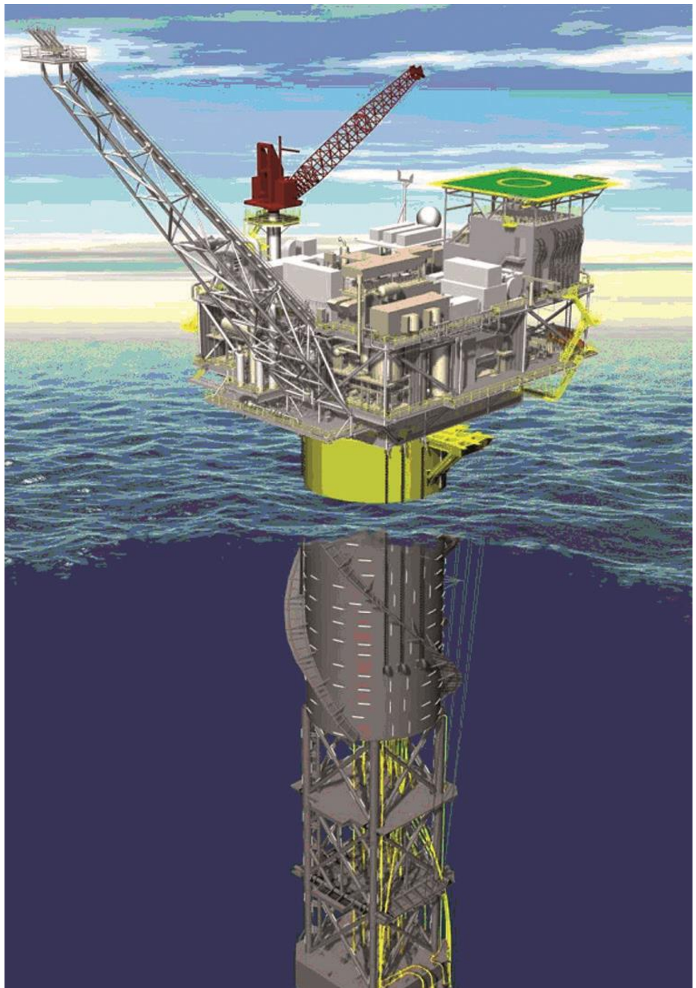
Keystone Lite Project: Final Proposal

Feasibility Study and Project Execution Plan of a Truss Spar in the Gulf of Mexico

December 9, 2015



Reprinted from Wartsila (2015)

VCBG International Engineering Group

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1 Executive Summary

VCBG International's objective is to design and analyze Keystone Lite, an offshore truss spar platform located 140 miles off the coast of Louisiana in the Heidelberg Field, Green Canyon (GC) block 903. Keystone Lite will be designed for production capacity of 80 Mbopd[1] and 88 Mcf/d[2] of gas per day at water depth of 5,310 ft. Recoverable resources were discovered in Heidelberg Field in 2009 with up to 400 million barrels of oil. Drilling and production operations have not yet begun at the site. Keystone Lite is justified as the most technically and economically feasibility project when compared with a conventional tension-leg platform and semi-submersible. The truss spar demonstrates superior stability characteristics and is able to support the operation of dry tree wells. The truss spar produces the best economical results with a net present value of $3.1 billion, internal rate of return of 27.8%, and breakeven analysis of 3.67 years. The Keystone Lite Project design phase execution is estimated to be completed in 800 man-hours, beginning January 18, 2016 and ending April 29, 2016. The task descriptions provide a detailed summary of the specific tasks to be completed during the design phase and include: required manpower, number of hours to complete each task, methodology, task dependencies, and the tools required to complete each task. The design execution phase is separated into 15 main tasks. Within each main task is a number of subtasks that serve to divide work into manageable sections. The Design Phase and Housekeeping Gantt Charts highlight important milestones in the design process and specify when tasks are to be started and completed. The Design Phase Gantt chart also serves as an accountability tool to verify that VCBG International is completing the project in a timely manner. Throughout the entire design and analysis phase, VCBG International will consider the environmental effects and safety as the highest priority.

[1] Mbopd represents thousands of barrels of oil per day
[2] Mcf/d represents thousands of cubic feet per day

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2 Introduction

The Keystone Lite Project Proposal Package includes technical and economic feasibility studies for project justification as well as the design execution plan. The project justification includes background on the current market, project geographical location, and comparison of alternatives both technically and economically. The design execution plan describes the strategy for the Keystone Lite project completion. This phase will be completed in a duration of four months, with a completion date of April 29, 2016. This plan includes task descriptions divided into manageable sections as well as Design Phase and Housekeeping Gantt charts for scheduling and accountability. The final stage of the design phase will be to re-evaluate the initial economic analysis and to conclude the final economic evaluation. Throughout the entire project, environmental and safety will be considered as the highest priority.

2.1 Current Market

Global demand for oil and gas is projected to increase by 53.9 percent between 2012 and 2035, as seen in Fig. 1 (Eyton, 2014). In order to prepare for this growing need, industry must develop all feasible energy sources as the world's increasing demand cannot be met by one single source. A growing number of energy sources are expected to emerge in this time period. However, oil and gas will continue to be an essential resource due to its availability, affordability, efficiency, and versatility (Tillerson, 2008).

There has been a 50 percent increase in the global economy over the last 60 years, which means demand for energy sources, especially oil and gas, will continue to increase for the projectable future. Our proposal for Keystone Lite truss spar in the Gulf of Mexico will create supply to match the growing demand for oil and gas.

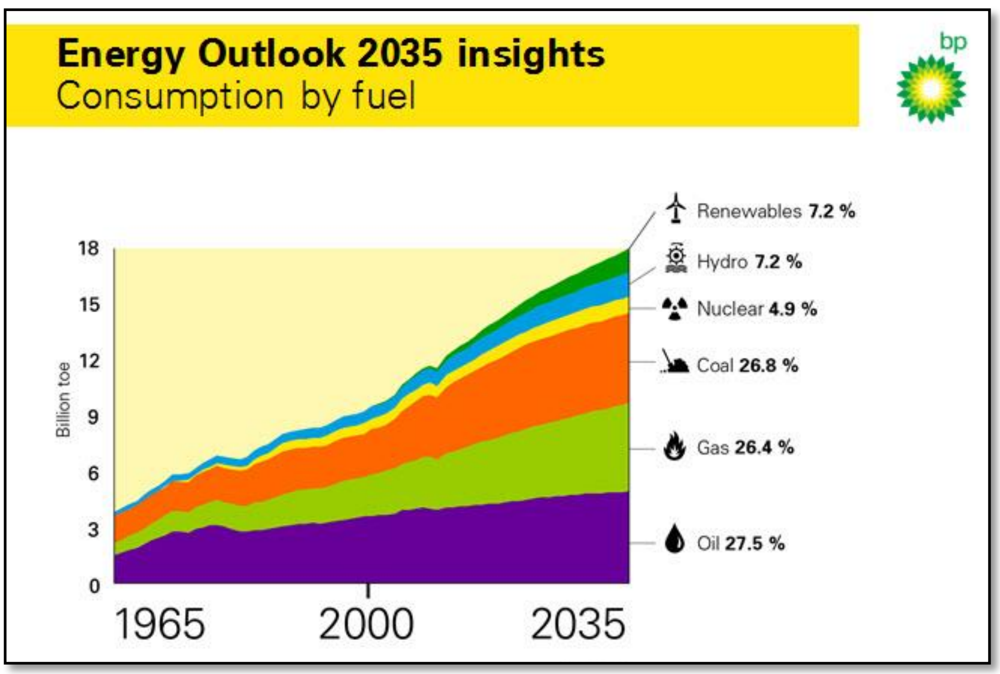

Figure 1: Energy Outlook from 1965 to 2035 reprinted from Eyton (2014)

2.2 Project Scope

VCBG International will complete a comprehensive design of the spar and mooring system, with a brief overview of the subsea pipeline connections. Hydrostatic and hydrodynamic analysis of the spar hull will be emphasized, specifically pertaining to optimization of hydrostatic stability and hydrodynamic response to wave loads.

2.3 Project Geographical Location

VCBG International analyzed three offshore oil and gas fields in the Gulf of Mexico (GOM). Sites were evaluated with respect to quantity of recoverable resources available, proximity to existing subsea pipeline infrastructure, water depth, bathymetry, seafloor sediment characteristics, sub seabed geology, geo-hazards, and bio-environmental issues.

The GOM has been a key producing area of oil and gas in shallow, deep, and ultra-deep waters. Today, deep and ultra-deep oil and gas exploration is a prime area of focus with many new exploratory discoveries. Most of the key prospective GOM deep-water exploration areas are in 4,000 ft. to 10,000 ft. A majority of this region is located in a sub-salt environment containing sub-salt canopies, with thickness ranging from 7,000 ft. to 20,000 ft. as seen in Fig. 2 (Close, 2008).

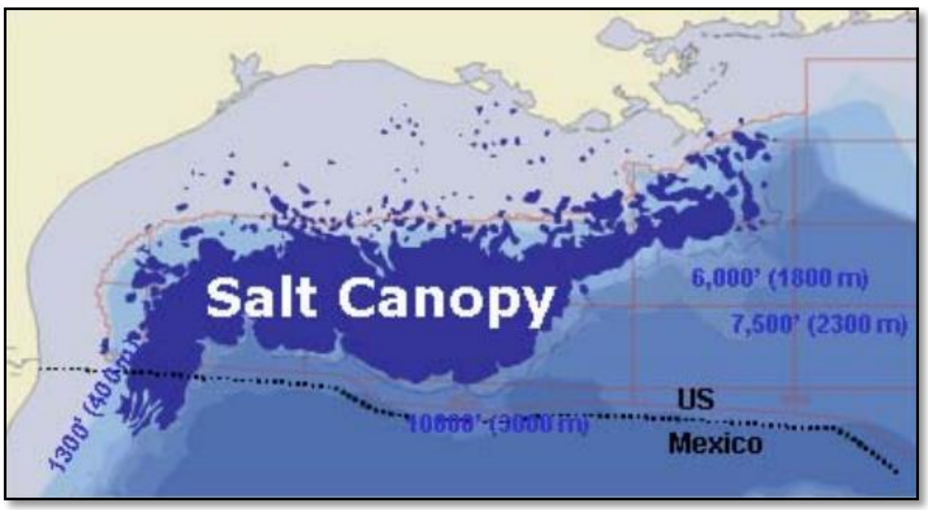

Figure 2: Subsalt Canopy in the Gulf of Mexico reprinted from Close (2008)

The Middle Miocene trend reservoirs within the sub-salt canopy have proven to be a crucial area in oil production. These reservoirs are made up of fine to very fine grain, quartz rich, unconsolidated sands with little clay and cement. Today, many of the proven reserves in U.S. waters of the GOM have been found in the Miocene aged sand. Geophysicists have determined that the presence of oil is the greatest along the continental slope offshore of Texas and Louisiana, as shown in Fig. 3, (Blattner, 1967).

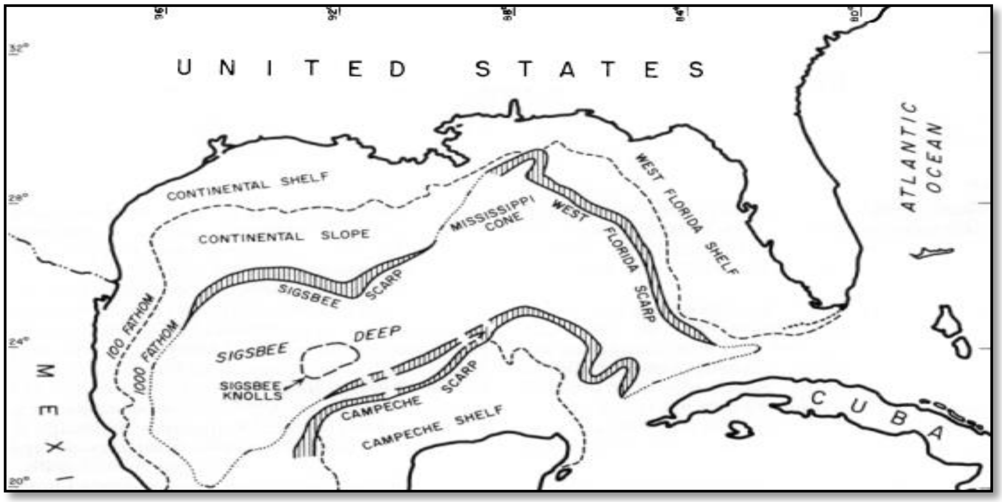

Figure 3: Gulf of Mexico Bathymetry Map reprinted from Blattner (1967)

Three major oil reserve fields considered within the sub-salt region of the GOM are Lucius Field, Julia Field and Heidelberg Field. Lucius Field, located in Keathley Canyon, is 240 miles south of Port Fourchon, LA and contains 300 million barrels of oil. The water depth is 7,000 ft. (Lamey, 2015). Julia Field, located in Walker Ridge 265 miles southwest of New Orleans, has a water depth of 7,000 ft. and 6 billion barrels of recoverable resources (Exxon, 2014). Heidelberg Field, located in Green Canyon, is 140 miles offshore of Port Fourchon, LA with a water depth of 5,310 ft. and 400 million barrels of oil available. Each of the fields are located within key prospective deep-water regions in the GOM (Heidelberg, 2015). Lucius and Julia Field are located in the Lower Tertiary Trend while Heidelberg Field is located in the Middle Miocene Trend. Table 1 compares the three fields.

