Radar Forecast

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FPS-117(V)/TPS-77(V)

Outlook

- The Danish Ministry of Defense has formally accepted two TPS-77 radars into service that were delivered under a contract signed in June 2006
- In December 2007, Lockheed Martin received a contract valued at $44 million from Latvia for two TPS-77s, as well as options for long-term technical support
- Latvia contract includes options for up to four additional TPS-77 radars for Estonia and Lithuania

Orientation

Description. The FPS-117 is a long-range, 3-D search radar. The TPS-77 is a mobile version of the FPS-117.

Sponsor
U.S. Air Force
Electronic Systems Center
ESC/PAM
Joint Program Office
Hanscom AFB, MA 01731-5000
USA
Tel: +1 (617) 377-5191
Web site: http://www.hanscom.af.mil (Management)

Status. In service, ongoing logistics support.

Application. Air surveillance/defense with air traffic control applications.

Price Range. Based on recent contracts, the cost of a single TPS-77 ranges between $14.6 and $15 million.

Contractors

Prime
Lockheed Martin Ocean Radar & Sensor Systems
http://www.lockheedmartin.com, 6417 Deere Rd, Syracuse, NY 13206-1304 United States, Tel: +1 (315) 431-4546, Prime

Comprehensive information on Contractors can be found in Forecast International’s “International Contractors” series. For a detailed description, go to www.forecastinternational.com (see Products & Samples/Governments & Industries) or call +1 (203) 426-0800.

Contractors are invited to submit updated information to Editor, International Contractors, Forecast International, 22 Commerce Road, Newtown, CT 06470, USA; rich.pettibone@forecast1.com

July 2008
**Technical Data**

### Dimensions

<table>
<thead>
<tr>
<th></th>
<th>Metric</th>
<th>U.S.</th>
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</thead>
<tbody>
<tr>
<td>Antenna array</td>
<td>7.3 x 7.3 m</td>
<td>24 x 24 ft</td>
</tr>
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</table>

### Characteristics

#### Performance

<table>
<thead>
<tr>
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<th>Metric</th>
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<tbody>
<tr>
<td>Range</td>
<td>9.25 to 462.5 km ± 46m</td>
<td>5 to 250 nm ± 0.25 nm</td>
</tr>
<tr>
<td>Azimuth</td>
<td>360° ± 0.18°</td>
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<tr>
<td>Altitude</td>
<td>328,000 m</td>
<td>100,000 ft</td>
</tr>
<tr>
<td>Elevation angle</td>
<td>-6° to 20°</td>
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#### RF (transmitter) characteristics

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>Frequency</td>
<td>1,215 to 1,400 MHz</td>
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<tr>
<td>Bandwidth</td>
<td>185 MHz</td>
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</tr>
<tr>
<td>Agility</td>
<td>20 frequencies (quasi-random selection, beam-to-beam)</td>
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</tr>
<tr>
<td>Type waveform</td>
<td></td>
<td></td>
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<tr>
<td>Pulse width</td>
<td>51.2 µsec (short range)</td>
<td>409.6 µsec (long range)</td>
</tr>
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</table>

#### Power

<table>
<thead>
<tr>
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<th>Metric</th>
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</thead>
<tbody>
<tr>
<td>Total system</td>
<td>70 kW maximum</td>
</tr>
<tr>
<td>Transmit power</td>
<td></td>
</tr>
<tr>
<td>Peak</td>
<td>24.75 kW</td>
</tr>
<tr>
<td>Effective radiated</td>
<td>125 MW</td>
</tr>
<tr>
<td>Duty factor</td>
<td>16 percent maximum</td>
</tr>
<tr>
<td>Power supply</td>
<td>28 volts</td>
</tr>
</tbody>
</table>

**FPS-117(V)**

- MTBF: 1,076 hr (required)
- MTTR: 30 min
- Availability: 99.6%

**TPS-77(V)**

- MTBF: > 2,000 hr
- MTTR: 30 min
- Availability: 99.7%
- Periodic maintenance: 35 hr/yr

### Process and control

- Pre-processor
- MTI/Pulse compressor
- Doppler/Target processor
- Data processor
- Beacon/Target processor
- Data entry terminal
- Power supply equipment

### Operation control

- Operations control console
- P/M status display
- Target data display

**Design Features.** The FPS-117(V) air defense radar is a solid-state, L-band, three-dimensional system that was designed to provide long-range aircraft detection and position data for air defense, navigational assistance, and tactical control for both counter-air operations and close air support. It is a fixed-site derivative of the TPS-59(V) tactical radar.

