'The Chicken and Egg of On-Orbit Servicing'

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Introduction

Is there a market for On-Orbit Servicing (OOS) and if so, when will that market emerge? If there is a market for OOS, why has it not emerged already and what is holding it back? Will it be the technology that drives the market and if so, how should it be presented to a potentially sceptical audience?

These questions illustrate the dilemma facing the proponents of OOS. OOS concepts have been around for many years and yet there is no apparent surge in demand for such services. A 'chicken and egg' scenario exists and no one is quite sure how to solve the problem. There are signs that the technology is available and private investors willing to gamble on the emergence of a whole new sector of space-related business. Is this just 'pie in the sky' or are the opportunities real. This paper does not answer the question, but aims to identify the issues that surround it as a basis for collective discussion and debate within the context of the OOS 2002 workshop.

The broader objectives for the presentation and this paper are as follows:

- To identify OOS stakeholders & beneficiaries;
- To consider OOS demand issues and drivers;
- To assess potential benefits, risks & uncertainties of OOS.

To support this paper and presentation, several preliminary stakeholder interviews have been carried out and the responses summarised here. In the interests of confidentiality, no individual names or views are made public.

The current status of OOS

Characterising the status of the OOS sector requires a clear definition of what is meant by OOS. There is an argument to suggest that here already exists an OOS market illustrated by endeavours such as the rescue and repair of the Hubble space telescope. The shuttle was used to support this and has also been used to capture and repair rogue communication satellites.

Autonomous salvage of so-called lost satellites has also been achieved, such as HGS-1. Hughes Global Services rescued a stranded Asia Satellite Communications bird by sending it on a sequence of lunar passes.

Such innovative activities do not however constitute what is understood by OOS in the context of this paper. The OOS market here represents a sustained and consistent demand for servicing of orbiting spacecraft by way of autonomous robotic vehicles. There is no manned intervention and the target vehicle is in no way capable of taking care of its own needs.

With this more explicit definition, we can see that the current OOS market is primarily a RTD market. Several projects and programmes have been undertaken or are in place to develop the technology required for true OOS. Although engineers and scientists may disagree, even this does not constitute a market in the true sense of the word. What is lacking right now is the presence of a true paying customer that benefits directly from the service provided.

One problem inhibiting people's ability to see whether a market exists is the lack of appropriate technology demonstrations. Often people need to see what is being proposed before mentally connecting with its usefulness. So far, there are a limited number of servicing events and demonstrations and this feeds the perception of impossibility.

At the moment, the issues that OOS aims to deal with are solved through a variety of means. These include:

- System redundancy through over-engineering;
- Insurance;
- Launch of spare capacity;
- Lease of spare capacity;
- Retrieval of insurance write-off's through other means.

Despite the availability of alternatives, a small number of commercial entities are emerging that signify the potential that may exist.

General views on OOS

When asked about views on the potential and viability of OOS, views tend to fall within two distinct camps: the 'Yes' camp and the 'No' camp.

- The 'Yes' camp

Arguments for OOS include:

- It will make access to space cheaper, allowing cheaper satellites to be built
- Operators will enjoy enhanced revenues through extended lifetimes, fewer losses and reduce the need to waste resource on de-orbiting
- The technology is ready to perform tasks that were not possible previously.

A major implication of the pro-view is a wholesale change in how satellites are built launched and operated. The idea naturally leads to a situation where satellites are designed to be serviced and this changes the whole way in which business is done today. The idea of extended lifetimes then becomes irrelevant as a new approach to whoel missions is adopted.

- The 'No' camp

Arguments against OOS include:

- It will actually make space more expensive since new designs cost money and launch costs are the same for servicers as they are for new satellites
- Long design lifetimes mean that technology becomes obsolete and new satellites are required
- Increasing satellite complexity makes it difficult to see how a servicer can handle the potential challenges
- Docking is risky and more damage may be caused than solved.

If there is one thing that most people agree upon, it is that OOS should be a commercial activity and therefore the business case must make sense. Finding the right equilibrium between demand and cost of supply is the main challenge facing the OOS industry right now.

Who are the stakeholders?
To understand the market potential, we need to examine the various stakeholder groups connected to OOS and see how they might benefit from it.

The various stakeholders can be broadly divided into the following groups:

- Satellite operators (public and private)
- User community
- Insurance community
- OOS service providers
- Satellite manufacturers
- Launch industry
- Space agencies – operators and investors
- International bodies
- Other manufacturers

Satellite operators, end users and the insurance community are viewed as being the main beneficiaries of OOS. Satellite operators and insurers are likely to be the main customers of an OOS service company while end users would indirectly benefit from any improvements in service or reduction in costs.