Table 1: Field Comparison created by VCBG International with Data Gathered from Exxon (2014), Lamey (2015), D'Souza (2014)

Field	Water Depth (ft.)	Amount of Recoverable Resources (barrels)	Trend	Sub-Salt Region?
Lucius	7,000	300 million	Lower Tertiary	Yes
Julia	7,000	6 billion	Lower Tertiary	Yes
Heidelberg	5,310	400 million	Middle Miocene	Yes

Production in the Lower Tertiary Trend is declining at a rapid rate, as seen in Table 2. The Miocene Trend has a moderate decline in production rate (D'Souza, 2014). Due to differences in production decline between Miocene Trend and Lower Tertiary Trend, Heidelberg Field was selected as the site location for the VCBG truss spar.

Table 2: Miocene Trend vs. Lower Tertiary Trend reprinted from D'Souza (2014)

Item		Units	Miocene Trend	Lower Tertiary Trend
Extent, Length x Width		square miles	300 x 50	300 x 80
Distance from Shore to Northern Boundary		miles	50 – 150	150 – 175
Water Depth Range		ft	1,000 – 7,000	5,000 – 10,000
Reservoir Depth Range		ft	20,000 – 30,000	25,000 – 35,000
Deep Salt Canopy Cover		-	Over 1/3 of the Area	Mostly Eastern Areas
Reservoir Rock		-	Blocky, Unconsolidated High Permeability Sands	Thick, Low Permeability Rock
Completion Intervals		ft	+/- 250	1,000
Production Decline Rate		-	Moderate	Rapid
Fluid Properties	GOR	-	Moderate	Low
	Well Shut-in Pressure	ksi	< 10ksi Except for Deep Reservoirs	Generally High (> 10 ksi)
Discovered Reserves		billion boe	10 (5 in case of Subsalt)	5 (3 in case of Subsalt)

Heidelberg Field was discovered in February 2009 by Anadarko Petroleum Corporation. The field is located 140 miles southwest of Port Fourchon, LA and 390 miles east of Corpus Christi, TX. The truss spar will be installed in Green Canyon (GC) block 903, located at coordinates of 27.04 N, 90.49 W. Heidelberg Field contains an estimated 400 million barrels of oil, where recoverable resources were traced to a total depth of 9,278m (30,440ft).

Heidelberg Field is operated by Anadarko Petroleum Corporation with a 44.25 percent working interest. Partners include: Eni (12.5%), Apache Deepwater LLC (12.5%), StatoilHydro (12%), Exxon Mobil (9.375%), and Cobalt (9.375%). First oil production is expected in 2016. Metocean data for will be extracted from NOAA buoy stations numbers 42360, 42395, and 42362. Locations of buoys 42360 and 42362 in relation to the GOM can be seen at the Heidelberg Field in Fig. 4.

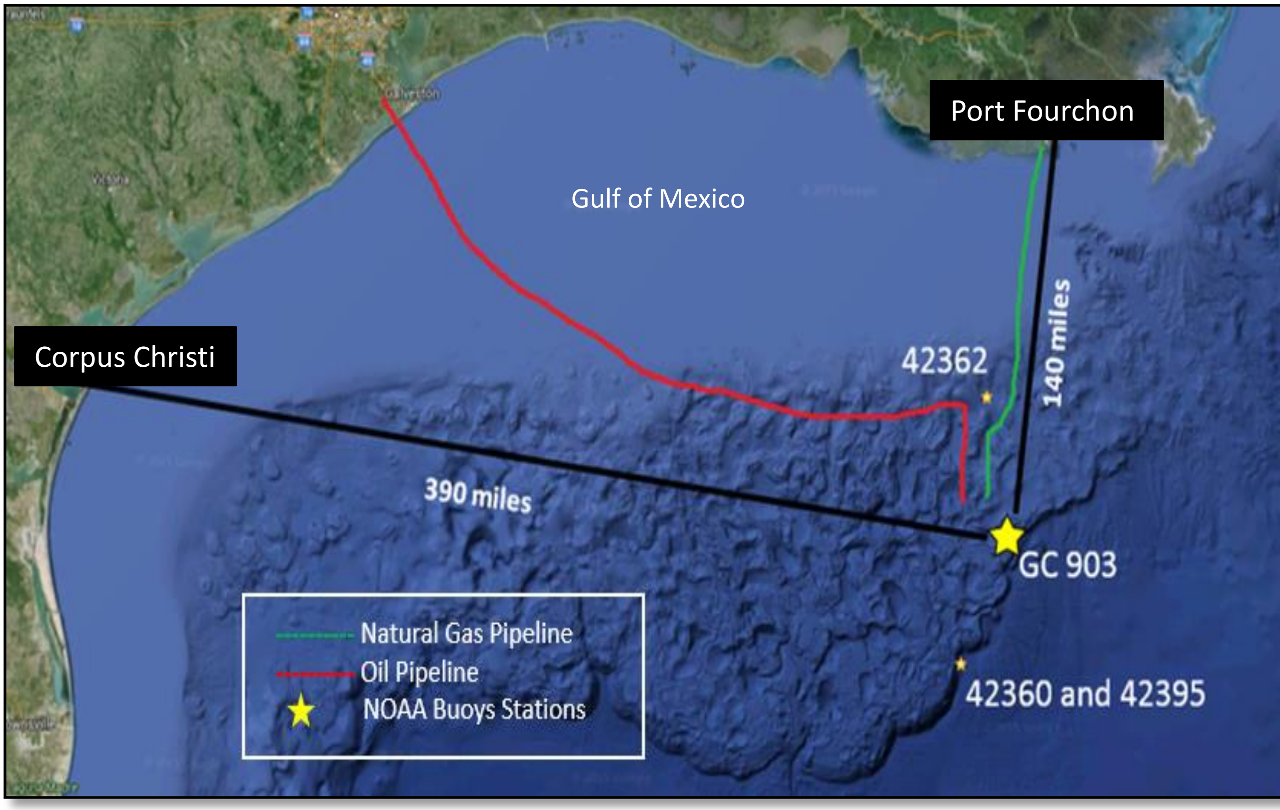

Figure 4: Heidelberg Field location relative to major coastal cities reprinted from Furlow (2015) with modifications

VCBG International has selected GC 903 in Heidelberg Field due to discovered recoverable resources within the profitability threshold. Based on historical data regarding regional Miocene sands and profitable resource attainment from same or similar sand types, GC 903 is a key producing area for oil in the GOM.

3 Evaluation of Alternatives

VCBG International will compare three offshore structures for installation in Heidelberg Field, GC 903. The three structures compared are the truss spar platform, tension-leg platform (TLP), and semi-submersible platform. Technical and economic feasibility of each structure will be compared and the best option is concluded.

3.1 Truss Spar Platform

Truss spars are characterized by their deep draft and cylindrical shape, as shown in Fig. 5. The top portion of the hull is completely enclosed and houses the buoyancy tanks, also known as hard tanks. The bottom section of the hull is made up of a truss structure that connects the ballast tank, also known as the soft tank, located just above the keel, to the top section. The truss spar incorporates a truss structure that requires less material in comparison to a classic spar, whose hull is completely enclosed. Placed above the hull is the topside structure which is designed for refinement and drilling operations of the crude oil extracted from the subsea well (Bangs, 2002).

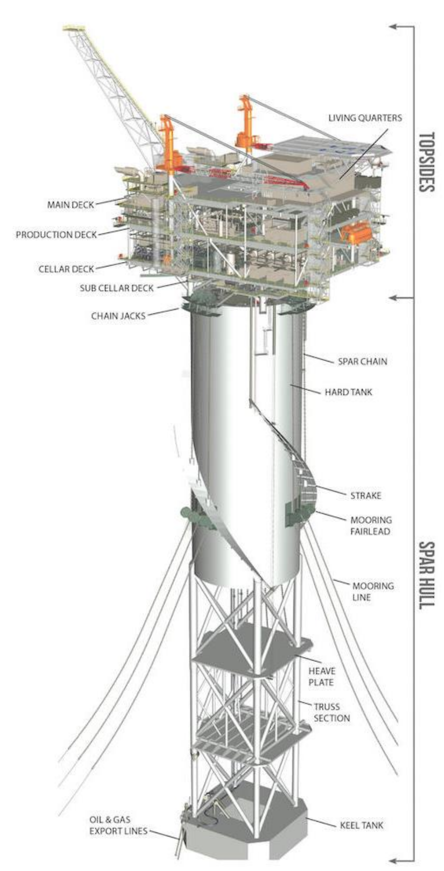

Figure 5: Truss Spar Diagram reprinted from Furlow (2015)

Truss spars are ideal for deep water operations. They have been field tested to operate at depths up to 5,610 ft. and are considered qualified to operate up to an estimated depth of 10,000 ft. Production capabilities of truss spars vary depending on platform size and well output. They have ranged from 40 Mboe /d to 154 Mboe /d and are qualified to produce an estimate of 200 Mboe /d (Albaugh, 2006).

Truss spars are freely floating and rely only on mooring systems to resist movement in sway and surge directions. Due to a low center of gravity and high center of buoyancy created by the distance between the hard tank and soft tank of the hull, truss spars have a large metacentric height. This increases stability due to the large righting moment. Truss spars also have a large heave stiffness due to their large draft and total effective mass, giving them excellent response to wave loads. This allows for significant topside loads to be applied to the spar with minimal change in draft, and allows for the operation of dry wells that may be accessed at the surface. Load eccentricity also has minimal effect on the spar's orientation (Zhang, 2014).

Truss spars are more sensitive to longer wave periods because the natural frequency of the spar is comparatively larger than the TLP and semisubmersible. The truss spar requires a more integrated installation that requires multiple support and installation vessels. The spar hull and topside must be transported in two sections, the hull and topside, via two vessels with the presence of a heavy crane ship to mate the two components. Environmental factors may delay the complete assemblage of the spar, as it is already a complicated and high-risk operation. Truss spars are relatively heavier than TLPs and semisubmersibles because of their deep draft, adding to costs of construction due to more material. Due to the relatively small cross sectional area in the horizontal plane, truss spars have limited center well space for Top Tensioned Risers (TTRs) (Zhang, 2014).

3.2 Tension-Leg Platform

Tension-leg platforms are offshore oil and gas production floating structures that are vertically moored to the sea floor using steel tendons that keep tension on the structure, shown in Fig. 6. The combination of the structure's positive buoyant force and tensioned tendons significantly minimize motion in the heave direction due to the tendon's high axial stiffness. The placement of the tendons also significantly increases the structure's roll and pitch stiffness, creating a stable platform. However, these tendons cannot prevent horizontal translation of the platform caused by wave action or currents (Pauling, 1971). Since the structure relies heavily on its buoyancy for stability, it is limited in its topside payload capacity.

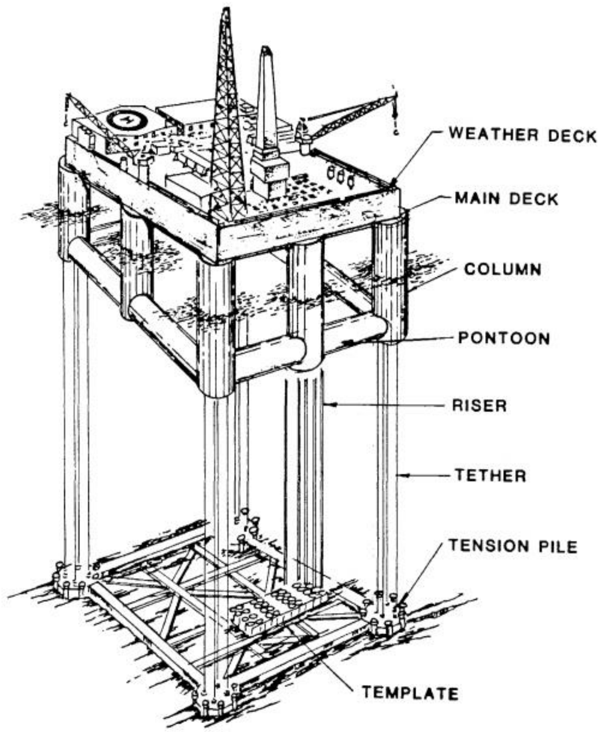

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Figure 6: Tension-leg platform reprinted from Stract (1982)

Conventional TLPs may operate in a water depth range of 2,000 to 5,000 ft. with a maximum proven depth of 4,674 ft. (Albaugh, 2005). However, in water depths exceeding 5,000 ft., TLPs are not ideal structures. As the water depth increases, larger diameter tendons must be used to account for greater tensile stresses due to the increase in length. This combination in increase in diameter and length creates a significant increase in required material which becomes costly.