The planar antenna is made up of 44-row transceivers, 44-row feed assemblies, four-column feed assemblies, and 12-row power supplies. The exciter and final receiver are located in the platform electronics unit mounted at the base of the antenna itself. The TPS-77(V) uses 34 solid-state transmitters and receivers located on the antenna array and directly coupled to their antenna elements. Both carry a separate monopulse beacon system with Mode 4 and Mode S Identification Friend or Foe (IFF) systems. The antenna is mounted on top of the radar sail.

The planar array produces a series of pencil beams phase-positioned to scan up to 20° in elevation while the complete antenna rotates. The elevation scan consists of 5- to 100-nautical-mile short-range beams, and 100-
to 250-nautical-mile long-range beams. Through use of pencil beams, the radar provides elevation coverage while eliminating some of the clutter problems typically associated with CSC² beams.

The radar was designed for high reliability and can tolerate component failures, continuing to operate effectively. Downtime is put at less than 35 hours per year for corrective and preventive maintenance. The system has a 30-minute mean time to repair (MTTR). MTBF (mean time between failures) for each power module is over 300,000 hours, with the automated maintenance computer controlled using built-in fault isolation. An FPS-117(V) at King Salmon Airport in Alaska demonstrated an MTBF of 1,432 hours, exceeding the 1,076 hours specified in the contract.

The antenna array electronics of older systems have been upgraded. The changes capitalize on available commercial components and technologies.

**Operational Characteristics.** The FPS-117(V)/TPS-77(V) provides long-range, accurate aircraft detection and position data for early warning surveillance, and supplements air traffic control systems. Clutter rejection processing automatically adapts to or rejects land, sea, and weather clutter. MTI (moving target indication) processing is used to enhance low-beam coverage and increase siting flexibility. Sidelobe nulling is used to eliminate ground clutter for the higher elevation beams.

The radars use a variety of interference rejection techniques. These include greater than 10 percent agile bandwidth, pulse-to-pulse frequency agility, low side-lobes, sidelobe blanking, MTI and constant false alarm rate processing, pseudo-random pulse repetition frequency, pseudo-random beam positioning, and a linear frequency-modulated waveform.

The system automatically adapts to changing ground and sea clutter environments, maintaining accuracy and target resolution capabilities under a variety of surveillance conditions. The data processor controls radar performance and monitors system status. Sweep-to-sweep and scan-to-scan correlation reduces false alarms and multiple reports.

The TPS-77(V) was tailored to be adaptable to a variety of siting situations. It can “look down” into valleys to detect low-flying aircraft in spite of severe clutter. Performance in rain and mountainous/forested locations is good.
**Variants/Upgrades**

**FPS-117(E)1.** The basic solid-state NATO Class 1 fixed-site radar.

**FPS-117(E)1T.** A transportable version, used in Croatia, that features most of the characteristics of the basic radar. Five Croatian systems interface with air traffic control centers. This version is modified to conduct coastal surveillance and search-and-rescue missions. It also is used to monitor commercial shipping and border areas.

**FPS-117(V)3.** This version is used by Saudi Arabia as part of the Peace Shield air defense system.

**FPS-117(V)4.** This version is installed at North Warning System (NWS) sites. The NWS radars were upgraded with the ability to detect low radar cross-section cruise missiles. The most important element of the upgrade was the provision of a correlator to separate small-target tracks from surrounding clutter.

**FPS-117(V)5.** This system was installed in Iceland. The (V)5 version saw some significant changes and formed part of the Iceland Air Defense System (IADS).

**FPS-117(V) Tactical Ballistic Missile Defense Upgrade.** This upgrade improved detection and missile cueing capabilities to provide for long-range detection of ballistic missiles, launch and impact point prediction, and better air surveillance capability. The radar can be tailored to meet specific theater ballistic missile (TBM) requirements as needed.

A high-power aperture provides sufficient energy for small target detection. Full monopulse processing ensures “one hit” position determination and provides programmable beam coverage to adapt to the environment. Electronic counter-countermeasures (ECCM) are designed to counter most jamming, while programmable data interfaces provide data handoff flexibility.

**Type 92 (T92).** This is the Royal Air Force nomenclature for two systems installed at remote sites in Scotland. They are early-production versions of the radar. Under an RAF contract, the transmit/receive electronics in the array were upgraded in August 2001.
**TPS-117/77(V).** This version features enhanced siting adaptability. Pencil beam terrain-following, MTI processing, and Doppler filtering, in combination with sidelobe nulling to eliminate ground clutter in high-angle beams, all allow the radar to be sited for optimal mission performance. The radar can “look down” from elevated sites to detect aircraft in valleys without the need for gap-filler radars, and it can “step over” mountains to avoid transmitting into mountains or population centers. It features 80 percent commonality with the FPS-117(V). A six-person team can have the radar set up and operational in 30 minutes. The antenna and electronics shelter can be transported by two trucks or in two C-130s. It can be operated remotely.