Satellite manufacturers, OOS service providers and the launch industry are the main contributors to the supply side of the OOS equation. Satellite manufacturers determine what satellite capabilities can be provided at what price. Issues such as co-operative satellite design impact the manufacturers directly. OOS service providers take it upon themselves to provide the link between manufacturers and customers.

The other stakeholders can be seen as 'enablers'. In particular, the space agencies that invest in OOS technology are producing the conditions around which servicing concepts can be designed. At the same time, space agencies can also be direct beneficiaries through the employment of OOS for publicly funded missions.

International bodies such as UN OOSA are responsible for the regulatory framework within which certain market drivers may exist. At the moment, international regulators have resisted the imposition of directives regarding the de-orbiting of satellites (as one example) and hence the drive for economic means of doing so is absent. However, if this were to change, then suddenly a new range of market drivers may exist.

Other manufacturers represent those suppliers of technology (such as robotics) that have a vested interest in seeing OOS become a reality.

Market segmentation
To examine the range of type of benefits OOS could provide it is necessary to derive a market segmentation. The precursor study to the present work constructed a market segmentation based on the following variables:

By customer type	By service type	By orbit	By application
• Public • Commercial	• Inspection • Motion • Manipulation	• GEO/GTO • MEO • LEO/SSO	• Broadcast and telecomm • Navigation • Earth observation • Science • Security

Customer types

Public and commercial customer will have different expectations and attitudes towards the benefits of OOS. Public operators do not have to worry about revenue generation but about the overall value for money of a mission. Ensuring the mission objectives (usually science related) are met with minimum cost is usually the order of the day.

Commercial operators have to make a return to shareholders in most cases. Business conditions are becoming increasingly difficult and generating profit is the main challenge. Revenue extension and protection are probably the main drivers for operators to consider OOS. They are also technically savvy, unlikely to have the wool pulled over their eyes! Weak arguments and justifications will fail.

Both customer groups will have a high level of risk avoidance and a major challenge is to prove that OOS is a less risky option than other available risk mitigation measures. This does raise the question whether OOS is more of a risk management tool than a revenue-related tool.

Benefits by service type

What are the expected benefits of OOS and can we quantify them? These are the questions that need answering if we are to determine the potential size of the market and deduce its overall viability.

The three main service groups are outlined above and can be further described in the table below.

Service Class	Kind of Service	Demand	
		Emergency	Scheduled
"Motion"	Re-Orbiting	X	
	De-Orbiting	X	X
	Salvage	X	X
"Manipulation"	Maintenance		X
	Repair	X	
	Retrofit		X
	Docked Inspection	X	X
"Observation"	Remote Inspection	X	X

All service classes have distinct sub-groups that can be also defined by whether they are emergency and scheduled services. Emergency services are those that cannot be accurately predicted and are 'reactive' services. Scheduled are 'proactive' services and are hence more manageable in terms of predictability of demand.

Lower value services are probably generally scheduled services and those of a more observational nature. However, they may be highly frequent.

Motion services are likely to occur on a less frequent basis but would tend to be of a higher value nature. Re-orbiting a commercial telecommunications satellite injected to the wrong orbit at launch would be a highly valuable service given the revenue potential at stake.

Finally, manipulation services could potentially be of greatest value, particularly where mission-critical functions are restored.

Demand factors and drivers

We need to look at some of the factors and drivers that shape our assumptions on demand. First is the issue of what customers are likely to be willing to pay for services. This is directly related to the perceived benefits of using the service. Benefits are typically related to either operational benefit, cost savings and improved revenue capability.

A key factor affecting willingness to pay is the point at which servicing is required. The earlier in a satellite lifetime that the service is required, the more is at stake for the mission operator, whether private pr public.

The other element to modelling market demand is the number of service opportunities. This is a function of issues such as failure rates but also whether the servicing concept includes scheduled or emergency services. Scheduled services imply a consistent known level of servicing based on servicing intervals. Emergency services are an unknown quantity and related to the issue of failure rates. How many satellites are mis-placed in orbit each year or how many experience premature malfunction?

Legislation is also a key driver of demand. Currently there is no binding legal requirement to de-orbit satellites properly, only general principles which are not adhered to totally. If this scenario were to change, then the market potential would improve. This could potentially be a circular argument if the options for OOS were demonstrated clearly enough. This would give legislators the tools required to justify imposition of legal requirements. This is similar to the issue of seat belts in cars. Once the technology is available and proven, it can be specified as legal requirement.

Demand inhibitors

There are significant constraints on the OOS market potential. This is by no means an exhaustive list but highlights some of the main issues raided by interviewees.

