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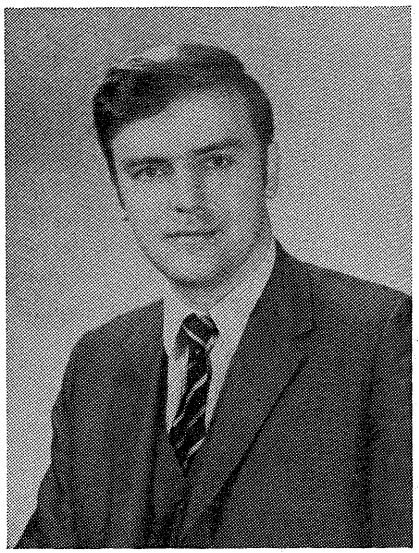


Mr. Peter M. Lovie.

Mr. Peter M. Lovie, president and co-founder of Engineering Technology Analysts, Inc. (ETA), has been active in the offshore field for several years. Prior to forming ETA, a Houston-based engineering firm, he gained experience in the oil and gas industry in Houston, Texas, at Cameron Iron Works, Inc. and the Offshore Company. Mr. Lovie has made numerous studies of the strength and behavior of mobile offshore drilling units under various storm and other operating conditions which have resulted in many innovations in drilling unit design by ETA. He received his B.Sc. degree from the University of Glasgow in Glasgow, Scotland, and was awarded an E.S.U. joint fellowship to study at the University of Virginia in the U.S. where he obtained his Master of Applied Mechanics degree. He has published many technical papers and holds several patents. He is a registered engineer in Texas and a registered engineer in the U.K. A native of Glasgow, Scotland, he therefore carries with him an understanding of the European and U.S. viewpoints on recent progress offshore. "Northern Offshore's" U.S. correspondent interviews Mr. Lovie.

— There is much discussion concerning which is the best unit to use for drilling in the North Sea, the jack-up rig or the semi-submersible. Since you have made detailed studies of the situation, what are your conclusions Mr. Lovie?

— The point of view that jack-up designs are not feasible for the North Sea is a valid one if you take existing jack-ups and just make them bigger, at the same time adhering to the old oil patch idea that "if big is good, bigger is a whole bunch better." It is quite true that using that theory jack-up designs rapidly get out of hand in terms of cost. In that case, semi-submersibles win easily. Then, too, there are trends. People in the industry, especially in the North Sea area, perhaps went a little to one extreme over the semi about three years ago. Now, however, they are realizing that there are a lot of areas with up to 350 ft. water depths in the Notrh Sea that can be drilled better with a jack-up.

A jack-up has a number of advantages. Perhaps the most important one is that since it is the closest thing to drilling on land that you can get offshore, the proportion of time spent actually drilling is higher than with semi-submersibles. Some contractors maintain that it is easier to find crews to work on the jack-up. Now it's true that it is difficult to get on and off location with a jack-up in rough weather and in the past jack-ups have been unable to withstand the more extreme North Sea environments, but innovations are now being made to solve these problems.

There have been a lot of problems in the construction of semi-submersibles that cause delays, cost overruns, and very rapidly increasing construction costs. Consequently, where emphasis has been placed on the ease of construction of semi-submersibles, they have been more successful — such as with the outstanding Aker H-3 design. Incidentally, this is the approach we have taken too in ETA's design of a small semi-submersible that will be easy to build, for less severe S.E. Asia or U.S. Gulf Coast criteria. There seems therefore to be two trends: 1) towards easier-to-build semi-submersibles and 2) towards very much higher construction costs (maybe 50 % more than 2 years ago!).

As the trend to deeper water in the North Sea continues, the demand for semi-submersibles has increased. These units are needed in the deeper waters. Operating semi-submersibles in shallow water is costly at the up to $ 30 to $ 40 million it now costs to construct and equip one. Although semi-submersibles are designed and rated for 600-ft. plus water depths, available information indicates that the majority are being used in the 300—450 ft. range. In a great many locations, the jack-up rig can easily handle these depths and at a much more reasonable cost.