The capacity of TLPs range from 100 to 225 Mboe/d[3], with a maximum proven capacity of 250 Mboe/d. (Albaugh, 2005). TLPs are able to support dry tree wells that are easily accessible on the topside structure due to their excellent heave stiffness. The installation of TLPs is simple, as the structure's hull and topside are assembled at an onshore site. They are then transported to the offshore site via towing vessels or aboard a floating dock ship. After positioning the platform, the tendons must be installed using specialized equipment. Fabrication of the tendons is timely and its cost is comparable to the cost of the hull.

[3] Mboe/d[3] represents thousands of barrels of oil equivalent per day

3.3 Semi-Submersible Platform

A column stabilized semi-submersible is a popular design of semi-submersibles offshore platforms, as shown in Fig. 7. They consists of two horizontal pontoons connected via cylindrical or rectangular columns to the topside which may be arranged for drilling or production of oil and gas. Semi-submersibles are freely floating platforms that are moored to the seafloor in order to keep station. These structures allow translational movement in the horizontal plane but restrict movement in the roll and pitch directions (Zhang, 2014).

Figure 7: Semi-Submersible Platform reprinted from World (2014)

Semi-submersible platforms are versatile because they may operate in a wide range of water depths of up to 10,000 ft. and have been proven to operate in water depths up to 7,070 ft. Production capabilities may range up to 360 Mboe/d (Wilhoit, 2008).

The pontoons of a semi-submersible have a large water plane area, allowing the platform to easily transit to the offshore site via towing or dry dock ships and then easily installed. Since semi-submersibles are completely assembled onshore, they require a less integrated installation team, helping to reduce cost. Once pontoons are submerged, the columns produce a smaller water plane area, helping to reduce motion characteristics induced from waves, especially during sea swell and storms. However, because the submerged hull of a semisubmersible is largely located towards the free surface, the structure is still subject to significant wave induced vertical motion in comparison with other offshore platforms. Due to the semi-submersible's smaller heave stiffness, it cannot support dry tree wells at the surface, and must operate submerged wet tree wells (Zhang, 2014).

3.4 Technical Feasibility

Parameters to be analyzed with respect to technical feasibility include maximum operational water depth, support of dry or wet trees, floatation, heave stiffness, stability in roll and pitch, operation capability in rough seas, maximum production capability, installation requirements, and weight. Table 3 includes a comparison of the structures regarding technical parameters.

Table 3: Structure Technical Comparison created by VCBG International with Data from Zhang (2014), Albaugh, (2006), Pauling (1971)

Structure Type	Max Water Depth (ft)	Dry Wells	Freely Floating	Heave Stiffness	Roll and Pitch Stability	Continuous Operation in Rough Seas	Max. Production Capability (Mboe/d)	Ease of Installation
Truss Spar	10,000	Yes	Yes	Excellent	Excellent	Yes	200	Difficult
TLP	5,000	Yes	No	Excellent	Excellent	Yes	250	Moderate
Semi-submersible	10,000	No	Yes	Moderate	Good	No	360	Easy

Since the Heidelberg site water depth exceeds 5,000 ft., the TLP is not an ideal offshore platform to operate at the site. TLPs rely on a system of multiple large tendons whose diameters must be designed to resist tensile stresses. As water depth increases, larger diameter tendons must be used to account for larger tensile stresses. This increase in diameter, combined with length, creates a significant increase in required material and becomes costly. After a certain water depth, the TLP is no longer the feasible offshore platform.

Truss spars and semi-submersible structures are freely floating platforms whose stability is independent of the use of tension tendons, enabling them to operate in significantly deeper sites than TLPs. Both the truss spar and semi-submersible use mooring lines only to restrict translational movement and are more economically and technically feasible than tension cables simply because the tensile stress is significantly reduced due to its intended use. Therefore, the truss spar and semi-submersible remain feasible options for the Heidelberg site.

VCBG International selected the truss spar over the semi-submersible platform due to its superior stability characteristics and because it can support dry tree wells, whereas semi-submersibles may only support wet trees. The truss spar has greater heave stiffness in comparison with the semi-submersible due to its mass and smaller surface area, minimizing vertical motion. Since semi-submersibles have pontoons with considerably larger surface area, they are more susceptible to wave induced forces that cause large vertical motion. The spar's large heave stiffness allows for continuous drilling, while the semi-submersible must temporarily suspend drilling in serious wave conditions due to safety concerns.

The truss spar's large heave stiffness allows for the operation of dry trees, which are beneficial because both the well and drilling operations may be controlled from the surface. Operation on the surface allows for better intervention and control of the well in the case of an unlikely blow out. Dry wells require less construction and installation and require simpler offshore maintenance operations in comparison to wet trees, helping to reduce costs (Natarajan, 2010). Dry trees also have higher production reliability, a lower downtime, and have the capability of extending the platform to floaters with minimum modifications (Zhang, 2014).

Considering these, VCGB International will operate a truss spar in the Heidelberg field.

3.5 Economic Feasibility

The three alternatives, truss spar, TLP and semi-submersible, were compared economically by analyzing the cost of each structure, the net present value (NPV), internal rate of return (IRR), and breakeven analysis of the structures.

3.5.1 General Costs Analysis

The price of oil and the United States royalty rate in the Gulf of Mexico were considered constant throughout the economic comparison of the alternatives. An average of $53.57 per barrel is the projected price of oil for 2016, according to the U.S. Energy Information Administration (U.S., 2015). The current United States royalty rate in the Gulf of Mexico is 18.75%, which was determined from the U.S. Department of the Interior Bureau of Ocean Energy Management report on Oil and Gas Lease Sales for 2015-2017 (Gulf, 2015).

The field development costs were totaled at $2 billion. This was determined by comparing oil fields with similar characteristics to Heidelberg, such as Lucius and Julia (Kable, 2015). Pipelines will be installed heading 12.5 miles east and west of Heidelberg to connect with existing oil and gas pipelines, respectively. The current price of submarine pipeline is $38,181 per in.-mile (Parker, 2004). For a 25 mile pipeline length, the cost of a 16 in. pipeline will be $16 million. This cost was constant for each alternative.

The total costs were considered for each of the three alternatives and are displayed in Table 4. The numbers used to obtain these costs are based on similar size projects for each alternative. Structure cost of each alternative included hull, topside, mooring, and anchoring costs. Project management cost considered cost of the engineering, design, and project administration. Cost of transportation to the site location is considered part of installation.

Table 4: Total Cost of Each Alternative are reported by McAllister, 2013; Taylor, 2003; Kable, 2015; Parker, 2004

Cost	Truss Spar (million)	Semi-Submersible (million)	Tension-Leg Platform (million)
Structure	$304	$417	$569
Project Management	$127	$150	$115
Installation	$250	$150	$190
Field Development	$2,000	$2,000	$2,000
Pipeline	$15	$15	$15
Total Cost	**$2,696**	**$2,732**	**$2,890**

4 Project Economic Analysis

4.1 Investment Analysis

The investment analysis for each of the three alternatives is compared in Table 5.

Table 5: Investment Analysis

Investment Analysis	Truss Spar (million)	Semi-Submersible (million)	Tension-Leg Platform (million)
Total Revenue	$15,505	$15,505	$15,505
Total Cost With Royalties and Taxes	$10,699	$10,998	$10,626
Total Profit	$4,806	$4,507	$4,879
Net Present Value	$3,141	$2,883	$3,139
Internal Rate of Return	27.8%	25.5%	26.0%
Break Even Period (Years)	3.67	3.89	3.82

Results displayed in Table 5 demonstrate the truss spar is the most economical offshore structure for oil production in Heidelberg Field. Detailed analysis of the calculation may be viewed in Appendix A, B, and C.

4.2 Economic Justification

VCBG International has selected the truss spar as the most economical offshore structure for production in GC 903. The truss spar had the lowest total project cost of $2,696 million. The price difference between the truss spar and TLP is $200 million, and between the truss spar and semi-submersible is $40 million dollars, both in favor of the truss spar. Since the alternatives are within a reasonable range of each other, no structure can be ruled out based on total cost. The NPV of the truss spar is $3.1 billion, which is also within reasonable range of the NPV of the TLP and semi-submersible. Therefore, no structure can be ruled out based on NPV. The difference in the IRR between the semi-submersible and the truss spar is within 1% of each other, where the TLP has a bigger difference in IRR. This difference in the IRR rules out the TLP making the comparison between the truss spar and the semi-submersible. The breakeven between the semi-submersible and the truss spar were also close with the truss spar having a breakeven of slightly less at 3.67 years. Due to these economic similarities between the truss spar and semi-submersible, the deciding factor was dependent on the technical feasibility and how the semi-submersible cannot operate in rough seas. This causes the semi-submersible to lose operation days throughout the year, therefore losing profit. Due to these analyses, VCBG International selected the truss spar as the most economically feasible solution.

5 List of Detailed Task Descriptions

Each of the 59 tasks to be completed in the design phase is described in this section. The design phase will include main tasks of literature review, metocean parameters, site data, general layout and modelling, hydrostatic analysis, preliminary hydrodynamic analysis, structural hull model, wave and current induced forces, topside structural analysis, hull structural analysis, mooring analysis, subsea pipeline analysis, environmental impact, economic evaluation, and project reporting. Within each main task is a number of subtasks that serve to separate work into manageable sections. The design phase will be executed from January 18, 2016 to April 29, 2016, a duration of four months. It is estimated that this phase will require a total of 800 man-hours. A flowchart of the primary design areas of the design process with corresponding software tools and theory required for completion are illustrated in Fig. 8.

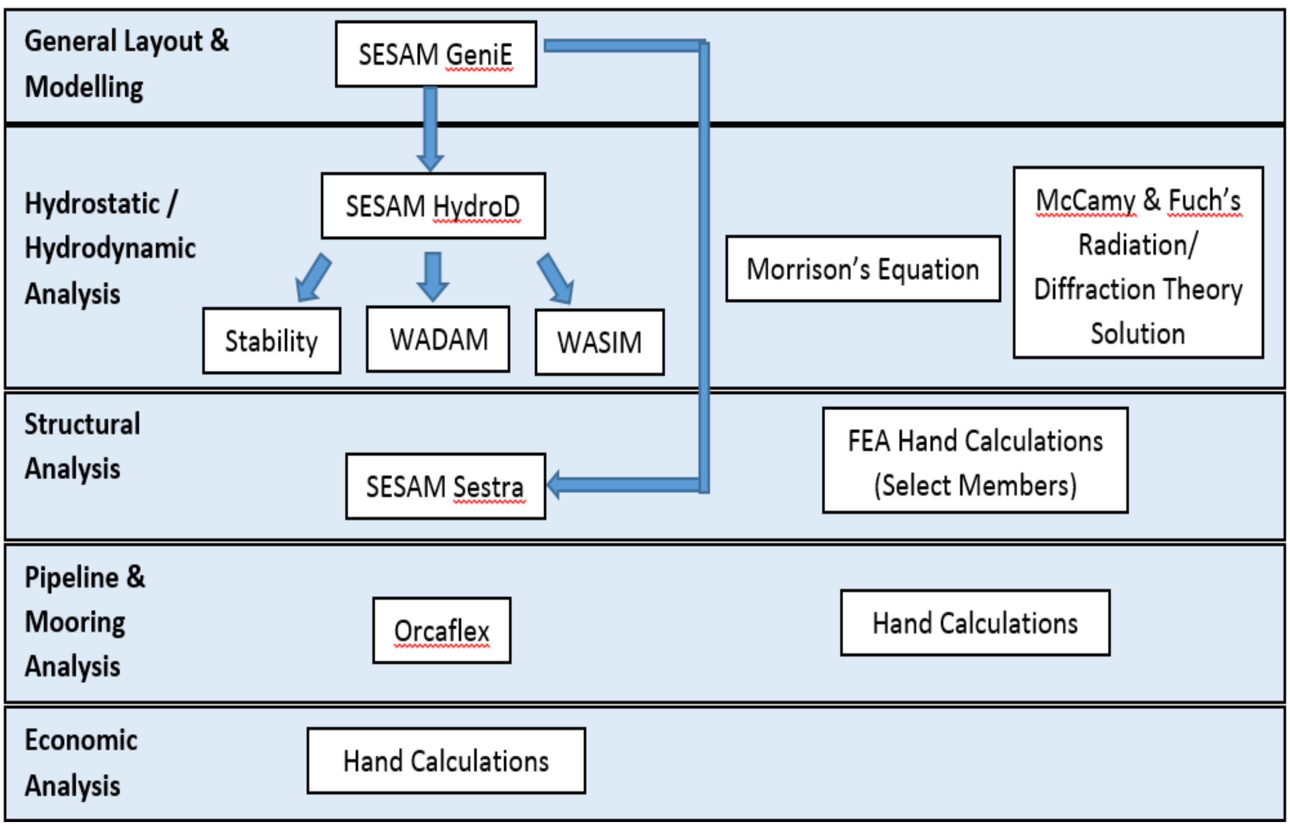

Figure 8: Overall Design Process Flowchart by VCBG International

5.1 Literature Review

5.1.1 Task 1- Field Surveys

Manpower: Sarah Braden
Duration: 6 hours
Time Period: 9/14/15 – 9/18/15
Dependency: None
Tools: Literature

Blattner, S. D. (1967, January 1). Exploration in the Gulf of Mexico. World Petroleum Congress.

