Launching Norway’s new spear
Uncovering the Joint Strike Missile
Raising the bar: JSM sets a new threshold for Norway

Norway is investing in the development of a new air-launched, low-observable cruise missile to provide its F-35A fleet with a long-range precision-strike capability against heavily defended targets. Richard Scott examines how and why.

Norway's strategic situation appears relatively benign. A large but sparsely populated country stretching up through Europe's far north and into the Arctic circle, it exists in a low tension area and, following a June 2011 agreement with Russia on sea borders, has no territorial disputes.

Notwithstanding this, the sometimes unpredictable nature of its large northern neighbour, and the growing interest in the Arctic region amongst a number of countries, demands that surveillance and intelligence gathering operations endure. Although Russia is not seen as a threat, its increasingly self-assertive stance in its 'near-abroad', coupled with recent improvements in its military capability and an increase in the tempo and complexity of exercise activity, have naturally attracted close attention in Oslo.

"Recent events have shown actors who are capable and willing to use military force to achieve their political objectives," Lieutenant Colonel Sigurd Fongen, senior staff officer in the Norwegian F-35 programme office told an audience at the Farnborough International Airshow in July 2014. "Hence, we are committed to retaining a small but technically capable military force."

"That process is continuing with the acquisition of the F-35 Joint Strike Fighter [JSF] and the Joint Strike Missile [JSM]," he added. "The JSM will give us a stealthy, stand-off precision-guided weapon able to defeat advanced defensive systems. We are raising the bar to make any potential adversary understand that an attack would be very costly."

On 19 June 2014 Norway's parliament – the Storting – voted by a margin of 90 to 4 to approve investment amounting to almost NOK 7.7 billion (USD552 million) to complete development of JSM and prepare it for integration with the Lockheed Martin F-35 Lightning II. Two weeks later, on 2 July 2014, the Norwegian Defence Logistics Organisation (NDLO) awarded the Kongsberg Defence Systems a NOK 1.1 billion contract to move forward with the third and final phase of JSM development and integration running through to 2017. A second contract, announced on 19 July and valued at NOK 280 million, has funded Kongsberg to build and flight test JSM development-standard missiles from early 2015.

Inextricably bound up in Norway's acquisition of the F-35A to meet its Future Combat Aircraft capability requirement under Project 7600, JSM is an important programme for many reasons. At a politically-defence level, it will underpin a so-called threshold capability designed to dissuade any would-be aggressor from using military force against Norway (the term 'threshold' is deliberately used so as to avoid the nuclear connotations often associated with 'deterrence'). From an industrial standpoint, it provides Norwegian defence industry with a new 'engine' for sustaining and developing indigenous knowledge, skills and expertise in its sovereign guided-weapons sector. And on the international stage, it gives other JSF partner countries the opportunity to acquire a long-range precision-strike capability that complements the inherent low-observable characteristics of the fifth-generation F-35.

However, such a capability does not come cheap, with the total cost of the JSM programme now estimated at over NOK8 billion, which is about one-third higher than initial assumptions. Furthermore, having originally sought international partners to share development and integration costs, Norway is, for the time being at least, funding this endeavour on a purely national basis.

New fighter

Under Project 7600, Norway plans to purchase up to 52 F-35A aircraft to meet the Royal Norwegian Air Force's (RNAF's) Future Combat Aircraft programme requirement at
an estimated cost of NOK 66.2 billion. Integration of JSM into JSF is planned as part of the Block 4A/4B update, due in service by the 2022-24 timeframe. This will enable the RNoAF’s F-35 fleet to achieve Full Operational Capability (FOC) in 2025.

According to Norwegian defence minister Ine Eriksen Søreide, the acquisition of the JSF, along with the JSM, will strengthen Norway’s national threshold, and also serve wider NATO interests. “I think every country needs to have a threshold whereby there are consequences for any would-be aggressors who step over it,” she told IHS Jane’s in May 2014. “We don’t see any such aggression as of now...but as part of our national defence we need to build that threshold.