— Is it your opinion then that the time has come to use the jack-up rig in the North Sea?

— Yes, they've always been used there to limited extent, but there are now strong economic reasons for extending this considerably. Several industry sources are predicting a shortage of jack-ups in the North Sea each year for the next several years of 21—25 units. Analyses made on the technical problems of getting a jack-up rig on and off location, operating under the severe North Sea wind and wave conditions, construction

costs and operating efficiencies all indicate that it is practical to use the jack-up rig in up to 400 ft. water depths. The first such study was made two years ago: the *Oil & Gas Journal* ran a story on it. [1]

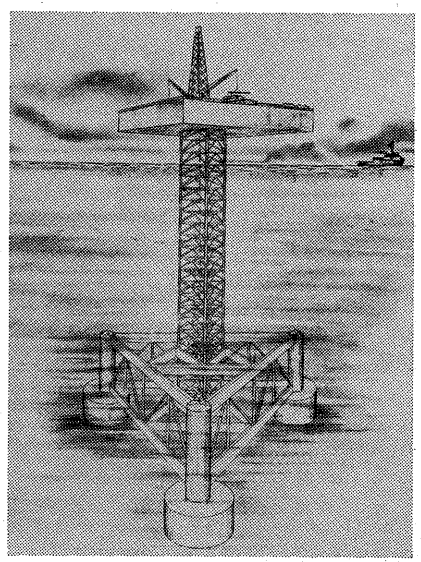
Such a unit could be applicable to the North Sea at water depths like this where rough weather causes excessive loss of drilling time with semi-submersibles.

— You have touched upon some problems confronting the use of jack-ups to be used up to about 400 ft. of water depth and commented that the analysis indicated that jack-ups could be used. Would you give some of the details of the problems you mentioned and what solutions you or others have found to overcome them?

— Let's start with the difficulty of getting a jack-up on and off location. The problem naturally increases with greater water depths, the consequent increase in leg length, the increases in inertia of the hull/leg combination. This problem is compounded by the rough sea conditions that prevail in areas where such a large unit may be used. The unit may have to get on or off location with 10-foot swells running, or in higher, confused seas. It's a difficult problem to quantify. We ended up about two years ago developing a mathematical model of the problem, formulated as a computer program. Then we could try fiddling with all the variables to see what was important. It gave us many insights into what to do.

We decided that a whole fresh new design philosophy was needed in the basic structure of the jack-up rig unencumbered by past traditions. We took the approach of designing the rig from throughout from scratch. Our Norwegian friends have compared this approach to that taken on the extremely successful Aker H-3. In fact, some of them describe our ETA Europe class jack-up design as the *"Aker H-3 of jack-ups!"* It is not a bad comparison. Much of what we have done is the result of a great many computer-based analyses, including structural, naval architectural, and dynamic analyses. Some of our principles are completely new and in fact, we have acquired patents on many of our design features. At the same time, a lot of practical marine experience went into the design, too.

With most jack-ups, it is necessary to take some of the top of the legs off so they will not get too top heavy while the unit is in tow causing the dynamic stresses to become too severe and causing lack of stability. Several approaches have been taken in this area in the past. Some owners believe in mechanical disconnects to take off the top portion of the leg and then put it back again. We frankly are prejudiced against this method since the mechanical device has to keep working throughout many years of submersion, and since it has to be installed in one of the most highly stressed areas of the legs. I wouldn't feel safe working on one with this feature. Other people just cut some of the leg off and then weld it back on when the unit has finished its ocean tow. With our new information and designs, we have been able to provide a jack-up that can be towed on ocean tows without taking the top of the leg off. The important thing is mobilization; you save time with this design which means you save money. If you have to make the payments on a $ 18 million piece of equipment, even a few days is a pile of interest!



ETA Mobile Monopod, operational.

The ETA range of jack-up designs are very light in terms of steel weight for a given function. Performance has been checked out very thoroughly. It was the thoroughness of analysis and the scientific approach to designing the unit which has resulted in these very light-and-economical-to-build designs. Like in so many of these engineering ventures, "doing one's homework" has paid off handsomely in shipyard weight i. e. costs.

