

These initiatives, with industry partnership, are pathfinders for influencing future long duration space missions and advancing the Technology Readiness Levels (TRLs) to make the AM environment viable in space.

Economic sensitivity (Cost modeling)

Maturing AM technologies are making an economic impact in many industries. LSCs worldwide see how they can capitalize on AM and Lean principles to minimize waste, increase efficiency and maintain enterprise competitiveness.

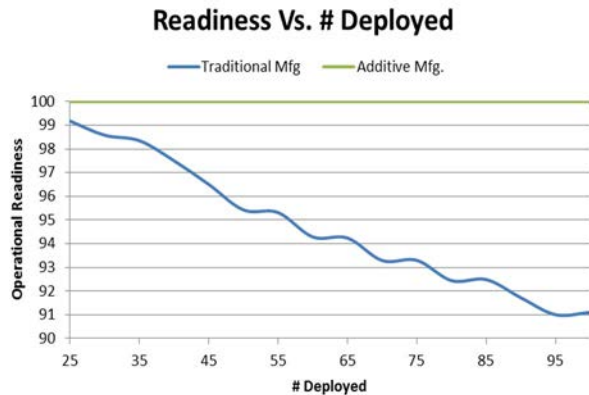


Figure 13 – Using AM methods Readiness can easily be maintained at or near 100% at minimal cost

Figure 12 illustrates the cost savings potential of AM. The 3:1 difference in production costs estimated for the manifold in Figure 10 is conservative when compared to reported savings by those working in the AM field. When operation and support phase is considered, there is an additional benefit to production costs by avoidance of the creep caused by added initial supply to fill the pipeline as deployed quantities increase. The AM capability to print on demand eliminates lead times; even with consideration of the significant cost of 3D printers, the saving is substantial.

The greatest savings opportunity by far occurs in the sustainment phase where differences in acquisition costs for spares, shipping, and maintenance labor are magnified. Operationally, and perhaps of greater importance to the user of a system is the difference between readiness potential of AM versus traditional manufacture. With AM, a constant readiness of almost 100% can be maintained regardless of the number of deployments. All it really takes is a printer and raw material at or near the using location to maintain a high rate of constant readiness. The graphic (Figure 13) clearly shows what is reported about many systems today; the struggle to maintain effective readiness in the face of increasing usage.

5. COST DRIVERS IN THE SUPPLY CHAIN

Beyond machine, material and post processing cost drivers for AM shown in section 1; there are two primary cost drivers in the LSC. They are uncertain demand and item

lead times. In order for LSCs to maintain adequate readiness levels, they either need to have on-hand inventory or be able to quickly obtain it from a supplier. This was demonstrated in Figure 4 where uncertain demand drove inventory to minimal levels, then as orders were placed, inventory was maximized resulting in disposals. When lead times are long, the problem is exacerbated due to longer forecast periods. Figure 14 illustrates the impact AM can have on cost versus traditional methods for sustainment costs.

There will always be a level of uncertainty in demand. Significantly reducing lead times will drive LSC efficiency and reduce costs through minimizing inventory and holding costs. Future LSCs will be agile and integrate Lean principles, point of use manufacturing and other lead time reduction initiatives. As AM is fully integrated into new systems, infrastructure to leverage the technology will be more seamless. Holding cost will be minimized and lead time will be near zero making the future LSC perform optimally.

6. FUTURE RESEARCH

It has been shown in this paper the advantages of integrating AM and 3D printing technologies into LSCs. The economic benefits will continue to grow as new systems integrate AM at the beginning of the lifecycle along with an ability to better forecast demand and reduce lead times to meet readiness objectives. Our research will periodically investigate the progress in these areas.

There is no doubt, AM is a disruptive technology. This applies to technology management as well as to its implementation. All aspects of management including cost modeling and estimating is different when compared to subtractive manufacturing. Our research has clearly identified some cost drivers of AM and suggested others. At this stage, we are left with two overarching implications of AM for cost estimators and modelers³⁰:

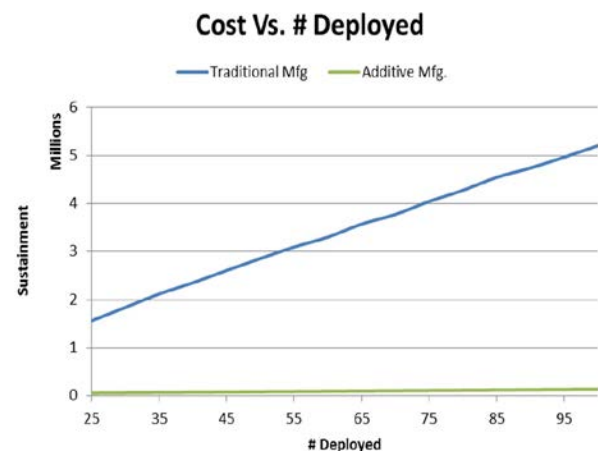


Figure 14 – Trade of AM versus Traditional sustainment costs for number deployed.

