JT

Stations for boresighting multi-sensor systems

Fig. 1.Photo of the JT400 boresight station

BASIC INFORMATION:

Boresight is a process to align optical axis of single system or a series of optical or electro-optical systems with a certain reference optical axis or mechanical axis. Proper boresight is particularly critical in case of multi-sensor electro-optical surveillance systems built from a series of systems like thermal imager, VIS/NIR camera, SWIR camera, laser range finder, laser pointer.

Test stations offered by Inframet for testing multi-sensor surveillance systems (MS series) can do not only expanded testing but also boresight of these surveillance systems. However, these quasi universal test systems are also costly. JT are more economical systems that offer accurate boresight and basic tests of of multi-sensor electro-optical surveillance systems.

JT stations are image projectors combined with set of laser image sensors can be used to align all typical surveillance systems to a reference optical axis (situation when axis of all electro-optical sensors are parallel). This is a typical requirement for properly functioning multi-sensor surveillance system. These stations are built from three main blocks: 1)image projector that projects images of standard targets into direction of tested multi-sensor system, 2)laser imaging sensors that can create image of laser spots of laser range finders, laser designators or laser pointers, 3)an optional computer that carries analysis of information from tested imager determines relative angular coordinates of axis of optical sensors. The JT stations are offered in form of a series of versions of different size and boresight/test capabilities.

TEST CAPABILITIES

Measurement/checking of:

1. Alignment error for a thermal imager working in different FOVs,
2. Alignment error for VIS-NIR camera working in different position of zoom objective,
3. Alignment error between optical axis of VIS-NIR camera and a thermal imager,
4. Alignment error between LRF and VIS-NIR camera,
5. Alignment error between LRF and thermal imager,
6. Alignment error between laser pointer and VIS/NIR camera/thermal imager
7. Resolution/sensitivity VIS-NIR cameras,
8. Resolution of thermal imagers,
9. Divergence angle of LRFs.

Options:

Measurement/checking:

1. Alignment error between VIS-NIR camera and SWIR imager,
2. Alignment error between thermal imager and SWIR imager,
3. Resolution/sensitivity of SWIR imagers.

TEST METHO|DOLOGY

The principle of work of JT system s is based on an idea to design a systems that could:

1. Generate and project into direction of a tested multi-sensor imaging system an image that could be detectable by all imaging sub-systems (both thermal imager, VIS-NIR camera, SWIR imager) of the tested multi-sensor system,
2. Generate an image of the spot irradiated by transmitter of LRF, laser designator or by laser pointer that could be visible by at least one of the imaging sensors or tested system or by VIS-NIR camera that is a part of JT system .
3. Use optional advanced software that could analyze acquired images and calculated boresighting errors.

The presented above idea was implemented by use of:

A) CJT reflective collimators. These are on-axis reflective collimators capable to project images in wide spectrum from about 400 nm to over 15000 nm. The collimator simulates targets located at its focus at infinity distance. Collimators of different apertures from 150mm to over 600mm are used depending on aperture (minimal diameter of circle where all sensors can be located) of tested system

B) Special VIR light source. The source is built as a blackbody integrated with visible LED source (version VIR-A) or as a blackbody integrated with visible LED source and additionally SWIR LED light source (version VIR-B). The VIR light source irradiate targets placed at collimator focal plane. This solution creates possibility to see the targets by both thermal imagers, VIS-NIR cameras and by SWIR imagers.

C) Set of resolution targets (typical glass USAF 1951 target, IR USAF 1951 target, multi-pattern target) that are used to measure resolution of imaging systems.

D) Set of sensing cards that show a point illuminated by transmitter of LRF, laser designator or by laser pointer. MON, MOG, TEG, TEP cards are used when testing mono-pulse LRFs or designator. The tested LRF/designator creates a spot on these cards that are visible by VIS-NIR camera/thermal imager (part of tested system) or by BRL camera (part of test system). ABS card and FOS card are used when testing multi-pulse LRFs. The effect of use of these cards is the same.

E) ILU cards are diffusive, reflective cards of two different reflectivity levels that that when illuminated by laser pointer reflect radiation into direction of tested VIS-NIR camera (part of tested system) or direction of BRL camera (part of test system).

F) Set of optical attenuators and mechanical holder integrated with CJT collimator. The AH1 holder enable precision positioning of several optical attenuators (OA4 series) in beam emitted by monopulse laser range finders. In this way mirrors of CJT collimator are protected against strong pulses emitted by transmitters of monopulse LRFs. The attenuators protect also receivers of LRFs against radiation reflected back by sensing cards.

