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## Analyses Of Alternatives (AoAs) Across The Milestones

### Report Information

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ANALYSES OF ALTERNATIVES (AoAs) ACROSS THE MILESTONES

Dr. George Akst
Senior Analyst
MCCDC
Purpose of an AoA

• An Analysis of Alternatives (AoA) can:
  – Illuminate risk, uncertainty, and relative advantages and disadvantages of alternatives
  – Show sensitivity to changes in key assumptions
  – Help decide whether military/economic benefit is worth the cost
  – Help to refine requirements documents (CDD, CPD)
  – Address “affordability”…
    • The degree to which the life-cycle cost of a program is in consonance with the long-range investment and force structure plans of the …Component
AoA Issues at Various Milestones

• Broader, more general questions at early milestones; more focused as the program matures

• Case Study for the Expeditionary Fighting Vehicle (EFV)*
  – Milestone I: Concept Development
  – Milestone II: Engineering Development
  – Milestone C: Limited Rate Initial Production (LRIP)

How have the questions/issues changed to support these different decision points?

*Formerly the Advanced Amphibious Assault Vehicle (AAAV)
Outline

• Background
• Milestone I COEA
• Milestone II AoA
• Milestone C AoA Update
• Conclusions
Previous History of Amphibious Vehicles

- LVT-7 begins fielding in 1972
  - Slow swimming (~7 knots)
  - Weapon station: 50-caliber machine gun
- Late 1970s: LVA program to develop fast swimmer
  - COEA: technology couldn’t support program
- Early 1980s: Upgrade to AAV7A1
  - Upgunned weapon station: 50-cal/40mm grenade launcher
- Mid 1980s: LVT(X) program to enhance firepower
  - COEA: Military benefit not worth the cost
- Late 1980s: AAAV program born
  - Fast swimmer and enhanced firepower
Outline

• Background

• Milestone I COEA

• Milestone II AoA

• Milestone C AoA Update

• Conclusions
Milestone I Cost and Operational Effectiveness Analysis (COEA)

• Helped to refine the Operational Requirements Document (ORD)

• Narrowed the field from the broad array of possible candidates

• Supported the Technology Development Strategy
Summary of Milestone I COEA

• Examined 13 alternatives
  – Fast swimmers: AAAV(F); AAV7A2(F)
  – Slow swimmers: AAV 7A1; AAAV(S); AAV7A2(S); submersible
  – Non-swimmers: Bradley; LAV-25; M113A1; APC(X); FIFV
  – Non vehicles: All surface (LCAC); All air (MV-22)
  – And also mixes

• Screened out alternatives based on cost & performance
  – AAV7A2(F); submersible; LAV-25; FIFV; all air; Bradley
    • Bradley placed back in mix by ASN (RD&A)

• Supplemental analysis examined mixes and modular construction of AAAVs
Summary of Milestone I COEA (Cont)

• **AAAV(F) best performer and most effective**
  – Used campaign-level model (AWM) on 2 scenarios
  – MOEs: Loss exchange ratio; force movement; fraction surviving; ship-to-shore timelines
  – Influencing factors: speed (faster build-up) and firepower

• **But also substantially more expensive**
  – Not so if we account for number of ships to carry 3 MEBs

• **Procurement strategies**
  *(Fast swimmers for all amphibs; slow swimmers for rest)*
  – Some advantages of higher effectiveness at lower cost
Outline

• Background

• Milestone I COEA

  • Milestone II AoA

• Milestone C AoA Update

• Conclusions
What Should a Milestone II AoA Include?

• **Answer depends on:**
  – What was included in Milestone I AoA/COEA
  – What has changed since?