In October 2001, the radar was given the official designation TPS-77(V).

**L-88.** This is the aerostat version of the FPS-117(V). The L-88 system is tethered up to a height of 15,000 feet. From this altitude, the radar is capable of spotting small aircraft as far as 200 nautical miles away.

The U.S. Customs Service ordered four of these radar-equipped aerostats in 1988 for deployment to the Caribbean and along the southwest border of the U.S. for drug traffic interdiction.

**Program Review**

**Alaskan Radars Upgraded**

In February 1992, the Air Force issued a solicitation for contractors to improve the data-handling capabilities of the FPS-117(V) radars in Alaska. The resulting program integrated the FPS-117(V) and TPS-63(V) radars with the Aircraft Combat Maneuvering Instrumentation System, the Command Tactical Information System, the Advanced Interface Control Unit, and the Regional Operational Control Center. The system was intended to correlate target, IFF, and jamming strobes, in addition to offering data recording and playback, ground control intercept, and radar performance monitoring.

In January 1993, work began on a Kuwaiti air defense system based on a combination of the FPS-117(V) and French short-range equipment for a combined military/civilian air traffic control system.

**Reliability Upgrades**

In FY96 and FY97, the FPS-117(V)’s digital data processor and multi-modular processor were replaced with a new commercial off-the-shelf (COTS) radar data processor under a Radar Reliability, Maintainability and Supportability (RMS) upgrade. This upgrade improved the reliability of the process and control (P&C) group, eliminated manual adjustments within that group, and replaced the maintenance control system. The effort also replaced the multi-scan detection processing algorithm with an improved correlation algorithm, and replaced the maintenance control facilities processor with commercial equipment. These changes eliminated low MTBF and unsupportable equipment.

In May 2000, Lockheed Martin Naval Electronics & Surveillance Systems-Syracuse announced that it had been awarded a contract from the U.K.’s Royal Air Force (RAF) for continued upgrades to its FPS-117(V)
radars. The transportable radars were situated at two remote sites in Scotland and referred to by the RAF as Type 92 (T92). These were early versions of the radar. Each system received a new radar control and display system in the mid-1990s, followed by an upgrade of the electronics equipment. The new RAF contract upgraded the transmit/receive electronics. The installation was completed at the first site in August 2001, and at the second site a month later.

**Systems to Croatia/BALTNET**

On December 9, 1999, Lockheed Martin Naval Electronics & Surveillance Systems-Syracuse announced that the U.S. government had approved a license allowing it to provide an integrated radar surveillance system to meet Croatia’s civil and military needs. The contract included construction of five long-range, dual-use FPS-117E(1)T radars with associated display consoles, and five monopulse secondary surveillance radars. The license included the establishment of three operations centers equipped with large-screen displays and airspace management consoles. The communications system linking all the sites would use the expanding Croatian telecommunications network.

In December 2000, the Republic of Korea purchased four FPS-117(V) systems to supplement eight already in service. At the same time, Estonia selected the TPS-77(V) for its share of the expansion of BALTNET (a cooperative air surveillance network covering the airspace around Estonia, Lithuania, and Latvia). The last Estonian radar was delivered in May 2003.

In November 2001, the South Korean Air Force (ROKAF) contracted for three TPS-77(V) radars, along with integrated air operations, communications and logistics support. Deliveries began in 2004.

In December 2001, the Latvian Ministry of Defense contracted for one TPS-77(V) to expand the range of BALTNET. Delivery took place in 2003. The system was to be used by the Latvian Air Force for surveillance and air traffic control.

In July 2002, the Defense Security Cooperation Agency notified Congress of a possible Foreign Military Sale (FMS) to Pakistan of six Aerostat radar systems equipped with the L-66 and associated equipment and services. Pakistan procured these systems in response to Operation Enduring Freedom and used them to monitor ground traffic and low-flying aircraft along its western borders. The systems also enhanced the control of narcotics trade activities along the border.

**Romania Upgrades FPS-117s**

In February 2007, Romania contracted Lockheed Martin to upgrade its FPS-117s. The upgrades will consolidate the radar’s electronics from the current four cabinets into a single cabinet, in addition to increasing the capability and reliability of the system. The upgrades are intended to allow the radars to remain in service for another 15-20 years.

The Danish Ministry of Defense has formally accepted two TPS-77 radars into service. The radars were delivered under a contract signed in June 2006; the contract also includes four years of logistics support.

