

CALIBRATION SYSTEMS AND METHODS FOR SENSOR PAYLOADS

TECHNOLOGICAL FIELD

This invention relates generally to sensor payloads. Particularly, the invention relates to systems and methods for improving calibration of a payload including a plurality of imaging sensors.

5 BACKGROUND

Sensor payloads are generally mounted on vehicles such as aircrafts, ships or ground vehicles. Payloads can be provided with several imaging sensors to collect data on a scene observed, for example through different spectral bands. In some applications, it may be useful to perform a fusion of the images acquired by two or more sensors. In
10 the case of two sensors for example, image fusion generally consists of superposing the two images so that a user may more efficiently apprehend the data collected by the two sensors. Image fusion may preliminary require a step of registration in which a mapping between the two images may be determined so as to compensate for the sensors' misalignment, tilt, field of view difference, etc. Various techniques currently exist for
15 registering images acquired through two or more sensors. In some techniques, the registration of images acquired by several imaging sensors configured to observe the same scene may be based on determining a linear transformation, including rotation, translation and scaling to relate the images acquired by the two sensors. However, in
20 operation situations, because of material dilatation caused by temperature variations, linear transformation may have to be frequently recalculated so as to compensate for the relative displacements of the sensors. **Fig. 1** illustrates a standard configuration of an aircraft vehicle **1** mounted with a payload system **2** including two cameras monitoring a ground surface **3**. As can be seen on **Fig. 1**, the two cameras have different fields of view and the registration of images from these two cameras would therefore require
25 determining a magnification ratio between the images of the two cameras. Additionally,

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even though a relative position of the two cameras may be evaluated during manufacture, the exact positioning may have to be regularly calibrated.

Some techniques for determining linear transformation for image registration involve a periodical comparison of images of a ground surface scene acquired by the two sensors on a pixel by pixel basis in order to determine an exact mapping from one image to the other. However, these techniques are not well adapted for cameras having different fields of view. Some other techniques, as disclosed for example in US patent No. 5,274,236, are also based on comparison of images of a ground surface scene but further involve "hot spots" determination in the two images and a comparison limited to the hot spots of the two images so as to determine the best mapping from the hot spot coordinates of one image to the hot spot coordinates of the other. However, all these techniques require heavy image processing and are therefore complicated to implement, especially in situations in which the overall size and weight is limited, such as in unmanned vehicle control equipment.

15 GENERAL DESCRIPTION

In a first broad aspect, the present disclosure provides a calibration system suitable for in-flight calibration of a sensor payload. The calibration system comprises an emitting object being configured for emitting in a first emitting spectral band and in a second emitting spectral band a predetermined pattern comprising a plurality of lighted areas on a homogeneous background; and a collimation optical unit configured for setting the emitting object at infinity. The calibration system may have dimensions suitable for being mounted on a vehicle and preferably for being mounted in a payload system. The pattern emitted is particularly adapted for image registration and therefore requires a lesser amount of processing.

25 In some embodiments, the lighted areas are substantially of the same intensity within said first and second emitting spectral bands.

In some embodiments, the homogeneous background is substantially black within said first and second emitting spectral bands.

In some embodiments, at least some of the lighted areas have a circular shape and/or a simple polygonal shape.

30 In some embodiments, the pattern consists of the plurality of lighted areas on the homogeneous pattern.

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In some embodiments, the plurality of lighted areas consists of four circles.

In some embodiments, the first and second emitting spectral bands respectively belong to an infrared spectral band and a visible spectral band.

In some embodiments, the calibration system further comprises a distribution
5 optical unit configured for splitting a beam output by the collimation optical unit into two calibration beams.

In a second broad aspect, the present disclosure provides a payload system. The payload system comprises a first imaging sensor sensitive in a first receiving spectral band; a second imaging sensor sensitive in a second receiving spectral band; a
10 calibration system according to any of the preceding claims, wherein the emitting spectral bands are overlapping the receiving spectral bands. The calibration system and the first and second imaging sensors are relatively configured so as to enable optical alignment between said first and second imaging sensors and said calibration system thereby allowing simultaneous imaging of the emitting object through the optical
15 collimation unit. The payload system provides a built-in configuration allowing calibration on demand of both sensors and periodical check-up of the sensors calibration.