Close, F., McCavitt, R. D., & Smith, B. (2008, January 1). Deepwater Gulf of Mexico Development

D'Souza, R., Aggarwal, R., & Basu, S. (2014, May 5). A Comparison of Pre- and Post-2005 Sanctioned Gulf of Mexico Tension Leg, Semi-submersible, and Spar Floating Platforms. Offshore Technology Conference. Houston.

The objective of this task is to perform a literature review of various oil fields focusing on determining what features in an oil field is important in designing an offshore production platform. The purpose of this task is to obtain data necessary to choose a location for the project. Preliminary site information includes the general key regions for oil production, the type of sands, and the oil fields in those regions that have a sufficient amount of recoverable resources. The features considered for the oil fields in a region are the amount of recoverable resources, the historic and current status of oil production in the field, the water depth, and the location relative to the nearest accessible pipeline. The amount of recoverable resources found in a region will be an important aspect in designing an offshore oil production platform in order to maximize profit. The amount of oil produced per day in the field is also crucial for choosing what type of offshore structure would be the most suitable. The historic and current status of oil production in a region will also be an important factor in reviewing fields because if there has already been, or there is currently oil production, some of the recoverable resources available may no longer be accessible. The water depth will be important in determining what kind of offshore platform will be the most productive in the chosen location. Having an existing pipeline accessible near the platform will reduce pipeline laying, cost, and manpower.

5.1.2 Task 2- Spar Projects

Manpower: Benjamin Valentine, Brittney Crawford, Doran Golemon, Sarah Braden
Duration: 20 hours
Time Period: 9/14/15- 9/28/15
Dependency: None
Tools: Mendeley

The objective of this task is to perform an initial literature survey that will give the project team an idea of topics within truss spar projects that have proven data for verified accuracy. Topics will primarily be hydrodynamic in nature, including: hull geometry, heave motion, pitch motion, heave plates, moon pool configuration, coupled dynamic analysis, and Computational Fluid Dynamics simulation. Other topics may include: transportation, installation of the topside and hull components, and comparison to other offshore floating structures.

5.1.3 Task 3- Technical Parameters for Structures

Manpower: Ben Valentine
Duration: 4 hours
Time Period: 9/14/15 – 9/28/15
Dependency: None
Tools: Literature

Pauling, J. R. (1971). Analysis of the Tension Leg Platform. *Society of Petroleum Engineers Journal*, *11*(03), 285–294.

Zhang, D., Chen, Y., & Zhang, T. (2014). Floating production platforms and their applications in the development of oil and gas fields in the South China Sea. *Journal of Marine Science and Application*, *13*(1), 67–75.

A literature review of peer reviewed sources and technical reports for previous and current offshore platforms or theoretical models will be conducted for the three alternative offshore platforms: the Tension Leg Platform (TLP), semi-submersible, and truss spar. The purpose of this task is to determine the important technical parameters to make an informed decision of the most technically qualified offshore platform for operation in the selected field. Key technical parameters that will be considered in research and evaluated include: production capabilities, stability characteristics, continuous operation during rough seas (dependent on stability), operating water depth, use of wet or dry tree wells, and ease of installation.

5.1.4 Task 4- Economic Parameters for Structures

Manpower: Doran Golemon and Sarah Braden
Duration: 20 hours
Time Period: 9/14/15 – 9/28/15
Dependency: None
Tools: Literature

Aurich, C., Breedlove, T., Brown, E., Evans, S., Koska, R., & Read, B. (2007). *Design of Semi-Submersible Platform-GOM*. College Station.

Parker, N. (2004). Using Natural Gas Transmission Pipeline Costs to Estimate Hydrogen Pipeline Costs, 86. http://doi.org/DOI *World Oil*, *234*(3), 67–76. Retrieved from http://www.worldoil.com/magazine/2013/april-2013/features/topsides-engineering-best-practices-for-lightweight-design

Albaugh, E. K., Davis, D., Paganie, D., Ball, E., Mitchell, G., Beattie, M., Hawk, R. (2006). 2006 Worldwide Survey Of Spars, Ddcvs. Poster.

Albaugh, E. K., Davis, D., Royall, J., Ball, E., Schilling, E., Powell, R., Powell, R. A. M. (2005). 2005 Worldwide Survey Of Tlps , Tlwps. Offshore; Mustang Engineering. Poster.

Agalliu, I. (2011). Comparative Assessment of the Federal Oil and Gas Fiscal System. Retrieved from http://www.blm.gov/wo/st/en/prog/energy/comparative_assessment.html

Kable. (2015). The Lucius oil field is located in the Keathley Canyon block in the Gulf of Mexico. Kable. Retrieved from http://www.offshore-technology.com/projects/lucius-project/

A literature review of peer reviewed sources and technical reports for previous and current offshore platforms or theoretical models will be conducted for the economic parameters of each alternative. The purpose of this task is to determine the important economical parameters to make an informed decision of the most profitable offshore platform for operation in the selected field. Economic parameters will include the price of oil, pipeline cost, capital cost, taxes, royalties, installation, transportation, operations, pipelines and risers. Looking at the references from past projects, published, industry contacts will complete this task.

5.1.5 Task 5- Global Market for Oil and Gas

Manpower: Brittney Crawford
Duration: 3 hours
Time Period: 9/14/15- 9/28/15
Dependency: None
Tools: Literature

Eyton, D. (2014). Strategic role of technological advances in unlocking available and affordable oil and gas supplies. In International Petroleum Week 2014 (pp. 1–5). London: BP.

Tillerson, R. (2008). Meeting global energy supply and demand challenges. In 19th World Petroleum Congress (p. 3). Madrid.

The global demand for energy, specifically oil and gas, is the foundation for gaining financial backing to conceive and execute an offshore floating structure project. Global projections for the demand for oil and gas, as well as other energy sources, will be determined to argue the project's inception to create supply to match the increasing global demand. The positive qualities of oil and gas in comparison with renewable resources will be established in order to address why the transition to a primary reliance on renewable resources will not occur within this project's timeline.

5.1.6 Task 6- Environmental Impact

Manpower: Sarah Braden and Brittney Crawford

Duration: 3 hours

Time Period: 9/14/15- 9/28/15

Dependency: None

Tools: OPA '90, MARPOL '78, SOLAS, OSHA, Literature

Erik, Cordes. "Chemosynthetic Communities in the Gulf of Mexico." NOAA Ocean Explorer Podcast RSS. 25 June 2010.

Guide for the Environmental Protection Notation for Offshore Units, Floating Installations, And. (2014).

MARPOL 73/78. London: IMO, 1994. Print.

National Marine Fisheries Service. (1978). The Marine Mammal Protection Act of 1972. Annual Report. April 1, 1977 to March 31, 1978.

SOLAS. London: IMO, 2002. Print.

United States. Occupational Safety and Health Administration. OSHA. Washington, D.C.: U.S. Dept of Labor, Occupational Safety and Health Administration, 2011. Print.

United States. Oil Pollution Act of 1990. Washington, D.C.: U.S. G.P.O., 1990. Print.

VCBG Intl. is committed to a safe work environment for human and marine life. The consequences of any potential incident are of the upmost importance, so oil spill prevention and response, and protection of chemosynthetic communities and marine mammals is a top priority. This task will entail extensive research in order to understand procedures to reduce the probability of an oil spill, all the aspects of an oil spill and what protocols can be taken in case of a spill, and to protect all chemosynthetic communities and marine mammals in the selected field for the project. Regulatory requirements from Title I and Title IV of OPA 90, Annex I Chapter II and IV of MARPOL 78, SOLAs Chapter IX-Management for the Safe Operations of Ships, and OSHA will be adhered to in areas of planning, safety measures, prevention, protocol, safety of life, and pollution. Applications and research post- BP Deep Water Horizon Oil Spill in the Gulf of Mexico will be the primary source of scholarly literature for oil spill prevention. Literature review will also be completed to determine the rules and regulations that must be followed in order to avoid the protected chemosynthetic communities and marine mammals. VCBG Intl. will use this research to fully understand what chemosynthetic communities are, why they are important and are protected, and the rules required in order to protect them. VCBG Intl. will also use this literature review to fully understand which marine wildlife are endangered and affected by offshore platforms, and ways to protect the animals from the platform. Endangered marine mammals that are typically affected by offshore platforms include the sperm whale. Other marine wildlife that are usually affected by the platforms are sea turtles, birds, and fish. All negative effects the platform may have on marine mammals in the area, VCBG Intl. will have a thorough knowledge about and will provide possible solutions to the problems. VCBG Intl. will design Keystone Lite Truss Spar to follow all sections of the Marine Mammal Protection Act, and The Endangered Species Act.

5.1.7 Task 7 - Spar General Layout

Manpower: Ben Valentine, Sarah Braden, Brittney Crawford and Doran Golemon

Duration: 12 hours
Time Period: 1/1/16 – 1/5/16
Dependency: None
Tools: "Devil's Tower" as Parent Spar; ABS. MODU- Part 3 Hull Construction and Equipment (2015).

Literature review will be completed in order to determine the spar general layout and an appropriate parent offshore platform similar to the Keystone Lite Spar. The parent offshore platform is determined to be Devils Tower. Overall dimensions of the spar's layout to be determined include the hull, topside, truss system. Location and dimensions to be determined include buoyancy tanks, hard tanks, and ballast tanks. The key topside components that will be collected the general locations and dimensions of the living quarters, process and utility equipment, HVAC, helipad, and crane. This will be completed by comparing the sister platform's hydrostatic analysis and top side dimensions, which are dependent on the production capability, to the Keystone Lite Spar and by ABS code, MODU- Part 3 Hull Construction and Equipment.

5.1.8 Task 8- Truss Spar Hydrostatic and Hydrodynamic Analysis

Manpower: Ben Valentine, Brittney Crawford, and Sarah Braden
Duration: 4 hours
Time Period: 9/14/15 – 9/28/15
Dependency: None
Tools: Literature
Zhang, D., Chen, Y., & Zhang, T. (2014). Floating production platforms and their applications in the development of oil and gas fields in the South China Sea. *Journal of Marine Science and Application*, *13*(1), 67–75.

A literature review of peer reviewed sources and technical reports for previous and current offshore platforms and theoretical models will be conducted for the truss spar. The purpose of this task is to gather all relevant and applicable information on the hydrodynamic responses of a truss spar. Findings will be considered in the design and testing of the truss spar panel and structural models in the DNV SESAM software to optimize the structure's physical parameters in order to produce the most stable platform possible within the span of this project.

5.1.9 Task 9– Subsea Pipeline and Riser Parameters

Manpower: Doran Golemon
Duration: 6 hours
Time Period: 1/12/16-1/15/16

VCBG INTERNATIONAL
200 Seawolf Parkway
Galveston, TX 77554

Dependency: None
Tools: Literature Review, External Contacts

Bai, Qiang, and Yong Bai. Subsea Pipeline Design, Analysis, and Installation. First ed. Vol. 1. Waltham: Gulf Professional, 2014. Print.

Andrew C. Palmer & Roger A. King, *Subsea Pipeline Engineering*, PennWell 2004. ISBN 1-59370-013-X

Boyun Guo, Shanhong Song, Jacob Chacko & Ali Ghalambor, *Offshore Pipelines*, Elservier Inc., 2005. ISBN: 0-7503-7847-X.

Det Norske Veritas. 1988. RP E305: *On-bottom Stabillity Design of Submarine Pipelines*.

Det Norske Veritas. (2010). DNV-OS-F201 Dynamic Risers.

ASME B31.4 – 2006, *Pipeline Transportation Systems for Liquid Hydrocarbon and Other Liquids*.

ASME B31.8 – 2007, *Gas Transmission and Distribution Piping Systems*.

AGA, *Submarine Pipeline On-Bottom Stability*, Project PR-178-9333, America Gas Association.

Yong Bai and Qiang Bai, *Subsea Pipelines and Risers*, Elsevier Inc., 2005. ISBN:0-080-44566-7.

Veritas, D. N. (2012). Submarine Pipeline Systems - Offshore Standard DNV-OS-F101. *Norsok Standard*, 367.

Literature review initiated in the references above will be completed for the Subsea Pipeline Parameters. The purpose of the task is to obtain specific subsea pipeline parameters to suit the truss spar. The subsea pipeline parameters will include the length, flow rate, friction, wave and current data, well pressure, and pressure at the well. Looking at the references of the past projects, published documents, and industry contacts information will aid in pipeline design geometry calculations in Task 49.

