MV-22 Internal Capable Vehicle vs the High Mobility Multi-Wheeled Vehicle

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I. Introduction

On 25 September representatives of the Studies and Analysis Division met with MGen Howard, Deputy Commanding General, Marine Corps Combat Development Command. During this meeting, MGen Howard raised several issues, which he wished to have examined. The purpose of this paper is to compare a MV-22 Internal Capable Vehicle (MICV) with the High Mobility, Multi-Wheeled Vehicle (HMMWV) in support of the Ship-To-Object Maneuver (STOM) concept.

A. The HMMWV.

The HMMWV is the backbone of the Marine Corps utility truck fleet. Current variants include logistics, armored, command and control, and heavy weapons capable vehicles.

The MV-22 is unable to internally transport the HMMWV. As a result, all HMMWVs moved ashore by air during a STOM operation must be externally transported by either the MV-22 or the CH-53D/E. In past testing, it has been shown that being externally transported at airspeeds in excess of 120 kts is detrimental to the operational capability of the HMMWV. With a cruise speed of 250 kts, the MV-22 is unable to maximize its STOM capability when carrying the HMMWV externally.

B. The MICV.

There currently exists no "MICV" program. There are programs looking to develop/adapt vehicles for internal transport within the MV-22. However, these are specialized vehicles, primarily for use with various Special Forces units. What is required is a vehicle that can replace the HMMWV in the utility role. This vehicle must be internally transported by the MV-22 in order to maximize STOM capabilities.

To date only one vehicle has been internally loaded aboard the MV-22. DARPAs Helicopter Transportable Tactical Vehicle (HTTV) was loaded during an Operational Test conducted by the Multi-Service Operational Test Team. The HTTV will be compared to the HMMWV in the analysis section.

C. Internal versus External Transport.

There is a time cost associated with internally transporting a vehicle. The time required to drive the vehicle from some point on the flight deck to the aircraft; the time to back the vehicle into the aircraft; the time required to chain the vehicle down inside the aircraft; as well as the time to chock/chain and unchock/unchain the aircraft itself can easily exceed 15 minutes.

At the LZ, unchaining and driving a vehicle off of the aircraft could be as long as 5 minutes. This time is driven by the amount of clearance the vehicle has between itself and the bulkheads of the aircraft. The less clearance, the slower the unloading evolution.

By contrast, the time required to load external cargo usually takes no longer then 1-2 minutes. Unloading an external load typically requires the aircraft to hover for no more then 10-15 seconds. In the case of externally carried vehicles, extra time is required during the load/unload phase to board vehicle drivers. This must be taken into account when comparing the external versus internal transporting of vehicles.

Unless there are over-riding circumstances, the preference is to carry all loads externally. During STOM evolutions, distance and MV-22 airspeeds *may* become that over-riding circumstance.

D. Methodology.

A spreadsheet was developed in order to compare externally carrying the HMMWV to an internally transported MICV. This spreadsheet was then used for a two-phase comparison of the two vehicles.

Phase one compared the time to externally offload a given number of HMMWVs and an equal number of MICVs by internal transport. This comparison showed the benefits to the STOM concept if internally transported MICVs were to replace externally carried HMMWVs. This is considered to be a 1 for 1 MICV to HMMWV replacement strategy.

Due to the internal dimensions of the MV-22, it is not possible that the MICV will be a 1-for-1 replacement for all variants of the HMMWV. While a TOW or other fire-support variant HMMWV may be replaced by a single MICV, most will not. The HMMWV cargo and personnel carrying variants will most likely require multiple MICVs to provide the same capability as a single HMMWV.

The second phase of the analysis attempts to identify a maximum allowable MICV to HMMWV replacement strategy (maximum F_{MICV}) without having an adverse effect upon the STOM concept.

This paper only examines external versus internal transport. It does not go on to compare the maneuverability or performance of the MICV and HMMWV once the vehicles are ashore. It is unknown what affects the reduced wheelbase and size of the vehicle mandated by the MV-22 cabin size will have on a future MICV. The intent here is to determine the effects of such a vehicle on the STOM concept.

II. Analysis

Table 1 presents data to be used throughout the analysis section.

Parameter	Case A	Case B	Case C
Number of HMMWVs	95[1]	118[1]	10[1]
Distance	97	30	40
Number of MV-22s	48	48	10
Airspeed Internal (kts)	250	250	250

External (kts)	120	120	120
Cruise (kts)	250	250	250
Load Time Internal (min)	15	15	15
External (min)	5	5	5
Unload Time Internal (min)	5	5	5
External (min)	5	5	5
On-station Time Internal (hrs)	4.0	4.0	4.0
External (hrs)	3.5	3.5	3.5
Time to refuel (hrs)	0.2	0.2	0.2
F_{MICV}	1.22	0.93	1.0
MICVs	116	110	10

1. Calculations assume that all vehicles are transported by MV-22s, either internally or externally as required.

Table 1. Analysis Data Sets.

A. Time To Offload

The time to externally carry a given number of HMMWVs was compared to the time required to internally transport the same number of MICVs. The unit of measure for this comparison was the overall number of Flight Hours flown.