In some embodiments, the calibration system is movable within the payload system enabling the imaging sensors to simultaneously image the emitting object
20 through the optical collimation unit.

In some embodiments, the first and second imaging sensors are movable within the payload system enabling the sensors to simultaneously image the emitting object through the optical collimation unit.

In some embodiments, the payload system further comprises a retractile mirror
25 system enabling the optical alignment of the first and second sensors with the calibration system.

In some embodiments, the first and second imaging sensors are respectively sensitive in infrared and visible spectral bands.

In some embodiments, the first and second imaging sensors are coupled so that a
30 movement of an optical axis of the first imaging sensor is substantially identical to a movement of an optical axis of the second imaging sensor.

In some embodiments, the pattern is configured so that a signal to noise ratio of the lighted areas with regard to the background is superior to 10.

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In some embodiments, the payload system further comprises a laser designator.

In another broad aspect, the present disclosure provides a method of determining registration parameters between two imaging sensors of a sensor payload mounted on an aircraft. The method comprises providing onboard an emitting object configured for
5 being detected by the two imaging sensors, the emitting object emitting a pattern suitable for image registration; acquiring simultaneously a calibration image of the emitting object through an optical collimation unit with each imaging sensor; and determining registration parameters between the two imaging sensors by analyzing the calibration images. The pattern suitable for image registration may refer to a pattern as
10 previously described with reference to the calibration system.

In some embodiments, the pattern comprises lighted areas on a homogeneous background, the lighted areas having a high contrast.

In some embodiments, the two imaging sensors are respectively sensitive in an infrared spectral band and in a visible spectral band and the emitting object is emitting
15 in both the infrared and the visible spectral bands.

In some embodiments, determining registration parameters comprises determining the center of the emitted pattern on each calibration image, a calibration rotation angle around a central axis perpendicular to one of the calibration images for coinciding a reference direction of the emitted pattern in said calibration image with the
20 reference direction of the emitted pattern in the other calibration image and a ratio of magnification between the calibration images.

In some embodiments, determining the ratio of magnification comprises: determining the position of the gravity centers of at least two lighted areas for each calibration image; calculating the distance between said gravity centers in each
25 calibration image; and evaluating a ratio between said distances in the two calibration images.

In some embodiments, determining the calibration rotation angle comprises determining the position of the gravity centers of at least two lighted areas for each calibration image; and evaluating an angle between a segment joining the at least two
30 gravity centers in one calibration image and a segment joining said gravity centers in the other calibration image.

In another aspect the present disclosure provides a method of fusion of images acquired by two imaging sensors of a sensor payload mounted on an aircraft. The

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method comprises: determining registration parameters between the two imaging sensors according to the method of determining registration parameters previously described; and performing fusion of the images acquired by the two imaging sensors using said registration parameters.

5 In another aspect, the present disclosure provides a method of boresighting a laser designator with respect to a first and a second imaging sensor of a sensor payload mounted on an aircraft. The method comprises determining a position of the laser designator in images acquired by the first imaging sensor; determining registration parameters between the two imaging sensors according to the method previously
10 described; and determining a position of the laser designator in images acquired by the second imaging sensor based on the position of the laser designator in images acquired by the first imaging sensor and on the registration parameters between the two imaging sensors.

In some embodiments, determining the position of the laser designator in images
15 acquired by the first imaging sensor is performed by line of sight boresighting.

In some embodiments, the first imaging sensor is sensitive to a wavelength of the laser designator so that determining the position of the laser designator in images acquired by the first imaging sensor can be performed by determining the position of a spot corresponding to the laser designator on the images acquired by the first imaging
20 sensor.

BRIEF DESCRIPTION OF THE DRAWINGS

In order to understand the disclosure and to see how it may be carried out in practice, embodiments will now be described, by way of non-limiting example only, with reference to the accompanying drawings, in which:

25 **Fig. 1**, previously described, illustrates a payload including two cameras embedded on an aircraft.