5.2 Metocean Parameters

5.2.1 Task 10- Spar Location

Manpower: Sarah Braden
Duration: 5 hours
Time Period: 12/16/15-12/17/15
Dependency: Task 1
Tools: Excel

The objective of this task is to justify why the site chosen is the best site for the Keystone Lite Truss Spar. After comparing each of the three field alternatives, one site will be chosen based on its location relative to oil and natural gas pipelines, the water depth of the field, how much recoverable resources are available in the field, and the trend of its sand. The best site will be in a region where oil production has been successful, and has enough recoverable resources for a project lifetime of 20-40 years. The most efficient location will be in a field projected to have the most oil reserves and does not currently have a platform extracting oil. The best field should be located with sands where oil has been successfully produced. The field should also be located in a trend of sand that has a light or moderate decline in production. Once the location is chosen, the site will be justified by using the comparison table, by performing additional research in order to provide supplementary information on the field, and by further proving that the chosen field is the optimum location.

5.2.2 Task 11- Design Wind, Wave and Current Conditions

Manpower: Sarah Braden
Duration: 8 hours
Time Period: 12/18/15-12/20/15
Dependency: Task 10
Tools: American Petroleum Institute (API), API RP 2A-WSD 21st Edition and API 2INT-MET

The objective of this task is to determine the wind, wave, and current conditions necessary for the design of the offshore structure. The purpose of this task is to determine these conditions in order to use the correct values when calculating the forces on the structure. Hurricane design parameters for the Gulf of Mexico will be determined using codes provided by API. Offshore structures must be designed to withstand storms such as hurricanes. API RP 2A-WSD 21st Edition, Sections 1.3 Environmental Considerations, 1.3.2 Winds, 1.3.3 Waves, and 1.3.5 Currents provide definitions and recommendations for normal and extreme conditions that will be used as a reference when analyzing each metocean condition. In the API 2INT-MET: Interim Guidance on Hurricane Conditions in the Gulf of Mexico, Sections 4 Independent Extreme Wind, Wave, Current and Surge, 4.1 Wind, 4.1.2 Wind Profiles and Gusts, U.S. Customary Units, 4.1.4 Wind Spectra, U.S. Customary Units, 4.2 Waves, 4.3 Currents, and 4.5.2 West Central provide equations, tables, and specifications that VCBG Intl. will use in determining the design metocean conditions. Section 4.5.2 West Central contains tables providing Mean Wind Speeds, Gust Speed, Significant Wave Heights, Currents, and Water Level based on 100-year return period for operation and 1-year return period for installation. This table along with the recommendations from API RP 2A-WSD 21st Edition and API 2INT-MET will be used to develop design wind, wave, and current conditions in order to calculate the forces on the structure.

5.2.3 Task 12- Collecting Location Wind, Wave and Current Data

Manpower: Sarah Braden
Duration: 2 hours
Time Period: 12/21/15-12/21/15
Dependency: Task 10
Tools: NOAA National Data Buoy Center, Buoy Stations 42360, 42395, and 42362

The objective of this task is to collect the wind, wave, and current data at the chosen location. The purpose of this task is to obtain the typical wind, wave, and current forces that will be acting on the structure in the chosen location. This data includes significant wind, wave, and current data of the chosen location. VCBG Intl. will use NOAA buoy stations, which give public information of metocean parameters for the location of each buoy. VCBG Intl. will select buoy stations producing new data in the same region as the location chosen. The buoys will be narrowed to the three closest buoys to the block chosen. Once the three buoys are chosen, VCBG Intl. will analyze and compare the data from each buoy. If they produce similar metocean data for their fields, VCBG Intl. will average the wind, wave, and current data in order to obtain the data for the chosen field. If there is an outlier, the buoy producing the most conservative data for the structure design will be chosen within reason. The data for the VCBG project will be extracted from NOAA buoy stations 42360 (26.672 N 90.471 W), 42395 (26.407 N 90.845 W), and 42362 (27.795 N 90.648 W).

5.2.4 Task 13- Extrapolating Location Wind, Wave, and Current Data

Manpower: Sarah Braden
Duration: 2 hours
Time Period: 12/22/15-12/22/15
Dependency: Task 11, 12
Tools: Rayleigh Distribution, Hand Calculations

The purpose of this task is to use the wind, wave and current data collected in Task 12 to extrapolate them in order to obtain the extreme values of the chosen site. Once the wind, wave, and current data for the chosen location are extrapolated, they will be inputted into a Rayleigh distribution where the extreme values, such as significant wave height, maximum wave height and current, are determined for the chosen location. The calculated extreme values will be compared to the values obtained from the API recommended design conditions in Task 11. The extreme values of the location should not be larger than the API recommended design conditions.

5.3 Site Data

5.3.1 Task 14- Bathymetry

Manpower: Sarah Braden and Brittney Crawford
Duration: 6 hours
Time Period: 12/22/15-12/23/15
Dependency: Task 10
Tools: Google Earth, ArcGIS, NGDC Bathymetry and Global Relief

The objective of this task is to determine the bathymetric geography of the chosen location. The purpose of this task is to have this data in order to determine the pipeline route and to analyze the anchoring foundation of the platform. The general bathymetric layout of the chosen location will be determined using Google Earth, ArcGIS and NGDC Bathymetry and Global Relief. Bathymetry is an important aspect in both the design of an offshore production platform as well as the laying of the pipeline. Geophysical data can provide information that is important in understanding the soil foundation of the chosen location. This includes evidence of slumps, scarps, irregular or rough topography mud volcanoes, mud lumps, collapse features, sand waves, slides, faults, diapers, erosional surfaces, gas bubbles in the sediments, gas seeps, buried channels, and lateral variations in strata thicknesses.

5.3.2 Task 15- Geotechnical Data

Manpower: Sarah Braden
Duration: 6 hours
Time Period: 12/27/15-12/28/15
Dependency: Task 10
Tools: Literature

Cheon, Jeong Yeon. "Analysis of spatial variability in geotechnical data for offshore foundations." (2010).

The objective of this task is to determine the subsurface data of the chosen location. The purpose of this task is to have this data in order to calculate how the mooring and anchoring foundation of the platform will perform. The general subsurface data of the chosen location will be determined through literature review of “Analysis of Spatial Variability in Geotechnical Data for Offshore Foundation” by Jeong Yeong Cheong. Subsurface data is an important aspect in the design of the mooring system on the offshore platform. The geotechnical aspects of the soil, such as the sediment type, age, and layers can affect the quality of the anchoring and mooring of the platform. Important parameters to obtain in this task are undrained shear strength, density water content and porosity ratio. Obtaining the geotechnical data for the soil in the chosen location will help in designing the most efficient mooring system in Task 45.

5.4 General Layout

5.4.1 Task 16- Preliminary Topside Dimensions

Manpower: Brittney Crawford

Duration: 2 hours

Time Period: 1/6/16-1/6/16

Dependency: Task 7

Tools: Specific “Devil’s Tower” Literature

Albaugh, E. K., Davis, D., Paganie, D., Ball, E., Mitchell, G., Beattie, M., Hawk, R. (2006). 2006

Worldwide Survey of Spars , DDCVs. Poster.

The objective of this task is to gather realistic dimensions for the topside of the spar structure in order to create a CAD general layout. The purpose of this task is to define dimension parameters. The preliminary topside dimensions will include total height and total width of the topside structure, total height of the circular hull structure, total height of the lower truss structure, and diameter/width of the hull/truss structure. The dimensions of the main components of the hull will be determined. Dimensions to be determined include buoyancy tanks, hard tanks, and ballast tanks. The dimensions need to be exact to create an efficient platform for safety, production, and economics. The dimensions used and hand calculations will show that enough buoyancy was created to hold up the topside and the max oil production.

5.4.2 Task 17- Preliminary Hull Dimensions

Manpower: Brittney Crawford

Duration: 2 hours

Time Period: 1/7/16-1/7/16

Dependency: Task 7

Tools: “Devil’s Tower” Literature

Albaugh, E. K., Davis, D., Paganie, D., Ball, E., Mitchell, G., Beattie, M., Hawk, R. (2006). 2006

Worldwide Survey of Spars, DDCVs. Poster.

The objective of this task is to gather realistic dimensions for the hull of the spar structure in order to create a CAD general layout. The purpose of this task is to define dimension parameters. The preliminary topside dimensions will include total height and total width of the topside structure, total height of the circular hull structure, total height of the lower truss structure, and diameter/width of the hull/truss structure. The dimensions of the main components of the hull will be determined. Dimensions to be determined include buoyancy tanks, hard tanks, and ballast tanks. The dimensions need to be exact to create an efficient platform for safety, production, and economics. The dimensions used and hand calculations will show that enough buoyancy was created to hold up the topside and the max oil production.

5.4.3 Task 18– Prelim Spar Layout

Manpower: Doran Golemon
Duration: 2 hours
Time Period: 1/8/16-1/8/16
Dependency: Tasks 16, 17
Tools: AutoCad, "Devil's Tower" Literature

Albaugh, E. K., Davis, D., Paganie, D., Ball, E., Mitchell, G., Beattie, M., Hawk, R. (2006). 2006 Worldwide Survey of Spars , DDCVs. Poster.

ABS. MODU- Part 3 Hull Construction and Equipment (2015).

ABS. (2004). MODU- Part 4 Machinery and Systems.

ABS. (2012). Classification of Drilling Systems.

The objective of this task is to create general 2D AutoCad drawings of the intended spar layout. The purpose of this task is to build a general spar layout in AutoCad in order to create the spar model and perform the hydrostatic and hydrodynamic calculations. The Hull and topside will follow the ABS's MODU Part 4 Chapter 1 and chapter 3 and ABS's classification of Drilling Systems section 2. A few of the topside major components consist of living quarters, process and utility equipment, HVAC, helipad, and crane. The hull layout will be governed by ABS's MODU Part 3 Chapter 2. The hull main components consist of ballast, truss system and the compartments of the buoyancy hull are buoyancy tanks and hard tanks. This layout needs to be the most efficient for production, safety, and economics. The layout must be light and space saving. 2D AutoCad drawings will be completed to detail the components of the hull and topside structure using the Devils Tower dimensions in aid of the preliminary spar layout.

5.4.4 Task 19– Prelim CAD Model

Manpower: Ben Valentine and Doran Golemon
Duration: 10 hours
Time Period: 1/10/16-1/12/16
Dependency: Task 18
Tools: AutoCad

The objective of this task is to create a preliminary 3D AutoCad model of the spar. Preliminary CAD drawings will be created from 2D layout drawings developed in Task 18 and follow the code requirements in Tasks 17 and 18. The drawings will contain the layout with the dimensions that have been updated for the weight configuration of the spar's topside. Each major component needs to be represented by the prelim drawings on the CAD Model drawing to show that a safe oil production structure has been designed. A lightweight and space saving design need to be shown on the CAD Drawings for the structure to be economical. The CAD model will be completed on AutoCad to give a representation of the structure's configuration.

5.4.5 Task 20– Prelim Topside Weight Configuration

Manpower: Sarah Braden and Ben Valentine
Duration: 5 hours
Time Period: 1/13/16-1/13/16
Dependency: Task 19
Tools: Hand Calculations

The weight of the main components of the topside and their configurations will be calculated. The component's weight needs to be placed so that the structure has maximum stability and that the center of gravity is extremely close to the center of the structure. This configuration needs to be exact because the weight creates efficient topside for production and safety. The weight configuration also needs to be lightweight to conserve cost. Hand calculations will be used to determine the best configuration. Once the drawing is updated for the weight configuration proceed to the prelim CAD model.

5.4.6 Task 21- CAD Model with Topside Weight Configuration

Manpower: Ben Valentine and Doran Golemon
Duration: 10 hours
Time Period: 1/14/16-1/15/16
Dependency: Task 20
Tools: AutoCad

CAD Drawings will be created using the topside weight configurations calculated in Task 20 in order to create a CAD drawing of the topside including the weight configurations. The drawings will contain the layout with the dimensions that have been updated for the weight configuration of the spar's topside. Each major component needs to be represented by the preliminary drawings on the CAD Model drawing to show that a safe oil production structure has been designed. A lightweight and space saving design need to be shown on the CAD Drawings for the structure to be economical. The CAD model will be completed on AutoCad to give a representation of the structure's configuration. This design will be then put through hydrostatic and hydrodynamic calculations.

5.5 Hydrostatic Analysis

5.5.1 Task 22- Preliminary Estimate of Spar Hydrostatic Stability

Manpower: Ben Valentine
Duration: 6 hours
Time Period: 1/17/16-1/18/16
Dependency: Task 21
Tools: Hand calculations, Classical Naval Architecture Equations, MATLAB

The hydrostatic stability of the truss spar will be estimated for preliminary results through hand calculations using classical naval architecture equations and a simplified hull configuration to determine the metacentric height (GM) and plot a stability curve. The initial hull dimensions, including diameter and draft, Center of Gravity (COG), and Center of Buoyancy (COB) will be obtained from similar truss spars and adjusted to achieve preliminary satisfactory results for the Keystone Lite platform. Required values for estimated hydrostatic stability include: hull diameter appropriate for topside structure given in Task 21 and corresponding water plane area, hull draft, COG given by estimating the vertical centroid of topside and hull weight, and COB given by estimating the vertical centroid of the hull's submerged volume. MATLAB will be utilized in to verify hand calculation results.

