7. Technical Developments since 1945

The Japanese Maritime Self-Defense Force (JMSDF) installed its so-called 'first generation' hydrophone system at several of its new coastal defence stations in the mid- and late 1950s. This used drum-shaped hydrophones, 4 metres in diameter and 2.5 metres high, with a low discrimination capability.[1] The upward-looking arrays were mainly useful for harbour defence, but they could also be strung across key narrow straits. The coastal defence stations established in this period were located at Kannon Zaki, across the Uraga Channel leading into Tokyo Bay; Awaji, on the north-western side of Osaka Bay; Mutsure-jima, astride the entrance to the Kanmon Strait; and at Kogozaki, at the entrance to Sasebo Bay.

In the late 1960s and 1970s, the initial hydrophone system was replaced and supplemented by a total of 19 LQO-3 arrays, produced in Japan. The LQO-3 was designed for use across relatively shallow and narrow straits, especially the Tsugaru and Tsushima straits, with widths ranging from about 20 kilometres to about 50 kilometres. Five sets were installed in the Tsushima Straits, the first two of which were installed (at Kami-tsushima and Iki Island) in 1968, and another (at Shimo-tsushima) in 1972.[2] Another five sets were also installed, beginning in 1968, on the bottom of the Tsugaru Strait, connected to shore stations at Matsumae and Tappi Zaki, on the northern and southern sides of the western entrance to the strait, and at Hachinohe, which monitored submarines passing from the eastern end of the Tsugaru Strait into the Pacific and approaching the strait from the Pacific. A single LQO-3 array was laid in the Soya Strait.[3]

The LQO-3 arrays were upgraded to LQO-3A systems in the early 1980s. It has been suggested that the system had a 70 per cent probability of detecting a submarine travelling at 6 knots at a range of 1,000 yards, and a 15 per cent probability at 3,000 yards, which 'would be entirely acceptable in a barrier, as opposed to an open-ocean, tracking system'.[4]

These stations are also equipped with microwave antennas for transmission of the acoustic recordings, HF and VHF poles, and VHF/UHF/SHF antennas

1 Taoka Shunji, 'Sea-lane Defence', *Asahi Shimbun*, 1 May 1984.
2 Friedman, *Naval Institute Guide*, p. 21; Naoaki Usui, 'Japan Plans to Bolster Already Formidable ASW Ability', *Defense News*, 24 June 1991, p. 14; 'Sea-bottom Cable-laying Ship Operating Offshore', in *Asahi Shimbun*, 17 June 1984.
3 Richelson, *Foreign Intelligence Organizations*, p. 261; Naoaki Usui, 'Japan Plans to Bolster Already Formidable ASW Ability', p. 14.
4 Friedman, *Naval Institute Guide*, p. 21.

for electronic intelligence (ELINT) collection to support the development of electronic support measures (ESM) systems and electronic warfare (EW) tactics. Many of them also have marine surveillance radars.

Another sort of SOSUS (sound surveillance system), designed for open-ocean operations, was developed in the late 1960s and installed at one or more stations at the beginning of the 1970s. It was the subject of dogged questioning of the head of the Japan Defense Agency (JDA), Ezaki Masumi, by a Japanese Communist Party representative, Watanabe Takeshi, in the Diet on 18 December 1971. In 1970–71, the JMSDF received three long cables manufactured by the Ocean Company Ltd (OCC) in Yokohama, together with amplifiers designed by the US Navy. The cables incorporated new techniques developed in the United States during production of the first transatlantic telephone cables, including techniques for the emplacement of the cables and booster stations at extreme ocean depths. The cables were 200 kilometres (110 nautical miles), 330 kilometres (180 nautical miles) and 1,150 kilometres (620 nautical miles) in length, were relatively thick, and most suitable for deep-sea use. The repeaters/amplifiers were on average about 70 kilometres (38.7 nautical miles) apart. The cables were delivered to the JMSDF's District HQ at Ominato, for deployment by the *Tsugaru* cable-laying ship.[5] There has been considerable speculation that at least the longest one was installed off the Matsumae Coastal Defense Station.[6] (It is only about 500 kilometres from Matsumae directly west to the Russian coast; a cable of this length could only be laid in a southerly direction, towards the Korean Peninsula and the Tsushima Strait.)