• **Contention:**
  – Milestone II AoA should avoid duplication as much as possible
  – It should focus on the key issues of the time

• **Above all, remember goal is to support decision on whether or not to proceed into SDD**
  – Not narrowing down design decision
  – Not nailing down detailed fielding plan
COMPONENTS OF AoA

- Develop alternatives
- Effectiveness analysis
- Logistics supportability
- Cost analysis
- Historical comparisons
- Affordability analysis
- Conclusions
Alternatives

AAV RAM/REBUILD (RS)

• Achievable performance improvements
• Substantial cost savings (over AAAV)

 Reduced Procurement Objective

AAV IMPROVED AAV(I)

• Mixed fleet
  • AAAV, AAV(RAM/RS)
  • AAAV, AAV(I)

AAAV

Stretched procurement
Results: Maneuver at Sea (LPS 3)
Night; High Tech Threat; AAVs Ride

Threat System Losses

<table>
<thead>
<tr>
<th></th>
<th>AAV</th>
<th>AAV(I)</th>
<th>AAAV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Armor</td>
<td>6.8</td>
<td>7.6</td>
<td>8.4</td>
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<tr>
<td>Launcher</td>
<td>1.6</td>
<td>1.7</td>
<td>1.9</td>
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Threat Personnel Losses

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<tr>
<td>Losses</td>
<td>34</td>
<td>52</td>
<td>73</td>
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Friendly System Losses

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<th></th>
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<th>AAAV</th>
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<tbody>
<tr>
<td>Losses</td>
<td>14.9</td>
<td>13.1</td>
<td>8.4</td>
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- Statistically worse than all alternatives
- Statistically better than Baseline (AAV)
- Statistically better than all alternatives
Logistics Supportability

- **Reliability**

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<thead>
<tr>
<th></th>
<th>AAV RAM/RS</th>
<th>AAV(I)</th>
<th>AAAV</th>
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<td>MTBOMF (hours)</td>
<td>43.5</td>
<td>37.2</td>
<td>70.0</td>
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<tr>
<td>MTTR (hours)</td>
<td>2.3</td>
<td>2.4</td>
<td>1.5</td>
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Maintenance ratio: AAAV better than AAV by 3:1 margin

- **Personnel**

Change from baseline (AAV RAM/RS)
Summary Life-Cycle Costs
(By Phase)
Conclusions

- AAAV substantially better in performance and effectiveness than other alternatives
- Stretched procurement address near-term bow wave, but not long-term affordability
- Reduced procurement achieves significant savings but with some operational risk
- AAV RAM/RS mixed fleets provide substantial savings, with benefits of AAAV, but also add some operational risk and maintainability issues
Recommendations

- Decision at hand is whether or not to proceed into E&MD for the AAAV

- All viable alternatives contain AAAV

- Proceed into E&MD for AAAV

- Weigh RAM/RS mix and procurement strategies against affordability concerns in near-term (POM 04?)
Outline

• Background

• Milestone I COEA

• Milestone II AoA

• Milestone C AoA Update

• Conclusions
Milestone C AoA “Update”

• Several things have changed since last Milestone and AoA
  – Reliability KPP decreased
  – Costs have increased
  – Program changed to reflect SPG direction
• OSD requested AoA update to address changes
## Alternatives

### Program of Record

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<tr>
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<th>33 Inf Bn</th>
<th>11 1/3 EFV Co</th>
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1,013 EFVs

### Mixed Fleet Alternative

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<th>33 Inf Bn</th>
<th>8 1/3 EFV Co</th>
<th>3 LAV(P) Co</th>
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573 EFVs

<table>
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<th>581 LAVs</th>
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<tr>
<td>• 498 LAV(P)</td>
</tr>
<tr>
<td>• 24 LAV(C)</td>
</tr>
<tr>
<td>• 21 LAV(R)</td>
</tr>
<tr>
<td>• 38 LAV(L)</td>
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## Life Cycle Cost Estimates

**FY07$B (40 year life)**

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<th>RDT&amp;E</th>
<th>Procurement</th>
<th>O&amp;S</th>
<th>AVTB</th>
<th>Facilities</th>
<th>Total</th>
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<tr>
<td>EFV</td>
<td>$0.9</td>
<td>$10.9</td>
<td>$15.6</td>
<td>$0.1</td>
<td>$0.06</td>
<td>$27.5</td>
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<td>POR</td>
<td>$1.0</td>
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<td>$13.4</td>
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<td>$0.06</td>
<td>$22.5</td>
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## O&S Cost Implications of Reduced Reliability (in $B FY07)

