Space & Offshore

Future Opportunities for the Offshore Industry

Authored by Knut I. Øxnevad©.
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Parallels Between Offshore and Space Technologies (Introduction)

Why is it important for the offshore industry in general and the Norwegian offshore industry in particular to understand and explore the parallels between offshore and space technology?

Parallels can exist on different levels. One may see parallels between components and concrete technologies, such as robotic arms. There may be parallels between systems, such as life support systems. And finally, there may be similarities between the way different functions such as maintenance and repair have to be planned and carried out. All these different levels are included in the wide term of technology used here.

Parallels mean similarities. This means that if parallels exist similar technology may be used in both sectors. There may be technologies developed for the space industry that may find applications also in the offshore industry. More importantly seen from the point of view of the offshore industry, there may be offshore technologies with space applications. This is especially interesting when these offshore technologies are ahead, in development, of similar space technologies. When that is the case, technology developed for the offshore sector may in a slightly modified version also be used in space projects.

At the company level, this would mean new markets, increased sales and a higher degree of utilization of already developed technology. At the bottom line this would mean a higher net present value (NPV) on the money invested in developing a new technology. This in itself should be a good enough reason for any offshore company to get involved with the space sector. Some companies like Oceaneering, SINTEF, NUTEC, Prototech and Det norske Veritas are already using their offshore expertise in a number of space projects. Other companies such as Kongsberg Offshore (KOS) have the relevant expertise, but are at this point unfortunately not involved in the space sector.

Seen on a national scale new opportunities and markets for the offshore industry, in the space sector, would mean higher employment in that industry. Getting involved with the space sector would also mean getting access to various space technologies. If Norway wants to be at the forefront of technological development it would therefore be a smart strategy to also get involved with the space sector. A good way for Norway to get involved would be to build on the unique expertise developed in the offshore sector.

There is another dimension to this. Some companies especially SINTEF have been able to use what they learnt in their space engagements to further improve and make offshore technologies safer and more efficient. SINTEF UNIMED's diving helmet directly based on experience gained from their involvement in the concept study of the European Space Helmet is here a perfect example. Next, perhaps experience gained from the diving helmet may be used to improve the space helmet (See SINTEF). In other words, an infinite feedback cycle that should benefit both sectors has been set in motion. These should be strong arguments for getting the various oil & gas companies interested in utilizing the parallels between offshore and space technologies.

A company or an industry never raising the eyes to look at what is going on in other similar industries may end up developing technologies that have already been developed in other industries, or they may develop inferior solutions. The space sector earlier had that problem. Today however, they are actively looking at technologies and experiences from other sectors that may also be applied in their space projects. One such sector is the offshore and especially the subsea sector.

The issue of parallels between offshore and space technologies is not new in Norway. In 1986 a joint study between Norwegian and German authorities and industries, called "German/Norwegian Joint Study on Similarities between Space and Off Shore Activities" was carried out. Companies and institutions involved included Dornier Systems, NTNF Space - now the Norwegian Space Center, NUTEC, Statoil, Det norske Veritas and Norsk Hydro. The year after another study was done to look into the synergies between space and subsea. This report named "Synergy Effects Space - Subsea" was done jointly by NUTEC, SINTEF, Det norske Veritas, SI (Center for Industrial Research), Statoil, the University of Bergen and the University of Trondheim. At that point the Norwegian Space Center had the utilization of these parallels as a priority for the Norwegian space involvement. Unfortunately not much came out of these studies. As a result the Norwegian Space Center no longer puts priority to utilizing these parallels.

Why should offshore companies get involved in space now rather than later? To be part of future space projects requires early investments in technology developments, much in the same way, as has been the case in the offshore industry. There are today planned a number of interesting manned space projects where offshore technology can be applied. The International Space Station scheduled for the late 90's, and the US SE&I (Space Exploration Initiative) initiated and endorsed by President George Bush should be mentioned in this connection. The SE&I program sets forth for manned expeditions to the Moon around year 2000 and then to Mars 2015 (See SE&I). Naturally, a wavering United States Congress can delay these projects. On the other hand, not since the race to the Moon has the President personally committed himself and given space development a direction. Even if funds may be scarce a strong momentum has been created for developing the required technologies for these expeditions, both in the NASA (National Aeronautics and Space Administration) system and at a number of independent institutions. Therefore, any company or institution that wants to play a role in these projects should get involved now, rather than later...!