Development of the LQO-4, a lower frequency, longer range system than the LQO-3 or LQO-3A, began in the 1970s. It was designed by the Technical Research and Development Institute's (TRDI) 5th Research Center together with Oki Denki (Oki Electric Industry Company). It was reported in May 1984 that development of the system was scheduled for completion in FY 1985, with initial deployment in 1986.[7] It 'initially coordinated operations of P–2J patrol aircraft'.[8]

In February 1985, *Sekai* magazine reported that installation of LQO-4 systems was proceeding apace. It said that the LQO-3 variants at Cape Shirakami and Tappi Zaki on the northern and southern sides of the western entrance to the

5 67th Diet, Special Committee on Okinawa and the Northern Problem, 18 December 1971, at kokkai.ndl.go.jp/SENTAKU/sangiin/067/1650/06712281650001c.html

6 『北海度のC3I基地に見る新たな福強と変化』、松井愈　（著者）、1993年日本平和会国際会議、C3I分科会・18th　全道基地闘争活動者会議（93・10）[Matsui Masaru, 'Looking at New Developments and Changes in Hokkaido C^3I Bases, Japan Peace Committee International Conference, C3I Sub-committee; and 18th National Base Struggle Activists Conference (October 1993)', Hokkaido Peace Committee Study Document No. 26, 8–1994], p. 5.

7 Taoka Shunji, 'Sea-lane Defence'.

8 Friedman, *Naval Institute Guide*, p. 21.

Tsugaru Strait had already been replaced by 'new model LQO-4s', and that 'seven LQO-4s are deployed in the Korean and Tsushima Straits', connected to the shore stations at Kami-tsushima, Shimo-tsushima and Iki Island.[9]

The geography of the Sea of Japan is favourable to fixed-bottom sonar operations. Except for the Yamato Seamount at the centre, the bottom of the sea is fairly flat. The straits leading into it – i.e., the Soya, Tsugaru, Tsushima and Shimonoseki Straits – are narrow and mainly shallower than 100 metres, with accessible shorelines for installation of the hydrophone terminals.[10]

A survey of JMSDF contracts for electronic systems since the early 2000s indicates that the LQO-4 was the principal hydrophone system in service until around 2007. There were frequent contracts for components as well as maintenance and repair of LQO-4 systems. On 13 September 2006, for example, Oki Denki's Defense Systems Division received a contract worth 94,132,500 yen for the supply of 8,301 rolls of recording paper for LQO-4 systems. Delivery was due on 31 May 2007.[11] In addition, three contracts were awarded to a variant of the LQO-4, the LQO-4B-1L in 2007–09 (viz: 23 October 2007, 8 October 2008 and 7 October 2009).[12] Since 2007, however, the majority of contracts concerning fixed hydrophone systems have been for LQO-5s (as reported by the Ministry of Defense (MoD) on 23 October 2007, 8 October 2008, 7 October 2009, 8 October 2010, 19 November 2011 and 16 November 2012). There is also a system, the LQO-6, for which a contract was awarded on 7 October 2009.[13]

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9 'White Paper: Nuclear War and the Self-Defense Forces', *Sekai*, February 1985, pp. 74–139, in Foreign Broadcast Information Service (FBIS), *Japan Report*, (JPRS–JAR–85–013), 9 May 1985, at www.dtic.mil/cgi-bin/GetTRDoc?Location=U2&doc=GetTRDoc.pdf&AD=ADA349828

10 Richard Deacon, *A History of the Japanese Secret Service* (Frederick Muller, London, 1982), pp. 243–44; Hideo Sekino, 'Japan and Her Maritime Defense', *US Naval Institute Proceedings* (Vol. 97, No. 819), May 1971, pp. 105, 120.