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<th>Fleet Type</th>
<th>70 hours MTBOMF</th>
<th>43.5 hours MTBOMF</th>
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<td>POR (1,013 EFVs)</td>
<td>$15.27</td>
<td>$15.64</td>
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<tr>
<td>Mixed Fleet (573 EFVs)</td>
<td>$10.32</td>
<td>$10.54</td>
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Difference ranges from about $225M to $370M – About 5% in both cases of total O&S costs.
Summary

• Mixed-Fleet alternative maintains significant forcible entry capability
  – Two MEBs as directed by SPG
  – All amphibs and MPF(F) equipped with EFVs

• LAV(P) augmentation provides equivalent tactical lift capability
  – Enhances potential for support to Irregular Warfare

• Mixed Fleet saves $3B PMC, $5B life-cycle

• Mixed Fleet increases risk in training (EEAP) and MCOs (reduced firepower)

• Reliability changes increase overall O&S by about 5%

• EFVs still required for forcible entry

Mixed Fleet a viable option for future Marine Corps capabilities
Outline

• Background

• Milestone I COEA

• Milestone II AoA

• Milestone C AoA Update

• Conclusions
Conclusions

• Alternatives will be broader at earlier milestones
• Level of detail will typically increase at later milestones
• Milestone C AoAs are the exception
  – Only required when specific areas demand additional investigation

It is important to continually bear in mind the decisions to be made at the milestone when structuring the AoA

There is no “cookbook solution” to performing and AoA – they must be customized for each milestone
Backups
Limitations of Analysis

• Effectiveness
  – Only addresses “pure” alternatives
    *Summary explores operational implications of others*
  – Does not fully account for command and control capabilities
    *Provided equivalent C-variants in all alternatives*
  – Limited to two scenarios
    *Did extensive exploration in vignette analysis, and sensitivity analysis*

• Logistics
  – Not completely independent estimates (reliability, operational profile)
    *Included sensitivity analyses in cost analysis*
Limitations of Analysis (Continued)

• Cost analysis
  – Alternatives are not always directly comparable (age of alternatives, phasing, etc.)
  
  Attempted to even playing field as much as possible: Total vehicle-years; added substantial SLEPs

  – Did not account for contractor logistics support
  
  This could theoretically provide benefit to all alternatives; because it is yet to be substantiated, and would not be a discriminator, it was not considered.
Effectiveness Analysis

Scenarios

• Vignettes
  – Smaller, more focused
    • Maneuver at sea
    • Meeting engagement
    • Hasty defense
    • Attack on a deliberate defense
  – Use for exploring system capabilities, sensitivities

• Scenarios
  – Use for main runs--operational-level analyses
    • MTW-E -- amphib assault
    • Lesser Regional Contingency (LRC) - SLOC
Scenario Sensitivities

- Threat levels
  - Projected vs. high technology threat
- Day vs. night
- Maneuver at sea
- Water Speed: 20 kn (threshold) vs 25 kn (objective)
- NBC Threat
Effectiveness Summary (Comparison of MOEs)

Comparison to AAV RAM/RS

Comparison to each other

Maximum Score: 224

Maximum Score: 224
Logistics Supportability (Cont.)

- Fuel consumption
  - Based on 150 hours/yr
  - Alternatives comparable on a per-mile basis
  - Sensitivity analysis

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<td>40mm</td>
<td>576</td>
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<tr>
<td>.50 cal</td>
<td>3,370</td>
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<tr>
<td>7.62mm (on C- and R-variants)</td>
<td>650</td>
</tr>
<tr>
<td>30mm</td>
<td>1,100</td>
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<tr>
<td>7.62mm (on AAAV-P)</td>
<td>4,500</td>
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Historical Analysis

- Examine historical Marine Corps operations
  - STARLIGHT (VietNam); URGENT FURY (Grenada); SHARP EDGE (Liberia); DESERT STORM (Iraq); RESTORE HOPE (Somalia)
  - Of these, which could have benefited from AAAVs?