“We have been quite clear that [JSM] is a very important part of our acquisition of the F-35 because it has the capacity that we need. At the same time our acquisition of the F-35 and our development of the JSM missile...also serves the [NATO] alliance as a whole. This demonstrates our ability and willingness to invest in both our own security as well as that of the alliance.”

Political commitment is strong, with the Storting having voted through funds to complete JSM development, and given authorisation for an initial 16 F-35A aircraft for delivery between 2015 and 2018. In October 2014 Eriksen Søreide presented the Ministry of Defence’s (Forsvarsdepartementet’s) 2015 budget proposal to the Storting. This proposed NOK 1.038 billion in supplementary funding in 2015 to support the continued procurement of the F-35 (along with associated base infrastructure), plus an additional NOK 308 million to continue Phase III development of JSM and its integration on the F-35.

**Sovereign capability**

Norway has, since the 1960s, nurtured and sustained a small but highly proficient sovereign guided-weapons sector. The origins of this indigenous scientific and industrial capability go back to the Cold War, and the development of the Penguin anti-ship missile. Penguin was conceived to meet the Royal Norwegian Navy’s (RNoN’s) requirement for a highly discriminative anti-ship missile that could navigate precisely through archipelagic waters and terrain, and then select and home onto its intended target.

“Other navies were developing systems optimised to hit ship targets in open seas, but these were not able to operate effectively in the complex littoral environment of Norway’s coastline,” Harald Annestad, Kongsberg Defence Systems’ president, told IHS Jane’s. “What was needed was a weapon system that could operate effectively among the difficult terrain of the fjords. That is what drove the adoption of an infrared homing system.”

The original Mk 1 ship-launched version of Penguin entered service with the RNoN in 1972, with a first export contract signed by Turkey the same year. Subsequently, Penguin has evolved through several distinct design iterations, spawning the helicopter-launched Mk 2 Mod 7 variant (sold to Australia, Brazil, Greece, New Zealand, Spain, Turkey and the United States) and the fast-jet Mk 3 version developed to equip the RNoAF’s F-16.

“Being a small nation,” said Annestad, “we developed a very close cooperation between ourselves, the Norwegian Defence Research Establishment [Forsvarets Forskningsinstitutt – FFI] and the Royal Norwegian Navy. And being such a small community meant very short lines of communication, so everyone had a good understanding of each other.

“Also, we had to develop Penguin on a much smaller budget. So while other nations could afford very large and diverse engineering teams, we had to make our technical resource much more multi-skilled. Their knowledge had to extend to the whole missile, not just a part of it.”

More than 40 years on, Penguin continues to generate sales for Kongsberg, with over 1,000 missiles having been sold to date. Towards the end of the 1980s the RNoN began to consider its requirement for a new ship-launched anti-ship missile. As studies undertaken by the RNoN and FFI progressed, it became clear that none of the surface-to-surface guided weapons available on the market could do the job,” said Annestad. “They came to the conclusion that the only solution was to start a new national development programme.”

The staff requirement for what became the Nytt Sjømønsmissil (NSM) – subsequently re-branded and anglicised as the Naval Strike Missile – called for a high-performance extended-range anti-ship missile with excellent target discrimination, a high probability of penetrating enemy defences, effective in both open and confined waters and easily adaptable to platforms of varying sizes from fast attack craft upwards. “If you want to penetrate defences, you have two choices,” said Annestad. “You fly very fast at supersonic speed, or you fly subsonic and remain passive and stealthy. We chose the latter – a supersonic missile cannot operate effectively in the Norwegian fjords, and the thermal build up in the nose does not allow for the infrared guidance required for precision targeting.

“Our belief is that by staying passive means you avoid detection for as long as possible, enabling ingress into the inner circle of the missile engagement zone. We understand that you will be detected late on in the terminal phase, so that demands very good agility to outpace close-in weapon systems.”

