FLEET ACQUISITION, HIRING & RENEWAL OPTIONS IN OFFSHORE LOGISTICS: APPLICATION OF A COMPUTER-BASED MODEL

Abstract

As key members in the supply chain, Offshore Supply Vessels (OSVs) play a vital role in ensuring that the core business of oil and gas exploration and production is carried out without any hindrance. Apart from their capability to meet the supply function, OSVs are usually called upon to perform a number of additional duties. The optimum size and composition of the OSV fleet needs to be determined on the basis of an assessment of the duty-wise demand and matching of the demand profile, through a number of iterations. The key issue involved in the pre-design stage of fleet acquisition or renewal is that of striking the right balance between reliability and redundancy in terms of vessel numbers and payload and other design features.

NSDRC has been involved in the development of a computer-based model that serves as an investigative tool for exploring various options in terms of OSV payload and service speed. The model takes into account, the complexity of external operational variables and assists in selecting the number of vessels that are required to meet the logistic demand, from a range of payload-speed combinations. The present paper summarises the work carried out by the NSDRC team in developing the model and its application to the decision-making process, in situations where OSV acquisitions, renewals and hiring are contemplated.

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1. INTRODUCTION

That offshore oil and gas exploration and production play a vital role in the world's economy is an indisputable fact. The exacting business of offshore exploration and production necessitates a prompt and efficient logistics support function. The offshore logistics are characterised by Offshore Supply Vessels (OSVs), which render the all important supply and support services so that the core business of oil and gas exploration and production is carried out without any hindrance. Apart from their capability to meet the supply function, a number of OSV are also fitted out for additional duties such as towing and anchor handling, fire-fighting and rescue. Compared to the conventional merchant vessels, which are typically engaged in a fixed cycle of loading, sailing, discharging and ballast passage, there are two distinct aspects that set the OSVs apart:

a) the multi-functional duty profile and
b) frequent and seasonal fluctuations in the demand for OSV services.

In fact, one of the difficult choices to be made in acquiring an OSV fleet is that of choosing between specialist and multi-purpose vessels. Experience shows that it is the scale of operations and the corresponding economics that determine the choice. It is appropriate to state here that as the scale of operations rises, the option of specialist vessels begin to appear attractive. Whatever may be the case, there is no doubt that the OSV fleet size catering to a given set of operational needs has to be optimised through minimisation of:

1) capital cost
2) operating cost

By attributing the above costs to drilling and production activity levels separately, say over a year, one can arrive at the annual cost of logistics a) per metre drilling and b) per ton of production. It needs to be emphasised here that while choosing the fleet size and its composition, the operator should ensure that a 'reasonable' degree of redundancy is built-in and the drilling and production operations are never interrupted for want of logistic support. What is reasonable, however, is matter of judgement, based on previous experience.

2. MATCHING LOGISTIC SUPPLY WITH OPERATIONAL DEMAND

The operational demand for logistic support flows from:

- Number of duty stations (sum of rigs, production platforms, specialist vessels, etc.)
- Number of standby stations (for the purposes of rescue and emergency evacuation, a single OSV can be called upon to provide the standby support for a maximum of two duty stations, as long as they are within a radius of 5 nautical miles; the basis is the targeted response time and this norm is in accordance with the North Sea practice)
- Cargo consumption rate in terms of tons of each cargo, per duty station per day
- Distance of duty station from the supply base

- Duties that OSV are called upon to perform in addition to supply and standby, e.g., rig-moves
- Margins for contingencies
- Overlap required (e.g., between relieving standby vessels)

The net logistic supply is determined by:

- Fleet size
- Fleet composition in terms of distribution of vessels by size and duty-wise capabilities
- Deadweight (DWT) of each OSV
- Payload [= DWT – (Self consumption + Dead load + Reduced loading due to operational reasons)] measurable in terms of Loading Factor [= (Payload / DWT) x 100] (%)
- Service speed
- Non-availability due to downtime, which tends to rise as the OSVs age