**Related News**

**Latvia Orders TPS-77** – On December 18, 2007, Lockheed Martin received a contract valued at $44 million from the Latvian National Armed Forces for two long-range TPS-77 transportable air surveillance radar systems, as well as options for long-term technical support. Included in the contract were priced options for up to four additional TPS-77 radars for Estonia and Lithuania. (Lockheed Martin, 12/07)

**Contracts/Orders & Options**

(Recent contracts over $5 million)

<table>
<thead>
<tr>
<th>Contractor</th>
<th>Award ($ millions)</th>
<th>Date/Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lockheed Martin</td>
<td>14.7</td>
<td>May 2004 – Letter contract modification to add a second long-range radar at the Pacific Alaska Range Complex. The system was to include a TPS-77(V), microwave equipment, support equipment, critical spares, and training. Completed Sep 2006. (F19628-03-C-0048, P00008)</td>
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July 2008
Radar Forecast

FPS-117(V)/TPS-77(V)

Award

Contractor | Award ($ millions) | Date/Description
Lockheed Martin | 44 | Dec 2007 – Contract from the Latvian National Armed Forces for two TPQ-77 radar systems as well as long-term technical support. The contract includes options for Estonia and Lithuania to purchase radars as well.

Timetable

<table>
<thead>
<tr>
<th>Month</th>
<th>Year</th>
<th>Major Development</th>
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<tbody>
<tr>
<td>Feb 1985</td>
<td>Contract for first 10 FPS-117(V) radars for the North Warning System</td>
<td></td>
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<tr>
<td>Apr 1985</td>
<td>First contract for the FPS-117(V) segment of the Saudi Arabian Peace Shield program</td>
<td></td>
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<tr>
<td>Jul 1987</td>
<td>Completion of contract for first radars for NWS; contract for four FPS-117(V)5s for the NATO Iceland Air Defense System</td>
<td></td>
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<tr>
<td>May 1988</td>
<td>Germany selects FPS-117(V)s</td>
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<tr>
<td>Mid 1988</td>
<td>Four L-88-equipped aerostats ordered by U.S. Customs Service</td>
<td></td>
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<tr>
<td>Aug 1988</td>
<td>NWS Initial Operational Capability</td>
<td></td>
</tr>
<tr>
<td>Jan 1989</td>
<td>Last FPS-117 installed at NWS</td>
<td></td>
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<tr>
<td>Oct 1991</td>
<td>First Peace Shield radar delivered</td>
<td></td>
</tr>
<tr>
<td>1Q FY95</td>
<td>Peace Shield installations completed; North Warning System fully operational</td>
<td></td>
</tr>
<tr>
<td>May 1992</td>
<td>Installation of additional radars in Canada and Turkey</td>
<td></td>
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<tr>
<td>Mar 1995</td>
<td>NWS IOC; radars installed in Alaska</td>
<td></td>
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<tr>
<td>Dec 1999</td>
<td>Croatia approved for five FPS-117E(1)T air defense/ATC radar and control systems</td>
<td></td>
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<tr>
<td>May 2000</td>
<td>RAF contract for T92 upgrades</td>
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<tr>
<td>Oct 2000</td>
<td>MSSR solicitation announced</td>
<td></td>
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<tr>
<td>Dec 2000</td>
<td>ROKAF requests four FPS-117(V) radars</td>
<td></td>
</tr>
<tr>
<td>Aug 2001</td>
<td>First RAF upgrade completed</td>
<td></td>
</tr>
<tr>
<td>Sep 2001</td>
<td>Second RAF upgrade completed</td>
<td></td>
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<tr>
<td>Nov 2001</td>
<td>ROKAF issues contract for three TPS-117/77(V) radars</td>
<td></td>
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<tr>
<td>Dec 2001</td>
<td>Latvia purchases FPS-117(V)</td>
<td></td>
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<tr>
<td>Apr 2002</td>
<td>Estimated end of Croatian production</td>
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<tr>
<td>Jul 2002</td>
<td>Jordan requests an FPS-117(V)</td>
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<tr>
<td>May 2003</td>
<td>Pakistan requests six Aerostat radars with the L-88</td>
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<tr>
<td>Nov 2003</td>
<td>Latvia takes possession of first BALTNET radar</td>
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<tr>
<td>1Q 2004</td>
<td>Delivery of TPS-77(V) radars for ROKAF</td>
<td></td>
</tr>
<tr>
<td>Jun 2004</td>
<td>RAF accepts T92 upgrades</td>
<td></td>
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<tr>
<td>Sep 2006</td>
<td>Delivery of second, and last, long-range radar for Pacific Alaska Range Complex</td>
<td></td>
</tr>
<tr>
<td>Feb 2007</td>
<td>Romania awards Lockheed Martin contract to upgrade FPS-117</td>
<td></td>
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</tbody>
</table>