- Similar analysis for projected future operations
  - Selected from Dynamic Commitment vignettes
  - NEO and peacekeeping/HA operation
Historical Analysis (Continued)

- **AAAV** would provide better:
  - **Operational flexibility**: Better exploit STOM
    - Eliminate operational pause
    - Reduce chances of landing on defended beaches
  - **Operational tempo**: Allows fully capable night operations
  - **Firepower and survivability**: Collective protection

- **AAAV** also has two major shortcomings:
  - Lack of three-shot line charge
  - Reduced cargo-carrying capacity
Conclusions (Pure Alternatives)

• AAAV substantially better in performance and effectiveness than other alternatives

• AAV(I) buys some increase in effectiveness
  – Still has significant operational shortfalls
  – Life-cycle cost over 80% that of AAAV

• AAV RAM/RS substantially lower in effectiveness
  – Significant operational shortfalls

Eliminate AAV(I) and AAV RAM/RS pure alternatives from further consideration
Conclusions
(Procurement Strategies)

• Stretched Procurement
  – Achieves nothing toward long-term affordability
  – Addresses near-term bow wave
    • Saves about $300M/yr PMC during peak years (2008-10)
    • Pushes an additional $800M further down the bow wave

• Reduced Procurement
  – Achieves actual near-term savings of $900M (PMC)
  – Adds additional savings of $1.3B in long term (O&S)
  – Incurs some risk from fleet reductions

These strategies warrant further consideration in conjunction with affordability concerns
Conclusions (Mixes)

• Eliminate AAV(l) mixes
  – Almost as expensive as AAAV, with less effectiveness

• RAM/RS mixes provide substantial savings with added benefit of AAAV

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<th>AAAV</th>
<th>Low Mix</th>
<th>High Mix</th>
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<tr>
<td>Life Cycle ($B)</td>
<td>16.2</td>
<td>12.0</td>
<td>13.3</td>
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<tr>
<td>Procurement ($B)</td>
<td>6.2</td>
<td>3.0</td>
<td>4.0</td>
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– Affordability: Low mix can reduce expenditures by almost $300M/yr throughout DPP
Concerns About Mixes

- Effectiveness of mixed fleets
  - Serious concern – leads to increased operational risk

  however
  - “Loading up” of all amphibious ships requires

  \[
  (2.5 \text{ MEBs}) \times (103 \text{ amtracs/MEB}) \times (85\% \text{ avail.}) = 219 \text{ amtracs}
  \]
Concerns About Mixes (Cont.)

- Overhead of maintaining two fleets of vehicles
  - Cost analysis incorporated much of this

- Problems with training with two different vehicles

- Operational risk
  - Can reduce effectiveness in 2\textsuperscript{nd}, near-simultaneous MTW

- Age of AAV RAM/RS
  - Basic hull would approach 50 years
    \textit{however}
  - Current assessment of hull is that it is adequate
  - Alternative (and corresponding cost) includes substantial SLEP during mid-life
Capabilities Comparison

• CONOPs
  – Both alternatives provide 2 MEBs forcible entry capability
  – Both alternatives equip MPF(F) with EFVs
  – POR provides infantry battalion EFV capability at 29 Palms, vice company for Mixed Fleet
  – Mixed Fleet provides less threatening alternative for lesser contingencies

EFV versus LAV(P) Comparison

• Survivability
  – Blast and ballistic protection comparable
  – Mine protection better for EFV
Capabilities Comparison (Cont)

EFV versus LAV(P) Comparison

• Firepower
  – EFV significantly more capable
    • 30mm stabilized cannon vice pintel-mtd 7.62mm MG

• Mobility
  – LAV offers no surf or open-ocean mobility
    • Must ride on connectors from ship to shore
  – Land mobility comparable on open terrain, but tracks always more capable than wheels
Shipboard Implications
(for 2015 Notional MEB)

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<tr>
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<th>Square</th>
<th>Weight</th>
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<tr>
<td></td>
<td>(1000 sq ft)</td>
<td>(1000 lbs)</td>
</tr>
<tr>
<td>EFV</td>
<td>35.3</td>
<td>6,272</td>
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<tr>
<td>LAV</td>
<td>42.9</td>
<td>7,348</td>
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- Relative differences significant (LAV over EFV)
  - 22% increase in square; 17% increase in weight
- Absolute increase for entire MEB only 2%
- Only impact on MPF-legacy or black-bottom
  - Both alternatives have EFVs on amphibbs and MPF(F)
Assumptions