There certainly are a number of good arguments for the offshore industry to get involved in space projects! On the other hand their lack of involvement may be traced to the lack

Future of Today

of knowledge about what the space sector really is. Lack of knowledge easily leads to misconceptions. A number of people in the offshore industry has expressed that they felt that offshore technology was inferior to space technology.

At the same time people in the space sector are impressed with what they see of offshore technology. As an example a representative from NASA Ames was shown and explained the technologies that go into the construction and operations of subsea structures in the North Sea. After the session he was quite impressed and had one final question. "Why haven't these systems made headlines?". The person in question is directly involved in NASA's efforts of planning a future Mars base. This shows that there is a need to educate both sectors about each other and to improve communication between them.

We hope through this article, to be able to raise the level of knowledge about space and space technologies in the offshore industry and encourage offshore industries to actively search for and utilize parallels in their fields.

Space has many meanings. To start with space seems to be infinite and truly beyond our comprehension. On a more practical level space can be regarded as everything that is above an aircraft. For some people, space technology would mean satellite technology, for others, technology for exploring the universe, and still for others, technology to explore and set up bases on other planets.

The technological proximity of the space and offshore industries is especially relevant for larger manned space projects. Such projects can range from the planned International Space Station to manned expeditions and settlements on other planets.

Parallels exist between the offshore and space industries mainly because both sectors operate in extreme environments. Consequently there are extreme demands on technologies and systems. The consequences of failure in any such extreme environment can very easy turn out to be fatal for both man and technologies. Both space and the offshore industry, including subsea has therefore been willing to invest heavily in developing sound and efficient technologies.

The Space Environment

The space environment can be divided into two categories - free space, and planetary surfaces.

Free space has the same characteristics independent of place. There is no gravity, no oxygen and a state of vacuum exists. Accordingly, humans have to carry their own supplies of oxygen and protect themselves by wearing pressure suits. Radiation is also major problem. Space vehicles designed for longer interplanetary missions therefore, have to include some form of shielding mechanism. A solar storm can wipe out a whole crew. Consequently, special solar storm shelters have to be fitted into these space vehicles. Such shelters are likely to be surrounded by water or kerosene in a wax form.

The Moon and Mars are the only planets near Earth where a permanent human presence is possible at this stage. They are also the planets earmarked for exploration in the SE&I program (See SE&I).

On the Moon there is no atmosphere, no pressure - vacuum and no protection from radiation or solar storms. Again a solar storm shelter has to be built possibly from Lunar Regolith (Lunar surface gravel). Gravity is 1/6 of Earth's and the temperature can vary between degrees Celsius -173 to +127. Under these circumstances humans have to wear pressure suits that can protect them, even at extreme temperatures, and they again have to carry their own oxygen supplies. The low gravity on the Lunar surface makes weight of suit and life support system less critical. Because of the lack of atmosphere there is no wind and getting rid of dust and pollution constitutes a major problem. Dust tends to cling to any surface. Together with high surface tension this fine dust has rendered simple drilling operations for geological samples almost impossible.

Lunar Regolith also called Lunar soil tends to be rich in oxygen (41%) and silicon (19%). Metals such as iron, aluminum, magnesium, and calcium occur in an oxidized form, and their concentrations vary from highland to lowland locations. In addition to oxygen Lunar Regolith contains smaller concentrations of other volatiles such as He-3, He-4, Hydrogen, Oxygen, Nitrogen and carbon Dioxide. At one stage these materials and volatiles may be commercially viable to extract in connection with expeditions to Mars and beyond. He-3 may also find use in future fusion reactors on Earth. Communications delay or time for a radio signal to travel back and forth to the Moon is 2.6 seconds.

