater reliability and safety through equipment redundancy, higher attention to system fail-safes and isolation of equipment problems without loss of vessel function at critical times.

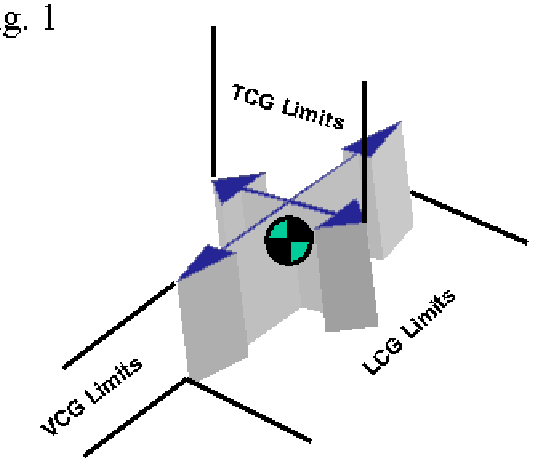
### Stability Concerns For Today's DP Platform Supply Vessel:

Stability Management for a DP Platform Supply Vessel is essential for the safe operation of the vessel under all loading conditions, damage scenarios and environmental states. Stability Management begins with the proper planning and understanding of a DP Platform Supply Vessel's hull design, loading characteristics and the limits of center of gravity. This is only the beginning, as a yard must produce the vessel to the designer's intent. Once ready for delivery, a Port Captain or Master selects a competent shakeout crew with the skills and experience to handle vessel testing and make ready. Extensive training in the vessel itself and the procedures that will be used under a host of stability scenarios gives the crew and company knowledge they can plan safe operations and respond to any radical change in either Center of Gravity or Buoyancy should it occur.

In Figure 1, we graphically see an illustrated example of the safe limits of VCG, LCG and TCG for a given hull form. Regardless of cause, we know when predetermined Center of Gravity (CG) limits (weight value and position) are exceeded for a given vessel, the vessel is in an unsafe condition and overall risk rises as these limits are approached. It should be noted that Figure 1 assumes the combined weight acting through one Center of Gravity location within predetermined limits set by the hull designer. A designer finds this value by hydrostatic analysis of the hull form using proven mathematical methods and advanced software programs.

CG limits may change from a variety of reasons including ship modification, loss of intact vessel buoyancy and through environmental factors that reduce the ability of the vessel to maintain stability. Once original vessel design parameters no longer apply, a competent Naval Architect will create a new set of operating limits or on board personnel must have the tools to apply these changes to the stability baseline to determine the impact of these changes and what countermeasures are required to bring the vessel to best stability condition.

Fig. 1




Each ship has VCG, LCG, TCG safe operating limits

## Proper Management of Stability:

Proper management of stability on a DP Platform Supply Vessel begins with good vessel design. VCG, LCG and TCG of the design loaded ship and adequate GM all contribute to a stable ship. Since we wish to take an operational influence in this paper, let’s assume the vessel designer has done his or her job correctly and the building yard executed the designers’ intent correctly.

At vessel completion the vessel undergoes an inclining experiment to determine the exact location of the Center of Gravity and lightship weight. Based on this test, a “stability booklet” is prepared by the designer to instruct the master and crew about the safe limits of the vessel under a variety of loading and operating conditions. This stability booklet establishes the principal

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stability guidelines for the vessel and if followed correctly the vessel is operated within safe limits. The booklet however does not advise "how" to react to unplanned changes in load or buoyancy, but gives vital information necessary to overcome or mitigate these events should they occur. It is still up to the loading coordinator and ultimately the master of the ship to apply the information in the booklet to the vessel under a variety of environmental and loading conditions. Proper management of stability therefore is a full time job as long as the vessel is afloat by people trained in the practice of stability management. How often this occurs on a loaded vessel offshore we feel is significantly below the requirement to meet a low risk managed stability condition.