Flight Hours were chosen as the measure of effectiveness for one reason. The objective of the STOM concept is the rapid build-up of combat power ashore. If it takes one flight hour to externally transport a HMMWV and 30 minutes to internally transport the MICV, then the external vehicle "cost" STOM 30 minutes. During this 30 minutes, additional combat power could have been moved ashore. In a MEF sized operation with 48 MV-22s operating, 30 minutes per serial rapidly escalates the "cost" of externally carried vehicles to the STOM operation.

In this paper, flight hours account for more than the traditional meaning of "time spent in the air". A flight hour here also includes the time required to load and unload vehicles, and refueling times. In effect, the number of flight hours required to move a vehicle ashore is the time cost to STOM of that vehicle.

1. One Aircraft Moving One Vehicle.

In the simple case, one vehicle will be transported internally by the MV-22 and one externally. This case is shown in Figure 5. The time cost associated with internal versus external operations is plainly visible.

The MICV is not seen as purely an internally transported vehicle. Due to the difference in loading and unloading times, it is more efficient to externally transport a MICV than to internally transport it until some "break even" operating distance is reached. At this distance, the time to internally transport the MICV is the same as the time to externally transport it.

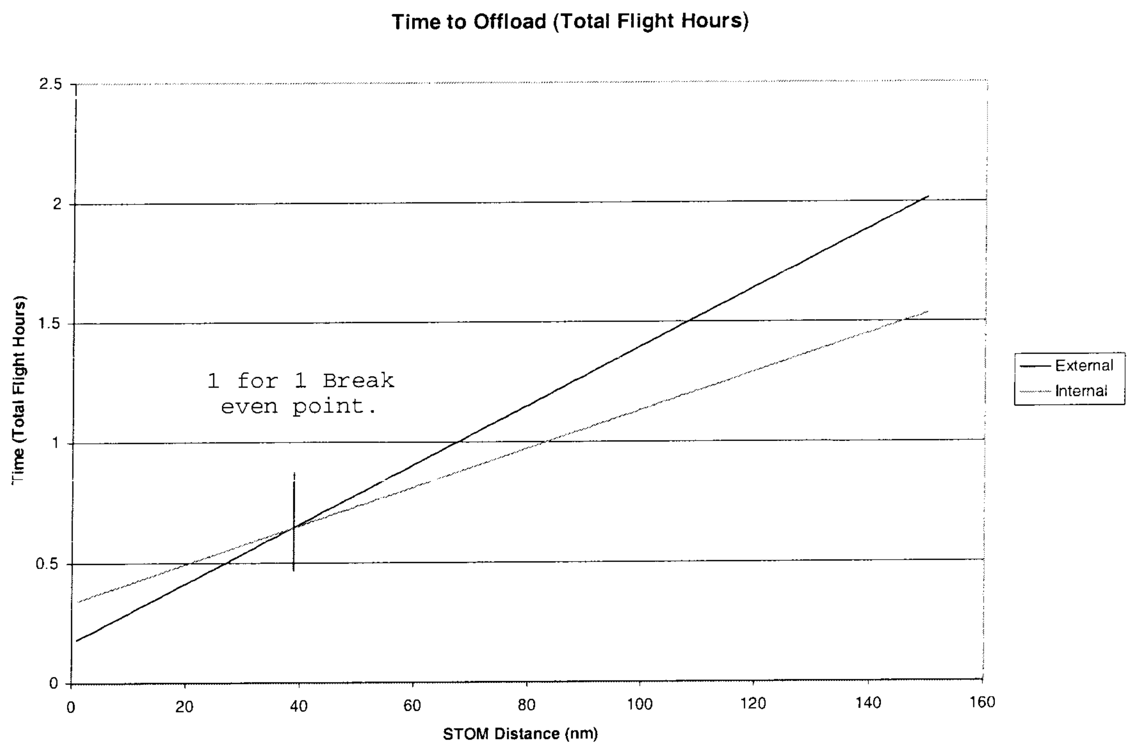

Figure 1. Time to Move One Vehicle Ashore.

In Figure 1, the break-even point is where the two lines cross, about 39 nm. Until STOM operating distances reach 39 nm, it is more efficient to transport vehicles externally. In essence, it takes an operating distance of 39 nm for the superior internal transport airspeed to overcome the time cost of internally loading a vehicle.

The timesaving achieved by internal transport is also present in Figure 5. At 39 miles, it requires 38.4 minutes to transport the vehicle ashore, either internally or externally (using the data in Table 1.) At 97 nm, external transport requires 1.3-flight hours, internal transport requires 1.1-flight hours, a timesaving of 0.2 flight hours.

2. Multiple Aircraft Moving Multiple Vehicles.

With a single aircraft, a 0.2 flight hour savings may not seem like much. However, with multiple aircraft, the timesaving add up rapidly. Figure **Error! Not a valid link.** shows the flight hours required to conduct an offload using the data from Case A above.