Mars on the other hand has a thin atmosphere, consisting mainly of carbon Dioxide (95%) and Nitrogen (2.7%). Surface pressure is still very low, at 0.006 bar, approaching vacuum. The atmosphere and the magnetic field around Mars give protection against harmful radiation. Gravity is 1/3 of Earth's, and lighter pressurized suits and life support systems would be critical for a successful exploration of Mars. Temperatures can vary between degrees Celsius -143 to +17.

Violent dust storms rage across the surface every year. Although the surface composition is similar to the Earth's, a higher concentration of iron oxide has given the planet its characteristic red color. Frozen water has been observed at the poles and is likely to found subterranean over most of the planet. Even the possibility of finding sub-surface liquid water reservoirs cannot be ruled out.

Mars also contains a number of materials that would be important for a permanent settlement there. Silicon (21%) and iron (13%) seem to be the most abundant. Other metals such as magnesium, aluminum, calcium, etc. occur in smaller concentrations. All these metals seem to exist in an oxidized form. Communications delay 10 - 41 minutes.

Critical Technologies

A number of technologies are critical for a successful exploration and finally - utilization of these space environments.

Safe, reliable and cost effective launch systems are important. Research is currently taking place to develop horizontal take-off and landing concepts for tomorrow's light launcher systems. These launchers will take off and land like a plane and, through advanced air-breathing technology, reach speeds up to 25 MACH (1 MACH = speed of sound) to escape the Earth's gravity field. The US NASP (National Aero Space Plane - X30) and the German Sænger/Horus projects represent the most interesting concepts in this connection. The US is also making efforts to develop concepts for a heavier launcher for the SE&I Lunar and Mars missions. The launchers will have payload capacity up till 250 tons. The Russian Energiya would here represent an alternative.

To get faster to Mars the use of nuclear thermal propulsion technology may be required. The technology is today available, but needs to be improved.

The Lunar Space consept (Shimizu Corp.)

For man to survive in space, pressurized space suits and highly reliable breathing systems are critical. Pressurized space suits make movement and gripping of tools, handrails, etc., difficult. Overcoming that problem and making space suits more comfortable to wear in different gravity environments is a critical issue. Moving around in zero g, 1/3 g or in 1/6 g present different challenges, and puts different requirements on space suits and breathing systems.

Setting up and operating a space station requires sophisticated robotic technology, standardized tools and standardized interfaces. On the system level, procedures have to be developed for the robots to perform its various tasks, ranging from construction to maintenance and repair. Procedures have to be developed for defining EVA (extra Vehicular Activities) tasks to robots and astronauts. Methods for defining degree of autonomy of the various robotic systems would also be important.

As for any extreme environment methods for performing total system life cycle analysis have to be developed. The same goes for methods for integrating repair, maintenance, and operational procedures into the early design phases of the project. This would include developing standardized tools and procedures securing easy access to maintenance points and repair prone components.

For all systems designed to perform and operate in extreme environments, repairs and maintenance typically will have to be performed on site. A fixed platform cannot be brought back to shore for repairs. Similarly it will be difficult to bring a subsea structure to the surface for repairs. The same goes for a space station. Trying to bring it back to Earth for repairs would be impossible. The structure would simply burn up, as it entered the atmosphere.

To reduce repair and maintenance time on the space station intelligent monitoring devices may be built into the design early on.

Additional technologies and methodologies are needed to deal with the environment encountered on a planetary surface. Surveillance and search techniques and methodologies are important for selecting landing sites and sites for permanent bases. These activities would include visual surveillance, surface sampling, and deeper soil sampling. Issues of concern would include suitability of site, possibility of rocks and other obstacles, soil density, interesting geological formations, and the availability of minerals and other resources.

Robots will be needed for setting up planned habitats, and other constructions. Virtual reality controlled robots can become a tool for exploring planetary surfaces, almost as effective as humans can do it themselves, but with less risk involved.

Seismic equipment must be developed to get a full understanding of the details of geology of the planet and the availability of resources. Efficient drilling equipment would be needed to perform deeper coring and sampling to further enhance this understanding. Later, even mining technology for mining the planet may have to be developed.