11 「平成18年度 9月期　随意契約一覧表」海上自衛隊艦船補給処管理部長，市川 順，神奈川県横須賀市田浦港町無番地。['List of Negotiated Contracts for Period 24 September 2006', General Manager, MSDF Ship Depot, Tauriminato, Yokosuka, Kanagawa Prefecture], Item 33, at www.mod.go.jp/msdf/bukei/yd/nyuusatsu/200609.pdf

12 「海幕公示第３ 号、１９．１０．１２、一部訂正１９．１０．２3. 自衛艦のとう載武器等の検査・修理工事の契約希望者募集要項」、防衛書, ['Sea Acts, Public Notice No. 3, 12 October 2007, with Corrections 23 October 2007. Guidelines for Applicants for Construction Contracts, such as Inspection and Repair of MSDF Ship-mounted Weapons', Ministry of Defense], at www.mod.go.jp/msdf/bukei/m0/nyuusatsu/K-19-2020-0003.pdf; 「艦船の検査・修理等工事の契約希望者募集要項」, 海幕公示第、 海幕公示第３号 ２０．１０． ８、防衛省, ['Guidelines for Applicants for Construction Contracts, such as Inspection and Repair of Vessels', Sea Acts, Public Notice No. 3, 8 October 2008. Ministry of Defense], at www.mod.go.jp/msdf/bukei/t1/nyuusatsu/K-20-0000-0003.pdf; 「艦船の検査・修理等工事の契約希望者募集要項」, 海幕公示第、 海幕公示第３号

２１．１０．７、防衛省 ['Guidelines for Applicants for Construction Contracts, such as Inspection and Repair of Vessels', Sea Acts, Public Notice No. 3, 7 October 2009. Ministry of Defense], at www.mod.go.jp/msdf/bukei/d0/nyuusatsu/K-21-2610-0043.pdf

13 「艦船の検査・修理等工事の契約希望者募集要項」, 海幕公示第、 海幕公示第３号

２１．１０．７、防衛省 ['Guidelines for Applicants for Construction Contracts, such as Inspection and Repair of Vessels', Sea Acts, Public Notice No. 3, 7 October 2009. Ministry of Defense], Item 239, at www.mod.go.jp/msdf/bukei/d0/nyuusatsu/K-21-2610-0043.pdf

Since the 1940s, the main company involved in the design and production of hydrophones has been Oki Denki. During the Second World War, it manufactured key parts of the Type 97 hydrophones, including the sonic bearing evaluator and the 'maximum sensitivity phasing mechanism'.[14] It has played major roles in the development of all successive LQO systems, including the current LQO-4 and LQO-5 systems. As the MoD explained with respect to the LQO–4 in 2006, Oki Denki 'is the manufacturer of this device' and is the only company 'having the equipment and technology that can guarantee the quality [required for LQO-4 components]'.[15]

Over the past couple of decades, Oki Denki technicians and engineers have been at the forefront of new technical developments. For example, they have constructed hydrophones with porous piezoelectric ceramics, significantly reducing vibrational noise, and hence improving sensitivity compared to non-porous hydrophones;[16] and they have designed an advanced SSBL (super short baseline) acoustic reference system, using a planar hydrophone array consisting of many hydrophone elements for estimating directions, ranges and positions of noise sources.[17] They have made particularly rapid advances with optical fibre hydrophones, obtaining higher sensitivity than that available with piezoelectric sensors.[18] For example, they have recently patented a design for optical fibre hydrophones in which the fibre is coiled around an elastic cylinder, hence enabling the hydrophone to resist high water pressure but retain high sensitivity.[19] They have experimented with optical fibre hydrophones which use fibre Bragg gratings (FBGs) to maintain signal strength in interferometric

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14 US Naval Technical Mission to Japan, 'Japanese Electronic Harbor Protection Equipment', 14 February 1946, p. 11, at www.fischer-tropsch.org/primary_documents/gvt_reports/USNAVY/USNTMJ%20Reports/USNTMJ_toc.htm

15 「平成18年度 9月期　随意契約一覧表」海上自衛隊艦船補給処管理部長, 市川 順, 神奈川県横須賀市田浦港町無番地。['List of Negotiated Contracts for Period 24 September 2006'], Item 33, at www.mod.go.jp/msdf/bukei/yd/nyuusatsu/200609.pdf

16 Toru Arai, Kazutoshi Ayusawa, Housaki Sato, Tetsuji Miyato, Kazutami Kawamura & Keiichi Kobayashi, 'Properties of Hydrophone with Porous Piezoelectric Ceramics', *Japanese Journal of Applied Physics* (Vol. 30), 1991, pp. 2253–55.

