MS systems

Testers of multi-sensor surveillance systems

Fig. 1. Photo of the MS300 test system

Fig. 2. Photo of the MS150 test system (with optional CDT660 collimator)

BASIC INFORMATION:

Multi- sensor surveillance systems represent a fast growing group of electro-optical systems of critical importance in both defense and civilian applications.

Most advanced but rarely met multi-sensor surveillance systems are built from a long series of sensors like thermal imager (or two thermal imagers, color VIS camera, low light VIS-NIR camera, SWIR camera, laser range finder, laser designator, laser pointer, illuminator located on a stabilized platform. Simpler systems built from two-three sensors located on smaller stabilized or non-stabilized platforms are more common.

All sensors used in the multi-sensor surveillance systems should be tested to assure that they fulfill assumed requirements. Next, such test should be periodically repeated to detect early deterioration of sensor parameters. Further on, all the sensors must be in properly aligned to assure proper performance of overall multi-sensor system. Deviations from the proper alignment must be corrected by periodic boresighting.

Inframet offers two lines of systems to support testing and boresight multi-sensor surveillance systems: MS and MIS for expanded testing and boresight; and JT and JAT systems for boresight and basic testing.

MS systems are quasi universal test systems optimized for task of extensive testing and boresighting of big/medium size multi-sensor surveillance systems at laboratory/depot conditions. Some of Inframet customers built special platforms that make possible transport of these systems and they carry out tests outside laboratory. However, such situation is an exception from the rule and making tests at field condition is not easy.

MIS systems can be considered as a special lightweight mobile version of MS optimized for testing small size multi-sensor systems.

The MS systems are one of the most technically sophisticated test systems offered by Inframet. They are recommended for testing high value multi-sensor surveillance systems (payloads) used for long range surveillance in air, naval and ground applications. However simpler, smaller versions can be used also for testing portable, multi-sensor surveillance systems.

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1 MS system structure

MS test system is a modular system built in most advanced version using a long series of modules:

1. CDT off axis reflective collimator (collimators of different aperture, focal length and optical quality are available for different applications)
2. TCB differential blackbody (can be delivered in different versions: typical/improved temporal stability; optimization yes/no for cooperation with light source).
3. MRW-8 motorized rotary wheel (optimized for cooperation with a sets of VIS and IR targets and visible targets)
4. Set of IR targets (targets to be used for testing thermal imagers - different configurations are possible)
5. Standard analog video frame grabber (for capturing images of resolution/frame rate not higher than typical TV signal)
6. Optional CameraLink/ or GigE/ or LVDS or other type of frame grabber
7. PC - typical PC working under Windows 7 operating system (laptop or desktop PC are delivered)
8. TCB Control program - computer program used for control of TCB blackbody and MRW wheel.
9. SUB-T program - computer probgram that delivers software support during measurement of subjective parameters like MRTD, MDTD, (and TOD - option) of thermal imagers.
10. TAS-T-program for semi-automatic measurement of of parameters of thermal imagers. Program is delivered in form of different versions of different test capabilities.
11. Visible/NIR light source: several different light sources are available of different performance: a)SEM light source, b)HAL light source - halogen light source, c) DAL light source
12. Set of visible/NIR targets (targets to be used for testing VIS-NIR cameras)
13. Light Control programs (different versions: SEM Control, HAL Control, DAL Control)
14. TAS-V: computer program for semi-automatic measurement of a series of parameters of VIS-NIR cameras
15. SWIR radiation source (SIR (LED light source for SWIR), SAL (version of DAL light source of expanded spectral range into SWIR range), or/and MTB medium temperature blackbody)
16. Programs for control of SWIR light sources (MTB Control, SIR Control, SAL Control)
17. Set of laser sensing cards
18. Set of optical power probes
19. OSA optical signal analyser (for testing LRFs/laser designators)
20. OSA Browser program
21. Set of boresight targets
22. SR100 boresight camera – SWIR camera for accurate measurement of divergence angle of LRFs/designators
23. BOR computer program (enables calculation of aligning errors of thermal imagers, VIS-NIR cameras, SWIR imagers, laser systems)
24. Set of optical attenuators
25. Optical pulse generator OPG10 – to simulate laser pulse reflected by a target irradiated by LRF