## What Causes A Loss of Stability on a DP Platform Supply Vessel?

A loss of stability is the direct result of an unplanned change in the vessel's Center of Gravity or Buoyancy over some defined time period. We divided events that cause a loss of stability into internal and external events. Internal events are those that originate by the vessel itself while external events are those that originate beyond the vessel's immediate control. The following examples in Table 2 are all potential causes of stability loss on a DP Platform Supply Vessel:

**Table 2**

| External Events | Internal Events |
|---|---|
| Collision | Operator Error |
| Dropped Load | Dropped Load |
| Environmental | Unplanned Load Shift |
| Blow-out (Causing Loss of Buoyancy Potential) | Vessel Modification |
| Mooring Failure | Overloading |
| | Unplanned Load Gain |

As we can see in the above list, certain causes can be eliminated by normal good practices. Others, however, must be managed on a case-by-case basis. Managing unplanned events is where sound training, onboard drills and stability loss simulation training really pay off to reduce asset risk. One fact is clear…*Advance knowledge of the stability limits and how far the vessel is in real time from stability limits greatly increases the ability of a crew and management to make informed decisions for any given situation.*

## People Influence Vessel Stability Management:

From the vessel asset owner to the able body seaman on deck and all stakeholders in between, each stakeholder plays an important role in the proper management of stability. DP Platform Supply Vessel Stability Management begins by early establishment of safe vessel concepts meeting a specific trade or business segment needs. In early conversations, trade offs are made between speed, length, beam, cargo deck height, propulsion, deck features, living spaces, machinery, and the all-important cost. The ship designer attempts in each design decision to give the owner best value. This effort includes the establishment of initial design stability and adequate provisions for the management of intact and damage stability.

Table 1 describes some of the more important stability management decisions and possible additions to asset value through stability management. In this table we also made a distinction between the role of the owner and operator. While it could be the same party, we highlighted the difference in roles and perspectives.

**Table 1**

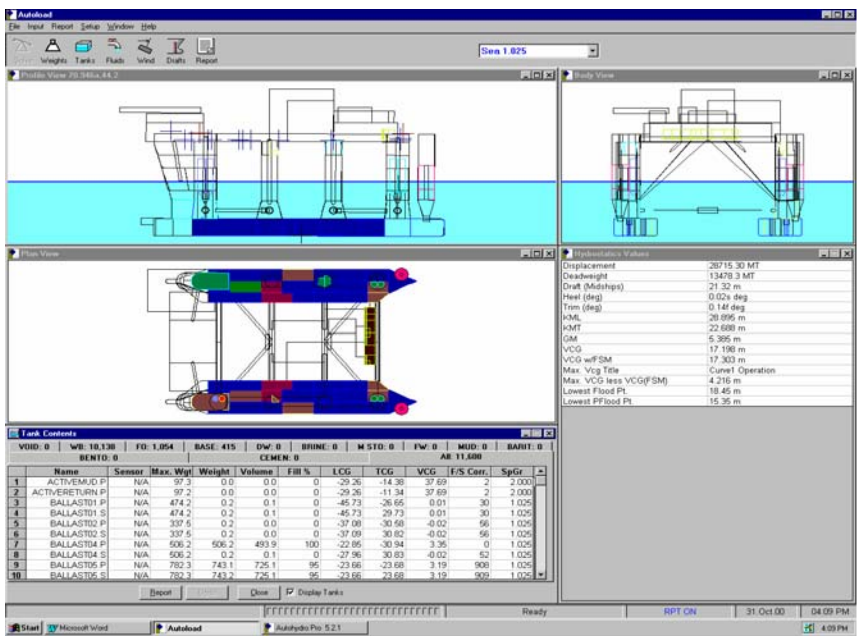
| | **Strategic** | **Tactical** |
|---|---|---|
| ***Owner*** | Manages the life cycle of the vessel for maximum revenue under minimum risks | Sets goals and objectives relative to asset characteristics and value |
| ***Designer*** | Establishes the baseline for intact stability and the means to manage a loss of buoyancy through collision or flooding | Applies science and good marine design practice to ensure safe and stable vessel stability under a host of anticipated operating conditions |
| ***Builder*** | Creates the initial asset from designers information and skilled construction experience, incorporates details of quality the crew uses to safely operate the vessel | Executes designers intent and adds construction features that serve to protect hull and propulsion integrity |
| ***Operator*** | Reduces stability related asset risk through proper planning and decisions | Plans vessel loadings within safe limits and uses available tools and assets to know when stability limits are reached |
| ***Crew*** | Maintains asset value and executes revenue earning potential through safe stability management | Understands basic and damage stability. Knows specific vessel stability limitations, operates vessel within safe loading conditions and executes plans to maintain stability under all operating conditions |
| ***Regulatory Body*** | Establishes criteria for vessel stability testing and safe stability management | Provides best practices and controls for actions for the safe management of stability |