The Europe class jack-up was specifically designed for North Sea operation under very severe criteria in up to 260 ft. of water. The criteria for this unit are more severe than for any jack-up currently in existence. The unit can also be stretched to operate in up to 350 ft. water depths under less severe criteria. The other two jack-up designs currently being contracted are the ETA Asia class and ETA America class jack-ups. The former is used in milder conditions such as S. E. Asia or the U.S. Gulf Coast, in up to 300 ft. of water. The latter is used in more severe environments in up to 430 ft. of water.

In the course of our design and consulting engineering practice our engineers have worked with nearly every design of jack-up in existence. Consequently, we feel that we know many of the good things as well as the bad things about practically everything out there; therefore, we have known what to avoid and what to include. For this reason, this experience input has been important. In addition, a number of design innovations had to be made, especially in the design of the legs. If there is too much leg up there with the wrong shape of hull, stress and floating stability get critical because the rig will be top heavy. One can enter a vicious circle in the design process too: there is a need to make the jack-up strong enough to resist wind, wave and dead weight loads. At the same

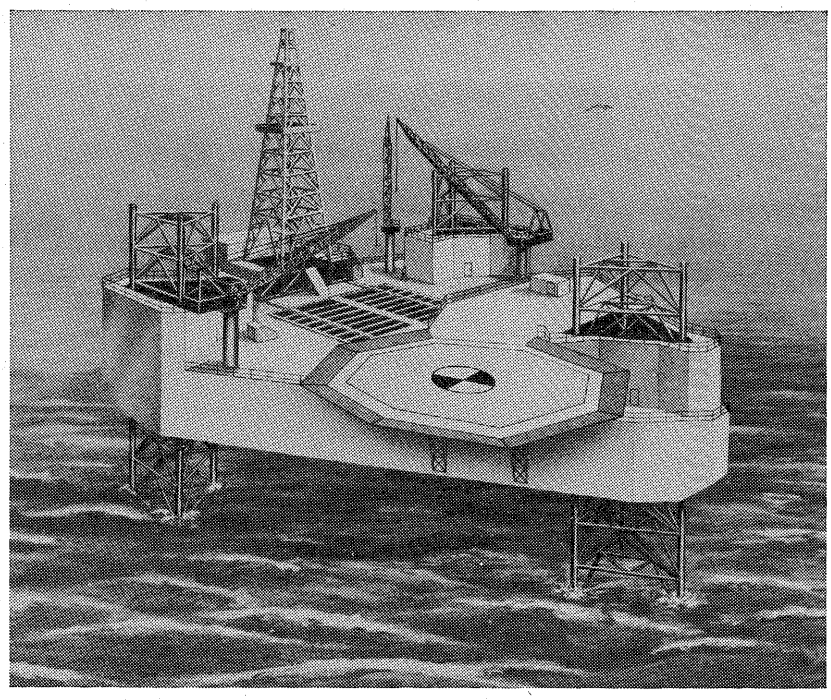
[1] Lovie, P. M., Lowery, E. L., "Jack-up for 400-ft. Water Depths Feasible", *Oil & Gas Journal*, pp. 86—89, January 10, 1972.

time the size and steel weight makes these loadings worse. It gets difficult to burst out of this trap when faced with these extreme North Sea conditions. It's kind of the same problem aircraft designers have (maximum speed, minimum drag, minimum weight possible).

Concerning wind and wave conditions, as water depths increase, the wind and wave storm criteria usually become more severe. Stresses caused by storm action tend to increase exponentially with wave height and wind velocity. Location influences this too: a rig designed for the severe storm conditions typical of 400 ft. of water in the North would probably be good for 500 ft. under less severe conditions such as those found in the Gulf of Mexico during the non-hurricane season or off the coast of West Africa. To be useful and safe in the areas where 400 ft. jack-up rigs are needed, the unit may have to be able to withstand perhaps 125 mph winds and 80 ft. waves.