2 Test concept

- Testing thermal imagers -> MWIR/LWIR image projector combined with computerized system for analysis of images generated by tested thermal imager. CDT off axis reflective collimator, TCB differential blackbody, MRW-8 rotary wheel and set of IR targets create this projector.
- Testing VIS-NIR cameras -> visible/NIR image projector combined with computerized system for analysis of images generated by tested TV camera. CDT off axis reflective collimator, MRW-8 rotary wheel , visible/NIR light sources, and set of visible/NIR targets are used for such projections.
- Several different radiation sources can be used for such projections (light source of spectral band expanded into SWIR range or/and medium temperature blackbody). and set of SWIR targets are used for such projections.
- Boresight of imaging systems -> computerized test system carries out analysis of images generated by thermal imagers, TV cameras, SWIR imagers and calculates angle between a)optical axis of thermal imager at several FOVs, b)optical axis of VIS/SWIR camera at different magnification of zoom objective, c) optical axis of thermal imager relative to optical axis of TV camera or SWIR imager

- Boresight of laser systems -> computerized test system carries out analysis of images generated by lasersystems on laser sensing cards and calculates angle between a)optical axis of laser system (LRF, laser designator, laser pointer/illuminator) relative to optical axis of a reference imaging system.
- Testing LRFs/laser designators: MS system can carry out expanded tests of LRFs (tests of transmitter, tests of receiver, total performance tests)
- Testing imagers of different electronic image formats -> analog video frame grabber is used when testing imagers of resolution lower or equal to 720x576 at 25 FPS. Optional digital frame grabbers (CameraLink, or GigE, or LVDS, USB 2.0, etc) can be used for testing imagers of high image resolution or high frame rate.

3 Versions of MS test system

MS test systems are modular test systems that can be delivered in form of different versions of different configurations, test capabilities and price. The latter parameter can vary several times depending on version.
The basic division of MS series system is based on output aperture of the collimator (1).

Table 1. Division of MS series systems based on the collimator aperture

System aperture code	Collimator output aperture
MS 100	100
MS 150	150
MS 200	200
MS 250	250
MS 300	300
MS 320	320
MS 350	350
MS 400	400
MS 450	450
MS 500	500
MS 600	600

Attention: price of MS system rises quickly with aperture.

Possible application areas of the MS series test systems are listed below:

- MS 100 - testing multi-sensor systems in ultra small gimbals for mini-drones
- MS 200 - testing portable multi-sensor system of overall apertures below 200 mm
- MS 300 - testing multi-sensor surveillance systems (payloads) used for long range surveillance in air, naval and ground applications of optical apertures up to 300 mm.

The rule of thumb for choosing proper aperture is following:

- Recommended situation: the collimator aperture is bigger than diameter of a circle overlapping fully optics of all sensors
- Barely acceptable situation: the collimator aperture is bigger than diameter of a circle overlapping at least 50% of optics of the sensors (valid only for boresight tests)

Collimator aperture is only one of a series of technical parameters that should be determined to optimize MS system for required applications. We need also to determine:

1. Test range of thermal imagers (number of parameters to be measured)
2. Frame grabbers (acceptable electronic image formats of tested imagers)
3. Source of light in VIS-NIR bands
4. Light simulation conditions
5. Test range of VIS-NIR cameras
6. SWIR radiation source
7. Test range of SWIR imagers
8. Test range of LRFs
9. Test range of laser pointers/illuminators
10. Boresighting capabilities

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Therefore collimator aperture code and additional code composed from ten letters are use to describe precisely parameters of MS series systems. Definitions of 10 letter code are shown in Tab.2. The columns 1-10 present what letters are to be chosen to define precisely required version of MS test system.

Table 2. Definitions of the ten letter code used to describe versions of MS test system

	1	2	3	4	5
Code	**Test range of thermal imagers**	**Frame grabbers**	**Light source**	**Light level**	**Test range of VIS-NIR cameras**
a	Basic: MRTD	No frame grabber	No source	No	No
b	Typical: MRTD, MTF, SiTF, NETD, FPN, non uniformity, distortion, FOV	Standard analog video (PAL/NTSC)	SEM- computerized broadband LED light source (to be integrated with differential blackbody)	Day DAL-> 0.02-10000 cd/m^2 (SEM/HAL- max 1000 cd/m^2)	Basic: resolution (at regulated illuminance conditions)
c	Expanded: as in 1b but also: Auto MRTD, MDTD, PVF, SRF, ATF, NPSD, 3D noise,	As in point 2b but also additional software accepting USB 2.0/3.0 cameras	HAL - computerized halogen light source (to be integrated with differential blackbody)	Night 0.00001 - 1cd/m^2	Typical: resolution, MTF, Distortion, FOV, Sensitivity, SNR, NEI, FPN, Non Uniformity, Responsivity function
d	As in point 1c but additional targets or custom designed targets	As in 2b but also additional frame grabber: CL, GigE, LVDS, Y/Pb/Pr, CoaXPress, HD-SDI, HD-CVI, HD-TVI, AHD, DVI, HDMI, Fire Wire or another type	DAL - computerized halogen/LED light source (to be used as a separate module)	Day/Night DAL-> 0.0001 – 10000 cd/ m^2 (SEM/HAL- max 1000 cd/m^2)	Expanded: as in 5c but additional measurement of MRC (minimal resolvable contrast)
e	As in 1c but also: virtual imager test support		Both SEM light source and DAL light source		Ultra expanded: as in point 6d but additionally 3D Noise, number/position of bad pixels