5.5.2 Task 23- Hull Panel Model

Manpower: Brittney Crawford
Duration: 6 hours
Time Period: 1/19/16-1/24/16
Dependency: Task 17
Tools: SESAM GeniE

The truss spar hull with initial dimensions determined in Task 17 will be modeled in SESAM GeniE as a panel model. The panel model will simply be a shell of the hull with a small, finite thickness and no mass. Sections of the model that will be created include: the hard tank, soft tank, truss members, and heave plates. A "wet surface" will be placed over the external surface of the panel model where a hydro dummy pressure will be applied normal to the surface. When completed, a Finite Element Mesh (FEM) will be placed over the panel model and exported as a .FEM file to SESAM HydroD for hydrostatic and hydrodynamic analysis.

5.5.3 Task 24-Hydrostatic Pressure Verification of Spar Hull Panel Model

Manpower: Doran Golemon

Duration: 2 hours
Time Period: 1/25/16-1/25/16
Dependency: Task 23
Tools: Hand Calculations, MATLAB

Preliminary hand calculations of the hydrostatic pressure will be completed for the spar hull model created Task 23 modeled in SESAM GeniE as a panel model. The hydrostatic pressure will be applied normal to all surfaces of the hull. The purpose of this task is to verify the mesh results over the modeled hull surface in SESAM GeniE. MATLAB will be utilized in addition to verify hand calculation results.

5.5.4 Task 25- Topside Structural Model

Manpower: Sarah Braden
Duration: 12 hours
Time Period: 1/19/16-1/22/16
Dependency: Task 16
Tools: SESAM GeniE

The topside structure will be modeled in SESAM GeniE as a structural model using the dimensions and general layout determined in Task 16. The purpose is to complete a full design of the topside for a structural analysis in SESAM Sestra to ensure the structure may handle applied design loads with acceptable stress states. The structural model will consist of all necessary plates, beams, and girders with appropriate materials and their corresponding characteristics. The COG and total mass of the topside structures will be calculated in SESAM GeniE.

5.5.5 Task 26- Verification of Structural Topside Model COG and Mass

Manpower: Brittney Crawford

Duration: 3 hours
Time Period: 1/24/16-1/24/16
Dependency: Task 25
Tools: Hand Calculations, MATLAB

The objective of this task is to verify that the COG and total mass of the structural topside model in SESAM GeniE is comparable to hand calculation values. The purpose of this task is to ensure that the topside model in SESAM GeniE has an adequate COG and total mass. The calculated total mass and COG of the topside structure in SESAM GeniE in Task 25 will be verified through estimation by hand calculations. MATLAB will be utilized in addition to verify hand calculation results.

5.5.6 Task 27- Hydrostatic Stability Analysis

Manpower: Ben Valentine
Duration: 3 hours
Time Period: 1/25/16-1/27/16
Dependency: Task 11, 13, 23
Tools: SESAM HydroD: Stability Application

The preliminary hydrostatic stability analysis of the truss spar will be completed through the Stability application in SESAM HydroD. The purpose is to ensure that the structure is stable and has an acceptable GM and roll period for when the structure is moving in active seas. Environmental inputs required include general fluid and air properties of density and viscosity, 1 and 100 year return period for wind speed obtained in Task 11 and 13. Inputs required for the platform include COG, total estimated mass, and preliminary draft. Main outputs to be considered in the Stability application include GM, stability curve, and COB.

5.6 Preliminary Hydrodynamic Analysis

5.6.1 Task 28- WADAM Panel Analysis for Hull Panel Model

Manpower: Brittney Crawford
Duration: 6 hours
Time Period: 1/25/16 - 1/28/16
Dependency: Task 23
Tools: SESAM HydroD: WADAM Application

Preliminary hydrodynamic analyses of the truss spar will be completed in the linear frequency domain of the WADAM application in SESAM HydroD. The purpose is to determine whether the structure has acceptable responses to wave loads and displacements for use in designing the mooring system. WADAM calculates wave-structure interaction of a stationary platform through use of radiation diffraction theory and Morison's equation, which is an ad hoc approach, specifically for slender members. The truss spar hull panel model created in Task 23 will be analyzed. Environmental inputs required include general fluid and air properties of density and viscosity, 1 and 100 year return period for wind speed and wave field conditions obtained in Tasks 11 and 13. Inputs required for the platform include COG and draft. Outputs of the WADAM panel analysis include the structure's stiffness matrix, external hydrodynamic forces acting on the model, and the Response Amplitude Operators (RAOs) for a given range of frequencies, which will be displayed through SESAM Postresp.

5.6.2 Task 29- WASIM Panel Analysis for Hull Panel Model

Manpower: Sarah Braden
Duration: 6 hours
Time Period: 1/25/16-1/29/16
Dependency: Task 11, 13, 23
Tools: SESAM HydroD: WASIM Application

The second preliminary hydrodynamic analysis of the truss spar's hull panel model will be analyzed in SESAM HydroD's WASIM application. WASIM linear time domain analysis is used for hydrodynamic analysis of fixed and/or floating vessels with or without forward speed, and includes calculation of global motions and pressure loadings on the platform. The program obtains these results through solving the radiation/diffraction problem in a three dimensional domain using the Rankine panel method. Environmental inputs required for the program include general fluid and air properties of density and viscosity, 1 and 100 year return period for wind speed and wave field conditions obtained in Tasks 11 and 13.

5.7 Structural Hull Model

5.7.1 Task 30- Hull Structural Model

Manpower: Doran Golemon
Duration: 12 hours
Time Period: 2/2/16-2/8/16
Dependency: Task 19
Tools: SESAM Genie

The platform's hull structure will be modeled in SESAM GeniE as a structural model using the preliminary CAD model parameters created in Task 19. The purpose is to analyze the current induced forces on the structure for use in designing the mooring system. The structural model will consist of all necessary plates, beams, girders, etc. with appropriate materials and their corresponding characteristics. Key components of the structural model that will be include are the buoyancy tanks, keel tank, truss members, and keel tank. The COG and total mass of the hull structures will be calculated in SESAM GeniE.

5.7.2 Task 31- Verification of Hull Structural Model COG and Mass

Manpower: Ben Valentine
Duration: 3 hours
Time Period: 2/9/16-2/10/16
Dependency: Task 30
Tools: Hand Calculation, MATLAB

The objective of this task is to verify that the COG and total mass of the hull structure and closely matches the calculations completed by hand. The purpose of this task is to ensure that the COG and mass of the hull structural model is adequate. The calculated total mass and COG of the hull structure in SESAM GeniE from Task 30 will be verified through estimation by hand calculations. MATLAB will be utilized in addition to verify hand calculation results.

5.7.3 Task 32- Buoyancy Tanks (Soft Tanks)

Manpower: Sarah Braden

Duration: 15 hours
Time Period: 2/10/16-2/18/16
Dependency: Task 23
Tools: SESAM GeniE, SESAM HydroD: Stability Application and SESAM HydroD: WADAM Application, Postrep, ABS Mobile Offshore Units

The objective of this task is to create and analyze buoyancy tanks for the spar. The purpose of this task is to create sections in the hull in order to provide buoyancy for the spar. The buoyancy tanks will be designed and added to the already designed spar hull panel model, from Task 23, using SESAM GeniE. Chapter 3 of ABS Mobile Offshore Units rules and regulations will be followed in the design and analysis of buoyancy tanks. Once the buoyancy tanks are created, the center of gravity and total mass of the hull structure will be calculated in SESAM GeniE. A "wet surface" will be placed over the external surface of the hull panel model in order to apply a hydro dummy pressure normal to the surface. The model hull, including the buoyancy tanks, will be exported as a .FEM file and imported into SESAM HydroD. In SESAM HydroD, the Stability Application will be used to ensure the structure, with the buoyancy tanks, is stable and has an acceptable GM and roll period in active seas.

5.7.4 Task 33- Buoyancy Tanks (with Hull)

Manpower: Sarah Braden
Duration: 15 hours
Time Period: 2/18/16-2/19/16
Dependency: Task 32
Tools: SESAM GeniE, SESAM HydroD: Stability Application and SESAM HydroD: WADAM Application, Postrep, ABS Mobile Offshore Units

The objective of this task is to incorporate the buoyancy tanks into the hull panel model in order to be analyzed. The purpose of this task is to verify the spar has acceptable buoyancy. The hull panel model will also be run through SESAM HydroD: WADAM application, where the response amplitudes and corresponding frequencies given by the RAOS in HydroD's Postresp will be visualized and analyzed.

5.7.5 Task 34- Damage Stability

Manpower: Brittney Crawford

Duration: 4 hours

Time Period: 2/21/16- 2/24/16

Dependency: Task 23

Tools: SESAM GeniE, SESAM HydroD, Hydroflow, Openfoam, ABS MODU Rules, SOLAS Regulation

Belenky, V., & Breuer, A. (2007). Intact and Damage Stability of Ships and Offshore Structures – Bridging the Gap. *10th International Symposium on Practical Design of Ships and Other Floating Structures*, 211–218.

The objective of this task is to optimize the spar structure design based on damage stability analysis in accordance with SOLAS Chapter II-1 using the probabilistic method. The purpose of this task is to evaluate structure stability during compartment flooding due to damage to create the damage control plan and damage control booklet, required by SOLAS regulation II 1/19. This will provide clear information on the vessel's watertight subdivision and equipment related to maintaining the boundaries and effectiveness of the subdivision so that, in the event of flooding, proper precautions can be taken to prevent progressive flooding and, where possible, recover the vessel's loss of stability. Damage stability using the probabilistic method will include the probability that one or more compartments considered will be flooded (pi), the probability of survival after flooding (si), and the required subdivision index (R), which is a function of length. The attained subdivision index (A), which is the summation of pi and si, must be greater than the required subdivision index (R). Numerical methods will be employed as the changing areas and volumes when various compartments are flooded become tedious.

5.8 Wave and Current Induced Forces

5.8.1 Task 35- Morrison's Equation

Manpower: Brittney Crawford
Duration: 5 hours
Time Period: 2/9/16-2/11/16
Dependency: Task 30
Tools: Hand Calculations, MATLAB, Literature

Agerschou, Hans A., and Jeppe J. Edens. "Fifth and first order wave-force coefficients for cylindrical piles." ASCE, 1965.

Morison, J. R., J. W. Johnson, and S. A. Schaaf. "The force exerted by surface waves on piles." *Journal of Petroleum Technology* 2.05 (1950): 149-154.

Wave and current induced forces will be calculated by hand on the truss spar hull using Morrison's Equation. Morrison's Equation is an ad hoc approach on an assumed slender and cylindrical structure, and considers the drag forces due to water particle velocity and inertial forces due to water particle accelerations around the structure. The drag coefficient, C_D, and added mass coefficient, C_A, will be required for calculations, and are traditionally obtained through model experiments. However due to the scope and available resources of this project, the coefficients will be obtained through Agerschou and Edens (1965) recommended values based statistical analysis of published data. The significant sections of the hull that will be considered for calculations include the cylindrical portion of the hull, truss members, and keel tank.

5.8.2 Task 36- McCamy and Fuch's

Manpower: Sarah Braden
Duration: 8 hours
Time Period: 2/9/16-2/28/16
Dependency: Task 30
Tools: Hand Calculation, Matlab, Literature

Newman, John N. (1977), Marine Hydrodynamics, The MIT Press, 432 pp., ISBN: 978- 0262140263.

Wave and current induced forces on the cylinder will be estimated by hand calculations on the truss spar hull using McCamy and Fuch's solution for linear wave diffraction theory. This solution is applied to linear waves of small amplitude in a finite depth and does not consider viscous effects. The total velocity potential is solved through the incident, diffraction, and radiation/scattering potentials throughout the domain. When the total potential is determined, it will then be applied to Euler's integral to solve for pressures along the surface of the hull. For simplification of calculations, the domain will be considered to be two dimensional and the hull will be considered to be a single cylinder, excluding the truss members and keel tank considered in Task 30.

5.9 Topside Structural Analysis

5.9.1 Task 37- Wind Loads on Topside

Manpower: Sarah Braden
Duration: 15 hours
Time Period: 2/16/16-2/21/16
Dependency: Task 11, 13, 25
Tools: API RP-2A WSD 21st Edition and SESAM Sestra

The objective of this task is to determine the effects the wind load has on the topside. The purpose of this task is to analyze the wind loads on the topside in order to ensure the topside will be able to withstand the forces. The standard wind conditions for the chosen location from Task 13 will be used to provide realistic load states to analyze the topside reaction. The design wind condition determined in Task 11 and from the API RP-2A WSD 21st Edition, will also be used to test the topside using storm winds. The model of the topside completed in Task 25 along with the necessary wind conditions previously imported into SESAM GeniE, will be imported into Sestra. Sestra will then create the Finite Element Model and compute the loadings on the topside. Statically, Sesam will analyze the topside by either the direct analysis or the super element analysis. The results will illustrate the topsides ability to withstand the wind loads of the chosen location.