17 Masao Igarashi & Kazuhiko Nitadori, 'An Advanced SSBL-Acoustic Reference System Using a Planar Hydrophone Array', *Electronics and Communications in Japan (Part 1: Communications)* (Vol. 65, No. 3), 1982, pp. 1–9.

18 Hiroshi Kamata, 'Realizing Dreams – Yesterday, Today, Tomorrow – An Acoustic/Environmental Sensing Technology Based on Optical Fiber Sensors', *Oki Technical Review* (No. 189), April 2002, pp. 43–47, at citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.197.1088&rep=rep1&type=pdf

19 Saijo Kenji, Ogawara Chiaki, Shimamura Hideki, Sato Ryotaku, Minami Makoto & Tadokoro Yasuaki, 'Optical Fiber Hydrophone Having High Water Pressure Resistance', Patent Number JP2012068087, 5 April 2012, at old.qpat.com/RenderStaticFirstPage?XPN=TCpRzetWHTd7fYsXyd3avbmsLuw/R4oY%20QgpgFzVRnM=

designs,[20] and they have designed miniaturised optical fibre hydrophone arrays using Fabry-Perot interferometers that can operate in deep sea environments and which can easily be mass produced.[21]

Together with the advances in hydrophone technology, Japan has also made enormous progress in signal processing capabilities, whereby acoustic signatures are extracted from background noises. According to reports in the late 1980s, for example, the Japanese acoustic systems were frequently unable to determine the nationality, let alone the identity of individual submarines, by their sound signatures. Since the 1990s, however, Japan has emerged as second only to the United States with respect to military applications of digital acoustic signal processing technologies.

Magnetic Detection Systems

In addition to the various hydrophone arrays, the JMSDF has also developed a variety of magnetic anomaly detection (MAD) systems for both harbour defence and monitoring submarine passage through key straits, which operate in conjunction with the sea-bottom sonar systems. During the Second World War, 'magnetic loop' detection systems were generally installed at all major harbours for anti-submarine protection.[22] For example, Type 2 Model 1 and Type 2 Model 4 magnetic loop systems were used together with Type 97 hydrophones to protect Tokyo Bay and the entrances to the Inland Sea. In the case of the Bungo Strait, seven Model 1 systems were installed on the sea bottom, three off Fuka-Shima at the south-western side of the outer entrance and four across the strait from Oshima to Yura on the outer side of their Type 97 hydrophone field.[23]

Similar magnetic detection systems were installed in the mid- and late 1950s at several of the new coastal defence stations that are responsible for the defence of

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20 Kenji Saijyou, Chiaki Okawara, Tomonao Okuyama, Yasuyuki Nakajima & Ryotaku Sato, 'Fiber Bragg Grating Hydrophone with Polarization-maintaining Fiber for Mitigation of Polarization-induced Fading', *Acoustical Science and Technology* (Vol. 33, No. 4), 2012, pp. 239–46.

21 Satou Riyoutaku & Koji Dobashi, 'Optical Fiber Hydrophone', Patent Number JP3160092, 16 February 2001, at www.sumobrain.com/patents/jp/Optical-fiber-hydrophone/JP3160092.html; Hiroshi Asanuma, Satoshi Hashimoto, Shin-ichi Tano, Sho-ichi Takashima, Mitsutomo Nishizawa, Hiroaki Niitsuma & Yugo Shindo, 'Development of Fiber-optical Microsensors for Geophysical Use', July 2003, at niweb.kankyo.tohoku.ac.jp/PDF/SSC2003_Asanuma.pdf; Hiroshi Asanuma, Mitsuyuki Tanaka, Hiroaki Niitsuma & Ryotaku Sato, 'Development of an Optical Micro Hydrophone for Mass Production', *Society of Exploration Geophysicists*, October 2006, at www.onepetro.org/mslib/servlet/onepetropreview?id=SEG-2006-0436

22 US Naval Technical Mission to Japan, 'Intelligence Targets Japan: Japanese Anti-Submarine Warfare', 8 February 1946, p. 9, at www.fischer-tropsch.org/primary_documents/gvt_reports/USNAVY/USNTMJ%20Reports/USNTMJ-200I-0244-0309%20Report%20S-24.pdf

23 US Naval Technical Mission to Japan, 'Japanese Electronic Harbor Protection Equipment', 14 February 1946, pp. 7–8, 10, at www.fischer-tropsch.org/primary_documents/gvt_reports/USNAVY/USNTMJ%20Reports/USNTMJ_toc.htm

important harbours. It is likely that these included the stations at Kannon Zaki (Tokyo Bay), Awaji (Osaka Bay), Mutsure-jima (Kanmon Strait) and Kogozaki (Sasebo Bay).