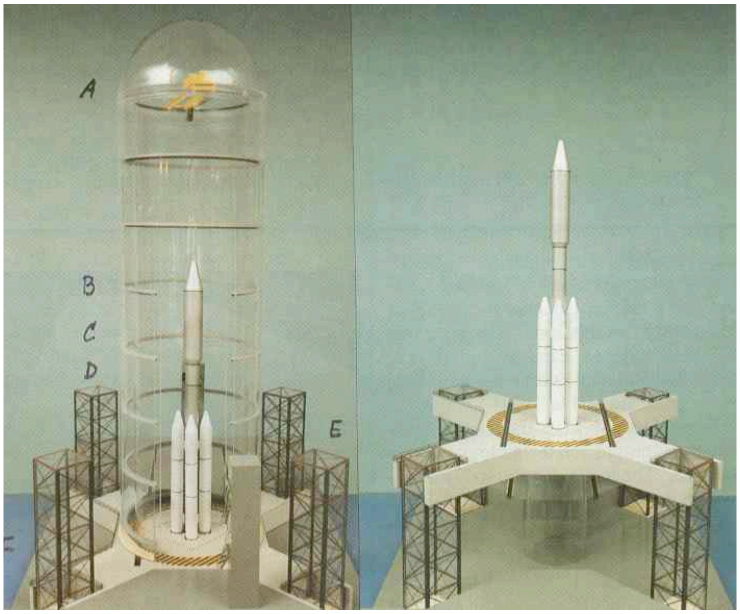
For the space station and also for a possible Lunar base logistic systems, safety & evacuation systems will play important roles.

Utilized Offshore - Space Synergies

Although the offshore industry has no expertise in building rockets or protecting people and machines from radiation, it possesses technologies and expertise that may be even more relevant for the development of space.

The offshore industry, and especially the offshore industry in the North Sea has accumulated over 20 twenty years of operational experience from two extreme environments - ocean surface and subsea.

This has been experience from fully operational and commercial systems. The commercial aspect is important because it has been a driver for continuously seeking for more efficient solutions. Efficient meaning reducing costs or increasing production of generated income. They have therefore been willing to invest large amounts of money in research if they could see that such research would increase future profits. There has in total probably been invested more than USD 100 bill in the North Sea. This would be enough to get the International Space Station in orbit, and to set up a Lunar base. A major reason why this has not happened is that there has been no commercial driver behind these projects. Space projects are only regarded as costs.



Universal space launchR assembly building (B) designed by Brown & Root shown in the model features a polar crane (A), payload environmental cover (C), access door (D), mobile access towers (E) and launch pad jack-up towers (F).

The parallels may seem most obvious between subsea and space. All astronauts would practice EVA submerged in water. That is the only environment on Earth that can simulate micro gravity. As in space humans have to be protected from the environment, and have to carry their own oxygen. Oceaneering Space Systems (OSS)is currently engaged in developing a liquid oxygen system for future life support systems for Mars astronauts (See Oceaneering). In this work OSS will be drawing on its experience with life support systems for divers. NUTEC, another subsea technology company had the opportunity to use its hyberbaric psychological and physiological expertise in the ISEMSI - Isolation Study for the European Manned Space Infrastructure (See NUTEC). SINTEF, meanwhile, used its expertise from the diving industry to define upper limits for concentrations of toxic and bacteriological pollutants in the Hermes cabin under flight (See SINTEF).

Human access to subsea and space environments is limited and involves a high risk. The development of robotic technology has therefore in both sectors, had a high priority. The major difference being that the subsea sector has been operating and continuously improving robotic systems and technologies for over 20 years. These have been commercial systems and not prototypes or test models, which is at the stage that most space robotic systems are today. The most sophisticated space robot system today is the CanadaArm, and this is by no means more advanced than most subsea robotic systems. Over twenty years of operational experience has also helped the subsea operators better understand how to utilize the ROV (Remotely Operated Vehicle) and its robotic tools, independently and together with divers. As subsea constructions moved into deeper waters the need for ROV's to both set up, operate, repair and maintain these structures came apparent. Since it would be nearly impossible to bring a subsea construction to the surface ones installed, all considerations related to likely future robotic repair and maintenance procedures had to be built into the early design phases of the projects. At the same time standardized tools and standardized interfaces had to be developed.