5.9.2 Task 38- Dead Loads on Topside

Manpower: Sarah Braden
Duration: 8 hours
Time Period: 2/22/16-2/23/16
Dependency: Task 25
Tools: SESAM Sestra, API RP-2A

The objective of this task is to determine the effect the dead loads have on the topside. The purpose of this task is to analyze how the dead loads affect the topside and whether the topside will be able to withstand those loads, or if a new design is necessary. Section 2.1.2.b of API RP-2A will be used to determine which elements of the topside are dead loads in order to perform adequate computations. The model of the topside, including all equipment, production modules, and personnel, completed in Task 25 in SESAM GeniE, will be inputted into SESAM Sestra. Sestra will then create the Finite Element Model and compute the loadings on the topside. Statically, Sesam will analyze the topside by either the direct analysis or the super element analysis (grouping of finite elements that may be regarded as an individual elements for computational purposes). The results will illustrate the topsides ability to withstand the dead loads on that will be added to the topside.

5.9.3 Task 39- Live Loads on Topside

Manpower: Sarah Braden
Duration: 8 hours
Time Period: 2/24/16-2/25/16
Dependency: Task 25
Tools: SESAM Sestra, API RP-2A

The objective of this task is to determine the effect the live loads have on the topside. The purpose of this task is to analyze how the live loads affect the topside and whether the topside will be able to withstand those loads, or if a new design is necessary. Section 2.1.2.c of API RP-2A will be used to determine which elements of the topside are live loads in order to perform adequate computations. The model of the topside, including all equipment, production modules, and personnel, completed in Task 25 in SESAM GeniE, will be inputted into SESAM Sestra. Sestra will then create the Finite Element Model and compute the loadings on the topside. Statically, Sesam will analyze the topside by either the direct analysis or the super element analysis (grouping of finite elements that may be regarded as an individual elements for computational purposes). The results will illustrate the topsides ability to withstand the live loads on that will be added to the topside.

5.9.4 Task 40- FEM Analysis of Topside

Manpower: Sarah Braden
Duration: 25 hours
Time Period: 2/26/16-3/7/16
Dependency: Tasks 37, 38, 39
Tools: SESAM Sestra

The objective of this task is to perform the Finite Element Model (FEM) analysis on the topside. The purpose of this task is to ensure that the topside will be able to withstand all stress states without failing. SESAM Sestra will be used for linear static and dynamic structural analysis for the topside using the displacement based finite element method. Sestra computes the local element matrices and load vector and then assembles them into global matrices and load vectors. Algebraic numerical algorithms are used to perform the static and dynamic buckling analysis of the global matrices. The results of the analysis will illustrate the topside topsides ability to withstand all stresses without failing. Wind, dead and live loads will be applied to the hull structural using SESAM Sestra. Codes and procedures outlined in Tasks 37, 38, and 39 will be verified in completing this task.

5.10 Hull Structural Analysis

5.10.1 Task 41- Wave Loads

Manpower: Brittney Crawford
Duration: 8 hours
Time Period: 2/12/16-2/14/16
Dependency: Task 30
Tools: SESAM Sestra, ABS Steel Vessel Rules, ABS Mobile Offshore Drilling Unit Rules, API RP-2A

API 2P-2A 2.3.1.c Dynamic Wave Analysis will be used to complete wave load analysis. Dynamic analysis will be used since wave loads are dynamic in nature (API RP-2A 2.3.1.a) and due to the Keystone Lite spar's significant flexibility in which static wave analysis could not adequately describe the true wave loads induced on the platform. The wave energy spectra calculated by linear wave theory in Task 30, will be used to determine the particular waves that will be applied to the hull structure. Key parameters of mass, damping, and stiffness will be reflected in the model. Since the spar structure is inertia-dominant in the Morrison's equation, frequency domain methods will be used.

5.10.2 Task 42- Current Loads

Manpower: Brittney Crawford
Duration: 8 hours
Time Period: 2/15/16-2/15/16
Dependency: Task 30
Tools: SESAM Sestra, API RP-2A

The objective of this task is to analyze hull structure reactions due to current loads using the Finite Element Analysis method. The purpose of this task is to predict structure performance, test metocean scenarios, and ensure optimal design by verifying that hull stress states are within reasonable range as to not buckle or fail. Equations and design parameters relating to current conditions will be taken from Section 2.3.3 Current of API RP-2A. The hull structural model built in Task 30 in DNV Sesam GeniE will be inputted into DNV Sestra.

5.10.3 Task 43- Marine Growth Loads

Manpower: Brittney Crawford
Duration: 15 hours
Time Period: 2/15/16-2/16/16
Dependency: Task 30
Tools: SESAM Sestra, API RP-2A

The objective of this task is to analyze hull structure reactions due to marine growth loads using the Finite Element Analysis method. The purpose of this task is to predict structure performance, test metocean scenarios, and ensure optimal design by verifying that hull hull stress states are within reasonable range as to not buckle or fail. The hull structural model built in Task 30 in DNV Sesam GeniE will be inputted into DNV Sestra. API RP-2A 2.3.1.b states that drag and inertia force coefficients are determined in part as functions of member roughness because of marine growth. API RP-2A 2.3.1.b.6 Marine Loads describes in more depth that structural members should be increased in cross-sectional area to account for marine growth thickness and classified as rough or smooth. API RP-2A 2.3.1.c.6 Structural Modeling states mass should include the mass of marine growth expected to accumulate and added mass of submerged members accounting for increased member diameter due to marine growth. API RP-2A 2.3.1.d.2 Marine Growth states to use 1.5 inch thickness from Mean Higher High Water (MHHW) to 150 ft. MHHW is one foot higher than MLLW. Structural members can be considered hydrodynamically smooth if they are above MHHW or deeper than 150 ft., where marine growth with be assumed to be zero. API RP-2A D2.3.1b6 Marine Growth provides additional equations and figures helpful for marine growth structural considerations.

5.10.4 Task 44- FEM Analysis of Hull Structure

Manpower: Brittney Crawford
Duration: 25 hours
Time Period: 2/17/16-2/22/16
Dependency: Tasks 41, 42, 43
Tools: SESAM Sestra

The objective of this task is to analyze hull structure reactions due to combined wave, current, and marine growth loads using the Finite Element Analysis method. The purpose of this task is to predict structure performance, test metocean scenarios, and ensure optimal design by verifying that hull stress states are within reasonable range as to not buckle or fail. The hull structural model built in Task 30 in DNV Sesam GeniE will be inputted into DNV Sestra. Sestra is a general purpose finite element analysis software for linear structural analysis. Governing equations of PDE and ODE are solved at the nodes, the local element matrices and load vector are computed, and then global matrices and load vectors are assembled. Algebraic numerical algorithms are used to perform the static and dynamic buckling analysis of the global matrices. The final output will include reaction forces, displacement animation with color shading, results at each particular node, and a report. Wave and current forces will be applied to the hull structural using SESAM Sestra. Codes and procedures outlined in Tasks 41, 42, and 43 will be verified in completing this task.

5.11 Mooring Analysis

5.11.1 Task 45- Mooring Design

Manpower: Sarah Braden
Duration: 8 hours
Time Period: 3/8/16-3/9/16
Dependency: Task 14, 15
Tools: ABS, MODU- Part 3 Hull Construction and Equipment (2015), Orcaflex, API RP-2SK

The objective of this task will be to design the mooring system for the platform. The purpose of this task is to design the mooring system to keep the motion of the platform within a reasonable range. Task 15 will be used to understand how the mooring system will perform on the seafloor of the chosen location and will be taken into design considerations. Chapter 4 Mooring Systems and Equipment of ABS's Rules for Building and Classing Mobile Offshore Drilling Units 2015 Part 3 Hull Construction and Equipment and API RP-2SK Chapter 7 will be used to understand and abide by all rules pertaining to the mooring design. Orcaflex will be used to create a general visualization of the mooring system design chosen.

5.11.2 Task 46- Mooring Configuration

Manpower: Sarah Braden
Duration: 8 hours
Time Period: 3/10/16-3/11/16
Dependency: Task 45
Tools: Literature, ABS, MODU- Part 3 Hull Construction and Equipment (2015), Orcaflex, API RP-2SK

The objective of this task will be to configure the mooring system for the platform. The purpose of this task is to configure the design of the mooring system from Task 45 in order to keep the motion of the platform within a reasonable range. Chapter 4 Mooring Systems and Equipment of ABS's Rules for Building and Classing Mobile Offshore Drilling Units 2015 Part 3 Hull Construction and Equipment and API RP-2SK Chapter 7 and 9 will be used to understand and abide by all rules pertaining to the mooring design. Orcaflex will be used to create a visualization of the mooring system by configuring the design created in Task 45.

5.11.3 Task 47- Mooring Stress Analysis

Manpower: Sarah Braden

Duration: 15 hours
Time Period: 3/13/16-3/15/16
Dependency: Task 46
Tools: ABS, MODU- Part 3 Hull Construction and Equipment (2015), Orcaflex, API RP-2SK

The objective of this task is to analyze the quasi static stress of the mooring system. The purpose of this task is to analyze the stress on the mooring system in order to ensure that the mooring lines will be able to withstand the motions of the structure with respect to the wind, waves, and currents. Chapter 4 Mooring Systems and Equipment of ABS's Rules for Building and Classing Mobile Offshore Drilling Units 2015 Part 3 Hull Construction and Equipment and API RP-2SK Chapter 5 will be used to understand and abide by all rules pertaining to the mooring design and configuration. Orcaflex will be used to perform stress calculations and outputting S-N curves for the mooring system configured in Task 46. Orcaflex uses multi-threaded fatigue calculations and provides options for frequency domain and response RAOs fatigue analysis.

5.11.4 Task 48- Mooring Fatigue Analysis

Manpower: Sarah Braden
Duration: 15 hours
Time Period: 3/16/16-3/18/16
Dependency: Task 46
Tools: ABS, MODU- Part 3 Hull Construction and Equipment (2015), Orcaflex, API RP-2SK

The objective of this task is to analyze the fatigue of the mooring system. The purpose of this task is to analyze the fatigue on the mooring system in order to ensure that the mooring lines will be able to withstand the motions of the structure with respect to the wind, waves, and currents. Chapter 4 Mooring Systems and Equipment of ABS's Rules for Building and Classing Mobile Offshore Drilling Units 2015 Part 3 Hull Construction and Equipment and API RP-2SK Chapter 6 will be used to understand and abide by all rules pertaining to the mooring design and configuration. Orcaflex will be used to perform fatigue calculations and outputting T-N curves for the mooring system configured in Task 46. Orcaflex uses multi-threaded fatigue calculations and provides options for frequency domain and response RAOs fatigue analysis.

5.12 Subsea Pipeline Analysis

5.12.1 Task 49 –Pipeline Design Geometry

Manpower: Doran Golemon
Duration: 6 hours
Time Period: 2/10/16-2/11/16
Dependency: Task 9
Tools: Hand Calculations, Mathcad

Det Norske Veritas. 1988. RP E305: *On-bottom Stabillity Design of Submarine Pipelines*.

ASME B31.8 – 2007, *Gas Transmission and Distribution Piping Systems*.

Veritas, D. N. (2012). Submarine Pipeline Systems - Offshore Standard DNV-OS-F101. *Norsok Standard*, 367.

The Subsea Pipeline Parameters will be inputted into hand calculations and Mathcad. We will use these calculations to help as a design aid in future input into Orcaflex. The calculations will be adjusted for the parameters determined in Task 9. The calculations include minimum pipeline diameter, minimum thickness, maximum velocity before erosion happens, pressure drop, friction, Reynold's number. These calculations will express the design geometry.

5.12.2 Task 50– Pipeline Installation Considerations

Manpower: Doran Golemon
Duration: 6 hours
Time Period: 2/12/16-2/14/16
Dependency: Tasks 14, 15, 49
Tools: Hand Calculations, Mathcad, Matlab

ASME B31.4 – 2006, *Pipeline Transportation Systems for Liquid Hydrocarbon and Other Liquids*.

Veritas, D. N. (2012). Submarine Pipeline Systems - Offshore Standard DNV-OS-F101. *Norsok Standard*, 367.

Calculations will be used to determine the best installation methods for the pipeline. The bathometry and subsurface data will be used to pick the best pipeline route and to complete calculations. Hand calculations, Mathcad, and Matlab will be used to determine the effects of the possible ways to install and operate the pipeline. The calculations will be created for the parameters calculated in Task 49. The calculations include maximum span length, on-bottom stability, and Installation Bending Stress Control. These calculations and the hand calculations will express the considerations needed for the installation of the pipeline.