At 97 nm, the external offload takes 129.5 flight hours, the internal offload 105.4 flight hours. The external transport costs STOM an additional 24.1 flight hours. With 1.1 flight hours required for each internal round trip, 21 additional serials could have been moved ashore in the same amount of time.

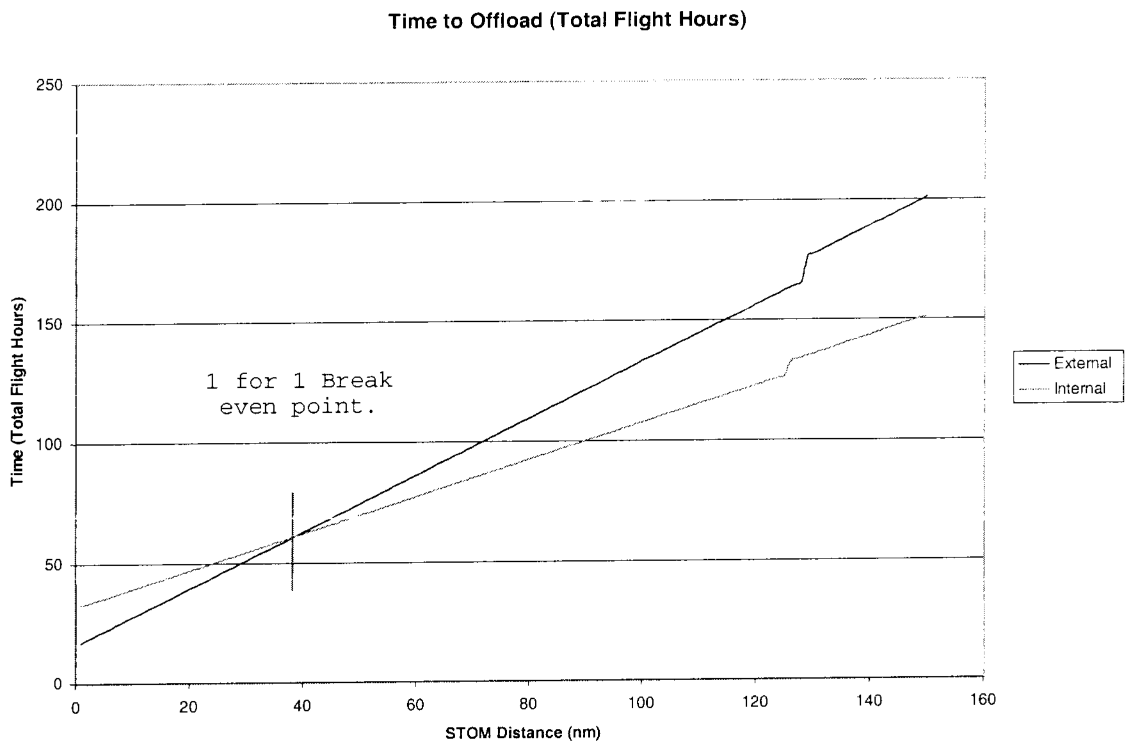

Figure 2. 48 Aircraft Moving 95 Vehicles Ashore.

B. MICV Replacement Factor (F_{MICV})

It was stated above that not all HMMWV variants could be replaced by a single MICV. As shown in Figure **Error! Not a valid link.** above, there is a timesaving to be gained at longer distances by internally transporting vehicles using the superior A/S of the MV-22. During phase two of the study, the question became "What is the maximum MICV for HMMWV replacement strategy?".

Since no actual MICV data is available, a direct comparison was not possible. Instead, it was decided to compare the HMMWV to a "MICV Factor" (F_{MICV}). This MICV factor would be the number of MICVs required to equal the capabilities of one HMMWV. This F_{MICV} then translates directly into a replacement strategy. If it is decided that the MICV to HMMWV replacement will be one for one, then $F_{MICV} = 1$.

For example, the HMMWV cargo variant carries 88 cubic feet of cargo. If it is envisioned that the MICV would carry 44 cubic feet of cargo due to size restrictions, then it would take 2 MICVs to equal the cargo capability of 1 HMMWV. In this case the F_{MICV} would equal 2.0. Note that a $F_{MICV} > 1$ implies that the MICV is less capable then the HMMWV. Therefore, more MICVs must be transported to provide capability equal to a given number of HMMWVs.

A $F_{MICV} < 1$ implies that the MICV is more capable then the HMMWV. However, this is not intuitively possible. With the inside dimensions of an MV-22 significantly smaller then that of a HMMWV, a MICV is probably not going to be more capable then the HMMWV. Practically speaking, the smallest possible F_{MICV} would appear to equal one.

1. MAA Scenario Studies.

During a recent MAA study, a shore-to-shore and a ship-to-shore movement were modeled (Cases A and B in Table 1). In Case A, operating 97 nm from the objective allows a maximum $F_{MICV} = 1.22$. The long distance combined with the MV-22 internal airspeed advantage allows for more vehicles to be moved ashore internally than externally for the same cost in terms of flight hours.