We found in preparing the above table that a second table was possible that looked at the overlapping roles using the various stages of life of the vessel and unique operating conditions. We will extract that information and offer that table in another paper on the subject.

## Technology "Enables" Affective Stability Management:

On a DP Platform Supply Vessel, variable loads such as dry and wet cargos place considerable demands on crew and personnel attempting to properly manage vessel stability under changing environmental conditions. Manual stability calculations take significant time to perform properly and quite often, routine vessel management takes precedence over detailed stability analysis. Today there are advanced software solutions designed to help manage vessel stability and loading in "near real time" for the DP Platform Supply Vessel. These highly advanced software programs marry the precise 3D numerical hull form developed by the designer of the vessel, automated and semi-automated load values and precise loading placements to produce a host of important stability calculation/s. The results can be presented both as onscreen user information and as written reports for other stakeholders. Normal user outputs consist of on-screen loading profiles of the vessel and basic and reserve stability of the vessel. In addition to performing real time analysis of the loading condition of the vessel, better software programs notify the user or third party if a given stability condition is outside of a vessel's design parameters. Better software programs have features that enable the user to "*simulate*" loading scenarios and retain historical loading conditions of the vessel. Advanced software solutions provide the loading planner and Master with near real time stability information and track the current loading condition of the vessel. Damage scenarios and dropped/shifting load scenarios are common simulations. In Figure 2 we have captured a typical user's screen of one of the better software packages.

**Figure 2**



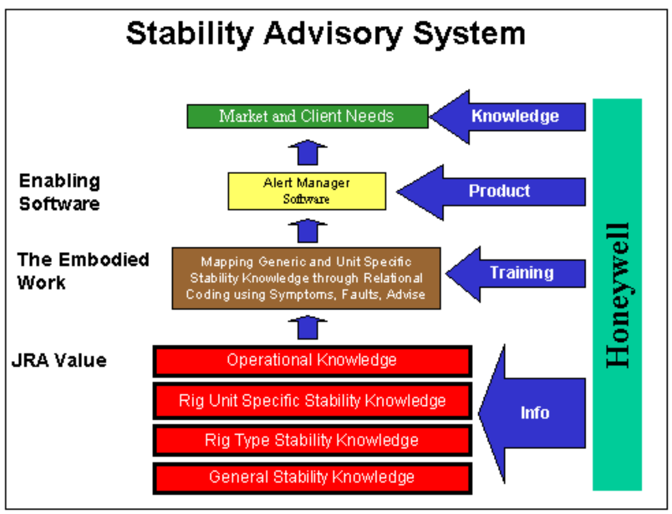
Note that the user is presented with graphic representations of the stability of the vessel, tabular load forms and calculation results for the selected outputs. Views are enhanced by allowing the user to select what he wishes to see and in what form. Calculation time is measured in seconds in place of minutes.

### ***Stability Advisory Systems*...The Next Generation of Stability Management**

Our company is creating the next generation in stability software that advises the operator about *"faults"* and delivers *"advise"* in the form of solution options. We have called the software solution a *"Stability Advisory System"* or *"SAS"* for those liking shorter titles. This exciting software uses highly intelligent mathematical algorithms to form qualified solutions based in part on knowledge elements including vessel type dependant data and vessel specific information. The solution can be configured for closed loop an open loop operation allowing for operator decision and implementation. For those wondering what *open and closed loop* means, open loop requires human intervention before a solution is actually converted to machine instructions. As an example suppose the vessel is listing to port two (2) degrees. In a "closed loop system" the software would automatically correct the situation based on a predetermined rule set without any operator intervention. In an open system the system will advise on the corrective solution but will not perform the solution automatically.