3. NEED FOR COMPUTER-BASED LOGISTICS MODEL

Given wide range of scenarios that can occur due to changes in the above set of variables on the demand side and the possible combinations available on the supply side, it was resolved at an early stage in the study undertaken by NSDRC that development and application of a computer-based model offers the best course. It is interesting to note here one major offshore company has been functioning, using a simple index-based approach to arrive at the fleet size, viz.,

No. of OSVs = Index Number (1.2 to 2.5) x No. of duty stations

However, the index number, arrived at on the basis of experience gathered over the years following continuous refinement, remains rather subjective. In general, the assessment of OSV requirement by means of an index number is of limited use since it does not take any of the factors listed in section 2 into account. NSDRC, therefore undertook to evolve a more realistic method of arriving at the fleet size and composition which takes into account, the complexities of demand as well as supply profiles. The methodology evolved by NSDRC is illustrated by the flowchart that follows.

“Rig-clock” and “Shore-clock” constitute the basic elements of the model. Rig-clock is a hypothetical counter that keeps ticking at a pre-set daily consumption rate and points to a time by which the supply requirements are to be met. The rig-clock is “reset” only when an OSV arrives with the supplies. Through scanning of all the rig-clocks, and depending upon the priorities (i.e., which rig-clock is closest to a situation of “station-loss” occurrence), the programme directs the waiting OSV to the needy installations in the order of priority. Non-availability of standby vessel is also considered as station-loss. Station-loss being zero is the primary condition that needs to be fulfilled for ascertaining the fleet size.

"Shore-clock" represents the time period over which, an OSV is waiting at the base to be allocated. Ideally, all the shore-clocks should point to zero, implying that the fleet is continually and fully utilised and the cumulative "shore-loss" is also zero. However, it has been observed that well before the primary condition, i.e., station-loss being zero is achieved, shore-loss tends to accumulate, which is considered as the "buffer" or margin.

The number of OSV deployed is incremented and the programme returns that value of number of OSVs, which:

a) just meets the requirement of station-losses being zero *and*
b) the available shore-loss equals the required buffer (to meet down time, rig-move duties, contingencies, etc.) is available in terms of minimal required shore-loss, measured in OSV days.

The above approach is illustrated by Fig. 1:

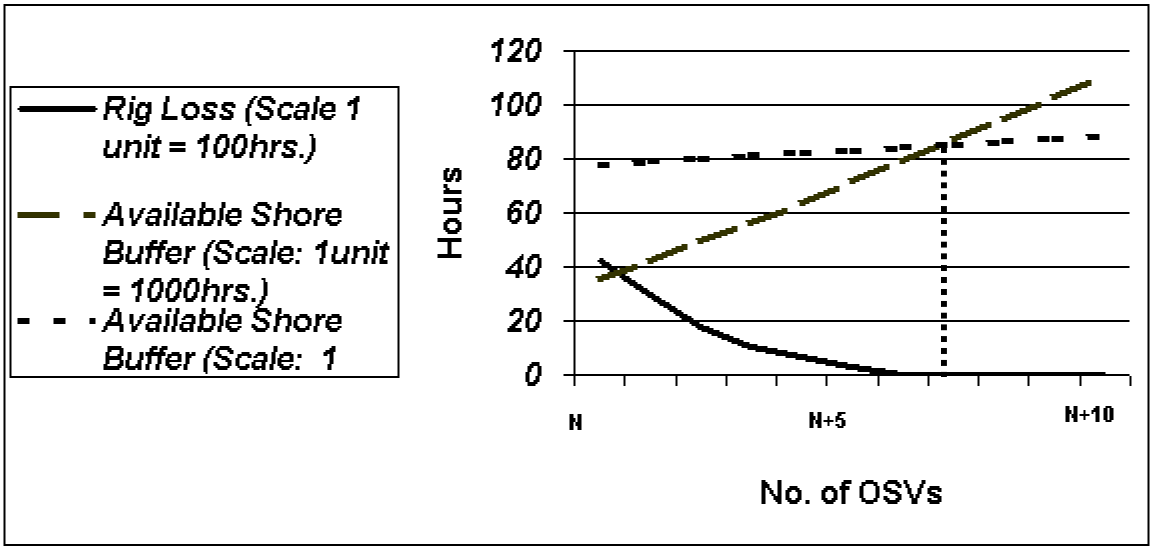
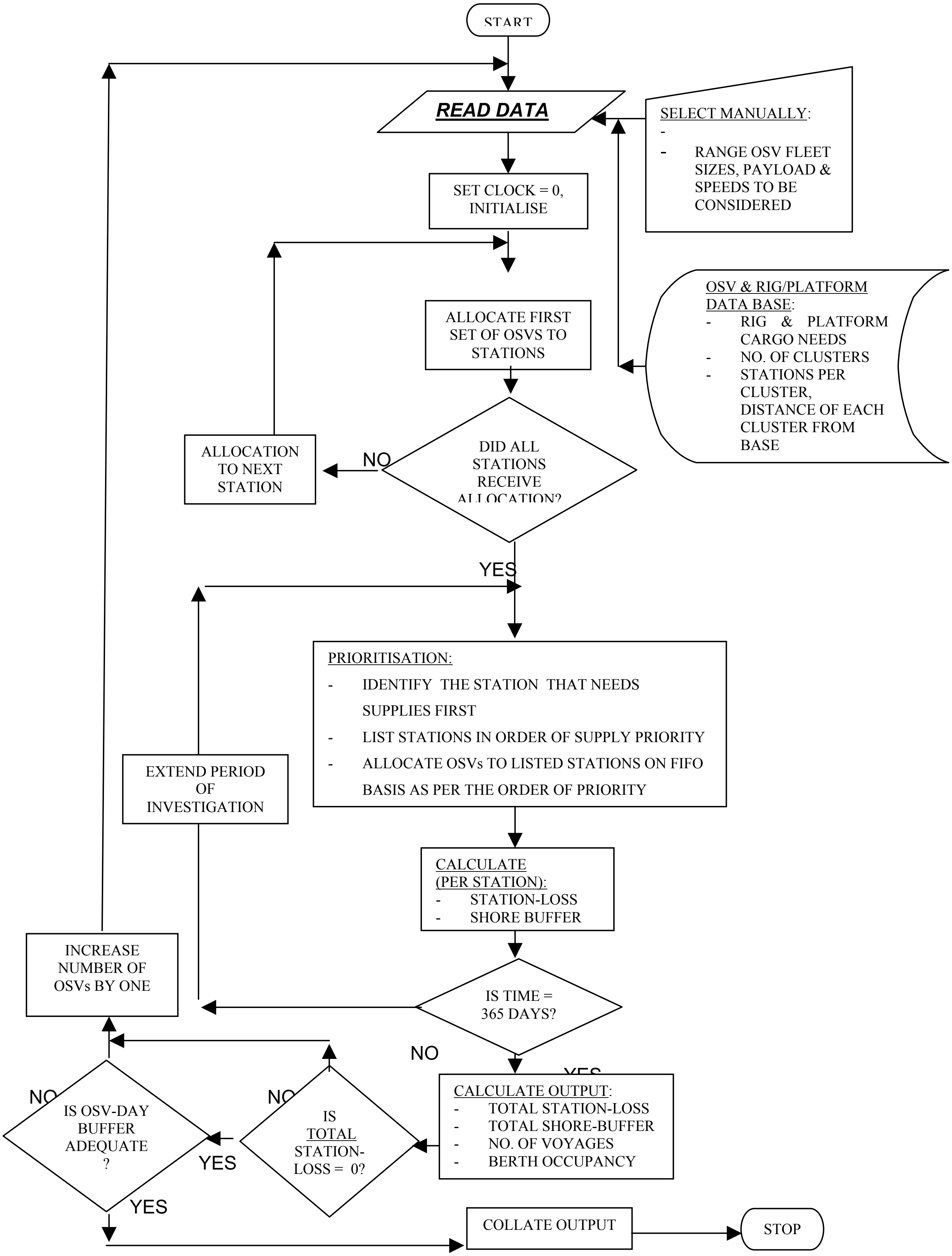


Fig. 1: Basis for arriving at the Fleet Size

The simplified algorithm for the development of the software of the model is illustrated by the following flowchart.