In September 1991, Kongsberg was awarded a definition study contract that considered how best to engineer a guided-weapon solution to meet the RNoN’s requirements. A full development contract followed in December.
Although sharing much technology with NSM, the JSM has evolved into essentially a new missile.

1996 and while design, engineering development, testing and qualification of NSM proved to be somewhat more challenging than originally envisaged, the RNoN finally took the weapon into its inventory in 2012.

The design philosophy and operational concept underpinning NSM emphasises the penetration of ship defences through a combination of stealth, onboard intelligence, and endgame kinematics. This is achieved by the synthesis of low signature; advanced engagement planning; precision navigation (exploiting local topography to mask the approach to target); an ultra-low wave-adaptive sea-skimming flight profile; the use of a high-resolution passive imaging infrared (IIR) seeker; salvo compression by near-simultaneous programmable ‘fire on Target’; and exceptional agility in the terminal phase.

NSM’s aerodynamic configuration features two mid-body wings and cruciform control surfaces aft. Requirements to minimise radar signature have resulted in a chined airframe body manufactured from composite materials and carefully shaped to reduce radar cross section (RCS). Significant attention has also been paid to shroud the inlet feeding the Microturbo TR40 turbojet engine in order to suppress radar returns.

The GPS-aided multisensor precision-navigation package consists of a tactical grade Inertial Measurement Unit (IMU) aided by a military L1/L2 SAASM GPS receiver and a laser altimeter to provide terrain correlation for overland flights, and height estimation over water. The fibre-optic IMU is the core sensor in the navigation system; inertial navigation system algorithms integrate IMU measurements, which are combined with measurements from the GPS receiver and a

The decommissioned frigate Trondheim is struck by an NSM warshot during a June 2013 test. JSM will use the same blast/fragmentation warhead.

100 n miles. The missile manoeuvres in the same way as an aircraft — executing a bank to turn — so as to confer excellent agility. This is particularly important in the terminal phase where the missile combines sustained, pseudo-random high g manoeuvres in three dimensions with a high subsonic end-game speed (exploiting a 1:1 thrust-to-weight ratio to continuously change acceleration without losing speed).

The lethal payload is an MRDA-TGW 120 kg armour-piercing blast/fragmentation warhead combining a titanium alloy warhead casing (with a steel grid for fragmentation effect) and insensitive high explosive fill. Warhead initiation is by a void-sensing Programmable Intelligent Multi Purpose Fuze designed to optimise effect against hard targets.

A live warshot firing from the strike craft KNM Stav in June 2013 demonstrated both the precision and lethality of the NSM missile. The weapon was programmed to hit a designated aimpoint on the superstructure of the decommissioned frigate ex-Trondheim so as to destroy its operations room. It achieved this, with the resulting blast obliterating the command space and the decks above.

The RNoN has introduced NSM on its Frigten Nansen-class frigates and Skjold-class fast strike craft, while the Polish Navy’s coastal defence squadron has acquired a shore-based coastal battery system. In September 2014 the US Navy (USN) fired an NSM from the Littoral Combat Ship USS Coronado under the Foreign Comparative Test programme.

**JSM genesis**

The origins of JSM are interwoven with Norway’s search for a new combat aircraft to replace the RNoN’s current F-16 fleet.

“When we were considering options for a new fighter, we recognised the need to exploit the sensor suite of the aircraft to get good situational awareness, both at an early stage in any crisis, and to direct weapons if necessary,” remarked Lt Col Fongen.

“We did a lot of analysis. This showed that we needed a combat aircraft that could handle a variety of threats and a wide range of target sets, up to heavily defended naval ships.

“We saw that most of these target sets were well covered, but saw that the heavily defended naval target was not adequately addressed. True, we could use a larger number of other weapons, but that would in turn create a driver for a greater number of sorties. So there was a need for a new weapon with increased lethality against this naval high
value unit) target set.”