In 1972 we had designed such a *jack-up rig — good for 400 ft. of water with 80 ft. waves and 125 mph winds.* A second unit was then designed to operate in 100 ft. waves and 125 mph winds. However, back then, we got very little interest from owners — it was probably too much of an advance over existing units. Even now, two years later, it is still or seems to be more than anyone wants to invest in. Maybe they think it's too wild an idea, I don't know.

Technology had previously limited the jack-up to water depths of 300 to 350 ft. However, a great deal of designing has been done. ETA has always tried not only to stay abreast of current technology but to actually lead in the field. There's a balance between methodical progression and taking bold new steps. For example, on the innovative side, we now have the ETA Mobile Monopod which is a novel design of a gravity-based exploration, drilling, and production unit. The unit is designed for service in up to 450 ft. of water and the severe criteria of the North Sea.



Europe class jack-up, operational.

I have to admit the Monopod is a weird looking thing. It has a big hull at the bottom and has a single center leg. Its upper hull sits on the lower hull: the upper hull acts as an erection platform for building the single leg during construction. The completed unit is about 600 ft. high overall.

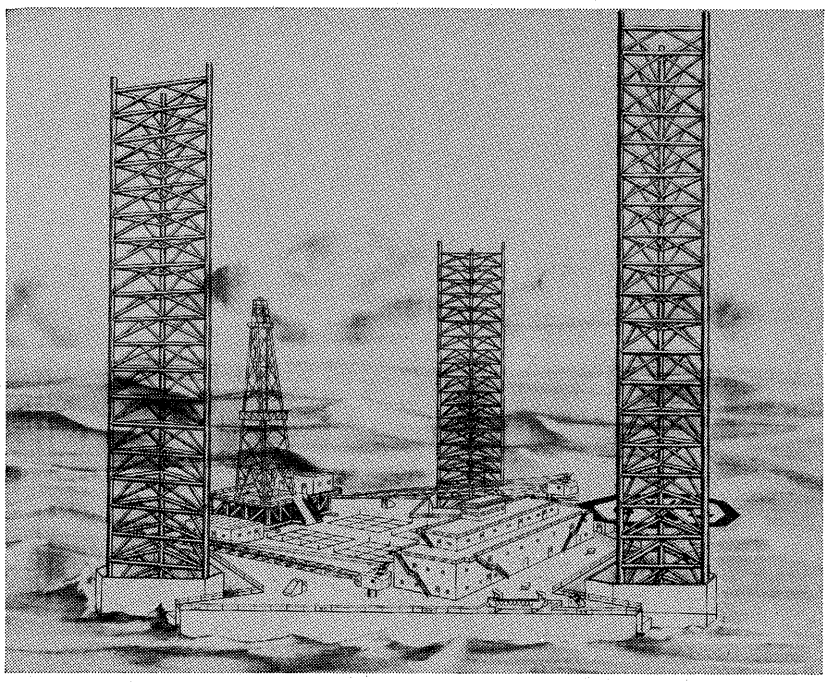
When the Monopod is taken to location, the lower hull is, of course, flooded and lowered to the seabed using the jacking system in the upper hull. When engineers have a situation requiring controlled flooding, there is always the mightmarish possibility that the flooding could go completely wrong and the platform would be lost. The flooding problem can be a tough one. It is a problem for gravity structures, particularly those built out of steel for deeper water such as 400 ft. and above. In the new type of rig we have devised, the ETA Mobile Monopod, you still have a control system for efficiency but in addition you have a safety guard since even if flooding of the lower hull goes all wrong, there's enough buoyancy in the upper hull to enable the unit to still be placed on location. We feel this is truly an innovation — never offered before. And of course, with the single space frame leg, the unit is very transparent to the waves, thus reducing wave forces dramatically.

— Since vast expenditures are plaguing the exploration and production of the necessary oil and gas to provide the world with energy, what is the situation relative to cost of the jack-up rig being used more extensively?