However, if Case A is modified to a distance of 30 nm with all other factors constant, a F_{MICV} of 0.93 is required. In essence, unless the MICV replaces the HMMWV at less than a one for one basis, external transport is preferred. The additional time required to internally load/unload the vehicles can not be overcome by internal load airspeeds due to the relatively short distance involved.

In Case B, changing the distance from 30 nm to 97 nm yields similar results. At 30 nm $F_{MICV} = 0.93$ and rises to $F_{MICV} = 1.25$ at 97 nm.

From these two cases, it is obvious that distance has a significant impact. Keeping the number of externally transported HMMWVs constant, more MICVs can be transported ashore the greater the distance. Obviously, the greater the distance, the more time available for an aircraft flying its internal load airspeed to make up for the added time required to load/unload.

This comparison demonstrates that no single F_{MICV} is applicable to all distances. Therefore, a MICV for HMMWV replacement strategy must be based upon operational distances likely to be encountered.

2. Operational Distance Comparison.

For a given sized unit (vehicles and aircraft), what are the likely operating ranges to be encountered? What is the maximum F_{MICV} allowable at these ranges?

For the sake of argument, assume that Case A above is a MEF sized unit operating in a STOM environment, while Case C represents a MEU sized unit. The model was used to determine F_{MICV} at distances from 1 nm to 150 nm.

For the MEU, Figure 3 provides a maximum F_{MICV} based upon a given distance. For example, at a distance of 40 nm a maximum F_{MICV} of 1 is obtained. As shown above, at any distance less than 39 nm, the MICV will be carried externally. Any $F_{MICV} > 1$ will benefit the MEU operating inside of 39 nm of the objective.

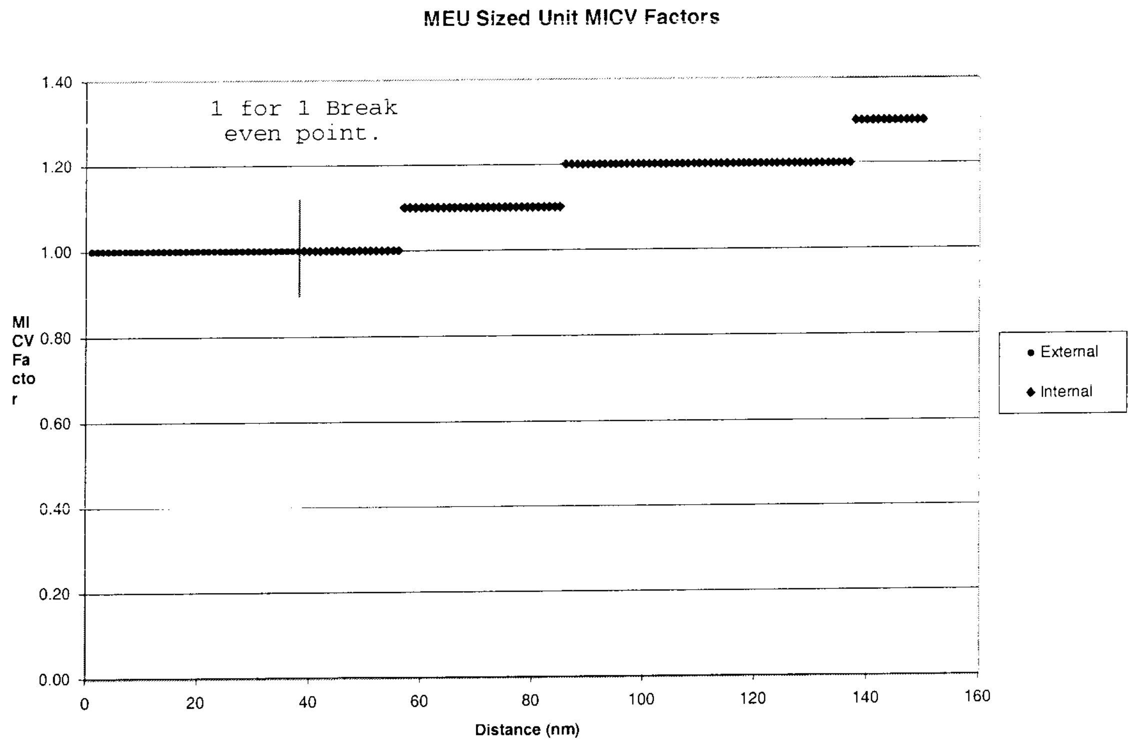

Figure 3. MEF Sized Unit MICV for HMMWV Replacement Factors.

The jumps in the graph reflect the fact that no partial trips to the landing zone are allowed. In essence, unless an aircraft can complete a round trip in the allotted time, it is not allowed. For example, if $FH_E = 12$ and $RTT_I = 1.1$, then only 10 round trips can be completed (in 11 flight hours). The last hour is "lost" to the aircraft internally transporting vehicles.