Figs. 2A-2B illustrate payload systems according to two variants of the present disclosure.

Fig. 3 is a block diagram illustrating general steps of a method of fusion of
30 images acquired by two or more sensors of a payload according to some embodiments of the present disclosure.

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Figs. 4A-4B illustrate calibration images of the calibration system acquired by two sensors of a payload system according to an embodiment of the present disclosure.

Fig. 5A-5B illustrate steps of a method for determining registration parameters from calibration images according to an embodiment of the present disclosure; and

5 **Fig. 6** illustrates a payload system according to an embodiment of the present disclosure.

DETAILED DESCRIPTION OF EMBODIMENTS

Described herein are some examples of systems and methods for improving calibration of a payload system including two or more imaging sensors.

10 In the following, it is to be understood that the term "calibration" at least refers to the registration of images from two or more sensors, for example by determining a linear transformation between said images. Further, the term "suitable for in-flight calibration" may comprise the features that the calibration system has attachment means for enabling attachment to a payload system, and/or that the calibration system faces
15 size constraints so that the calibration system may be compact and may fit into a payload system intended to be mounted to a vehicle, and/or that the calibration faces material constraints so that the calibration system may be configured to resist to temperature variations, accelerations, etc.

In the following detailed description, numerous specific details are set forth in
20 order to provide a thorough understanding of the subject matter. However, it will be understood by those skilled in the art that some examples of the subject matter may be practiced without these specific details. In other instances, well-known methods, procedures and components have not been described in detail so as not to obscure the description.

25 As used herein, the phrase "for example," "such as", "for instance" and variants thereof describe non-limiting examples of the subject matter.

Reference in the specification to "one example", "some examples", "another example", "other examples", "one instance", "some instances", "another instance", "other instances", "one case", "some cases", "another case", "other cases" or variants thereof
30 means that a particular described feature, structure or characteristic is included in at least one example of the subject matter, but the appearance of the same term does not necessarily refer to the same example.

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It should be appreciated that certain features, structures and/or characteristics disclosed herein, which are, for clarity, described in the context of separate examples, may also be provided in combination in a single example. Conversely, various features, structures and/or characteristics disclosed herein, which are, for brevity, described in the context of a single example, may also be provided separately or in any suitable sub-combination.

Unless specifically stated otherwise, as apparent from the following discussions, it is appreciated that throughout the specification discussions utilizing terms such as "generating", "determining", "providing", "receiving", "using", "coding", "handling", "compressing", "spreading", "transmitting", "amplifying", "performing", "forming", "analyzing", " " or the like, refer to the action(s) and/or process(es) of any combination of software, hardware and/or firmware. For example, these terms may refer in some cases to the action(s) and/or process(es) of a programmable machine, that manipulates and/or transforms data represented as physical, such as electronic quantities, within the programmable machine's registers and/or memories into other data similarly represented as physical quantities within the programmable machine's memories, registers and/or other such information storage, transmission and/or display element(s).

Figs. 2A and 2B illustrate two variants of a payload system according to some embodiments of the present disclosure. In both variants, the payload system comprises a calibration system **21**, a distribution unit **22**, a first imaging sensor **23** and a second imaging second sensor **24**. Since the two variants only differ in the feature that the distribution unit **22** is positioned either in the calibration system **21** or in the vicinity of the sensors **23**, **24**, they are described together for the sake of conciseness.

The calibration system **21** may comprise an emitting object **211** and a collimation unit **212**. The emitting object **211** may be configured for emitting a predetermined pattern comprising a plurality of lighted areas on a homogeneous background. The emitting object **211** may radiate (emit) in an infrared band and in a visible band. For example, the visible spectral band may be considered to comprise the wavelengths between 0.4 μ m and 0.8 μ m and the infrared spectral band may comprise either Near IR (NIR) between 0.75 μ m and 1.1 μ m, Short Wavelength IR (SWIR) between 1.1 μ m and 2.5 μ m, Mid Wave IR (MWIR) between 3 μ m and 5 μ m or Long wave IR (LWIR) between 8 μ m and 14 μ m. For example, the emitting object **211** may comprise a plurality of light emitting diodes arranged on a non emitting support. In

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another embodiment, the emitting object may comprise a homogeneous source of light collaborating with a diaphragm having a plurality of apertures. In some embodiments, the emitting object **211** may be of passive type i.e. configured for emitting when impinged by a stimulation beam, for example a laser designator of the payload system.

