SAND2006-5337P

# Gulf of Mexico Shelf Downer Problem

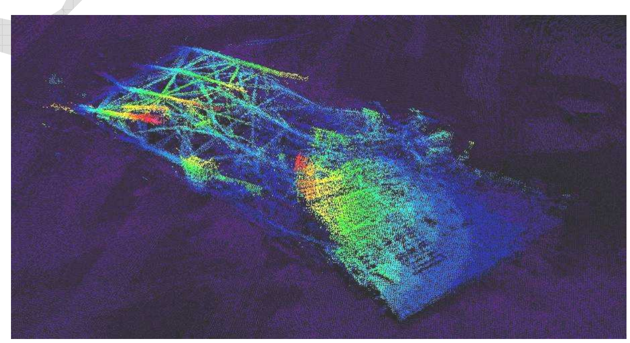
## 1. Problem Statement:

Several BP jacket-type platforms located in the Gulf of Mexico were collapsed by hurricane Katrina last year. The platforms, located on the gulf shelf, are in waters ranging in depth from approximately 80-135 feet. The ages of the downed platforms range from 30-40 years. The platforms are attached to the seafloor with a number of piles that range from 4 to 16 piles per platform. There are several pipelines that connect to each platform, ranging from 2 to 5 per platform and each platform also contains multiple wells, ranging from 2 to 12 per platform.



The state of the collapsed platforms is relatively unknown because visual inspection by divers is hampered by low visibility caused by murky waters. There are sonar-based images available that provide a rough idea of what the platforms look like currently, but without enough detail to identify key features (e.g., jacket members that may have separated at a joint from the rest of the structure) and/or smaller obstacles. Also prior industry experience indicates that although the platforms have collapsed, significant amounts of stored (elastic) energy may remain in the deformed structure. This stored energy could pose a potential danger to divers during the process of removing the platforms and cause significant complications for dismantling operations.

BP needs the collapsed platforms removed within the next two years. The wells need to be plugged and abandoned, and the process of platform dismantlement and removal must be performed with utmost safety and without significant environmental release.



## 2. Applicable SNL Technologies:

SNL's expertise in signal and image processing and in high-performance supercomputing may be able to enhance the downer sonar images to the point of identifying critical detail needed for the dismantlement process. If needed, SNL can propose alternative methods for developing internal-external 3D imaging of the platforms using underwater lasers

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(LDRI/LIDR)[1], high-intensity x-ray, and advanced sonar/ultrasonic technologies. X-ray diffraction technology may also be able to determine stored-energy in-situ. If this can be done, modeling & simulation coupled with testing facilities & capabilities put SNL in a unique position to bring to bear a comprehensive approach to the BP downed platform problem. For example, a scaled model of a jacket structure can be built and loaded to the point of collapse similar to the downed structures. An analogous computer model of the structure can also be built and loaded as per the scaled test. The various techniques described below to ascertain the state of the structure can then be assessed on the scaled-model and the results verified with the simulation. Once the technique is verified and validated, it can then be applied to the real structures. Real-time monitoring of structure orientation with RF/sonar-tags could determine any variance between analyzed stresses and resulting stresses during dismantling (for example, due to sea-floor interactions).

## 3. Possible Solution Paths:

Getting good images of the downed structures is paramount to any subsequent efforts. It is imperative to have a better knowledge of what the downed platforms look like in their current state because much of what follows needs detailed information about the deformed shapes of the structures; which members are still attached to other members; and what members are candidates to move upon removal of another specific member. Consequently, one proposed Phase 0 effort could be to take, as a sample, the BP data used to generate one of the downed images and allow SNL's signal & image processing group to use its high-performance computing capabilities to see if they can generate a cleaner image of the downed structure.

Conversely, all problems become more manageable if there is unlimited visibility at the individual downed platform sites -- for access during the dismantling process and for stored-energy evaluation/mitigation. SNL offers two ideas to address the issues from this perspective, both of which would require the primary design effort on the part of offshore construction firms with minimal effort from SNL. One approach would use an equalized-pressure cofferdam and the other differential-pressure cofferdam. The equalized-pressure cofferdam would simply be a portable barrier that only needs to minimally withstand ocean-current forces. It could be composed of movable pilings (with buoyancy capability for transport to sites) surrounded by a flexible or jointed envelop (metal or fabric material). The, e.g. 30m x 60m, enclosure would surround the platform. Filtered water would be pumped into the membrane displacing the low visibility water of the surrounding expanse. The increased visibility would greatly facilitate dismantling operations/safety and greatly enhance visibility. A reported, specialty, metal cofferdam with approximately one-half the require area cost $6M[2] (~$10M in 2006$). Multiple dams would allow parallel projects that further reduce cost by diversifying logistics risks.