START
READ DATA
SELECT MANUALLY:
-
- RANGE OSV FLEET SIZES, PAYLOAD & SPEEDS TO BE CONSIDERED
SET CLOCK = 0, INITIALISE
OSV & RIG/PLATFORM DATA BASE:
- RIG & PLATFORM CARGO NEEDS
- NO. OF CLUSTERS
- STATIONS PER CLUSTER, DISTANCE OF EACH CLUSTER FROM BASE
ALLOCATE FIRST SET OF OSVS TO STATIONS
DID ALL STATIONS RECEIVE ALLOCATION?
NO
ALLOCATION TO NEXT STATION
YES
PRIORITISATION:
- IDENTIFY THE STATION THAT NEEDS SUPPLIES FIRST
- LIST STATIONS IN ORDER OF SUPPLY PRIORITY
- ALLOCATE OSVs TO LISTED STATIONS ON FIFO BASIS AS PER THE ORDER OF PRIORITY
EXTEND PERIOD OF INVESTIGATION
CALCULATE (PER STATION):
- STATION-LOSS
- SHORE BUFFER
INCREASE NUMBER OF OSVs BY ONE
IS TIME = 365 DAYS?
NO
YES
CALCULATE OUTPUT:
- TOTAL STATION-LOSS
- TOTAL SHORE-BUFFER
- NO. OF VOYAGES
- BERTH OCCUPANCY
NO
IS OSV-DAY BUFFER ADEQUATE ?
NO
IS TOTAL STATION-LOSS = 0?
YES
YES
COLLATE OUTPUT
STOP

4. INVESTIGATIONS MADE USING THE COMPUTER-BASED LOGISTICS MODEL

The computer-based model and the analysis derived from investigating various scenarios using the model, form core of the NSDRC's approach. The objective of the model and the supporting programme developed by NSDRC is to arrive at the number of OSVs (of given cargo capacity and speed, sailing across a given distance) that will fulfil the cargo demands for a period (one year) without incurring drilling or production losses for want of supplies and standby support. In addition, the model also ensures that adequate buffer is available in terms of OSV days for meeting the rig-moves, downtime, overlap and miscellaneous duties.

For the purpose of the evolving the generic model developed in the course of the study the current number and geographic distribution of duty stations have been considered. The model being a highly flexible one, the number and the distribution can be changed, as and when required and the corresponding output can be generated.

The inputs that can be varied in the model are:

1) Number of clusters
2) Number of duty stations in each cluster
3) Distances from base to each cluster (Nautical Miles)
4) Speed of the OSVs (knots)
5) Payload per OSV (tons)

In addition to the above, it is also possible to vary intrinsically, the standby allocation logic (e.g., one OSV per cluster or one per duty station or one per a pair of duty stations, overlap, etc). When the programme is run with a set of the above inputs, the following outputs are generated:

1) Number of OSVs required and
2) Number of sailings

5. FINDINGS

Using the computer model developed, a large number of cases involving different payloads, speed and three different average hauling distances have been investigated. Three specific aspects that have been investigated cover:

1. Impact of speed and payload variations on the fleet size
2. Impact of introducing a small number of larger vessels on the fleet size
3. Impact of speed and payload on the annual number of sailings

Some of the findings of the investigations are summarised as follows:

5.1 Impact of Speed & Payload variations on Fleet Size

a) <u>Average distance of 100 nautical miles</u>

The key results of the investigations are depicted in the figure below:

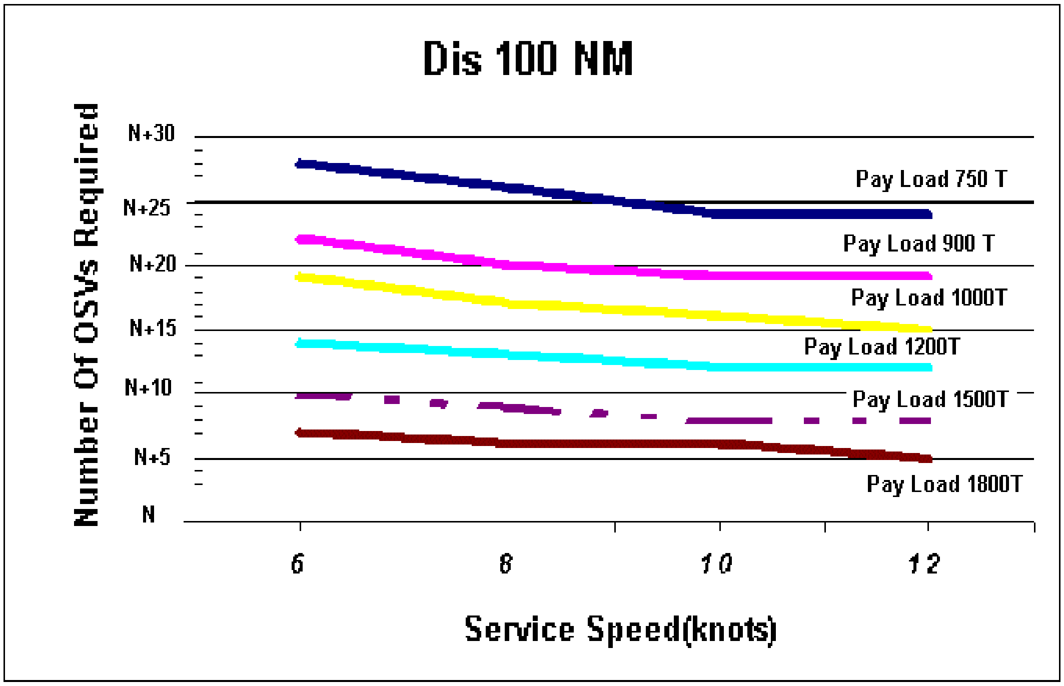


Fig. 2: Effect of Service Speed & Payload on No. of OSVs required at an Average Hauling Distance of <u>100 Nautical Miles</u>

As can be seen, the inverse relationship between speed and the number of OSVs is clearly brought out by the overall negative slopes of the curves. While there appears to be a significant gain in the increase of payload from 750 to 900 tons and rising of speed from 6 to 9 knots, further increases do not seem to have a comparable impact. In general, the slope of all the curves is found to be reducing at 10 knots, beyond which, increase in speed has little impact.