— It's trade-off between construction cost, drilling performance, number of holes to be drilled and operational water depth. A North Sea jack-up for up to 350 ft. of water will cost about $ 19 million ready to drill. It's a matter of whether you can get the same drilling performance from a semi or a ship. I don't think you can. So if you are in a part of the world where there are enough holes to be drilled in that water depth, then the jack-up is the obvious choice.

— Since operating costs on mobile offshore drilling rigs are skyrocketing, what are some of the ways to overcome this necessary expense?

— I'm not sure they're skyrocketing as badly as construction costs. Operation costs are formidable, especially in the conditions experienced in the North Sea. This was a factor that influenced the design of the ETA Europe class



ETA Deepwater jack-up, in tow.

jack-up. The consumables capacity for the jack-up (usable payload of liquids, diesel oil, liquid muds, dry mud, dry cement) is twice that for any existing jack-up. This is of particular use in the more remote, hostile areas where the rig cannot be supplied as frequently as the owner would like. This means that the rig can keep on operating although the supply boats can't get alongside for, say, a month. This is a most significant factor on operational costs, particularly in the North Sea.

Another approach already taken in the North Sea to save on operational costs on the production side is the mobile drilling unit as a production facility. Phillips did it at Ekofisk for awhile. The ETA Mobile Monopod rig, discussed earlier, can be used for exploration and then if oil is found, the rig can be left there as a production platform, with capacity for crude oil storage already built into it. This is especially advocated for the North Sea by many people as a means of getting an early cash flow from a field.

— Mr. Lovie, do you believe that the *problems of going above the 62nd parallel* will be extensive and expensive?

— The geological work indicates it may be very extensive. Expensive — yes, very expensive. From the design point of view, it is a problem that will have to be considered very, very carefully for drilling above the 62nd parallel. We've had enquiries for operation for further north than that too, with all kinds of ice problems. However, I believe it will be tough from an operational point of view, beginning with personnel. Just getting people to work under these conditions on the rigs will be a real problem because of the extreme cold. For example, if someone falls overboard — they can hardly live long enough to be fished out. It will be a matter of simple survival. Here's where the oil industry can learn a great deal from the Norwegians and others that have worked in these harch conditions for generations past.

As far as equipment is concerned, the ETA Europe class jack-up could probably be used up there in many places. Acceptable locations depend on what the criteria are for the wind, currents, waves, ice conditions, water depths. Given what the oceanographers say, we can figure out how to meet those problems. However, one has to be very careful about what material is used in these units. You get into continuous roughness of the water causing fatigue problems that don't exist elsewhere. You have that problem compounded with the very low temperatures which make it an extremely demanding area for materials, but there are probably areas where one can operate jack-ups up there.

Another problem about drilling above the 62nd parallel is that even though oil is found tomorrow, there is still the problem of getting the product to shore and that implies difficulties with production systems and laying pipelines. Much further south, the Forties Field, it has been difficult enough. I believe there were about 70 days of pipelaying this past summer, and they had expected to have about 230, about a third of what was expected. That is in a rough area but not as bad as would be experienced farther north. That pipeline is about 230 to 420 ft. deep which is deeper than has usually been laid in the past. But again it is not as deep as many other areas are. So going above the 62nd parallel implies a lot more than just drilling problems.

— Mr. Lovie, since ETA has considerable experience in the design and analysis of all types of offshore drilling units currently in existence, as well as in marine pipelaying and pipe stress analysis in fields all over the world, what is your opinion with regard to the potential output of the North Sea oil fields?

— I believe it may ultimately change the pattern of U.S. dominance in offshore drilling. But let me explain. I'm no geologist or petroleum engineer and it's really these experts that have to come up with information on what the potential will be. Our opinion here is based on what people with drilling contracters or oil companies say to us, that is, for the foreseeable future that the entire area is just going to keep on its explosive growth.

There has been a steady sequence of dramatically large finds. With the crisis of the energy shortage and the price of oil shooting up

the way it has in the past few months, the whole complexion of the industry has changed. Put that change on top of the increasing pattern of strikes in the North Sea in areas that a year ago were relatively inactive and you have a tremendous demand for drilling rigs. Delivery time on drilling equipment is getting longer and longer. The pressure for new sources of equipment and services has thus become intense.