Figure **Error! Not a valid link.** shows the distance-F_{MICV} comparison for the MEF. At 97 nm, a $F_{MICV} <$ 1.22 is required in order for the MEF to realize a timesaving between externally transporting HMMWVs and internally transporting MICVs. At 97 nm, a $F_{MICV} > 1.22$ implies that no timesaving will be realized. As the MEF closes the objective, the maximum allowable F_{MICV} decreases accordingly.

What is the maximum F_{MICV}? If a MEF operates at 97 nm, $F_{MICV} < 1.22$ is correct, for a MEU operating at 40 nm, $F_{MICV} < 1$. If it is expected that 80% of deployed MEUs will operate 50 nm from the objective, then a $F_{MICV} < 1.0$ is required, at 25 nm $F_{MICV} < 0.8$. For MEF sized units, 50 nm has $F_{MICV} < 1.22$; 25 nm $F_{MICV} < 0.88$. *It must be stressed that a F_{MICV} that is advantageous at one distance may not be at another, shorter, distance, for a given sized unit.*

In Figure **Error! Not a valid link.**, the jumps in the vicinity of 125 nm represent refueling effects. Table 2 shows the refueling effect.

At 125 nm, neither the internal nor the external aircraft require fuel. At 126 miles, the internal aircraft require 5.0 hours of refueling time. The internal aircraft are moving

	External Acft	Internal Acft	External Acft	Internal Acft
Distance	125	125	126	126
Refueling Time	0.0	0.0	0.0	5.0
$MICV_F$	1.27	N/A	1.24	N/A
Distance	128	128	129	129
Refueling Time	0.0	5.2	9.4	5.2
$MICV_F$	1.25	N/A	1.32	N/A

Table 2. Refueling Effects.

more vehicles; more round trips are required, therefore, more fuel is required.

At 128 nm, only the internal aircraft require fuel. At 129 nm, the internal aircraft do not require additional fuel, but now the external aircraft are required to refuel.

3. HTTV versus HMMWV Comparison.

The utility cargo variant (M998) of the HMMWV is listed as 185"L x 85"W x 69"H. The actual cargo compartment of this HMMWV is listed as 85"L x 75"W x 24"H which provides 88 cubic feet of storage space.

The dimensions of the HTTV are given as 174"L x 62"W x 65"H. Of this, a cargo area of 70"L x 62"W x 24"H provides for 60 cuft of cargo space. When compared to the HMMWVs cargo space of 88 cubic inches, a F_{MICV} = 1.46 is derived.

If the high-back version of the HMMWV (M1037) is considered, a F_{MICV} = 4.53 is obtained. Since 4.53 is completely off the F_{MICV} scale, the M1037 HMMWV will not be considered as a candidate to be replaced by the MICV.

Returning to Figures 3 and 4, F_{MICV} = 1.46 is not advantageous, at any distance, for either sized unit. A maximum F_{MICV} = 1.3 is shown by Figures 3 and **Error! Not a valid link.**. Note that a F_{MICV} = 1.3 is only advantageous at distances in excess of 139 nm. It is debatable whether any Marine unit would operate this far from its objective on a routine basis.

How long would the HTTV have to be in order to meet the 1.3 F_{MICV} given above? The cargo bay of the HTTV would have to be 80"L x 62"W x 24"H. On the HTTV, 104" is required for the cab (engine and drivers compartment). If a 104" cab is added to the front of an 80" long HTTV cargo area, the HTTV length would be 184". It is debatable whether a 184" long, two-axle vehicle can be loaded aboard the MV-22 due to the aircraft's' ramp angles.

4. Loading Time.

Besides airspeed and distance, the other major factor driving F_{MICV} is the time required to load/unload vehicles. If loading time for an internal MICV and external HMMWV are equal (remember, the HMMWV aircraft must load passengers), then what is the maximum