	6	7	8	9	10
Code	**SWIR radiation source**	**Test range of SWIR imagers**	**Test range of LRF/designators**	**Testing laser pointers/illuminators**	**Boresight capabilities**
a	No source	No	No	No	No
b	SIR light source (LED light source emitting at SWIR band)	Typical: resolution, MTF, Distortion, FOV, Sensitivity, SNR, NEI, FPN, Non Uniformity, Responsivity function	Beam divergence of LRFs and laser designators	power, divergence angle, nonuniformity	Boresight of imaging systems
c	DAL halogen light source in version of expanded spectral band (coded as SAL light source)	Expanded: as in point 6c but additionally MRC, 3D Noise, Number of bad pixels and bad pixel localisation	as in point 8b but additionally measurement of pulse energy of monopulse LRFs		Boresight of imaging systems and monopulse LRFs and laser designators to a reference optical axis
d	MTB-2D medium temperature blackbody	as in point 7c but additionally MRT, MDT	as in point 8c but additionally measurement of parameters of transmit-		As in 10c but additionally systems with multi-pulse LRFs can be

			ters of LRFs/designators		boresighted.
e	Two sources: SAL light source and MTB black-body		As in 8d but additionally measurement of performance/receiver parameters of LRFs		As in point 10d but additional boresight to a reference mechanical axis

Detail description of available options presented in table above is presented below.

1. Test range of thermal imagers

Test range of thermal imagers is described by a number of parameters that are to be measured. Test range can vary from a measurement of only MRTD parameter (tests by final users) to measurement of a long series of parameters (MRTD, MTF, SiTF, NETD, FPN, non uniformity, distortion, FOV, AutoMRTD, MDTD, PVF, SRF, ATF, NPSD, 3D noise) by a design team for extensive characterization of a new imager.

Test range of thermal imagers is determined by two factors:

1)number of IR targets to be delivered,

2)number of test modules in TAS-T computer program. or in TCB Control program.

Detail description of codes used in 2 column no 1 is presented below:

1a - IR targets: set of eight 4-bar targets; software test modules: SUB-T program is delivered. TAS-T program is not delivered.

1b - IR targets: set of eight 4-bar targets; edge target (for MTF measurement), square target (optional target for SITF or NETD measurement), FOV/distortion target. Software test modules: MRTD module in TCB Control program. MTF, NETD, FPN, non uniformity, distortion, FOV modules in TAS-T/S program.

1c - A set of eight pinhole targets is additionally delivered. Computer program TAS-T is delivered in version TAS-T/E having additional test modules capable to carry out measurement of the following parameters: AutoMRTD, PVF, SRF, ATF, NPSD, 3D noise.

1d - option to add new targets or new parameters to measure (to be fixed by customer)

1e - Dubterm program is delivered. This program enables to carry out measurement of Virtual MRTD to speed up MRTD.

2. Frame grabbers

Majority of cameras used in surveillance applications generate video using two standard analog video formats: PAL or NTSC. Therefore analog video frame grabber that enables acquisition of video signals in PAL/NTSC format is a standard module of MS test system.

There are nowadays on market cameras that generate images in higher resolution or at higher speed than mentioned above analog video formats (PAL: 720x576 at 25 FPS) or of the same resolution/speed but using digital transfer. A long series of video formats is used: USB 2.0/3.0, analog HD/SD TV (CVBS, RGB, YpbPr), LVDS or RS-422, Camera Link, CoaXPress, GigE, IEEE 1394 (Fire Wire), SDI, DVI, HDMI. Therefore Inframet offers also additional frame grabbers to enable acquisition of video from any camera available on market.

Detail description of codes used in column no 2 is presented below:

2a - no frame grabber is delivered. This option is optimal for situation when tested imager is equipped with its internal display and only MRTD is to be measured. This option is not acceptable when more extensive testing of thermal imagers/VIS-NIR cameras is to be done.

2b - Frame grabber accepting images in standard analog video format (PAL/NTSC) is delivered.