The developers of the International Space Station were facing the same maintenance and repair issues. (See CRITICAL TECHNOLOGIES). However, in difference to the subsea community, they had very limited operational experience from setting up, and robotically operating and maintaining such a project.

Oceaneering realized this, and from 1988 they have been supporting McDonnel Douglas Space Systems and NASA in developing standardized tools and robotic maintenance and repair procedures for the International Space Station (See Oceaneering). Wouldn't this also be an area where for example Kongsberg Offshore could apply its expertise, not really on a component level, but rather on a systems and functional level?

Monitoring based maintenance together with non-destructive testing systems have for some years been used in the North Sea. Compared to fixed maintenance schedules billions have been saved, both in terms of cost and loss of income during maintenance. For the International Space Station a fixed maintenance system was planned. However a suggestion from Veritas of using an intelligent monitoring based system instead may change this, at least on the Columbus part (See Veritas). Prototech together with Robit A/S are at the same time developing a robotic scanner arm that may be part of the proposed monitoring system (See Prototech). Parallel to all this Oceaneering is developing its own scanner tool, developed for ROV use, that may be used on the Space Station Freedom - the US part of the International Space Satin (See Oceaneering). A number of activities that would complement each other nicely!!!!

Being in an extreme environment forced the North Sea offshore sector to early develop sophisticated systems analysis tools. SINTEF has been a major player in developing these tools. Today they claim that their strong systems analysis capabilities have given them participation in a number of ESA (the European Space Agency) projects. These projects have ranged over areas such as simulation of maintenance and repair procedures for Columbus, human dependability & reliability and human factors engineering (See SINTEF).

Veritas has used its experience from developing safety & reliability systems for the offshore sector in various project management contracts for ESA and large space companies. Their contract with Aerospatial, for developing a Criticality Management Tool (CMT) is here of particular interest (See Veritas).

Brown & Root regarded as the world's largest offshore services company, saw another interesting use of offshore technology. They did a concept study of a "Universal Assembly Building & Launch Facility". Through this study, they concluded that by using proven petroleum industry construction techniques and applying offshore platform technology, operational costs and the costs of preparing, handling and launching the rocket could be reduced by up to 50%. An article about their study was published in Aviation Week & Space Technology in 1990.

The year before Brown & Root had done a study for McDonnel

Douglas exploring the possibilities of using semi-submersible platforms as launch sites. The developed concept included a monohull to be used for transportation of the launch vehicle and propellant from shore to the semi-submersible platform. The conclusions were quite favorable.

Unfortunately none of these concepts have been realized. Lower than expected Congressional funding for the for the SE&I program and the ALS project (Advanced Launch Systems, now called the NLS - National Launch Systems) led Brown & Root two years ago to merge the space operations activities into another unit.

Future Offshore - Space Synergies

The next step in space is likely to be the establishing of manned presence on the Moon. This is in accord with the SE&I program. In that connection new opportunities for utilizing offshore technology may occur - opportunities that may not be very well understood today.

Setting up a base or selecting a landing site on another planet, e.g. the Moon, requires careful surveillance by robotic precursor missions. The subsea sector had early to develop sophisticated systems for surveillance and inspection of the seabed before placing fixed platforms or underwater structures there. ROV tools had to be designed for taking surface samples of the seabed and for drilling to get deeper samples. Some of these tools and experiences may be directly relevant for such robotic precursor missions. NASA has only limited experience in this area and is keen to learn more about systems and methods applied subsea.

Seismic data gathering and analysis tools from the North Sea may be miniaturized and made less powerful to become an important part in a Lunar geological data-gathering package. Geology is a field that has a high priority in e.g. the SE&I program.