G) SR10 camera is a digital camera sensitive in spectral band from 900nm to about 1700nm of ultra high dynamic. The camera is used to visualize laser spots created by tested LRFs. It is a perfect solution for accurate measurement of divergence angle of tested LRFs. Sensing cards can be used only for rough estimation of divergence angle.

H) BRL camera. This is a VIS-NIR camera of very narrow FOV integrated inside CJT collimators. The BRL camera enables to increase accuracy of measurement of alignment errors between VIS-NIR camera and LRF and to increase accuracy of measurement of divergence angle of LRFs.

I) Image acquisition and analysis set built from an external frame grabber, PC and BOR software. This set enables acquisition and analysis of images generated by tested imaging sensors or by BRL camera and accurate measurement of boresight errors of tested multi-sensor system.

VERSIONS

JT test system can be delivered in form of different versions of different design (different modules are needed) , different test capabilities and different price level.

The basic division of JT series system is based on output aperture of the CJT collimators. The aperture is indicated by number after JT letters (see Table. 1).

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

Aperture code	Collimator output active aperture	Collimator output dead aperture	Dimensions
JT 150	150 mm	46	270x340x740 mm
JT 200	200 mm	51	320x410x980 mm
JT 250	250 mm	56	350x440x 1150mm
JT 300	300 mm	70	450x 520x1450 mm
JT 400	400 mm	81	550x 620x1850 mm
JT500	500 mm	96	650x 720x2300 mm
JT600	600 mm	125	750x 820x2750 mm
JT-EX	optional collimators: up to 600mm		

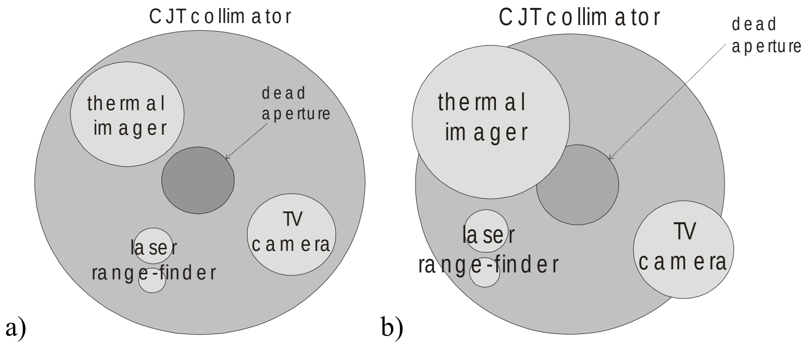

Fig. 2. CJT collimator and tested mltisensors system: a) collimator overlapping optical apertures of sensors of the surveillance system; b) collimator only partially overlapping optical apertures of sensors

Collimator aperture gives information about diameter of a circle that the sensors of tested multi-sensors system must overlap at least partially. In other words, bigger aperture of the collimator means than bigger multi-sensor system can be tested and aligned but size, mass and also cost of test system increases.
Aperture of CJT series collimators is an important and clearly seen parameter of JT series systems because bigger aperture of the collimator means bigger size and mass. However there are also three other criterion used to describe a version of JT test system.

1. Computerization,
2. Boresight capabilities,
3. Testing capabilities.

A series of versions of JT system was proposed to suit for different possible application. Version X1 can be considered as the simplest version, version Y3 - the most sophisticated version.
Computerization:
JT test system works in general as an image projector. Tested multi-sensor system typically have their own display that presents images projected by JT test system. Boresight errors can be noticed and evaluated subjectively by human observer. Therefore simple non-computerized version of JT test system is recommended for quick checking of boresight errors and basic testing of multi-sensor surveillance systems. Computerized version of JT test system (three modules are added: frame grabber, laptop. BOR software) enables capturing images from tested multi-sensor system (or from BRL camera). Boresight errors and resolution, divergence parameters of tested multi-sensor system can be determined with higher accuracy using computerized versions. These versions are recommended for manufacturers, integrators, or advanced users of multi-sensor surveillance systems.
Boresight capabilities:
Boresight capabilities refer to number of sensors that can be aligned using JT test system. Two sensor system built using a thermal imager and a VIS-NIR camera can be considered as the simplest case. Big multi-sensor systems built using both imagers and laser systems require more advanced versions of JT test system.
Testing capabilities:
Testing capabilities refer to number of parameters that can be measured or checked. The capabilities can vary from measurement of resolution of thermal imagers and TV cameras to measurement of resolution of thermal imagers, VIS-NIR cameras, SWIR imagers and measurement of divergence angle of LRFs/designators or laser pointers.