5 In contrast, in some other embodiments, the emitting object **211** may be of active type i.e. configured for emitting continuously when activated electronically or mechanically. The lighted areas may have substantially the same intensity within the visible and infrared spectral bands of interest i.e. all lighted areas being homogeneously intense. The homogeneous background in the pattern emitted by the emitting object **211** may be

10 substantially black within said visible and infrared spectral bands i.e. the level of emission in said spectral bands may be substantially equal to zero for the regions outside the lighted areas. The pattern may be further defined by a value of a contrast ratio between the intensity emitted by the lighted areas and the background. In some embodiments, the contrast ratio may be superior to 5, 10 or 100. Such a contrast ratio

15 may be measured independently of the sensors **23**, **24**, for example by an additional sensor sensitive in the same spectral band, and using an electronic oscilloscope to measure the ratio of the voltages of the lighted area and the voltages of the background for several sensor lines. The pattern may also be defined by using a signal to noise ratio between the lighted areas and the background as provided by one or more sensors of the

20 payload system. Such signal to noise ratio may be given by a ratio between the average value of the signal measured by one of the sensors (or an average value of the signals measured by several sensors) for one or more lighted areas and the average value of the noise measured by said one sensor (or an average value of the noise measured by said several sensors) for said one or more lighted areas. The emitting object **211** may be

25 configured so that the pattern has a signal to noise ratio superior to 5, 10 or 100. In some embodiments, as described later with reference to **Figs. 4** and **5**, the lighted areas may have a circular shape and/or simple polygonal shape. For example, the pattern may consist of four circular lighted areas.

The collimation optical unit **212** may be configured to set the emitting object

30 **212** at infinity. For example, the collimation optical unit **212** may comprise a converging optical element and the emitting object **211** may be positioned at a focal point of said optical element.

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The distribution unit **22** may be positioned downstream of the collimation optical unit **212** and configured to split a beam incident on the distribution unit **22** into two separate beams (calibration beams). Additionally, in some embodiments the distribution unit **22** may be configured so that the two separate beams are spectrally
5 separated. In order to spectrally separate the incident beam, the distribution unit **22** may comprise a dichroic mirror **221** and standard mirror **222** arranged in parallel to enable both spectral and physical separation of the incident beam. The distribution unit **22** therefore enables the first and second sensor **23, 24** to image simultaneously the emitting object **211** through the collimation optical unit **212**. As previously explained
10 and illustrated in **Figs. 2A-2B**, the distribution unit **22** may be arranged in the calibration system **21** or be arranged in the vicinity of the imaging sensors **23, 24**, for example within a common objective of the sensors.

The first and second imaging sensors **23, 24** may be respectively sensitive in a first infrared spectral band and in a second visible spectral band. For example, the first
15 and second imaging sensors **23, 24** may be an InSb sensor for the infrared spectral band and CCD sensor for the visible spectral band. In some embodiments, the calibration system **21** may also be used in a payload system having two imaging sensors sensitive in the same spectral band as long as the emitting object **211** emits in said spectral band, and the distribution unit **22** provides to both sensors, light within said spectral band.

20 The calibration system **21** provides a pattern suitable for image registration which lowers image processing calculation required to determine a linear transformation relating the images of the first and second sensors **23, 24** with regard to using an image of a background scene for image registration. The calibration system **21** and the first and second sensors **23, 24** may be configured so that said sensors are
25 capable of simultaneously imaging the emitting object **211** through the collimation optical unit **212**. For example, the sensors **23, 24** may be mounted on a movable plate (not shown) that can be moved upon request or periodically within the payload system so that the sensors **23, 24** are placed in front of the calibration system. In another example, the calibration system **21** may be mounted on a movable plate that can be
30 moved upon request or periodically within the payload system so that the calibration system **21** is placed in front of the sensors **23, 24**. It is to be understood that the term “in front” used hereinabove refers to an optical alignment and may also involve the use of additional optical elements such as movable mirrors. Optically aligning periodically or

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upon request the calibration system **21** and the sensors **23, 24** enables frequent and easy calculation of a linear transformation relating the images acquired by the first and second sensors **23, 24** thereby correcting relative displacements of the first and second sensors **23, 24**.