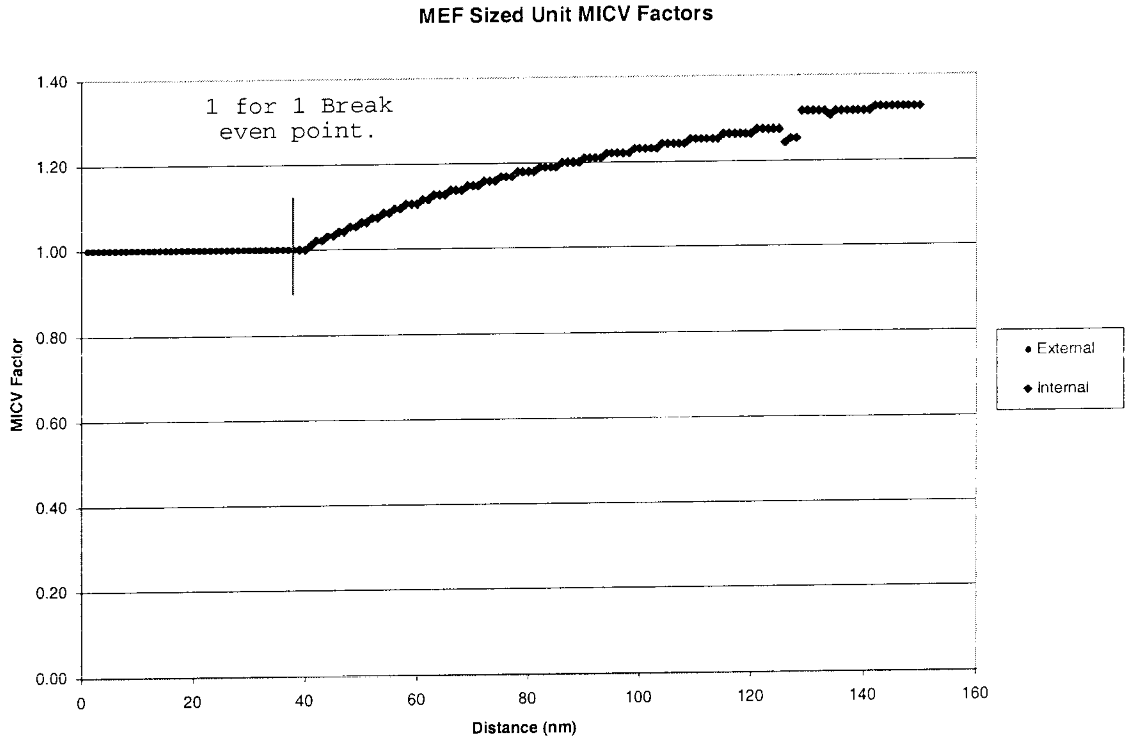

Figure 4. MEF Sized Unit MICV Factors.

F_{MICV}? Table 3 summarizes the distance/ F_{MICV} comparison. (Note: Figures 3 and **Error! Not a valid link.** *do not* reflect the data for this case)

	MEU	MEF
Max F_{MICV}	1.4 @ 60 nm	1.5 @ 130 nm
50 nm	1.3 (1.0)[1]	1.37 (1.22)[1]
25 nm	1.2 (0.8)[1]	1.29 (0.88)[1]

1. Results obtained from earlier cases with dissimilar loading times.

Table 3. Equal Loading Times for Internally and Externally Transported Vehicles.

A F_{MICV} = 1.5 is possible for the MEF, but again, it requires operations at distances outside of that reasonably expected for a MEF.