NSM, which was by then already in advanced development, provided the basis for a feasibility study for an air-launched stand-off precision-strike weapon, given the name Norwegian Multi-Role Missile or ‘Norseman’. Begun by the RNoAF, FFI and Kongsberg in 2004, this activity conceptualised a multi-role NSM derivative re-sized to fit inside the weapons bay of the F-35A and F-35C variants of JSF. Two key technology-enablers were identified: the integration of a two-way datalink (to facilitate network-enabled operation) and the implementation of modified ATR functionality to enable the prosecution of land targets.

Pre-design integration studies, to which Australia contributed limited funding, further defined the air-launched precision-weapon concept that became JSM. This early work saw Kongsberg engineers engage with counterparts at Lockheed Martin to optimise the JSF/JSF weapons system interface. In January 2007 the relationship was taken a step further when KDA, Lockheed Martin Aeronautics, and Lockheed Martin Missiles and Fire Control signed a joint marketing agreement for the missile (Lockheed Martin’s interest in JSM integration being tied to efforts to afford Norway greater industrial involvement in the JSF programme).

A market assessment completed by the two companies identified a ‘conservative’ sales estimate of approximately 790 missiles. The relationship with Missiles & Fire Control was later to lapse, however, owing to product overlap.

Having also evaluated the Saab JAS-39 Gripen NG (Kongsberg had also performed work to ensure that JSM could be carried in the JAS-39 as an external store), the Norwegian government in November 2008 announced its decision to procure the F-35A variant of the Lightning II to meet its Future Combat Aircraft requirement. Attendant to this, the decision was also taken to proceed with initial development of JSM, encompassing the maturation and validation of a preliminary design, analysis of operational and logistical requirements, and further integration studies for the F-35. A Phase 1 design definition contract, worth NOK166 million, was duly awarded to Kongsberg by NDLO in April 2009, with the programme completing its Preliminary Design Review in June 2010.

During this phase, the company iterated a JSM baseline design that, while re-using many existing NSM subsystems – including the seeker, warhead and navigation sensor suite – evolved so substantially in terms of air-vehicle design, packaging and propulsion so as to become essentially a new missile. For example, the redesign of the airframe to fit within the F-35 weapons bay means the JSM aft fuselage has been stretched and narrowed. Also, the wings on JSM are smaller, reprofiled and mounted further forward on top of the fuselage (rather than the centrebody position adopted by NSM), freeing up space for extra fuel and hence extended range; according to Kongsberg, JSM will be able to achieve a range of over 300 n miles flying a hi-hi-lo profile, and in excess of 100 n miles flying a nap-of-the-earth lo-lo-lo profile.

The aft fuselage is narrowed to such an extent to preclude the re-use of the TR40 turbojet engine used on NSM. This constraint, and a desire to increase the involvement of US industry in the programme, has seen Kongsberg instead turn to Williams International.
for an alternative engine in the shape of the WJ38-7K turbojet.

Another change is the bifurcated air intake arrangement with inlets on either side of the airframe aft. The airframe outer mould line is re-profiled because of these changes to the wing junction and inlet configuration; the cruciform tail surfaces aft have been reshaped.

New ATR functionality is introduced to enable the prosecution of land targets. “While the dual-band scanning IIR seeker is the same [as NSM], the scanning pattern will be changed, and we are introducing new algorithms and much more computational power,” said Annesstad. “The target library is of course populated by the customer. What we provide is a software application for the development of a national target database, a subset of which is downloaded into the missile before launch.”

To meet requirements for a two-way datalink, Kongsberg has selected a Link 16 network-compatible US weapon datalink. This is intended to enable data connectivity to support in-flight target updates, re-targeting, mission abort and battle damage assessment.

Finally, a number of other modifications have been introduced to reflect specific air-launch requirements. These include a thermal management system for F-35 internal bay conditions, and carriage lugs atop the airframe that stow post-launch.

