Radar and Optical Tracking System

Request For Information
Table of Content

1. Introduction
2. Technical Information Request
3. Commercial Information Request
1. Introduction

FMV, Swedish Defence Materiel Administration, is an independent, civil authority. Our primary task is to provide the Swedish Armed Forces with materiel, systems and methods that will be effective not only today, but also in the future. FMV also represents the government in complex international transactions. We also have customers within the civil security sector.

The Test and Evaluation Directorate (T&E) is the FMV resource with the main responsibility for the testing and evaluation of technical systems for the Armed Forces. We also provide testing services to foreign agencies and to Swedish, as well as foreign, defence industries. The Directorate has a wide range of resources and competences for testing components, equipment, subsystems, and full systems. Total testing is carried out with fixed and mobile test instrumentation under realistic conditions. Installations for climatic, mechanical, and electrical environmental testing are also provided. We do test and evaluation for Land systems, Aircraft and UAV systems, Missile systems, Command and Control systems, Sensor and Electronic Systems and Naval systems.

The Vidsel Test Range is located in northern Sweden and is Europe's largest overland test range. With more than 50 years of experience in testing, we are a reliable and competent partner for product development and evaluation as well as for military test & training activities. The mainstream of testing consists of different type of aircraft and air-, land- and seaborne missiles alongside with a wide scale of UAV systems. Instrumentation is according to the latest standards, allowing complex T&E activities to be performed with high reliability and exact results.

FMV intend to acquire one or two long range tracking and trajectory measurement combined radar and optical systems and hereby invites the industry to provide information on solutions how to meet the requirements.

FMV requests information about the system and also on the procurement in general. Please comment on as many topics as possible.

The industry should provide the requested information within the RFI period. The RFI period ends at May 31, 2014.

Information is also welcome after this date but FMV might not have time to consider it before a possible RFQ.

Questions can be asked at any time, preferable via email to thore.johannson@fmv.se and/or henrik.andersson@sscspace.com. FMV will continuously update the FMV procurement website with clarifications.
This RFI is to be understood as a request for information only and not a procurement. The RFI does not represent a contract, a promise to a contract, or a commitment of any kind on the part of FMV. FMV will not be liable to any payment for the information submitted in response to this RFI.

This market survey will also result in initial contacts and the gathering of information about possible suppliers and their ability to deliver requested equipment.

See included Technical Specification example on a similar, but not necessary identical, system based on a combined CW-Doppler radar and optical tracking system, an ‘optical total station’, for instance suitable radar- and optical performance and functional requirements. Please comment on problematic requirements or make suggestions on improvements in general.

Price versus performance is of priority for budget precision, including prices on various performance and/or properties options and enhancements.

### 2. Technical Information Request

Currently standard radar tracking is either to track weapons on a C-band (NATO/EU: G-band) transponder or to skin track the fighter and acquire, often with optical aid, the launched weapons and skin track the weapon for range safety, trajectory data and optical documentation.

One major goal is to make the radars less dependent on optical contact to acquire weapons without transponder and to replace almost 40 year old radars and optical systems with new radar and optical systems with much better properties needed for the test range.

FMV have identified a few radar criteria to make this successful:

- high resolution discrimination
- reliable and fast multiple object acquisition and tracking

… of weapons released from a fighter aircraft or from a ground based launcher. The weapon/objects types tracked are:

  - missiles and rockets fired from fighter aircrafts, helicopters or ground launchers.
    - Guided or spin stabilized. Targets can be moving in air or stationary or moving on the ground.
  - guided and unguided bombs
  - low flying cruise missiles over land and sea
  - fighter aircrafts, helicopters, UAV, target drones
  - calibration and weather equipment in balloons

- Long range, high loop-gain
- high accuracy

Key requirements of the radar system have been identified to fulfill these criteria:

- **Discrimination (fully coherent), TR-1:** Fully coherent radar (CW-Doppler, interrupted CW-Doppler or pulse-Doppler) with high resolution discrimination performance of multiple closely spaced objects of different sizes, ie small weapon(s) launched from a
high RCS aircraft. Discrimination in range and/or Doppler. Spatial radar imaging discrimination and interferometry is also very interesting. Can it be cost efficient on a long range system?

- **Discrimination (chase aircraft), TR-2**: The firing aircraft often have a chase aircraft closely spaced for documentation or tactical purpose. The radar must ensure reliable tracking of the firing aircraft and reliable lock on to the missile fired or bomb released. Simultaneous tracking of the chase aircraft is also of interest.

- **Target acquisition and tracking (signal processing), TR-3**: Signal processing to support fast and reliable automatic detection and track initiations of multiple objects. Manual track selection or automatic if very low false alarm tracks initiation can be guaranteed while providing high sensitivity on small weapons released from aircrafts and also ground launched.