5 **Fig. 3** illustrates schematically some steps of a method for fusion of images acquired in-flight by a plurality of sensors of a payload system mounted on an aircraft vehicle according to some embodiments of the present disclosure. In the following, the payload system is considered to include a calibration system as previously described. In a first step **S101**, calibration images of the emitting object may be acquired by the first
10 and second sensors through the collimation optical unit of the calibration system. The calibration images are images of the emitting object acquired by the first and second sensors. Step **S101** may comprise moving the calibration system so as to optically align the emitting object with the two sensors using the distribution unit. In a second step **S102**, the calibration images acquired are analyzed in order to determine registration
15 parameters i.e. a linear transformation relating the calibration image from one sensor to the calibration image from the other sensor thereby enabling to relate the images acquired thereafter by the first and second sensors. Step **S102** may include determining the center of the emitted pattern on each calibration image so as to derive a translation component of the linear transformation. Step **S102** may further include determining a
20 calibration rotation angle around a central axis perpendicular to one of the calibration images for coinciding a reference direction of the emitted pattern in said calibration image with the reference direction of the emitted pattern in the other calibration image so as to determine a rotation component of the linear transformation. Step **S102** may also include determining a ratio of magnification between the calibration images so as
25 to determine a scaling component of the linear transformation. Details as to the determination of the translation, rotation and scaling components are described below for an example of an emitted pattern with reference to **Figs. 4** and **5**. In a third step **S103**, the fusion of images acquired by the first and second sensors may be performed, given the linear transformation determined in step **S102**.

30 **Figs. 4A-4B** illustrate calibration images acquired by sensors of a payload system as previously described, in which the pattern emitted by the emitting object consists of four circular lighted areas. **Figs. 5A-5B** illustrate steps of a method of determining registration parameters between the calibration images presented in **Figs**

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4A-4B. A first calibration image **43** and a second calibration image **44** acquired respectively by the first and second sensors of the payload system are respectively presented in **Figs. 4A** and **4B**. The images of the lighted areas of the pattern in the first and second calibration images **43, 44** are respectively referenced **431** and **441**. The center of the emitted pattern in the first and second calibration images **43, 44** i.e. the image of the geometrical center of the pattern in the first and second calibration images **43, 44**, are respectively referenced **432** and **442**. A difference in the coordinates of the center of the emitted pattern **432** and **442** may enable to determine a translation component of a linear transformation relating to the first and second calibration images.

With reference to **Figs 5A** and **5B**, the determination of a rotation component of the linear transformation may include determining the position of the gravity centers of the images of the lighted areas in the calibration images **43** and **44** (the gravity centers of the images of the lighted areas in the calibration images are also referred to as the gravity centers of the lighted areas). In **Figs. 5A** and **5B**, the gravity centers of the lighted areas are simply marked by a cross inside the lighted areas. A first reference direction of the emitted pattern may be defined by a first segment joining two gravity centers of two predetermined lighted areas. In **Figs 5A** and **5B**, the images of the first segment in the first and second calibration images are respectively referenced under reference **433** and **443** and join the images of the gravity centers of said two predetermined lighted areas. In one embodiment, a rotation component of the linear transformation relating the first and second calibration images may be determined by calculating an angle formed by the images of the first segment **433** and **443** in the first and second calibration images **43, 44**. A second reference direction of the emitted pattern may be defined by a second segment joining two other predetermined lighted areas in the emitted pattern. In **Figs 5A** and **5B**, the images in the first and second calibration images of the second segment are respectively referenced under reference **434** and **444** and join the gravity centers of said two others predetermined lighted areas. In an embodiment, the rotation component of the linear transformation may be determined as an average between the angle formed by the images **433, 443** of the first segment in the first and second calibration images **43, 44** and the angle formed by the images **434, 444** of the second segment in the first and second calibration images **43, 44**.