The second option would produce a still floatable/submersible coffer dam, but one that could withstand the one-sided (differential) pressure up to even possibly 60psi (135 feet

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[1] http://en.wikipedia.org/wiki/Laser_Dynamic_Range_Imager; http://en.wikipedia.org/wiki/LADAR (Starfire Optical Range image is from SNL).
[2] http://www.usace.army.mil/usace-docs/eng-manuals/em1110-2-1605/c-6.pdf

depth). A quick assessment indicates that pumps available on the vessels BP would use, could remove the water from the coffer dam in a few days or less. Further, it could retain an adequately dry environment, thereby creating a "dry" site in which the dismantlement can take place as if it were occurring on dry land. The military reports the "normal" use of 20m high differential-pressure cofferdams even 20 years ago.[2] The differential-pressure cofferdam shown in the figure below is over 80 feet high and of comparable dimensions to that needed for the downers.[3] Highly reliable/safe dams could be built and used at depths beyond what BP currently needs.

The main idea is to build a cofferdam onshore and float it to the site. The cofferdam would be of sufficient size to encompass the plan view of the downed platforms and be as tall as necessary to reach above the surface of the water. The cofferdam interior could then be drained to allow working under dry conditions. Cranes could be installed on the corners of the cofferdam to facilitate working on the downed platforms and interacting with barges topside. Cranes could also be placed on the bottom to assist as necessary. Installation issues such as an uneven bottom surface could be addressed by making the bottom of the cofferdam out of hardened steel that would slice through any debris or rocks on the bottom surface. The steel would be wedge shaped to allow for easy penetration into the sediment. The coffer dam could be of locking, modular (e.g., concrete/metal components with buoyancy chambers) to minimize construction complications.

Because the primary concern during dismantlement is the stored (elastic) energy in the structure, the detailed path of how the structure got to its final configuration may not be completely necessary to get a first order estimate of the stored energy in the system. Assuming that we have a fairly good idea of the current state of the structure, a computer model of the structure can be built to simulate and hypothesize how the structure got to its final state. Once the computer model simulates the structure into its final configuration, it can subsequently be used to predict how the structure will respond and deform upon removal of its various members during the process of dismantlement. To verify that the computer model is indeed simulating what is really happening, it would be useful to build a scaled-model of a framed or space structure similar to a jacket structure and subject it to severe loadings that collapse the structure in a fashion similar to the full-sized jacket structures. Subsequent dismantlement of the scaled model could then be simulated with a computer model of that structure to verify that what the computer model predicts is indeed what happens in the physical scaled-model.

Conceptually there may be ways of mitigating the effect of spring back in a member when it is severed during the process of dismantlement. In an effort to minimize or

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[3] http://www.wai.com/Construction/cons-coffer.html

eliminate spring-back of longer members, simultaneous severing of both ends with shape charges should be considered. Among other concepts to consider are devices that could go around a member to take the member load (this device might also have built into it the capability to unload itself after cutting the member, thereby safely releasing the stored energy). There may also be ways of deducing if a member is stressed, by relying on simple elasticity solutions to change in stress induced by cutting a hole in a stressed plate. For a tubular member, it would probably be necessary to monitor four points around the circumference of the member to identify bending stresses. As an alternative to cutting a hole in a member to see if it is stressed, it may be possible to use x-ray diffraction to do this.

## 4. Schedule:

Phase 0 –

- Take sample sonar data and let SNL's signal & image processing group try to improve imaging; perform scoping computer model calculations for a simple scaled test; perform scale test planning to evaluate approach viability ($115K effort - approximately 3.0 person-months, including travel.)

Phase 1a –

- If can get improved images from phase 0 effort, proceed with imaging of all downed structures; Perform scaled-model test on simple structure on land; assess various techniques for taking member load and determining member stress to see if feasible; Perform computer model simulations of test to see if simulations correlate with results coming from physical scaled-model. (Budget TBD, based on final scope)

Phase 1b –

- Perform scaled-model test of one of downed platforms in water; assess various techniques for taking member load and determining member stress in water to ensure approach validity; perform computer model simulations of test (Budget TBD, based on final scope)

Phase 2 –

- Work with offshore contractor(s) to coordinate field-scale demonstration on one downer; build and run computer model simulation of downer; use most promising techniques for assessing state of structure; transfer technology to offshore contractor(s) for general use. (Budget TBD, based on final scope)

Phase 3 –

- Develop advanced methods to reduce cost and improve efficiency for Downer evaluation, analysis, and dismantling. (Budget TBD, based on final scope)

Phase 4 –

- Develop remote sensing techniques for store energy assessment. This will require new R&D on material properties that sensors can exploit. (Budget TBD)