Worldwide Distribution/Inventories

Australia | The RAAF uses several TPS-117/77(V) systems. |
Belgium | Has one FPS-117 in operation, the first production radar. |
Brazil | The Brazilian government has purchased the TPS-117/77(V) for its SIVAM (System for the Vigilance of the Amazon) environmental monitoring network. |
Canada/U.S. | The North Warning System program included the installation of 13 FPS-117(V)s – 10 to replace 10 Distant Early Warning/Long-Range Radar sites in Alaska and Canada, and three (one each) at three new sites on Canada’s northeast coast. FPS-124 gap-filler radars augment coverage between the FPS-117(V) sites. Canada added four new radars to coastal sites in Newfoundland and Nova Scotia in 1993 and held an option for one additional radar. |
**Radar Forecast**

**FPS-117(V)/TPS-77(V)**

**Croatia**
Approved for five joint air defense/air traffic control systems for use in air space management, maritime search and rescue, and the monitoring of commercial shipping.

**Denmark**
Denmark purchased two TPS-77s in 2005. They were formally accepted into service in 2007.

**Estonia**
Selected the TPS-117/77(V) to expand its share of BALTNET. The systems are supplemented by two smaller radars. BALTNET integrates the radars of Estonia, Latvia, and Lithuania.

**Germany**
Germany replaced an aging radar in Berlin with the FPS-117(V). The Berlin Radar Program upgraded the radar coverage and air traffic control capabilities of Tempelhof Central Airport. Three more radars were later acquired.

**Iceland**
Iceland installed four of the long-range radars in the four corners of the country.

**Italy**
Italy procured four FPS-117(V) radars.

**Korea**
Eight systems were procured.

**Kuwait**
One system was combined with existing French equipment to provide data for both military and civilian air traffic control.

**Latvia**
Procured one TPS-117/77(V) radar for BALTNET. Additional two radars ordered in 2007.

**Pakistan**
Pakistan is receiving six TPS-77s.

**Romania**
Acquired five FPS-117(V)s for its air traffic control system. These may be supplemented by possible co-production of 21 gap-filler radars.

**Saudi Arabia**
Saudi Arabia’s air defense system was upgraded under the Peace Shield program, which ties five regional control centers to a master command center. All the centers are linked with 17 FPS-117(V)/3 radars and five Boeing E-3A AWACS early warning aircraft. Saudi Arabia specified use of the FPS-117(V). The deployment of the FPS-117(V)/3 provides a nationwide air defense radar system that can, if needed, be expanded to the six nations of the Gulf Cooperation Council.

**Taiwan**
The Republic of China purchased two radars.

**Turkey**
Purchased one radar, with options for two more.

**United Kingdom**
Three T92 radars installed in Scotland.

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**Forecast Rationale**

Lockheed Martin continues to produce its TPS-77, finding buyers worldwide for its long-range radar. The TPS-77, based on the FPS-117, has been produced steadily over the past few years. A steady stream of contracts has kept the production line open. The most recent contract is for provision to Latvia of two TPS-77s. Also included in the contract is an option for four additional radars for Estonian and Lithuanian forces.

Lockheed Martin is marketing its radar throughout the world, and expects to sell between 15 and 20 radars over the next five to ten years. Under current contracts, production is under way for Latvia and Thailand. Romania is the latest country to award Lockheed a contract for upgrade work. Upgrades increase the radar’s capability and reliability while consolidating electronic components. They will allow the radar to operate for another two decades. Because these radars have a long lifespan, there will be upgrade opportunities for decades to come.

Three TPS-77 units will be produced over the next ten years. The number could, of course, change should new contracts be signed. The market that these radars occupy is characterized by stability and longevity, as ground-based radars are typically operated for many years once they are installed. Production levels will remain low but steady. Additionally, following the current trend, future orders will be from countries outside the United States.
## Ten-Year Outlook

### ESTIMATED CALENDAR YEAR UNIT PRODUCTION

<table>
<thead>
<tr>
<th>Designation or Program</th>
<th>High Confidence</th>
<th>Good Confidence</th>
<th>Speculative</th>
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<tr>
<td>Lockheed Martin Ocean Radar &amp; Sensor Systems</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TPS-77 =&gt; Latvia =&gt; Armed Services</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>TPS-77 =&gt; Thailand =&gt; Air Force</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Subtotal</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Total</td>
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<td>0</td>
<td>1</td>
<td>2</td>
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