- **Target acquisition and tracking (high sensitivity and clutter), TR-4**: High sensitivity in acquiring and tracking of small weapons in high clutter environments, such as:
  - ground clutter over land and instrumented launch and target sites. Infrastructure on the ground could be buildings for camera systems, shipping containers as targets, tower, masts, customer launcher equipment and other larger infrastructure. Radar location is elevated over an overland test range. Natural forest, cliffs, hills and mountains. Ground clutter must be suppressed while still tracking the small low flying weapons.
  - Sea clutter/large waves on open sea.
  - Clutter close to the radar. A mobile system usually sits close to the ground.
  - CFAR to acquire and track an object- and/or radar beam pass rain, snow, mist, heavy clouds in windy conditions.
  - Jet (JEM), propeller (PEM) engine and spin modulations.
  - Internal interferences such as intermodulation, harmonics, spurious and image signals.

- **Target acquisition and tracking (instantaneous dynamic range), TR-5**: Very high instantaneous (*) dynamic range to reliable detect and track small weapons while tracking large RCS instrumented fighters. Using multiple receivers for instance. Suppressing zero Doppler ground echo in early RF stages or handling the enormous zero Doppler return from ground clutter while still tracking small low flying moving targets. Low flying weapons and aircrafts will pass zero-Doppler in the presents of ground clutter from time to time, the track must not be lost even if some measurements at zero-Doppler will be lost. (*) Instantaneous dynamic range is not to be confused with high dynamic range over time. The latter is to track targets with low RCS at long range and high RCS targets at short range at different occasions.

- **Target acquisition and tracking (off-boresight), TR-6**: Off-boresight tracking to enhance acquisition probability and to increase antenna gain on small weapon acquisitions while suppress the tracked fighter SNR and JEM/PEM signals. Also to let
released weapons to separate far enough to be discriminated from the fighter aircraft signal when the launching geometry is close to zero range rate and zero elevation as seen from the radar.

- **Target acquisition and tracking (phased array), TR-7:** Phased array properties such as
  - beam steering to track and search for multiple objects in a time-interleaved fashion or multiple simultaneous beams
  - beam spoiling transmitter and multiple simultaneous high gain receive beams … is of great interest. Information on search and track volume versus price for instance.

- **Range and dynamic performance tracking (coherent integration), TR-8:** Coherent integration of multiple pulses or observations to support increasing object SNR internally by increasing detect times, supporting from one millisecond to seconds of data per detection (overlapping observations are encouraged), with joined pulses/observations at full average power. Independent of pulse repetition frequency. This is to both support tracking of aggressive accelerating objects at close range and still be able to track slow accelerating objects at extreme long range. Instrumented range longer than 900km should be supported; range can be resolved after a few cycles. Tracking of large satellites should be supported for calibration, or verifying calibration, against Envisat for instance. Servo system should also handle this long range, high speed and low update rate tracking. Other objects in air or space will be tracked using this coherently integration method included but not limited to satellites, space launch vehicles, sounding rockets, aircrafts at long range and also tracking at shorter range the long joined pulses/observations can be used to extend range on low acceleration weapons such as bombs and some cruise missiles.

- **Tracking (helicopter), TR-9:** The radar system should be able to track a hovering helicopter at low altitude over a high RCS ground clutter. Range should also be measured.

- **Accuracy, TR-10:** High optical- and radar accuracy in real-time and in post-analysis. Mount error and refraction corrected and so on in both tracking methods in real-time and in post-analysis.

- **Transportation, TR-11:** The system must be easy to transport. Short tear down and setup time on prepared sites. Only radar technicians or operators should be needed to tear down and setup and calibrate the systems. Transportation limits should be within 3.1 meter wide, 4.5 meter high and 24 meter long, including FMV standard truck. Semitrailer not recommended. Total transportation size is more convenient if within 2.6 meter wide, 4 meter high and 18 meter long. Operator shelter should be 20ft ISO standard. Suggest different transportation methods but the range does not have its own semi-trailer truck. Could the system consist of only one unit at the radar site? Only
electrical power and communication is needed externally. No external cooling equipment or shelter for other local (<40km) hardware.

Other requirements:

The system shall support remote control (TR-12) from a remote site >40km away. Preferable over a 100Mbit/s Ethernet/IP-network. Faster communication will be available at some sites. Only one or two fibers shall be needed if dedicated fiber is needed for >40km remote control. Low latency for radar presentation, HMI and HD-video is required at the remote site. Fiber (not necessarily fiber transmitters if dedicated fiber is required by the contractor, confirm attenuation with FMV) and network provided by FMV.

