5 COST CONSIDERATIONS

5.1 Rapidly Evolving Technology Will Contribute to MPAR Affordability

As chapter 1 noted, phased array radar technology has been used in DOD radar systems for 30 years, but a common perception has been that the technology was too expensive for civilian applications, even those as essential to the Nation as aircraft tracking and weather surveillance. However, the technology that has enabled an era of affordable, consumer-oriented wireless communications—cellular telephones, Wi-Fi computer networking (IEEE 802.11b wireless networking), and Internet access—has also brought opportunities to lower the cost of MPAR units substantially. MPAR for civilian applications has become a cost-effective alternative to a repair-and-replace strategy for meeting the Nation's radar needs as documented in chapter 2.

The continuing cost drops anticipated for solid-state T/R elements are fueled by a revolution in monolithic microwave integrated circuits (MMICs). MMICs are to radio frequency (RF) technology what digital integrated circuits (microchips) are to computing technology. The DOD spurred MMIC development through large investments in the 1990s. Investment in MMICs by the commercial wireless industry continues to drive improvements in their affordability.

High performance MMICs are generally made from semiconductors that are compounds of two elements, one with valence III and the other with valence V, called III-V semiconductors. With the exception of the power amplifier, highly functional MMICs for radar application can now be produced using lower-cost silicon technology. The tradeoff depends on the level of performance required. Low-cost silicon devices are used in modern cell phones for operation up to 2 GHz, with only the power amplifier made from III-V material. Silicon-germanium (SiGe) materials have demonstrated performance for the lower-power parts that approaches that of devices made of III-V semiconductor material.

Recent advances in solid state microwave circuitry using gallium nitride (GaN), one of the III-V semiconductors, has enabled design and production of MMICs for RF applications that are more powerful and efficient, yet less costly to build and cooler in operation, than competing technologies. The GaN-based MMICs currently being developed for use in military and commercial applications may further reduce the cost of phased array antennas like those needed for the proposed MPAR network. Relative to other high-power T/R element technologies, GaN-based devices will have the added benefit of not requiring a water-cooled heat dissipation and removal subsystem in the MPAR antenna, substantially reducing the design and manufacturing cost of the antenna structure. The GaN devices will also yield the same power as today's gallium arsenide chips in one-fourth of the chip area. These gains in device efficiency will reduce the cost per unit of performance.

The Defense Advanced Research Projects Agency (DARPA) has invested substantial R&D funds—currently $120 million—in its Wide Bandgap Semiconductor Technology program, which is pursuing the use of GaN devices for military applications. This investment will also accelerate the use of GaN-based MMICs in the commercial marketplace, likely resulting in further per-unit cost savings in production.

By leveraging technology trends in electronics and particularly in solid state devices, stable and highly reliable MPAR units can be fielded. By adopting commercial technology, system designers can keep the cost of spare parts and components low. Risk reduction R&D studies should be directed toward architectures that support this flexibility, such as open architectures. By contrast, there are no technological breakthroughs on the horizon that will lower the cost of conventional radars significantly from current levels.

5.2 Rough Order-of-Magnitude Acquisition and Operations and Maintenance Cost Summary

Appendix C contains a preliminary cost analysis comparing a national MPAR network with the cost for replacing existing networks with single-function MRCRs. Essential summary information about this analysis is presented below.

5.2.1 Acquisition Costs

A radar coverage analysis recently performed by Lincoln Laboratory at the request of the FAA indicates that the 510 radars in use today for weather and aircraft surveillance could be replaced with 334 MPAR units (Appendix C). This represents a 35 percent reduction in the number of surveillance radar units needed to perform current functions for current airspace coverage.

Per-unit average costs for the 334 MPAR units needed to replicate today's airspace coverage are estimated to be approximately $10 million, based on initial design work for an MPAR pre-prototype. This compares favorably with costs of today's MRCR systems and is likely to decrease substantially in the future as critical MPAR technologies evolve due to military and wireless industry development. Replacing current networks with 176 fewer radars with an average cost of $10 million each yields a $1.8 billion savings in initial acquisition costs.

5.2.2 Operations and Maintenance (O&M) Costs

In addition to the technical advantages of MPAR relative to MRCR, which are discussed in chapters 3 and 4, a second key consideration is the cost of operating national networks to meet existing and planned radar surveillance objectives. Maintenance and repair for the current MRCR units are significant contributors to life-cycle costs of their respective networks.

The current national weather and aircraft radar surveillance networks consist of 510 radars of seven different types. As shown in Table 3-1, the age of most of these radars ranges from 10 to 40 years. All seven have rotating antennas and high-power vacuum tube RF transmitters. Failure of either a moving part or a transmitter generally results in shutdown of the radar unit, which can have unavoidable economic and public safety consequences. Furthermore, the life-cycle cost of these units has been escalating due to:

- The age and cost of replacement parts;
- Training required on outdated technologies with different types of unique capability equipment; and
- More frequent upgrades to keep up with greater demands and capability.

An MPAR network with its graceful degradation characteristics will also reduce recurring maintenance costs by eliminating single-point-of-failure subsystems such as MRCR transmitters and antenna drive units, which require 24 hours-per-day, 7 days-per-week, maintenance contracts for guaranteed quick response to radar unit outages. To reduce the risk of a unit being down, preventive maintenance must be performed in advance of anticipated failure rates and adequate spares for any part or subsystem subject to single-point failure must be kept on hand. In comparison, MPAR maintenance and operations support is reduced because the radar unit has no moving parts and sufficient redundancy of operating elements to eliminate the need for maintenance personnel to be on call at all times, with spares available, for emergency repairs. Advanced techniques and architectures developed on military MPAR programs like Aegis allow trouble-shooting approaches that automatically isolate faults to the lowest replaceable unit. These approaches eliminate costly fault isolation procedures and reduce the use of scarce technical resources. The preliminary cost analysis by Lincoln Laboratory estimates a $3 billion savings in O&M costs over the 30-year lifespan of an MPAR network, if aggressively implemented, compared with the total O&M cost of continuing with the legacy systems. (See appendix C, figure 3, and accompanying text for the basis of this estimate.)

5.3 Summary

This preliminary comparison of cost factors suggests that an MPAR network could save $1.8 billion in acquisition costs and $3 billion in O&M costs. The cost per MPAR unit will be roughly comparable to the replacement cost for the legacy units based on MRCR technology. However, before a decision can be made, careful value engineering analysis is needed to establish a firm basis for the procurement, implementation, and O&M costs of an MPAR network. The risk-reduction R&D program proposed in chapter 6 includes this requisite cost-analysis effort.