Table. 2. Versions of JT system

Code	Computerization/Boresight/test capabilities	Modules
X1	Non computerized test system Boresighting of typical set of imaging systems (thermal imagers, TV cameras, optical sights) Test range: measurement of resolution of VIS-NIR cameras and thermal imagers	CJT collimator, DNSB dual color source, CDNSB controller, USAF 1951 target, IR-USAF 1951 target
X2	Non computerized test system Boresighting of typical set of imaging systems (thermal imagers, TV cameras, optical sights) and mono-pulse laser range finders Test range: as mentioned as in X1	CJT collimator, DNSB dual color source, CDNSB controller, USAF 1951 target, IR-USAF 1951 target, multi-pattern target, set of MON cards, set of MOG cards, set of TEG cards, set of TEP cards, set of OA attenuators, AH1 holder
X3	As in level X2 but multipulse LRF and laser pointers can be aligned too. ABS card, LIC card, and two ILU cards are added	CJT collimator, DNSB dual color source, CDNSB controller, USAF 1951 target, IR-USAF 1951 target, multi-pattern target, set of MON cards, set of MOG cards, set of TEG cards, set of TEP cards, set of OA attenuators, AH1 holder, ABS card, FOS card, and two ILU cards
Y1	Computerized test system Boresighting of typical set of imaging systems (thermal imagers, TV cameras, optical sights) and mono-pulse laser range finders Test range of imaging systems: measurement of resolution of VIS-NIR cameras/optical sights, and of thermal imagers. Rough measurement of divergence angle of LRFs is possible, too.	CJT collimator, DNSB dual color source, CDNSB controller, USAF 1951 target, IR-USAF 1951 target, set of MON cards, set of TEG cards, set of OA attenuators, AH1 holder , frame grabber, laptop, BOR software
Y2	As per level Y1 but multipulse LRFs and laser pointers can be aligned, too.	CJT collimator, DNSB dual color source, CDNSB controller, USAF 1951 target, IR-USAF 1951 target, multi-pattern target, set of MON cards, set of TEG cards, set of OA attenuators, AH1 holder , frame grabber, laptop, BOR software, ABS card, FOS card, two ILU cards
Y3	As in Y2 but optical axis of JT station can be aligned perpendicular to reference mechanical plane of platform where tested system is fixed.	As in Y2 but CJT station with auto-collimation capabilities relative to a reference plane is delivered. BOS boresight source and BRL camera are included.
Y4	As per level Y3 but divergence angle of tested LRFs can be accurately measured.	As in Y3 but SR10 camera and modified BOR software are delivered.
Y5	As per level Y4 but laser pulse receivers (in LRFs and laser trackers) can be aligned	As in Y4 but BRES boresight receiver system and CBRES control program are additionally delivered.

Additional options:

1. Any version of JT station can be expanded to test and boresight of SWIR imager. Please add letter *S* to chosen version.
2. Inframet can deliver special Borex stage to support professional boresight of EO systems to reference mechanical plane or axis. Please add option Borex.

To summarize, version of JT system is described by a code composed from two components: three digit aperture code shown in Table 1; letter/digit test capabilities code shown in Table 2.

Example **JT 300-Y3** means JT system of following features:

1. collimator aperture equal to 300mm,
2. type of system: computerized,

3. boresighting capabilities: thermal imagers, VIS-NIR cameras, mono-pulse laser range finders, multi-pulse laser range finders, designators, pointers
4. test range: measurement of resolution of VIS-NIR cameras/optical sights, and of thermal imagers. Measurement of divergence angle of LRFs, designators, and laser pointers.

Blocks of JT300-Y3 are: CJT collimator, DNSB dual color source, CDNSB controller, USAF 1951 target, IR-USAF 1951 target, set of MON cards, set of TEG cards, set of OA attenuators, AH1 holder , frame grabber, laptop, BOR software, ABS card, FOS card, two ILU cards, BOS boresight source and BRL camera.

In case of any problems with choosing suitable version of JT test system please send Inframet detail information about multi-sensor system to be aligned and tested. Inframet engineers then choose version of JT system optimal for your application.

Version: 7.1

CONTACT:

Tel: +48 22 6668780 Fax: +48 22 3987244 Email: info@inframet.com