In Figure 3 we have shown a high level system we have proposed to supply to the BP - Atlantis Project in addition to our contracted standard Load Management Software. BP - Atlantis is a deep-water oil production semi-submersible rig permanently moored in the GOM when completed in 2004.

**Figure 3**




In the brown box this new breed of software will automatically monitor a predetermined set of inputs or "conditions" to determine if "faults" have occurred. Once a fault has been determined the solution determines what "advise" or solution is required to correct or mitigate the fault. We feel this software will substantially reduce stability risk and increase the management of vessel loading activity and naturally the stability of the platform. This same intelligent software engine is applicable to a number of other systems including deck machinery, propulsion, communication, etc. This is proactive software that changes forever the dependence on reactive solutions to solving problems. Bringing world-class solutions within the hands of owner and crew at a reasonable cost is one goal for our technology development.

## Process Requirements to Manage Stability:

Process requirements to manage stability include a host of key elements. Each process is designed to support risk reduction from a stability related event. In Table 3 below, we have shown each major process we feel could be essential to the reduction of vessel risk from a loss of stability. When we think of processes, we use a chart form called a "RACI Chart" that stands for Responsible, Accountable, Consulted and Informed in that order. Each process described below is really is a process within itself. At the highest level, this chart gives some indication of the combined solutions we consider are best practice in the management of stability. Note we have not included all the possible stakeholders in the "Informed" box but have included the principal stakeholder/s.

**Table 3**

| | Responsible | Accountable | Consulted | Informed |
|---|---|---|---|---|
| ***Design for Stability*** | Principal Naval Architect | Design Firm | Regulatory/Vessel Operations | Owner |
| ***Produce for Stability*** | Building Yard | Owner's Agent | Regulatory/Vessel Operations/Master | Vessel Operations/Owner |
| ***Operate for Stability*** | Load Planner/Crew | Ship Master | Vessel Operations | Vessel Operations/Owner |

As you can see in Table 3, the opportunities to reduce stability risks are shared across multiple stakeholders. We think it is a best practice to bring Vessel Operations into the role of stability management very early in the vessel development process since ultimately they have direct responsibility to manage vessel stability. We feel it is essential to have their valued input early in the design phase long before it is solidified into a finalized vessel design.

## Improving Stability Knowledge and Operating Skills:

No longer is the DP Platform Supply Vessel an "*expensive truck*" that hauls goods on the water to offshore delivery locations. We are advocates for the enhancement of knowledge and skills for all personnel (not just crew or primary stakeholders) who have direct or indirect responsibility for asset risk reduction and specifically related to Stability Management. We feel Stability Management is a cornerstone of successful operations of a DP Platform Supply Vessel whose primary role is the movement of critical cargo. We also feel personnel deserve quality and intensive training not only in "Basic Stability", but also "Advanced Stability" for primary stakeholders such as the Master and Loading Officer. In addition to these training opportunities we have added the title for a comprehensive course designed to inform key personnel how what they do influences the larger picture of marine operations and offshore asset management called "Managing for Marine Integrity". In our example below in Figure 4, DP Platform Supply Vessel crewmembers would follow the same training path as Offshore Labor Contractors.

**Figure 4**

| Project Time Phase | Company Project Leaders | Operations and Maintenance Companies | Centers of Excellence | Offshore Labor Contractors | Suppliers | Regulatory |
|---|---|---|---|---|---|---|
| **Prerequisites** | Basic Stability Advanced Stability | Basic Stability Advanced Stability | Basic Stability | Basic Stability Advanced Stability | Basic Stability | Basic Stability Advanced Stability |
| **Design** | Managing for Marine Integrity | Managing for Marine Integrity | Managing for Marine Integrity | Managing for Marine Integrity | How Suppliers Can Positively Affect Floating Structure Marine Integrity | |
| **Construction** | Unit Specific Simulation | Unit Specific Simulation | | Unit Specific Simulation | | Unit Specific Simulation |
| **Installation** | | | | | | |
| **Operation** | | | | | | |

## DP…A Controlled Risk to Intact Vessel Stability:

Reliance on DP systems to set vessel-to-vessel proximity, vessel axis and watch circle control is a controlled risk. The greatest risk is from a "drift off" or "drive off" event that results in a vessel collision. Both "drift off" (e.g. thruster or power loss failure) and "drive off" (e.g. thruster fails to an unplanned "full on" condition) are both sources of possible vessel collision, position or track failure.