Magnetic measurement stations are currently maintained inside Osaka Bay and Sasebo Bay. The station at Kariya, on the northern side of Awaji township, is able to detect submarines approaching the Kobe–Osaka urban–industrial complex. In the case of Sasebo Bay, magnetic measurement stations were established at Sakibe, on the south-eastern side of the entrance to Sasebo Bay, built in 1976, and at Tategami, on the western side of the Sasebo port area, built in 1986.[24]

By the 1980s, 'enormous' magnetic detection systems had been mounted across the broader Tsushima and Tsugaru Straits. According to revelations in a Japanese 'novel' about Japan's plans for repelling a North Korean invasion, written by Iku Aso, a well-known journalist who specialises in intelligence matters, and first published in March 1998, which caused great anguish among the Japanese security authorities, these MAD systems detect the magnetic anomaly caused by submarines passing above them; these sensors can detect slower and quieter submarines that might elude the acoustic arrays. In the mid-1990s, after the Soviet Union had collapsed, this system reportedly monitored Russian missile submarines transiting to and from Vladivostok and Petropavlovsk, on the Pacific Ocean side of the Kamchatka Peninsula.[25]

Japan's Planned Ocean Surveillance Satellite Program

It was reported in July 2013 that Japan plans to launch nine satellites in the next five years to 'monitor the movements of foreign ships intruding into Japanese territorial waters'. The constellation will provide complete 24-hour coverage of all of the world's oceans, using infra-red sensors as well as other instruments.[26]

Japan began developing technologies for satellite-borne ocean remote sensing capabilities in the 1980s. For example, the Marine Observation Satellite (MOS)-1, launched on 19 February 1987, carried a Multispectral Electronic Self-Scanning Radiometer (MESSR); a Visible and Thermal Infra-red Radiometer

24 「崎辺地区海上自衛隊　佐世保市崎辺町」, 長崎平和委員会 [MSDF Sakibe District, Nagasaki Peace Committee], at www7b.biglobe.ne.jp/~chi-tan/sakibesdf.html; 「立神地区自衛隊　佐世保市立神町」, 長崎平和委員会 [MSDF Tategami District, Nagasaki Peace Committee], at www7b.biglobe.ne.jp/~chi-tan/tategamisdf.html

25 Iku Aso, *Sensen Fukoku* (Kodansha, Tokyo, March 1988), Vol. 1, pp. 91–92. See also 'Japan's North Korea War Plan Revealed in a "Novel"', *Shukan Gendai*, 4 April 1988, at www.kimsoft.com/1997/jp-dprk.htm

26 'Japan to Launch Satellites to Monitor Oceans', *Space Daily*, 7 July 2013, at www.spacedaily.com/reports/Japan_to_launch_satellites_to_monitor_oceans_999.html

(VTIR), to measure sea surface temperature (SST); and a Microwave Scanning Radiometer (MSR), to measure atmospheric water vapour. It was placed in a near-polar circular orbit, with an inclination of 99.1°, and an altitude of 909 kilometres. The second satellite in this series, MOS-1B, was launched on 7 February 1990.[27] The MOS program was succeeded by the Advanced Earth Observing Satellite (ADEOS) program, with ADEOS-1 (also called *Modori*-1) launched on 17 August 1996 and ADEOS-2 on 14 December 2002.[28]

27 Jet Propulsion Laboratory, 'Mission and Spacecraft Library: MOS 1A, 1B', at space.jpl.nasa.gov/msl/QuickLooks/mosQL.html; FAO, 'Environmental Satellites', at www.fao.org/docrep/003/t0355e/t0355e05.htm
28 'ADEOS II', Wikipedia, at en.wikipedia.org/wiki/ADEOS_II

This text taken from *The Tools of Owatatsumi: Japan's ocean surveillance and coastal defence capabilities*, by Desmond Ball and Richard Tanter, published 2015 by ANU Press, The Australian National University, Canberra, Australia.