Drilling techniques and a full understanding of the drilling process can become useful when developing drilling and coring systems for a Lunar environment. Rogaland Research is currently involved in testing and verifying the anchoring and drilling system for the Rosetta probe (See Rogaland Research). The company was asked to participate, because the Italian company TechnoSpazio, knew of Rogaland Research's special expertise in that area.

After a preliminary base, a more permanent base may be set up. Indigenous material is likely to be used for these construction tasks. Some form of cement is envisioned. NC's experience from building concrete platforms for the North Sea could be relevant. However, according to Huygen at NC, the company has no capacity at present to get involved in such activities.

As envisioned in the SE&I (See SE&I) program a permanent base may also lead to the utilization of Lunar resources. At this point space development may become commercial and the development of space is likely to speed up dramatically. This may happen in 20 years.

Future Visions or Science Fiction

Other companies with a strong commitment to look ahead has found the concept of a Lunar base of particular interest. Shimizu a major Japanese construction company has established a separate Space Division. Their philosophy is clear. Space has more to do with construction, than with aircraft technology, and they want to get into a position where they can play a major role in future space construction projects, especially commercial ones. This requires long-term investments in expertise - again, in many ways similar to what was required for the development of the North Sea. For space the entrance fee for late comers may be so high that companies like Shimizu, may get into a monopoly situation, with resulting monopoly profits.

Shimizu has done concept studies for larger Lunar bases and for hotels orbiting Earth. For some people this may sound like

Shimizu has done studies for hotels orbiting Earth

science fiction, but so was also the idea of landing a humans on the Moon in the early sixties. We need companies like Shimizu, who have visions, a capacity to define plans and readiness to put money into realizing them.

To be a visionary requires the ability to look at things from completely new perspectives. When Leonardo da Vinci (1452-1519) presented his helicopter concept, people probably thought that he was crazy. Man was supposed to be on the ground. However if he one day was to fly, it would be like a bird, with flapping wings. Leonardo was right, the others were wrong.

Werner von Braun a well respected scientist and visionary in the 50's introduced a the idea of a space station. He did not present his ideas as a futuristic fata morgana, but rather as a fully realizable concept. His contemporaries, on the other hand, probably regarded his ideas as realistic as the world of Flash Gordon at that time. Anyway, today the Russian space station MIR (In Russian MIR means peace) up is there, and the International Space station is to be finished by the end of this decade. Von Braun's concept was larger, but at least part of his concept, has been and will be implemented.

Another great visionary and scientist, Dr. Gerhard O'Neill of Princeton and president and founder of SSI (the Space Studies Institute), wrote the book "The Final Frontier". In his book he describes human colonies in space housing 25.000 people, including a complete biosphere with trees, running water, fish etc. Unfortunately he died in April this year. In him the world lost a great visionary.

Science fiction, many will say! Perhaps, but seen in the perspective of the visions of Leonardo da Vinci and Werner von Braun, we should probably be a little careful in drawing too rigid conclusions.

Quite detailed studies have been made on the feasibility of the project, concluding that it can be realized with today's technology. A project in Arizona, called the Biosphere 2, is today carrying through an experiment with the aim of developing a better understanding of how to construct closed biospheres for future space missions. The experience may also be relevant for potential future subsea cities. Currently 8 people are living inside the biosphere and will remain there for a total of 2 years. During that time they will have to eat only what the biosphere can provide, and recycle all wastes, and sewage. Quite an interesting project. Enough of visions!

Norwegian Industry

When writing this paper, a number of heavier players in the offshore/subsea sector, such as Aker and especially NC, Kværner and Kongsberg Offshore, were asked about their space involvement. Most of them showed an interest, but admitted that they had rather limited knowledge. None of them are involved in space related projects.

This is unfortunate, when comparing with a company like Oceaneering, who has a clear strategy for utilizing their offshore expertise in space projects, and has done so successfully. Brown & Root tried, but decided after a short period to withdraw.

The Norwegian Association of Space Companies, NIFRO, and its chairman, Per Holsen, clearly show an interest for the issue, but admitted that they had not considered these parallels. Per Holsen was however, interested to explore the issue.