Current DP technology can deliver exceptional control over a vessel's position often maintaining position within small margins in relatively high seas and current. In spite of the ability of the current technology, DP systems can and do fail for a variety of reasons as we list below.

The DP power systems fail

The DP target is lost, becomes contaminated or moves

There exists is a confusion between DP targets

When there is a loss of function within the DP system

Negligence of Operator

Poor training of Operator

DP systems are not yet perfect so redundancy is essential to eliminate single point failure and ensure system functionality after loss of one or more equipment components. Loss of vessel position can also occur from other factors including, loss of DP propulsive force, loss of control function, and loss of hydro-acoustic position reference system to name a few. All of the aforementioned failures are reasons for a drive off or drift off of a DP vessel.

In a collision, many influences on basic stability come into play. First, there is a potential loss of vessel buoyancy resulting from a hull breach. Second is a possible shift or loss of weight from cargo. Third, a potential for unplanned weight gain may exist from compartment flooding. Fourth, if flooding does occur, free surface effects impact stability. All of these changes must be quickly assessed and applied to the overall stability picture. Further, a number of other factors including the environment, state of equipment, operator training, technology employed, proximity of vessel to potential hazards, etc. will have a bearing on any given situation. Time is a critical commodity under these conditions and actions and procedures must be swift and sure.

It is a good practice to allow extra range or distance between the DP-PSV and other structures or vessels whenever possible but as we understand in offshore…competition and time pressures are intense. So intense is this pressure that rival vessels will compete for position alongside the rig. To prove leadership, often the Master will operate the vessel nearer to the outer capability limits of the DP vessel. We do not condone this practice and think it ill advised to promote this behavior. Simply put, there is no reason to be in close quarters unless a transfer procedure is in operation and only after the rig has coordinated the space and the time.

As DP Systems become more complex, a corresponding increase in system reliability is needed or failure events may increase. Upward movement of DP technology and features enhancement we believe should include a corresponding increase in operational training, simplification and higher reliability. This is perhaps one of the greatest challenges ahead for DP systems as the operational potential of the system is outside of a human's ability to react should a DP loss event occur in close quarter cargo operations under DP control. Often Operator recovery reaction time for a DP failure event is measured in seconds as the vessel may be operating at 80-90 percent power when such an event occurred. Heavy seas, windward side location and less than half a supply boats length to a stationary Floating Structure are all conditions that increase collision risk should a DP failure take place. Both a FEMA and FMECA assessment of the installed DP system should be made to uncover potential risks whenever possible.

## Summary:

Our goal in writing this paper was to raise awareness about Stability Management with special attention to the exciting world of the DP Platform Supply Vessel. We hope you agree our efforts highlighted the surface of the subject matter and proposed a different perspective. If this effort causes the reader to think, do, or act differently as a result of this paper than we have accomplished our primary objective for these are the foundations of change.

Proper Stability Management should be one of the goals of every stakeholder who crews, manages or has a financial interest in the management of a floating structure or ship asset. Stability management should be approached uniformly across the boundaries of the life cycle of the asset. We suggest an individual be assigned to communicate stability management best practices within the asset organization. This is done through adoption of technology, training and regular and frequent access to best practices.

The approach to stability management should be tailored to the environment and company culture. Unfortunately, real world conditions often place stability management far down the list of routine operational concerns until the stability related event occurs. By the time a crew realizes the symptoms of the failure, diagnoses the cause and understands the impact, precious time is lost…often to the total loss of the vessel. Cost effective technology based tools are now available that reduce situational assessment time to minutes and some as we have described can provide solution options for the vessel master to solve or mitigate the impact of the event. Company culture always embraces active stability management when risk management is better understood.

In closing we would like to add this paper is not a “call to arms” and good people manage vessel stability offshore everyday. However, for some companies, we hope this presentation is a “call to action” that proper training, advanced tools and cost effective processes are available to sustain asset value and reduce stability related risks.