Transponder tracking (TR-13) of non-coherent transponders can still be of interest (RCC 262-2), especially C-band.

The system records and handle military secret information and need to be designed to handle this accordingly and meet the Swedish requirements (TR-14). Secret systems should be surrounded with approved cabinet or shelter solution. In general this requires 4mm steel, fully welded construction with approved doors, windows and connector panels to full fill the requirements. With spare room for FMV provided encryption and communication equipment.

Post trigger (TR-15) of all data recordings would be a very useful feature. For instance start the recording from 20 seconds back in time. Data is of the type:

- raw radar data
- real-time processed radar data
- images from the four camera systems

Optical sub-system:

- Medium to high frame rate and a large aperture telescope (TR-16) is needed to see events in mid-air and to get a high update rate of the more accurate optical measured trajectory. Longer optical range and being independent on daytime light calls for use of thermal cameras. Post-analysis to generate accurate and corrected (for mount model, refraction etc) TSPI data from the optical angles and radar range shall be included with the delivery of the new system. Various in-house developed post-analysis solutions are currently used in FMV T&E, TrackEye is used for stationary high speed cameras currently for instance.

- The system could support optical tracking on two cameras (TR-17) at the same time to support reliable tracking while switching between two camera sources.

- The optical sub-system can either be mounted (TR-18) on the radar pedestal as ‘bore sight’ cameras or be co-located on a smaller tracking mount. The operator interface should still work as if the optics and radar sits on the same pedestal. Full accuracy must be ensured regardless if one or two pedestals are used for the radar antenna(s) and the optics. Should be transported as one unit.
• The optical real-time tracked objects should be fitted with matching individual radar range (TR-19).
• Three to four camera systems shall (TR-20) be fitted. See the included Technical Specification on details. The long range visual-, thermal and medium range thermal camera systems shall be included.

Maintenance (TR-21): Full construction material, including source code, in either the delivery directly to FMV or in an Escrow account solution.

UPS for computers only or for the total system? TR-22:
• The system shall handle a 30 seconds power failure. Servos and transmitter could be off line during power failure but the system should be fully operating 30 seconds (10 seconds possible?) after power is restored. UPS is probably needed for computers and other sub systems with long start up times and requires controlled shutdown. The system should have easy and fast access to the same settings as before the power is lost. Some operator interactions could be acceptable to bring the system running again, for safety for instance. The operator could be at the remote control site and shall not need to go to the radar site to restore functionality.
• The system should handle a one minute power failure without any system degradation. UPS needed for all system components, including servo motors, transmitter and enough cooling for instance, to guarantee full performance without wear.

Search radar and/or weather radar functionality? TR-23.

Verification methods to verify required range/loop-gain and measurement accuracy. TR-24.

Calibration- and other infrastructure requirements. TR-25.

Correction for objects in side lob in post-analysis, TR-26.
3. **Commercial Request of Information**

Delivery time, *CR-1*: Comment on 12, 15, 18, 24 month or longer delivery time required from contract.

Could the planned delivery time be accelerated if a contracted separated delivery (*CR-2*) of the tracking system could include a complete radar system with full radar performance, accuracy and at least one thermal camera? Some optical sub-systems could be delivered later. A significant amount of payment will then be withheld until full optical accuracy and performance have been verified.

Required time (*CR-3*) between …
- Contract awarded
- Systems Requirements Review. The first meeting to verify the requirements are understood and to start up the project. (SRR)
- Preliminary Design Review (PDR)
- Final Design Review (FDR)
- An intermediate design review to verify the design before FAT.
- Factory Acceptance Test (FAT), tracking and functional tests.
- Site Acceptance Test (SAT)
... to meet the delivery time and be able to manufacture or place orders on long lead time items.

Payment:
- How big price driving factor or suitability is payment on delivery (*CR-4*) or 50-70% at FAT and 30-50% at SAT. The payment for the FAT would not be done before the system is shipping.
- Alternatively, payment on early milestones, *CR-5*.
- How would price and bidding be affected if there are requirements that all payments before FAT should be met by a bank guarantee that guarantees full return of early payment in case full delivery is not met, *CR-6*?
- How much will the price be influenced if a 5-10% of payment remains until warranty period have been fulfilled? *CR-7*.
- Currency, *CR-8*: Which currency is preferred, SEK, EUR or USD? How will a contract in the other two currencies influence the price?
- Release of option, *CR-9*: The future RFQ might be based on ONE system with an option on a second system. How will the dead line to release the option for the second system affect the price and availability of the option for the second system? If the contract is on TWO systems: how will the delivery schedule and price be affected compared to an option on a second system?
• How large price driving factor is a 5% versus 10% maximum liquidated damages (CR-10) for late delivery or not contracted part-delivery?