5. CH-53E versus MV-22: Two For One.

In the past, it has been demonstrated that the CH-53E is capable of externally

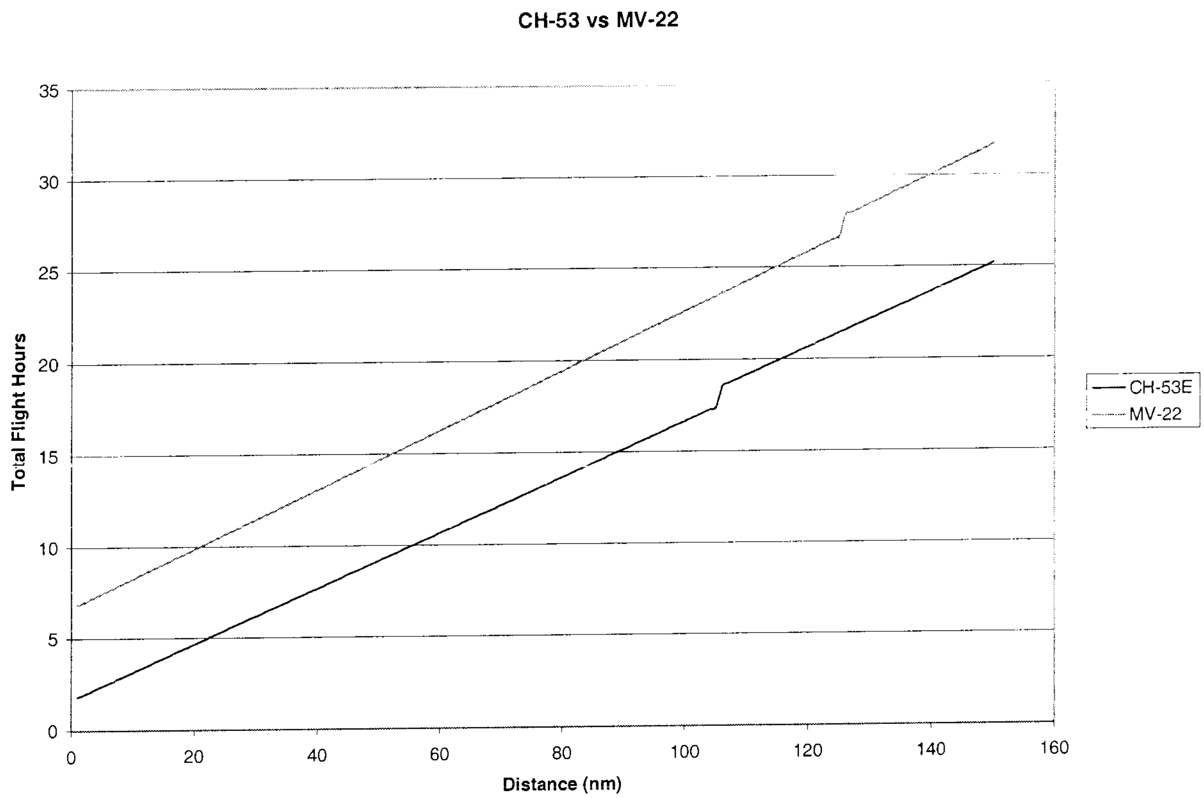

Figure 5. CH-53E vs MV-22

carrying two HMMWVs simultaneously. If MICVs replace HMMWVs on a 1 for 1 basis, it requires two MV-22s to carry the equivalent of one CH-53s worth of HMMWVs. In effect, $F_{MICV} = 2.0$. As shown in Figure 5, the total flight hours required for 5 CH-53Es to externally transport 20 HMMWVs (two per lift) is always less than that required to internally transport 20 MICVs using the MV-22.

III. Summary

In order to truly benefit STOM, the entire concept of moving vehicles ashore must be re-evaluated. Ideally, the CH-53E and MV-22 should be able to externally carry multiple vehicles simultaneously. Any vehicles developed in the future must provide the capability to fit internal to the MV-22 as well as being externally carried in pairs by any aircraft.

At times it is more efficient to externally carry a vehicle than it is to internally transport the same vehicle. At some break-even distance, it becomes more efficient to transport the vehicle internally. The time cost associated with loading and unloading internally carried vehicles is steep. In order to overcome this cost, the aircraft must have enough of a transit distance in which to utilize its faster airspeed when carrying internal cargo. Using a 1 for 1

MICV to HMMWV replacement strategy, this break-even point is approximately 39 nm. After 39 nm, it is more efficient to transport vehicles internally.

If the MICV to HMMWV replacement strategy is on a 1 for 1 basis, then MICVs should be transported internally out to distances of 39 nm. After 39 nm, STOM is better served by internally transporting the vehicles. If the MICV to HMMWV strategy is anything more than 1 for 1, caution is required. Depending on the number of MICVs required to replace the capability of a single HMMWV, savings in a STOM operation may not be realized. *It is stressed that a replacement strategy that is advantageous at one distance is not better at a lesser distance for a given sized unit.*

It would appear that the best a HTTV cargo variant could hope to achieve is a replacement ratio of 1.46 HTTVs for every HMMWV. However, this ratio is not advantageous at any operating distance.

Using the projected equipment set in 2007 (MV-22, CH-53E, HMMWV), the most efficient means of transporting HMMWVs is externally, by pairs, using the CH-53E. All currently owned HMMWVs should be retrofitted with lift points that allow for the lifting of HMMWVs in pairs.

A. The Spread Sheet Model

A. Variables.

Table **Error! Not a valid link.** contains the variables utilized by the model.

General Data	**Unit of Measure/Use**
Distance	NM distance from ship-to-shore.
# Acft	# of Acft in scenario
# HMMWV	# of HMMWVs to be moved externally
Airspeed (A/S) Data	
A/S w/External Vehicle	Acft speed w/external load (nm/hr)
A/S w/Internal vehicle	Acft speed w/internal load (nm/hr)
A/S Cruise	Acft cruise speed w/no load
Loading Data	
Loading (Internal)	Time to load internal vehicle (min)
Unload (Internal)	Time to unload internal vehicle (min)
Loading (External)	Time to load external vehicle (min)
Unload (External)	Time to unload external vehicle (min)
Refueling Data	
Endurance	Acft endurance (hrs)
Time to refuel	Time to refuel aircraft (hrs)

Table 4. Spreadsheet Model Data Variables.

B. Computations.

The goal is to compare the time required to transport a number of HMMWVs to shore with the corresponding time to move an equivalent (in terms of capability) number of MICVs (# of HMMWVS * F_{MICV}). In order to compute the total time required for the movement, several preliminary computations are required.

The following notional data will be used in the example. This data is not meant to reflect operational data for any unit or scenario. Rather, these data points were chosen in order to demonstrate all facets of the model during the given example. Variables used to compute externally transported vehicles have a subscript "E", those for internally transported vehicles have a subscript "I".

Distance 90 nm
Number of Aircraft 10
Number of Vehicles 25
Airspeed w/external load 120 kts
w/internal load 250 kts
cruise 250 kts
Load time 5 min (external load)

	15 min (internal load)
Unload time	5 min (external load)
	5 min (internal load)
Endurance	3.5 hrs (external load)
	4.0 hrs (internal load)
Time to Refuel	.2 hrs

1. Round Trip Time (RTT).

Round trip time is a function of: how long it takes to load a vehicle, fly to the LZ, unload the vehicle, and return to the ship. Round trip time is computed as follows:

RTT_E = (Distance / A/S w/External load) + (Distance / A/S Cruise) + (Unload Time/60) + (Load Time/60)

Where

Distance / A/S w/External Load used to compute flight time to LZ in hours
Distance / A/S Cruise used to compute flight time from LZ in hours
Load Time/60 is the load time converted to hours
Unload Time/60 is the unload time converted to hours.