Those companies that have seen the potential benefit of utilizing the parallels are mainly research and systems oriented organizations like SINTEF, Veritas, NUTEC, and Prototech. After this little introduction to the topic we hope that companies such as Aker, Kongsberg Offshore and Kværner also can be added to the list.

Conclusions & Challenges

There are strong synergies between the offshore sector and the space sector. It is just a matter of being able to utilize them. And again, now may really be the right time to get involved. An industry like the offshore industry that is successful should always keep its eyes open for new opportunities, especially those that are linked to their current activities. Most companies tend to wait to look for new opportunities till their current activities are going downhill and profits are declining. At that time they may not have the financial resources to be able to utilize these new opportunities. It may therefore, now be a good idea for the offshore industry to, at least, explore the opportunities in the space sector. The name of the game is to position oneself so that one can utilize on new opportunities as they arise.

Involvement in space projects could also lead to knowledge and insight that may be interesting for the original activities in the offshore sector. This interchange of technologies should be encouraged and the importance of it can hardly be overestimated. However, the primary goal should be to aim at utilizing the unique offshore, and especially the North Sea offshore expertise in current and future space projects. This could make space a new growth area for the Norwegian offshore sector.

Today unfortunately, funding for the larger manned space programs is being cut both in the ESA and the NASA system. It is therefore easy to conclude that the setting up a of Lunar base or the exploration of Mars are highly unrealistic and will never happen. But, then at the same time, who would in the mid sixties have taken a person any serious if he had predicted the scope of the North Sea development that can be witnessed today. A Lunar base may not come through the NASA or ESA systems, but may come as a result of commercial interests seeing the potential of utilizing Lunar resources. This may happen sooner than one would expect.

There are already commercial interests planning in cooperation with NASA to set up a little space station - the Outpost Platform - using the Space Shuttle external tank. Today these tanks are jettisoned when empty and left to burn up in the atmosphere. The company is called Global Outpost. More of these private space initiatives are likely to emerge towards year 2000.

The offshore sector can get involved in this interesting development, in a stepwise fashion. First one would see how the in-house expertise could be utilized, and set up a strategy. Next step would be to perform studies for various space projects. These studies would be paid studies. Third step could be to get into developing prototypes and delivering hardware to the projects. The initial steps should require no more than part of a person, and if there was a income potential activities could expand gradually.

Most of the Norwegian offshore companies already involved in the space sector tend to be looking at ESA only. However, NASA should also be an alternative. According to Alfred Lunde if a company can offer something unique, and is professional, nationality is not an issue.

Finally we will like to challenge the Norwegian offshore industry, the Norwegian space industry and the Norwegian Space Center to get into a dialog for looking at ways for better utilizing the offshore space synergies. We have three suggestions.

Three Suggestions

1. The subsea sector is moving towards extreme depths. At the UTC-92 (Underwater Technology Conference in 1992), they talked about the challenges of developing fully operational sub-sea systems for depths down to 1000 meters by the year 2000. During this timeframe the development of the International Space Station will be moving into the later design phases. An interesting challenge for the Norwegian offshore industry, would here be to explore the potential for developing in parallel technologies that are relevant for both the International Space Station and for subsea systems down to 1000 meters. Such a parallel development could have the potential of saving development cost and time, and open up the door to fruitful exchanges of ideas between the space and offshore communities to the benefit of both parties.

2. The Norwegian Space Center (See Norwegian Space Center) is planning to build a new launch pad at the Andøya Rocket Range. From this pad, rockets up till around 20 tons can be launched. The challenge for the offshore industry would here be to explore whether their offshore platform technology could be used in the project to improve efficiency and save costs (See Utilized Offshore- Space Synergies: Brown and Root): An interesting challenge for companies like Kværner and Aker one should imagine.

3. The KAPOFF (See NOR 12/91) has as far as we can see been a success. Therefore, perhaps a similar concept could be developed for assisting offshore companies with space relevant expertise in converting this expertise into a commercially sound product for the space sector.