5.12.3 Task 51– Pipeline Operation Considerations

Manpower: Doran Golemon
Duration: 6 hours
Time Period: 2/15/16-2/16/16
Dependency: Task 14, 15, 49
Tools: Hand Calculations, Mathcad, Matlab

ASME B31.4 – 2006, *Pipeline Transportation Systems for Liquid Hydrocarbon and Other Liquids*.

Veritas, D. N. (2012). Submarine Pipeline Systems - Offshore Standard DNV-OS-F101. *Norsok Standard*, 367.

Calculations will be used to determine the best operational methods for the pipeline. The bathometry and subsurface data will be used to pick the best pipeline location and to complete calculations. Hand calculations, Mathcad, and Matlab will be used to determine the effects of the possible ways to install and operate the pipeline. The calculations will be created for the parameters calculated in Task 49. The calculations include maximum span length, on-bottom stability, and Installation Bending Stress Control. These calculations and the hand calculations will express the considerations needed for the operation conditions of the pipeline.

5.13 Environmental Impact

5.13.1 Task 52- Oil Spill Prevention and Response

Manpower: Brittney Crawford
Duration: 4 hours
Time Period: 3/15/16-3/16/16
Dependency: Task 6
Tools: OPA '90, MARPOL '78, SOLAS, OSHA, Literature

Brekke, C., & Solberg, A. H. S. (2005). Oil spill detection by satellite remote sensing. *Remote Sensing of Environment*, *95*(1), 1–13. http://doi.org/10.1016/j.rse.2004.11.015

Griggs, J. W. (2011). BP Gulf of Mexico oil spill. *Energy Law Journal*, *32*(1), 57–79.

Goldstein, B. D., Osofsky, H. J., & Lichtveld, M. Y. (2011). The Gulf oil spill. *The New England Journal of Medicine*, *364*(14), 1334–1348. http://doi.org/10.1056/NEJMra1007197

Leifer, I., Lehr, W. J., Simecek-Beatty, D., Bradley, E., Clark, R., Dennison, P., Wozencraft, J. (2012). State of the art satellite and airborne marine oil spill remote sensing: Application to the BP Deepwater Horizon oil spill. *Remote Sensing of Environment*, *124*, 185–209. http://doi.org/10.1016/j.rse.2012.03.024

MARPOL 73/78. London: IMO, 1994. Print.

SOLAS. London: IMO, 2002. Print.

United States. Occupational Safety and Health Administration. OSHA. Washington, D.C.: U.S. Dept of Labor, Occupational Safety and Health Administration, 2011. Print.

United States. Oil Pollution Act of 1990. Washington, D.C.: U.S. G.P.O., 1990. Print.

VCBG Intl. is committed to a safe work environment for human and marine life. The consequences of any potential incident are of the upmost importance, so oil spill prevention and response is a top priority. Regulatory requirements from Title I and Title IV of OPA 90, Annex I Chapter II and IV of MARPOL 78, SOLAs Chapter IX-Management for the Safe Operations of Ships, and OSHA will be adhered to in areas of planning, safety measures, prevention, protocol, safety of life, and pollution. Multi-layer well control systems will be installed to minimize risks, so that if any of part of the system fails, a blowout is prevented. This task will entail extensive research in order to fully understand procedures to reduce the probability of an oil spill, all the aspects of an oil spill and what protocols can be taken in case of a spill in order to prevent any further problems and to complete timely and effective clean up. Applications and research post- BP Deep Water Horizon Oil Spill in the Gulf of Mexico will be the primary source of scholarly literature.

5.13.2 Task 53- Chemosynthetic Communities

Manpower: Sarah Braden
Duration: 4 hours
Time Period: 3/14/16-3/15/16
Dependency: Task 6
Tools: Literature

Erik, Cordes. "Chemosynthetic Communities in the Gulf of Mexico." NOAA Ocean Explorer Podcast RSS. 25 June 2010.

Guide for the Environmental Protection Notation for Offshore Units, Floating Installations, And. (2014).

The objective of this task is to research and understand all aspects of chemosynthetic communities and why they are protected. The purpose of this task is to understand these communities in order to abide by any rules in place to protect them while Keystone Lite Truss Spar is being installed, producing, or being decommissioned. In order to acknowledge all environmental impacts the offshore platform will have, the protection of the chemosynthetic communities in the Gulf of Mexico must be considered. Literature review completed in Task 6 will be used to determine the rules and regulations that must be followed in order to avoid these protected communities. VCBG Intl. will use this research to fully understand what chemosynthetic communities are, why they are important and are protected, and the rules required in order to protect them. This task will entail extensive research in order to understand and protect all chemosynthetic communities in the selected field for the project.

5.13.3 Task 54- Marine Wildlife Protection

Manpower: Sarah Braden
Duration: 4 hours
Time Period: 3/16/16-3/17/16
Dependency: Task 6
Tools: The Marine Mammal Protection Act, Endangered Species Act, Literature

National Marine Fisheries Service. (1978). The Marine Mammal Protection Act of 1972. Annual Report. April 1, 1977 to March 31, 1978.

The objective of this task is to research and understand all aspects of Marine Mammal Protection, and what marine wildlife is protected in the area of the chosen site. The purpose of this task is to ensure that Keystone Lite Truss Spar will not harm any marine mammals during the installation, production and decommissioning of the platform. Marine mammals are sometimes affected when offshore platforms are installed. Endangered marine mammals that are typically affected by offshore platforms include the sperm whale. Other marine wildlife that are usually affected by the platforms are sea turtles, birds, and fish. All negative effects the platform may have on marine mammals in the area, VCBG Intl. will have a thorough knowledge about and will provide possible solutions to the problems. VCBG Intl. will follow all sections of the Marine Mammal Protection Act, and The Endangered Species Act.

5.14 Economic Evaluation

5.14.1 Task 55- Construction Cost

Manpower: Doran Golemon
Duration: 3 hours
Time Period: 2/22/16-2/22/16
Dependency: Task 4
Tools: Excel

Project cost is divided into design, construction, installation and transportation, pipeline, and risers. The economic parameters for the spar are inputted in Excel. The Excel sheet format is broken down to show the input values gathered after the weight of the structure is confirmed then used to make the calculated values. Titles will be put next to each input with a main title over the inputs that are related to main calculations like each alternative's construction costs, pipeline cost, and the chosen field input data. The data inputted can now be used to do calculations for the revenue and cost can be calculated.

5.14.2 Task 56– Taxes and Royalties of the Spar

Manpower: Doran Golemon
Duration: 3 hours
Time Period: 2/23/16-2/23/16
Dependency: Task 4
Tools: Excel

The objective of this task is to obtain taxes and royalty rates for the chosen location in order to calculate the appropriate revenue for the project. Taxes and royalties will be determined for the spar. Royalty rates for outer continental shelf locations in the Gulf of Mexico will be used for the chosen field, because moving past the continental shelf the taxes will be federal with a standard rate. The information gathered in a literature review for the taxes and royalties will be used in the Excel sheet made for the project cost. The data will be used to calculate the revenue after royalties and taxes.

5.14.3 Task 57– Investment Calculations of the Spar

Manpower: Doran Golemon

Duration: 3 hours
Time Period: 2/24/16-2/24/16
Dependency: Tasks 55, 56
Tools: Excel

The objective of this task is to calculate the investment parameters for the spar in order to obtain adequate revenue the project will have. The internal rate of return (IRR), breakeven period, net present value (NPV), and the life cycle for the project's production field will be determined from revenue and cost calculated in Tasks 55 and 56. The information gathered in the literature review will plug into the Excel sheet and calculate the IRR, NPV, life cycle, and breakeven period. A typical offshore structure project has a return on investment of 20% to 30%. The NPV and IRR will be calculated with the revenue gained each year after taxes and royalties. The breakeven period will be calculated from plotting the total cost and revenue for each year and the years previous to determine where the total revenue equals total cost. The desired lifecycle of the project will be calculated from the chosen field and the desired production rate.

5.15 Project Reporting

5.15.1 Task 58- Project Report

Manpower: Benjamin Valentine, Brittney Crawford, Doran Golemon, Sarah Braden
Duration: 40 hours
Time Period: 2/15/16-4/25/16
Dependency: All
Tools: Microsoft Word

The MASE 407- Phase II Mid-Term and Final Report are driving milestones for project scheduling. These reports will be a combination of the aforementioned tasks with the addition of a short report summary of the projected environmental impact concerns of the project. Requirements and subsequent content for the MASE 407 Mid-Term Report and Final Report will be dependent upon transmission of project reporting requirements and expected outcomes from Prof. Juan Horrillo.

5.15.2 Task 59- Project Presentation

Manpower: Benjamin Valentine, Brittney Crawford, Doran Golemon, Sarah Braden
Duration: 24 hours
Time Period: 2/15/16-4/29/16
Dependency: All
Tools: Microsoft PowerPoint

The MASE 407- Phase II Mid-Term and Final Presentation are driving milestones for project scheduling. This presentation will be a combination of the aforementioned tasks with the addition of a short discussion summarizing the projected environmental impact concerns of the project. Requirements and subsequent content for the MASE 407 Mid-Term Presentation and Final Presentation will be dependent upon transmission of project reporting requirements and expected outcomes from Prof. Juan Horrillo.

6 Gantt Chart

Included is this section is a “Design Phase Gantt Chart” displaying each of the 60 tasks and a “Housekeeping Gantt Chart” denoting each of the important reporting and presentation milestones as well as advisor and internal group meetings.

6.1 Design Phase Gantt Chart

The project Gantt Chart displays tasks to be completed for MASE 407- Capstone Design II. This is the design process execution stage of the Keystone Lite Truss Spar. The Gantt Chart is a detailed visual representation of the event sequence and includes task duration, start and end dates, responsible person(s) to complete the work, and the critical path. The critical path involves the sequence of stages determining the minimum time needed to complete the Keystone Lite Truss Spar design. The Design Phase Gantt Chart serves as an accountability tool to verify VGBG International is continuing to produce the product in a timely manner.

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6.1 House Keeping Gantt Chart

The house keeping Gantt Chart is an internal reporting schedule in order to aid VCBG International in day to day scheduling operations. The house keeping Gantt Chart includes advisor meetings, VCBG International internal meetings, and major deadline milestones.

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7 Environmental Effects and Impact

In order to protect the environment, VCBG International will comply with all environmental protection regulations from American Bureau of Shipping (ABS) and Marine Pollution (MARPOL). Regulations enforced will include sections regarding sea and air discharge of all waste. Chemosynthetic communities are also considered for installation of the Keystone Lite Truss Spar and necessary pipeline. These communities consist of clusters of clams, mussels, and tubeworms found in areas where hydrocarbons are present or where active oil and gas seeps occur as seen in Fig. 9. These communities are protected in the Gulf of Mexico by the Marine Mammal Protection Act (MMPA) and must be avoided by all offshore construction activities by 250 feet (National). Suction pile anchors will be used in the design of the Keystone Lite Truss spar in order to aid in the protection of these communities.

Figure 9: Chemosynthetic Community reprinted from Cordes (2015)

GC 903 and the pipeline installation path are clear of all chemosynthetic communities allowing the Keystone Lite Spar to be properly installed without disturbing the marine communities on the sea floor.

8 Safety Considerations

Safety is of the upmost concern for VCGB International. VCBG International is committed to managing health safety and environmental policies in order pursue the goal of no harm to the people and the environment. In order to do this VCBG International will abide by all SOLAS, and OSHA rules and regulations throughout the design process.

9 Conclusions

VCBG International will design and analyze the Keystone Lite Truss Spar, an offshore oil and gas truss spar production platform located 140 miles off the coast of Louisiana in the Heidelberg Field of the Gulf of Mexico. The Keystone Lite Truss Spar will have a net present value of $3.1 billion, internal rate of return of 27.8%, and breakeven analysis of 3.67 years. The structure will be designed for 80,000 barrels of oil equivalent per day at a water depth of 5,000 ft. Heidelberg Field was selected for its estimated recoverable resources of up to 400 million barrels of oil and its proximity to pipeline infrastructure. The Keystone Lite Truss Spar was determined as the most feasible structure candidate when compared with a conventional tension-leg platform and semi-submersible. Economic and technical feasibility were proven, including superior stability characteristics and ability to operate dry tree wells. The design phase of the Keystone Lite Truss Spar will be executed over a duration of four months from January 18, 2016 to April 29, 2016, where the design will be completed on April 29. The project is expected to be completed with a total of 800 man-hours. The design execution phase is separated into 15 main tasks. Within each main task is a number of subtasks that serve to divide work into manageable sections. A design phase Gantt chart is included as a visual representation of the overall and specific task timeline as well as an accountability tool. Throughout the entire design and analysis phase, VCBG International will consider the environmental effects and safety as the highest priority.

10 Contact Information

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11 VCBG International Resumes

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12 References

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13 Appendices

13.1 Appendix A- Economic Analysis for Truss Spar Platform

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13.2 Appendix B- Economic Analysis for Semi-Submersible Platform

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13.3 Appendix C- Economic Analysis for Tension-Leg Platform

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