b) Average distance of 200 nautical miles

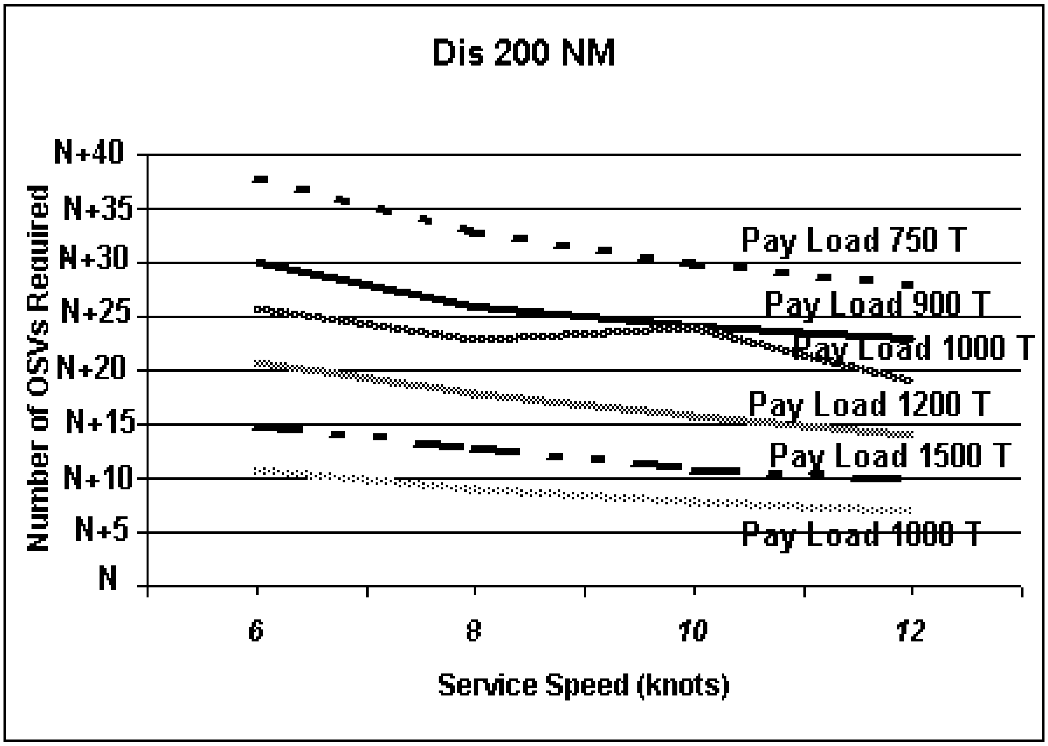


Fig. 3: Effect of Service Speed & Payload on No. of OSVs required at an Average Hauling Distance of 200 Nautical Miles

While a similar pattern as earlier is observed, all the cases have registered an increase in the number of OSVs required. In other words, increase in payload is beginning to make a significant impact as the distance is increased.

5.2 Impact of introducing PSVs on Fleet Size

Using the model, the impact of introducing large Platform Support Vessels (PSVs), (which are basically pure supply vessels), for the purpose of contributing to the pure supply duties, while keeping the daily cargo requirement per duty station as before, have been investigated. These PSVs contribute to the supply duty only while the standby-cum-supply duties continue to be attended by a reduced number of OSVs. The question therefore is whether the overall fleet size reduction accrued from introducing PSVs is attractive enough in terms of capital and operating costs when compared to a larger fleet of OSVs alone. In case the PSV option is found to be attractive, the next question to be addressed is what are the optimum payload and service speed parameters?

PSVs of 2200, 2600, 3000 and 3400 tons payload capacities have been introduced and the model was used to arrive at the number of PSVs needed in each case. Annual availability of 350 days and a service speed of 10 knot have been considered. The investigations pointed to the following results:

- The number of PSVs is determined by the number of "pure supply" vessels that can be replaced since a minimum number of standby-cum-supply type OSVs are essential for meeting the standby duty (pure supply vessels = total standby-cum-supply fleet – minimum OSVs required for standby-cum-supply duties)
- In general, biggest PSV payloads considered offered the greatest advantage in terms of the number of PSVs that need to be introduced into the fleet
- The number of PSVs arrived at as above can be reduced or optimised further by assigning each one of them to pre-determined routes (instead of having to divert them)
- Scheduling of the OSVs and PSVs (instead of staggering them) during the initialising of the model also has a favourable impact

5.3 Impact of Speed & Fleet Size on Number of Sailings

Any exercise involving vessel and fleet sizing needs to take into account, the existing port facilities. This aspect assumes even greater importance in offshore logistics, since most OSV users operate from a fixed base with given capabilities. Figures for the last three years (1997-2000) indicate the cumulative annual number of sailings of 1000 to1300. At this level of activity and assuming a loading time of one day per vessel per sailing, the occupancy of the 5-berth facility at the base works out to around 66% [1200/(5 x 365)]. The current occupancy is acceptable as per the queuing models. Any further increase, by 5% or more, is likely to create delays due to queuing. It is therefore necessary to consider the impact of fleet size on the number of sailings involved.

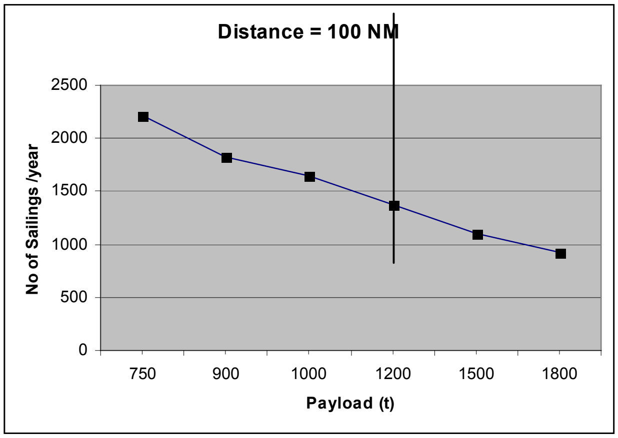


Fig. 4: Impact of OSV Payload on No. of Annual Sailings

Interestingly, while variation in speed had only nominal impact on the number of sailings, it was the changes in payload that contributed significantly to the numbers of vessels, for all the three average distances considered. Greater payloads have been found to be imperative to cope with increase in hauling distances beyond 200 miles, if the number of sailings is to be restricted.