Ex:

$RTT_E = (90/120) + (90/250) + (5/60) + (5/60) = 1.28$ hours

2. Flight Hours (FH).

The number of Flight Hours required to transport all vehicles externally (FH_E) is computed as:

FH_E = (Number of HMMWVs to move ashore)* RTT

Ex:

$FH_E = 25 * 1.28 = 31.92$ hours.

3. Time Spent Refueling (TSR).

The amount of time refueling, while a primitive calculation, does have a noticeable affect in scenarios involving a small number of aircraft moving a large number of vehicles.

a) Fueling Frequency (FF).

This computes the number of complete round trips the aircraft can make before fuel is required. This is rounded to the lowest integer (INT function). Intuitively, if 2.3 refueling evolutions are required, then the aircraft must refuel after two complete trips.

$FF_E = INT(Endurance_E/RTT_E)$

Ex:

$FF_E = INT(3.5 / 1.28) = 2$

The aircraft can make two round trips before fuel is required.

b) Number of Round Trips (NRT).

Two calculations are required here. The first computes the baseline number of round trips.

$NRT_B = INT(\# HMMWVS / \# Aircraft)$

In the example, this would be INT(25/10) = 2. If every aircraft were to make 2 round trips, only 20 vehicles would be moved ashore. The number of aircraft that must complete an additional round trip is computed as:

$ACFT_{B+1} = MOD(\# HMMWVS / \# Aircraft) = MOD(25/10) = 5.$

The number of round trips for these five aircraft is equal to:

$NRT_{B+1} = NRT_B + 1 = 3.$

The number of aircraft making a total of NRT_B round trips is equal to:

$ACFT_B = \# Aircraft - ACFT_{B+1}.$

So, 5 aircraft ($ACFT_B$) must make 2 round trips (NRT_B) and 5 aircraft ($ACFT_{B+1}$) must make 3 round trips (NRT_{B+1})

c) Number of refuels.

The total number of refueling evolutions required is:.

$NR_E = ACFT_B * [INT((NRT_B/FF_E) - 1 * IF(AND (MOD (NRT_B/FF_{E)} = 0), (NRT_B \neq 0)),1,0)[+$
$ACFT_{B+1} * [INT((NRT_{B+1}/FF_E) -) - 1 * IF(AND (MOD (NRT_{B+1}/FF_{E)} = 0), (NRT_{B+1} \neq 0)),1,0)].$

The first term gives the number of refuelings the 5 aircraft making 2 round trips must make. The second term gives the number of refuelings required by the 5 aircraft making 3 round trips.

The term "$[INT((NRT_B/FF_E) - 1 * IF(AND (MOD (NRT_{B+1}/FF_{E)} = 0), (NRT_{B+1} \neq 0)),1,0)]$", while daunting, is simple in practice. This term ensures that refuelings at the end of the flight are not counted. For example, if an aircraft has a refueling frequency of 2 and is only required to make two rounds trips, no refueling is required. The aircraft is able to complete its mission without refueling.

Ex:

$NR_E = 5 * [INT (2/2) - (1 * IF(AND(MOD(2/2) = 0), (2 \neq 0),1,0))]+$
$5 * [INT((3/2) - (1 * IF(AND(MOD(3/2) = 0), (3 \neq 0),1,0))]$

$= 5 * [1 - (1 * IF(AND(TRUE),TRUE,1,0))] +$
$5 * [1 - (1 * IF(AND(FALSE), TRUE),1,0))]$

$= 5 * [1 - (1 * 1)] +$
$5 * [1 - (1 * 0)]$

$= 5 * [0] + 5 * [1]$

= 5 refuelings required.

d) Time refueling (TR).

The total time spent refueling is the number of refuelings times the time required to refuel:

$TR_E = NR_E$ * Refueling Time

Ex:

$TR_E = 5 * 0.2 = 1.0$

4. Time To Offload (TTO).

The number of flight hours required to conduct the offload is the sum of the Time Spent Refueling and Flight Hours required to externally offload all vehicles.

$TTO_E = TR_E + FH_E$

Ex:

$TTO_E = 1.0 + 31.92 = 32.92.$

5. Number of MICVs.

The number of MICVs that can be moved ashore internally in the same amount of time as that required to move the HMMWVS externally is TTO_E divided by the round trip time to move a vehicle internally. This is an iterative calculation. In simplified form, # MICVs is calculated as:

$$\# \text{ MICVs} = \text{INT}\left(\left(TTO_E - TR_I\right) / RTT_I\right)$$

Ex:

$$\# \text{ MICVs} = \text{INT}((32.92 - 0) / 1.05) = 30$$

The integer portion is taken to ensure that partial trips with internal vehicles are not taken.

6. $MICV_F$.

The maximum allowable replacement factor for MICVs to HMMWVs is then the number of MICVs moved divided by the number of HMMVs:

$$MICV_F = 30/25 = 1.2.$$

C. Summary.

Using the data given above, if HMMWVs are replaced by MICVs at a rate that exceeds 1.2 to 1, then the externally carried HMMWVs are more conducive to the STOM concept *within this scenario.*