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The determination of the scaling component of the linear transformation i.e. a ratio of magnification between the calibration images, may be obtained by calculating a ratio of the lengths of the images **433**, **443** of the first segment in the first and second calibration images **43**, **44**. In another embodiment, the ratio of magnification can be
5 obtained as an average between the ratio of the lengths of the images **433**, **443** of the first segment in the first and second calibration images **43**, **44** and the ratio of the lengths of the images **434**, **444** of the second segment in the first and second calibration images **43**, **44**. Further, it is to be noted that the determination of the linear transformation may also require knowing with precision the intrinsic parameters of the
10 imaging sensors and relative parameters regarding the relative position of said imaging sensors.

Fig. 6 illustrates a payload system **2** according to some embodiments of the present disclosure. The payload system **2** notably includes an attachment mechanism **25** configured for mounting the payload system **2** on an aircraft vehicle and first and
15 second sensor optics **231** and **241** respectively associated with the first and second sensors for directing light onto said sensors. The payload system **2** further includes a laser designator unit **26**. In some embodiments, boresighting of the laser designator with respect to one of the image sensors may be derived from boresighting of the laser designator with respect to the other imaging sensor and from the registration parameters
20 of said sensor with regard to the other. The boresight procedure (also referred to as boresighting) may comprise identifying a pixel in an image acquired by an imaging sensor that corresponds to the centre of the laser spot of the laser designator on a distant target (scene). The boresighting of the laser designator with respect to a predetermined imaging sensor may be performed by line of sight boresighting. Line of sight
25 boresighting may comprise designating a target with the laser and finding the sub-pixel coordinates on the imaging sensor that corresponds to the center of the laser spot. In other embodiments, boresighting of a laser designator with respect to an imaging sensor may also be performed by having the imaging sensor sensitive to the wavelength of the laser designator so that the imaging sensor is able to image directly the spot. This kind
30 of imaging sensor is commonly called a "see spot" camera.

The above examples and description have of course been provided only for the purpose of illustration, and are not intended to limit the invention in any way. As will be appreciated by the skilled person, the invention can be carried out in a great variety of

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ways, employing more than one technique from those described above, all without exceeding the scope of the invention.

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CLAIMS:

1. A calibration system suitable for in-flight calibration of a sensor payload comprising:
 - an emitting object being configured for emitting in a first emitting spectral band
 - 5 and in a second emitting spectral band a predetermined pattern comprising a plurality of lighted areas on a homogeneous background; and
 - a collimation optical unit configured for setting the emitting object at infinity.
2. The calibration system according to claim 1, wherein the lighted areas are
10 substantially of the same intensity within said first and second emitting spectral bands.
3. The calibration system according to any of claims 1 and 2, wherein the homogeneous background is substantially black within said first and second emitting spectral bands.
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4. The calibration system according to any of claims 1 to 3, wherein at least some of the lighted areas have a circular shape and/or a simple polygonal shape.
5. The calibration system according to any of the preceding claims, wherein the
20 pattern consists of the plurality of lighted areas on the homogeneous pattern.
6. The calibration system according to any of the preceding claims, wherein the plurality of lighted areas consists of four circles.
- 25 7. The calibration system according to any of the preceding claims wherein the first and second emitting spectral bands respectively belong to an infrared spectral band and a visible spectral band.
8. The calibration system according to any of the preceding claims, further
30 comprising a distribution optical unit configured for splitting a beam output by the collimation optical unit into two calibration beams.