- Actual procurement costs for current EFV prototypes used to project average unit costs in production
- Delivery profile and fielding plans based on POM-08
- Excursion assessed additional impact of rate reduction from POR
- RDT&E effort, with 7 prototypes, necessary to convert the existing LAV-L into a personnel carrier estimated by PM LAV
- For procurement, LAV-L used as an analogy for LAV-(P). For O&S costs (e.g., operating hours), LAV-25 used as an analogy.
Rate Effect Excursion

- Basic assumption was that learning (cost improvement) curve accounts for rate.
- However, we ran a sensitivity analysis adding in an additional, partial reduction due to rate:
  - Modeled with a rate slope of 95%.
  - Adjusted costs to align POR costs.
- EFV procurement costs in Mixed Fleet alternative rise from $6.65B to $6.87B:
  - Increase of 3% in Average Unit Cost.
**MS C Update analysis – Surface STOM**

**Forces Going Ashore**

- Two BLTs with:
  - 2 – Infantry Battalions
    - Each with EFV or LAV Company
  - 2 – Tank Companies
  - 2 – LAR Companies
  - 2 – Combat Engineer Spt Dets
  - 2 – DS CSS Companies
  - 2 – LAAD Detachments
  - 2 – LW155 Batteries

<table>
<thead>
<tr>
<th>Item</th>
<th>EFV-equipped</th>
<th>LAV-equipped</th>
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<tbody>
<tr>
<td>PAX</td>
<td>3,818</td>
<td>3,818</td>
</tr>
<tr>
<td>EFV</td>
<td>98</td>
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<tr>
<td>Tank</td>
<td>28</td>
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<td>HMMWV wpn carrier</td>
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<td>LAV</td>
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<td>LCAC Loads</td>
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</table>
Surface STOM Results
Time to Complete Landing

- Land a BLT in hours of darkness (8-10 hrs)
- 2 Surface BLTs
- 1 Surface BLT
Infantry Moved Ashore Over Time

# Infantrymen landed in 3.5 hours with:
- LAV(P)s: 71
- Shifted LAV(P)s: 1,014
- EFVs: 1,426
Purpose

Analyze the impact of any changes to the reliability requirements of the EFV

• Original Threshold: 70 hrs Mean Time Between Operational Mission Failure (MTBOMF)

• Revised KPP: 43.5 hrs MTBOMF

• Rationale
  – Comparable systems significantly lower
  – Mission profiles used in derivation unrealistic
# Reliability Comparisons

<table>
<thead>
<tr>
<th>Program</th>
<th>ORD Req’t</th>
<th>Normalized Req’t MTBOMF</th>
<th>Demonstrated at MS III</th>
</tr>
</thead>
<tbody>
<tr>
<td>AAAV</td>
<td>70 Hrs MTBOMF</td>
<td>70 Hrs</td>
<td>N/A</td>
</tr>
<tr>
<td>AAV RAM/RS</td>
<td>43.5 Hrs MTBOMF</td>
<td>43.5 Hrs</td>
<td>58 Hrs</td>
</tr>
<tr>
<td>ABRAMS</td>
<td>320 MMBOMF¹</td>
<td>32 Hrs</td>
<td>42 Hrs</td>
</tr>
<tr>
<td>BRADLEY</td>
<td>280 MMBOMF¹</td>
<td>28 Hrs</td>
<td>36 Hrs</td>
</tr>
<tr>
<td>CRUSADER</td>
<td>62 Hrs MTBSA (SPH)</td>
<td>62 Hrs (SPH)</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>104 Hrs MTBSA (RV)</td>
<td>104 Hrs (RV)</td>
<td></td>
</tr>
<tr>
<td>GRIZZLY</td>
<td>21 Hrs MTBOMF</td>
<td>21 Hrs</td>
<td>N/A</td>
</tr>
</tbody>
</table>
Relation between Mission Duration and MTBOMF (Objective)

Initial goal: 75%* probability of completing the mission

Initial KPP (70 hours MTBOMF) actually achieved 74% mission reliability