**Phase II milestone**

An initial buy of four F-35A aircraft was voted through by the Storting on 16 June 2011. That same day the Storting approved continuation of the JSM engineering development – at an overall cost of NOK5.029 billion – through a Critical Design Review (CDR) in mid-2013 when design maturity was to have attained Technology Readiness Level 6 (TRL 6).

The NDLO awarded Kongsberg a Phase II development contract worth NOK543 million at the end of June 2011; the remaining funds covered preparatory integration studies funded through the JSF Joint Program Office (JPO), other programme costs borne by the Forsvarsdepartementet, and a risk contingency.

While approval of Phase II marked a significant milestone, there were two big issues still to resolve. In its case to the Storting, the centre-left coalition government was explicit that international collaboration was seen as a pre-requisite for continued development of JSM beyond Phase II: it would therefore be necessary to find like-minded JSF partners prepared to co-fund follow-on development, systems integration and test of JSM.

Also, the Norwegian government still needed the necessary assurances from the JPO that JSM would become a part of the Block 4 integration roadmap. Accordingly, JSM became a key lever in its effort to build an industrial participation programme linked to its F-35 buy. Speaking at the Paris Air Show in 2011, Rear Admiral Arne Roksund, then head of the Forsvarsdepartementet’s department for defence policy and long-term planning, said: “The Norwegian political objective is to achieve an industrial return of value equal to the purchase of JSF. In my view the purchase of the F-35 is closely linked to our national development of the JSM.”

The underlying message was polite but firm: integration of JSM into JSF as part of Block 4 was to all intents and purposes a sine qua non for Norway.

As part of the Phase II development programme, Lockheed Martin was funded by Norway to perform risk reduction study work for JSM integration. This included wind tunnel testing, engineering analyses, the design and build of an emulator and adapter, internal fit checks of the JSM missile in the weapons bay of the F-35A and F-35C versions, and external (wing hardpoint) fit checks on all three variants of F-35.

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**Raytheon, Kongsberg partner on JSM for OASuW**

With the USN expected to begin a competition for its Offensive Anti-Surface Warfare (OASuW) Increment 2 requirement in fiscal year 2017 (FY 2017), Raytheon Missile Systems and Kongsberg Defence Systems in July 2014 formally announced a teaming arrangement to develop the JSM “for air-launched OASuW applications”.

This follows the US Department of Defense’s decision to sole-source Lockheed Martin Missiles and Fire Control – Strike Weapons for follow-on development and accelerated acquisition of its Long Range Anti-Ship Missile (LRASM) to meet the near-term air-launched OASuW Increment 1. Under current plans, an Early Operational Capability (EOC) will be achieved on the US Air Force’s B-1B bomber in 2018, to be followed by EOC on the USN’s F/A-18E/F in 2019.

Having unsuccessfully protested the LRASM award to the Government Accountability Office, Raytheon and Kongsberg have now switched their sights to OASuW Increment 2. This is intended to deliver a multiple launch platform capability – air, surface, and subsurface – to meet a planned Initial Operational Capability of 2024.

“JSM is very complementary to our existing JSOW [Joint Stand-Off Weapon] C-1 and Tomahawk weapons,” Tom Bussing, Raytheon’s vice-president, advanced missile systems, told Jane’s. “It gives us an air-launched mid-range solution to go up against the OASuW threat. We believe it offers [the USN] a solution that is both more affordable and more survivable than LRASM.”

Bussing added that Raytheon would work with Kongsberg to further enhance the performance, survivability and affordability of JSM. “We come from the standpoint of a deep knowledge of advanced seekers, guidance and control, autonomy, and discrimination algorithms. We are also bringing some productivity initiatives to further drive down cost.”

The air-launched LRASM has similar attributes but our objective is to develop a lower cost solution that gives the navy a more affordable solution.”

Kongsberg’s Annesstad added: “JSM is also differentiated from the competition by its exceptional agility in the terminal phase. We can continue to change acceleration throughout the endgame without losing speed. "LRASM is a derivative of JASSM, which has been designed for a different mission set."