6. COST IMPLICATIONS OF VARIATIONS IN OSV FLEET SIZE

The smallest fleet size is bound to register minimal manning cost. However, the corresponding payload and speed combination need not necessarily result in the lowest overall cost, since it is determined by capital cost and fuel cost. While investigating the cost implications of fleet sizing, it is advisable to begin by using data from the standard designs that are offered by a very small number of player operating in this specialist market.

1) Minimising Capital Cost:

As brought out by the model, there exist two extremes in a given operating environment within which, the least capital cost option will need to be arrived at:

a) The cost of the largest number of smallest OSVs
b) The cost of the smallest number of the largest OSVs

The study pointed out to increased utility of large vessels when they are assigned solely to the supply function, and operated along ‘fixed’ routes, i.e., covering a number of duty stations en route.

2) Minimising Operating Cost:

Considering that the relationship between fuel and repair costs and vessel size is non-linear and the manning and pilotage costs per ton-mile transportation decrease significantly as the vessel size is increased, larger vessels tend to return a considerable reduction in the operating costs. From the analysis of the output from various cases investigated using the model, it was observed that the number of sailings required annually to meet a given level of logistic and other operational demands decreases significantly as the vessel size increases (see section 5.3). This reduction in turn, results in considerable direct savings in fuel and pilotage costs and indirect savings in maintenance costs. In other words, in pure financial terms, bigger vessels offer cost reduction in line with the well-established principle of ‘economies of scale’.

Reality however is more complex. Increasing the vessel size *per se* does not offer a straightforward solution operationally since the risk of under-utilisation becomes real due to a number of factors such as:

- scattered geographic distribution of duty stations
- limitations in storage capacities onboard the duty stations

- constraints on flexibility of fleet deployment, especially when the proportion of duties other than supply function is large

7. COST IMPLICATIONS OF INTRODUCING OF PSVS

It was agreed that a more detailed cost-benefit analysis needs to be carried out before finalising:

- Whether or not to induct PSVs; and
- What size (payload) and speed would result in the greatest operational financial advantage

As basic observation however, the following approach may be considered in case of acquisitions: [{(Acquisition cost per PSV + NPV of additional fuel cost across the life of PSV) x No. of PSVs} minus {Acquisition cost per “pure supply” type OSV x No. such OSVs that can be replaced with PSVs (both derived from the model)}]

Manning and repair/drydocking costs are ignored since it is assumed that they are the same for OSVs and PSVs.

If the above figure is positive, the PSV option may be considered, provided they are operationally suitable, as discussed earlier. Consequently, the maximum positive value obtained from out of a matrix of payload and speed will determine the design features of the PSVs to be inducted.

8. CONCLUSION

The practices that have been subjective or thumb-rule based in terms of planning and operations are now revalidated and refined using the model.

Speed emerged as a non-priority area for a given average hauling distance and service speeds beyond 10 knots are found to have little impact on the fleet size. It is therefore possible now for the operator to:

a) confidently order reduced speeds and take advantage of fuel savings
b) have a more rational basis for fixing the targeted post-overhaul output of older main engines or even replacing the older engines with those of less output and
c) fixing the speed requirements of chartered and replacement vessels at lower levels resulting in considerable saving

Average hauling distance emerged as the key determinant of payload capacity, i.e., vessel size. Larger vessels are found to be economical and they also became imperative as the distance increased. However, increasing of the vessel size cannot be pursued beyond a point since a number of operational factors begin to act constraints.

The study and the discussion that followed resulted in an increased appreciation of: the current OSV utilisation in terms of loading factor, downtime trends, distribution of logistic load by cargo type, etc.

On the whole, the computer-based logistics model proved to be an invaluable tool for assessing the fleet size and composition to meet the complex and dynamic demand profile.