Some changes will have to be made in the supplying of offshore equipment and changes in the people who build rigs. Several European companies have very successfully got into the semi-submersible building business, challenging the dominance of their traditional U.S. counterparts. Right now the jack-up business is dominated by two or three firms. Their deliveries are getting into 1977 and their capacity seems to be at its limit. That too is changing, as will be found in the technical press shortly, with several new builders entering the field. I think we will also probably see some changes in the people who make drilling equipment and prime movers that go onto the rigs because the traditional suppliers have got so bogged down. Right now, it is difficult to get drilling equipment deliveries anywhere better than the last quarter 1976. And there are some pretty sharp, progressive organizations in Europe that have good manufacturing facilities, too. In Norway in particular, you have a tradition of working in the North Sea for hundreds of years. The way that a small group of men work together under sometimes severe conditions on a ship is analogous in many ways to offshore drilling. Similarly, the Norwegian shipowners are analogous in many ways in their approach to business to the people that direct drilling companies. Both weigh risks carefully, act rapidly and aggressively.

All of these resources, coupled next with the scale and speed of action of the Europeans in entering the offshore drilling business worldwide, are going to change the pattern of things. The Norwegian entries to the offshore drilling business in the last two years demonstrate the forces of change in action.

— When the North Sea finds first appeared, nearly all of the technique, equipment and money was said to have come from the U.S. Is this still true or have the people in the countries involved in the North Sea fields made headway toward becoming more a part of the actual participation?

— They have made giant steps. No one in the world has a corner on "smarts." Only for a short time does it appear to be true. The great pressure to find more oil offshore may now break down many of the traditional patterns in technology, equipment suppliers, sources of capital. It is an exciting time for everyone involved. Unlike many other offshore boom areas in other parts of the world, this one is right in the middle of a highly educated experienced group of countries with the commercial structure to take advantage of the situation.

The people in the North Sea countries have become involved much more and much sooner than was expected, certainly earlier than expected by many people in the U.S. We've watched it happening from a kind of neutral position in that ETA is completely independent. This means that ETA designed rigs can be built in any yard that has the necessary technical capability. We work for Americans, Canadians, Frenchmen, Norwegians, British, and so on. We have seen this has opened up a number of opportunities for companies to get into the mobile offshore drilling rig construction business. The problem, however, still remains that there are not enough skilled people in the North Sea countries. It's a worldwide problem. The North Sea areas are fortunate in having many good marine people, although not enough drilling people. The need for technology seems often to boil down to the management teams with the years of experience from the U.S. who know what they are doing.

— Is there cooperation between companies in the industry on both sides of the Atlantic? Or do you think that there is something lacking in the business relationships of companies on both sides? If so, what do you think is the solution?

— It seems to us that there is pretty good cooperation. Occasionally there are national and company prides to be taken into account on both sides of the Atlantic, but that's inevitable. We do a lot of work over there now, and we've made many friends over there. I greatly enjoy working with our European clients; there's a thorough professional and yet really progressive and fast moving approach in their thinking so often that is very stimulating.

It makes basic sense for new companies, and even governments, involved in getting the oil out of the North Sea to cooperate with a company in the U.S. that already possesses the necessary technology. And in turn, it makes sense for a company with worldwide experience to apply that knowledge in the North Sea.

— Mr. Lovie, in this interview you have stated the needs of the future for the North Sea with regard to equipment, especially jack-up rigs. You have informed our readers of many innovations. To what do you attribute the success which you have had?

— There are the obvious technical reasons: meticulousness, experience gained from engineering work on a ride of assignments, and a fresh, creative approach in design. And then there is a lot of very hard work. But fundamentally, it is simply that ETA has been fortunate in having a young, live wire team of people with a mixture of backgrounds and talents: different engineering disciplines, different types of experience, different nationalities even. We're in an exciting interesting business, and when you have an enthusiastic creative group like this, really functioning as a team, then there's very little limit to what you can do.