During 2013 Kongsberg worked with Boeing to conduct a fit check of JSM on an F/A-18E/F Super Hornet at Boeing’s St Louis, Missouri, facility. Alongside this, the two companies have also performed integration feasibility studies to evaluate interfacing (physical and functional) with MIL-STD-1553 message format, load/sector characteristics, and safe separation/jettison.
Yet it was not until Phase II was approaching its conclusion that the Norwegian government finally got the definitive commitment it wanted regarding JSM integration. “The JSF Executive Steering Board took the decision in early 2013 that JSM would be integrated as part of the Block 4A/4B programme,” Norway’s F-35 programme director Anders Melheim told IHS Jane’s. “This of course was a big part of the decision for us to move forward with Phase III.”

He continued: “The Phase II programme, running through to the CDR in mid-2013, demonstrated that the missile would meet all of the operational needs laid down by the air force. The CDR [and subsequent audits] also showed that we had realised all the key technical milestones to achieve TRL 6. And Lockheed Martin's own review concluded that integration into the F-35 was low-risk because the missile had been designed ‘bottom up’ for JSF.

“We have also performed a thorough analysis of alternatives. This showed that JSM would deliver a level of performance unequalled by any other air-to-surface weapons planned integrated on the F-35 in the foreseeable future. We say this is a fifth-generation missile for a fifth-generation fighter.

“So we are pushing this programme forward because it is absolutely necessary to us operationally. At the same time it provides significant opportunities for Norwegian industry, and it is an important part of the industrial co-operation we are working to put in place in relation with the procurement of JSF.”

Norway’s objective for JSF industrial co-operation is for a return – over the planned 40-year lifespan of the programme – equating to half the value of the F-35A aircraft acquisition. Some of this will come from the delivery of aerostructures and technology for F-35 manufacture, but it is foreseen that a greater proportion will accrue from through-life sustainment, and the supply of weapons and ammunition. “JSF is therefore a key part of Norwegian plans for industrial collaboration, and there is a considerable potential for sale of the JSM to foreign customers,” Melheim said.

From the industrial perspective, Kongsberg believes that JSM is fundamental to its guided weapons business going forward, predicting that projected international sales of JSM could be worth around NOK2.5 billion over the next 25-30 years. “We see the programme potentially engaging more than 450 employees at Kongsberg, and generating significant long-term work for our supply chain,” said Amnestad. “We are working with close to 100 suppliers in Norway. This presents an opportunity to lift a broader scope of our national industry to a new level.”

**Bridging contract**

In late November 2013 Kongsberg was awarded a NOK48 million bridging contract by the NDLO. This provides the company with interim funding so as to maintain momentum on the JSM project ahead of a parliamentary vote on Phase III development.

Presenting its bill to the Storting on 23 May, new centre-right coalition government – elected to power in September 2013 – revealed that the projected cost of completing JSM development and integration on the F-35 had risen to NOK8.2 billion. Furthermore, it acknowledged that Norway would now face footing the entire bill for integration on JSF after failing to secure international partners.
Equipment profile

Explaining the escalation in its submission to the Storting, the government said that while an independent evaluation of the JSM programme has confirmed maturity to TRL 6, there was also a greater appreciation of the resources required to transition the missile from design to manufacture within the required timescale. Furthermore, there had been some underestimation of the challenges faced in developing and integrating such a complex air-launched weapon with an aircraft as advanced as the F-35; Kongsberg would need to undertake additional activity to prepare the missile for testing, increase the takeoff of development-standard missiles, and produce significantly more supporting documentation than previously expected. Taken together, these various factors are expected to increase the cost of Phase III development by over NOK 1 billion.

Furthermore, while a number of nations have expressed interest in JSM, Norway has so far failed to secure any agreement to share F-35 integration costs. This has seen the integration cost to be borne by Norway increase by about NOK 1.15 billion.