Orbital considerations are a key factor. GEO is expensive to reach but once there all the satellites tend to be readily accessible. However, GEO telco satellites are becoming increasingly powerful and complex. GEO satellites also have increasingly long design lives. The typical 12-15 year life space sees a multitude of technical developments that make existing technology obsolete. Who wants to service obsolete technology?

In LEO, the problem for OOS is that the satellites are increasingly designed to be expendable. Moreover, the S-PCN ventures have proved a market failure and questions hang over the future viability of commercial use of LEO. LEO/SSO earth observation satellites constitute a significant number of opportunities but generally similar economic difficulties apply.

Another problem for LEO is the use of different orbits, which poses a logistical problem for the servicer.

MEO is mainly used for navigation constellations. Although approval of Galileo will increase use of MEO, there will be little need to service what are fundamentally basic timing beacons in space. Similar orbital questions to LEO arise with different orbits used within the MEO domain. Removal of MEO objects could be an issue however.

Co-operative design issues are major areas of concern. Although the argument for OOS includes reducing the cost of access to space, the need for co-operative design could actually increase the cost thus having the opposite affect. Hubble is posed as an example of the cost of creating modular design. This is an issue for any new technology development and has to be included in business case calculations but the question of who pays for the development also remains.

Many respondents questioned the detail of what a servicing vehicle will actually be capable of. Satellites face a wide range of potential problems including electrical and mechanical. Will a single servicer be ready to service any event? How will it transport necessary parts or fluids?

What these questions illustrate is the mental gap many people have in seeing just how in practice a OOS mission would work. This is a fact that must be addressed with realism.

Launch costs are last major issue addressed here. They will presumably be similar from OOS mission launches as for other launches, in which case how will the high cost of launch be covered? The answer does depend on many factors such as the expected size and mass of the servicer but these in turn impact the capability of the mission. A workable trade-off has yet to be found.

Reality checking from the customer point of view

Demand drivers and inhibitors focus around one thing: the customer. Ultimately the customer must pay for the service and will have a series of questions and concerns that must be answered before committing funds to such a venture.

What are the questions a potential OOS customer will ask? The following are some suggested lines of questioning:

- What is the bottom line benefit to me of using an OOS service?
- What are the risks involved?
- Doesn't OOS involve as much risk, if not more, than existing options?
- What about technical complexity - have you shown you can do it?
- Should I be the first?
- Will my shareholders/tax payers be happy??

The issue of risk will be high on the list and is possibly just as important as bottom line savings or other economic benefits. Potential benefit will not come easy and any customer would have to be satisfied that they have a realistic chance of realising those benefits.

Issues arising

Some further issues are pertinent to raise here that shape the potential future direction of OOS.

The political context will always be important in the space sector. Since governments remain by far the biggest spenders in space, they will have to be a major force in its evolution. OOS implies dealing with a range of space infrastructure and activities that require widespread consensus. One example of this is orbital debris and the issue of removal of defunct satellites from GEO. Another is the potential role for the ISS as part of an OOS vision of the future.

On the subject if the ISS, the point has been made that any current OOS activities really only related to the ISS. There is also an argument to use it as the focal point of a future OOS scenario, possibly as a base for space tugs and/or a refuelling/retrofitting activities.

International co-ordination is a key factor for the success of OOS (illustrated by the bilateral nature of this workshop) and several areas for co-operation exist, including:

- Technology development and demonstration;
- Changing the market perception;
- International legislation.

A possible factor that has slowed previous progress on OOS is military concern. This is a strong lobby with significant interests to protect. The idea of uncontrolled access and close inspection of highly secret assets justifies the attention of military authorities.

Conclusions – something for everyone to consider

In conclusion, we have seen that OOS divides the wider space community broadly into those who see a positive future for OOS and those that remain highly sceptical of its viability. These opinions are not lightly held and results from many years examination of the OOS concept.

What all stakeholders agree upon is the need to see a viable business case developed that can generate buy-in from across the spectrum. Simply having the technology is not enough, the case for the customer to change existing buying and operational patterns needs to be made. So far, many experienced people have difficulty in seeing where this market equilibrium lies.

Some of this reticence may reside in current vested interest. Others may simply need to see before believing. Either way, the future way forward is probably an evolutionary process of demonstration and validation, shaped by the requirement to prove a valid business scenario.

While few see the long-term future of OOS in public hands, it is likely that the short term will continue to involve significant public investment. While this investment continues to develop and demonstrate mission feasibility, parallel efforts should be made to investigate the right commercial model.

Whether the end customers are public or private mission operators does not matter, as long as an efficient and sustainable approach to OOS can be found. This is the challenge for this workshop and I hope this paper has helped to start outlining the primary issues to be tackled.