2c - TAS software is modified to accept video in USB 2.0/3.0 format. Attention: Camera should be compatible with MS DirectX.

2d - Second frame grabber is delivered: Customer can choose from a long series of available frame grabbers: analog HD/SD TV (CVBS, RGB, YpbPr), LVDS or RS-422, Camera Link, CoaXPress, GigE, IEEE 1394 (Fire Wire), SDI, DVI, HDMI. TAS computer program is modified to accept images acquired by the frame grabber.

It is expected that customers knows parameters of tested camera needed to configure earlier mentioned frame grabbers.

Attention: More frame grabbers can be optionally delivered. Please contact Inframet with your specific requirements.

3. Light source

Light source is needed for testing VIS-NIR cameras. This module can be delivered in several versions characterized by different design, test capabilities and different price:

3a - No light source module. This version recommended when VIS-NIR cameras are not to be tested.

3b - SEM computerized broadband LED light source is delivered. SEM source is to be integrated with TCB differential blackbody.

SEM light source is a small light module that use broadband LED as emitter of light in 400-800 nm spectral band. Light intensity is electronically controlled from PC. The SEM module is attached to a modified TCB differential blackbody. After modification typical TCB blackbody becomes DCB blackbody (dual color blackbody). This DCB blackbody works as typical blackbody in MWIR/LWIR range but also works as a white reflector in VIS/NIN range. The integration of light source to differential blackbody enables testing both thermal imagers and VIS-NIR cameras at the same time. No movement of mechanical modules is needed.

This option is recommended for testing VIS-NIR cameras optimized for day applications.

3c - HAL - computerized halogen light source. HAL source to be integrated with TCB blackbody. The difference relative to previous point is the fact that HAL emits broadband light of 2856K color temperature (typical requirements for light sources for testing visible/NIR cameras) in both wide spectral band at least 400-1100nm.

3d - DAL computerized multi mode light source module is delivered. This light source can work in three modes: halogen of 2856K color temperature, white broadband LED, and mixed mode. DAL is characterized by extremely wide dynamic of regulation of light intensity. In this way DAL can simulate difference illumination scenarios met in different geographical regions.

DAL light source module is to be used a separate module. When VIS-NIR cameras are to be tested then TCB blackbody is to be replaced for DAL light source. This replacement is a bit time consuming (several minutes) but DAL light source offers higher dynamic of light source. This option is recommended when testing independent visible/NIR cameras is a crucial task and accurate simulation of both very dark nights and very bright days is needed.

4. Light level

All the light sources (SEM, HAL and DAL) can be delivered in different versions capable to simulate

4b)day conditions,

4c) night conditions

4d) both day conditions and night conditions.

However, only DAL light source can offer simulation of both very dark nights and very bright days (dynamic of regulation over 100 000 000 times up to 10 kcd/m). Max luminance of SEM and HAL light sources is limited to 1 kcd/m^2 (simulation of illumination up to about 10000 lx for targets of 33% reflectance).

5. Test range of VIS-NIR cameras

Test range of VIS-NIR cameras is described by a number of parameters that are to be measured. Test range can vary from a measurement of only resolution parameter (simplified tests by final users) to measurement of a long series of parameters

(resolution, MTF, Distortion, FOV, Sensitivity, SNR, NEI, FPN, Non Uniformity, Responsivity function, MRC, 3D Noise, Number of bad pixels and bad pixel localisation). by design teams developing new TV camera.

Test range of TV cameras is determined by two factors:

1)number of VIS/NIR targets to be delivered,

2)number of test modules in TAS-V computer program.

Detail description of codes used in 2 column no 5 is presented below:

5a - no testing of TV cameras

5b - only one USAF 1951 100% contrast target is delivered to enable measurement of resolution of TV cameras.

5c - TAS-V version S is delivered. The program enables to carry out measurement of MTF, Distortion, FOV, Sensitivity, SNR, NEI, FPN, Non Uniformity, Responsivity function.

5d - Set of 6 variable contrast USAF 1951 targets is delivered (contrast in range from 2% to 100%) and TAS-V version E is delivered.

5e Additionally to do measurement of 3D Noise, Number of bad pixels and bad pixel localization.

6. SWIR radiation source

Several options are possible:

a)SIR computerized LED light source emitting light in SWIR range

b)SAL broadband light source (halogen source of special design emitting light of color temperature 2856K in broadband range from 500 nm up to 1700 nm)

c)MTB medium temperature blackbody.

The first two sources enable testing performance of SWIR imagers simulating targets reflects incoming radiation, the third source enables testing performance when targets emit its own radiation.