This current government’s decision to move ahead unilaterally represented a clear reversal of the policy set out by the previous administration in 2011. “The need for international partners was seen by the previous government as a way to strengthen the case [to JPO] for getting JSM included in Block 4 and so achieve our FOC,” Melheim explained. “And of course, more partners meant more potential JSM sales.”

However, with JSM now secure in the Block 4 programme, the political imperative for international participation ebbs. “We haven’t given up finding partners to share some costs,” said Melheim. “But the biggest issue is operational – it’s what JSM and JSF bring to Norwegian defence and security. JSM is absolutely an operational necessity.”

The JSF partner nations that have shown most interest in JSM to date are Australia and Canada, as well as Italy and the United States. Lt Col Fongen revealed that Norway and Australia were in talks over the latter’s involvement. “Australia has signalled interest in (joining) the integration effort. We are in discussions as we speak…we expect a decision in the next 6-12 months.”

The Phase III effort is now ramping up, with Kongsberg already manufacturing a number of pre-production all-up-rounds to support flight testing between early 2015 and mid-2017 in the United States.

“We’ve done fit checks on an F-16 as we are using that legacy platform for qualification and certification starting next year, to get the missile ready for integration on the Block 4 F-35,” said Lt Col Fongen. “Five flight tests are planned from the F-16, with a number of further integration firings then to be conducted from the F-35A.”

Norway is contracting support from the US government to conduct JSM testing to qualify and certify the missile. Testing, to be conducted from Edwards Air Force Base in California, will use the Utah Test and Training Range facility; a first planned release of JSM is scheduled for the second quarter of 2015.

Phase III is planned to culminate with a Final Design Review in late 2017, at which point JSM will be deemed production ready. According to Kongsberg, its existing contract with NDLO includes firm option prices for JSM production offtake.

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Kongsberg eyes growth potential in JSM concept

Although the JSM is still in development, Kongsberg has already begun a pre-planned product improvement programme designed to enhance capability, and expand application. It has also completed initial studies aimed at de-risking integration in ship and submarine platforms.

A case in point is work – already at a prototype stage – to introduce a second seeker channel in the form of a passive radio frequency (RF) sensor. “We have been working on this for a number of years,” said Annestad, “and the option to introduce a dual mode seeker with both imaging infrared and ESM (electronic support measures) is already available to Norway. The JSM airframe will be prepared for the necessary antennas and we are already working with BAE Systems Australia on the electronics.”

Adding an ESM system would enable JSM to acquire hostile radar emissions at extended range, compute angle of arrival, and support target identification (there would be robust fusion with the IIR seeker). Furthermore, as a passive sensor, an ESM would maintain the missile’s stealth characteristics.

BAE Systems Australia has delivered prototype hardware to Kongsberg. Parallel work has identified locations for the antenna apertures, and the requisite space and power within the airframe.

Alternative payloads – the warhead is essentially a strap-on design – are another possibility. “The design of the missile is such that the warhead is not part of the structure, but contained in a ‘cargo bay’,” Annestad said. “So we could easily change that out for a different payload. For example, an electronic countermeasures device or a high-power microwave payload.”

Kongsberg has also performed early studies into ship- and submarine-launched versions of JSM as it looks to grow a wider family of precision-guided missiles. A vertical launch (VL) variant of JSM suitable for firing from a standard Mk 41 launcher cell would integrate an off-the-shelf booster (from ARROC or Tomahawk) using a reinforcement/attachment kit at the aft end of the missile. Feasibility studies, performed with support from Lockheed Martin and BAE Systems, have verified feasibility and shown no ‘show stoppers’, according to the company.

An encapsulated submarine-launched variant of JSM has also been studied, with the missile proposed as an option for Norway’s submarine fleet beyond 2020. According to the company, the size and shape of the missile airframe would allow for an encapsulation compatible with standard 533 mm heavyweight torpedo tubes.

A submarine-launched system would require the test and proving of the encapsulation to enable submerged firing, and integration into the submarine command and fire control system. The JSM missile itself would remain unchanged except for a tandem boost motor.