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9. A payload system comprising:
- a first imaging sensor sensitive in a first receiving spectral band;
 - a second imaging sensor sensitive in a second receiving spectral band;
 - a calibration system according to any of the preceding claims, wherein the
- 5 emitting spectral bands are overlapping the receiving spectral bands and wherein the calibration system and the first and second imaging sensors are relatively configured so as to enable optical alignment between said first and second imaging sensors and said calibration system thereby allowing simultaneous imaging of the emitting object through the optical collimation unit.
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10. The payload system according to claim 9, wherein the calibration system is movable within the payload system enabling the imaging sensors to simultaneously image the emitting object through the optical collimation unit.
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11. The payload system according to claim 9, wherein the first and second imaging sensors are movable within the payload system enabling the sensors to simultaneously image the emitting object through the optical collimation unit.
12. The payload system of any of claims 9 to 11, further comprising a retractile
- 20 mirror system enabling the optical alignment of the first and second sensors with the calibration system.
13. The payload system according to any of claims 9 to 12, wherein the first and second imaging sensors are respectively sensitive in infrared and visible spectral bands.
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14. The payload system according to any of claims 9 to 13, wherein the first and second imaging sensors are coupled so that a movement of an optical axis of the first imaging sensor is substantially identical to a movement of an optical axis of the second imaging sensor.
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15. The payload system according to any of claims 9 to 14, wherein the pattern is configured so that a signal to noise ratio of the lighted areas with regard to the background is superior to 10.

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16. The payload according to any of claims 9 to 15, further comprising a laser designator.
- 5 17. A method of determining registration parameters between two imaging sensors of a sensor payload mounted on an aircraft, the method comprising:
- providing onboard an emitting object configured for being detected by the two imaging sensors, the emitting object emitting a pattern suitable for image registration;
 - 10 - acquiring simultaneously a calibration image of the emitting object through an optical collimation unit with each imaging sensor; and
 - determining registration parameters between the two imaging sensors by analyzing the calibration images.
- 15 18. The method according to claim 17, wherein the pattern comprises lighted areas on a homogeneous background, the lighted areas having a high contrast.
19. The method according to any of claims 17 to 18, wherein the two imaging sensors are respectively sensitive in an infrared spectral band and in a visible spectral
20 band and the emitting object is emitting in both the infrared and the visible spectral bands.
20. The method according to any of claims 17-19, wherein determining registration parameters comprises determining the center of the emitted pattern on each calibration
25 image, a calibration rotation angle around a central axis perpendicular to one of the calibration images for coinciding a reference direction of the emitted pattern in said calibration image with the reference direction of the emitted pattern in the other calibration image and a ratio of magnification between the calibration images.
- 30 21. The method according to claim 20, wherein determining the ratio of magnification comprises:
- determining the position of the gravity centers of at least two lighted areas for each calibration image;

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- calculating the distance between said gravity centers in each calibration image;
and
 - evaluating a ratio between said distances in the two calibration images.
- 5 **22.** The method according to any of claims 20 and 21, wherein determining the calibration rotation angle comprises:
- determining the position of the gravity centers of at least two lighted areas for each calibration image; and
 - evaluating an angle between a segment joining the at least two gravity centers in
10 one calibration image and a segment joining said gravity centers in the other calibration image.
- 23.** A method of fusion of images acquired by two imaging sensors of a sensor payload mounted on an aircraft, the method comprising:
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- determining registration parameters between the two imaging sensors according to the method of any of claims 17 to 22; and
 - performing fusion of the images acquired by the two imaging sensors using said registration parameters.
- 20 **24.** A method of boresighting a laser designator with respect to a first and a second imaging sensor of a sensor payload mounted on an aircraft, the method comprising:
- determining a position of the laser designator in images acquired by the first imaging sensor;
 - determining registration parameters between the two imaging sensors according
25 to the method of any of claims 17 to 22; and
 - determining a position of the laser designator in images acquired by the second imaging sensor based on the position of the laser designator in images acquired by the first imaging sensor and on the registration parameters between the two imaging sensors.
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- 25.** The method of claim 24, wherein determining the position of the laser designator in images acquired by the first imaging sensor is performed by line of sight boresighting.

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26. The method of claim 24, wherein the first imaging sensor is sensitive to a wavelength of the laser designator so that determining the position of the laser designator in images acquired by the first imaging sensor can be performed by
5 determining the position of a spot corresponding to the laser designator on the images acquired by the first imaging sensor.