Detail description of codes is presented below:

6b - SIR light source is delivered. It is an PC controlled calibrated LED light source emitting in SWIR range.

6c - SAL light source is delivered. It is a special version of DAL light source of special design that emits light of 2856K color temperature in wide spectral band from 400nm to at least 1700nm. This light source enables comparison tests of both TV cameras and SWIR imagers at simulated day/night conditions. When SAL light source is delivered then there is no needed for typical HAL light source for testing TV cameras.

6d - MTB medium temperature light source is delivered. This blackbody enables simulation of targets of temperature as high as 600ºC. The blackbody is needed for measurement of MRT (minimal resolvable temperature) and MDT (minimal detectable temperature) parameters. This option is recommended when testing ability of SWIR cameras to detect hot targets.

6e-most expanded version: both SAL light source and MTB blackbody are delivered.

7.Test range of SWIR imagers

Following options are available:

7a - no testing SWIR imagers.

7b - Typical: resolution, MTF, Distortion, FOV, Sensitivity, SNR, NEI, FPN, Non Uniformity, Responsivity function.

7c – as per option 7b but additionally MRC, 3D Noise, Number of bad pixels and bad pixel localisation. Measurement of MRC is particularly recommended to estimate detection, recognition, identification ranges of target of interest.

7d – as per option 7c but additionally measurement of MRT (minimal resolvable temperature), MDT (minimal detectable temperature). Option recommended when testing cooled SWIR imager of sensitivity up to 2400nm.

8. Test range of LRFs/laser designators

8a – no testing LRFs and laser designators.

8b - measurement of beam divergence of LRFs and laser designators. Special SWIR camera of ultra high dynamic capable to work with ultra short pulses is delivered.

8c – additional measurement of pulse energy of monopulse LRFs/designators. COE optical pulse energy meter is delivered.

8d – expanded tests of transmitters of LRFs and laser designators. Pulse energy, pulse peak power, PRF, pulse width, and coding, missing pulses of LRFs and laser designators can be measured. Advanced OSA optical signal analyser system (part of our LTE system for testing LRFs) is delivered. Test capabilities of 8b are valid too.

8e – expanded tests of complete LRFs can be done. In addition to tests mentioned in 8d test of receiver (sensitivity) and complete LRF (distance accuracy, ER extinction ratio) can be carried out. Optical pulse generator OPG10 capable to simulate laser pulse reflected by a target irradiated by LRF is delivered.

9. Test range of laser pointers/illuminators

9a – no testing laser pointers/illuminators.

9b - measurement of power (laser pointer/illuminators), divergence angle (laser pointers and laser illuminators of divergence angle not bigger than 5 deg). These test capabilities are achieved using COP power meters and BRL test camera.

10. Boresight capabilities

10b - measurement of alignment error between a)optical axis of thermal imager at several FOVs, b)optical axis of VIS/SWIR camera at different magnification of zoom objective, c) optical axis of thermal imager relative to optical axis of VIS-NIR camera or SWIR imager

10c) as is 10b but additionally measurement of aligning error between a)optical axis of laser system (monopulse LRF, laser designator, laser pointer/illuminator) relative to optical axis of a reference imaging system (case of monopulse LRFs and laser designators).

10d) As per option 10c but systems with multipulse LRFs can be tested, too.

10e) Additional measurement of aligning error of any of optical sensors to a reference mechanical axis.

Exemplary versions

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MS 250 bbbbb-aabab - most typical version sold mostly for testing medium cost multi-sensor systems built from the following modules: thermal imager (most important and costly module), color TV camera for day application, and monopulse laser range finder.

MS 300 cdcdd-ecebd - version optimized for testing high end, expensive multi-sensor surveillance systems built from the following blocks: thermal imagers (optionally two thermal imagers), color TV camera for day applications, LLLTV camera for night applications, SWIR imager, mono-pulse/or multipulse LRF, laser designator, and laser pointer/laser illuminator.

4 Summary

1. MS system is one of most sophisticated Inframet test systems capable to test almost all electro-optical imaging/laser systems present market.
2. MS test system can be easily configured by potential user to suit for his applications by adding/removing modules
3. If you have problems to choose proper versions of MS test system using proposed code please **describe your application** in words and Inframet staff shall propose an optimal version. Problem to choose proper version is natural - the reason is complexity of testing multi-sensor systems.
4. This data sheet present a list of typical versions of MS test system. Inframet can deliver customized versions. This is particularly valid if more expanded testing of LRF/laser designators is needed.
5. Please contact Inframet if you have any questions. We are happy to serve you and work had to keep our status as leader in field of apparatus for testing electro-optical surveillance systems.

Version 5.2

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