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(54) **Title:** RAILROAD VIGILANCE SYSTEM CONTROL UNIT

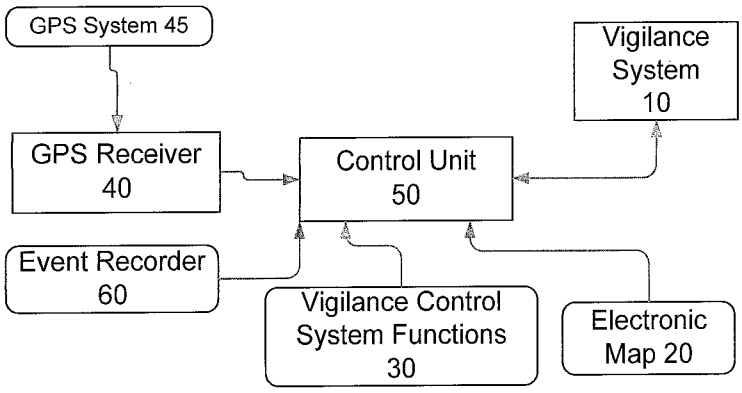


Fig. 1

(57) **Abstract:** This invention concerns railroad vigilance and in particular a control unit for a train driver Vigilance System. The control unit comprises a positioning unit in communication with a positioning system to receive up to date notifications of the current position of the train. An electronic map of the railroad track, for at least the current journey, wherein the track is divided into sections and each section is associated with a track class. A set of vigilance system control functions, one set for each track class. A control unit operable to determine the location of the train with respect to the electronic map, including the current section of the track and its track class; the control unit being further operable to select and invoke the set of vigilance system control functions for the current class. In another aspect the invention is a combination vigilance system and control unit, In a third aspect the invention is a method for controlling a train driver vigilance system, and in a fourth aspect the invention is software for performing the method.

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Title

Railroad Vigilance System Control Unit

Technical Field

This invention concerns railroad vigilance and in particular a control unit for a train driver's Vigilance System. In another aspect the invention is a combination vigilance system and control unit. In a third aspect the invention is a method for controlling a train driver's vigilance system, and in a fourth aspect the invention is software for performing the method.

Background Art

Two significant factors in rail accidents are driver incapacity or inattention. So called "dead man" devices have been installed in trains for many years to identify driver incapacity and to automatically stop the train when it has been detected.

More recently, Vigilance Systems have been installed that require the driver to respond to audible and visual warnings by making predetermined responses using switches or transducers; these response are known as "control inputs".

While the vehicle is stationary with the brakes applied, the vigilance system is usually 'suppressed'. Suppression criteria are chosen carefully so that the system can not be suppressed while the vehicle is at risk of moving. Typically, the presence of high brake cylinder pressure together with a vehicle speed of 0km/hr suppresses the system.

However, when the vehicle is energised, the vigilance system's control functions evaluate the inputs to the system and set a count in a downcounting timer accordingly. During normal vehicle running, the count in the timer may be adjusted (increased or decreased) depending upon control function evaluations.

The counter may be restarted before any warnings are issued if the driver shows signs of vigilance, such as by sounding the horn. Restarts resulting from driver activity are

designed reduce the frequency of the audible and visual warnings that are issued to the driver, and so avoid distracting the driver with requests for superfluous driver responses.

However, in one example, if the timer were set to 40s and 30s had elapsed without reset (so the count was reduced to 10), the driver would receive an audible warning and then a visual alarm requesting a control input. A control input from the driver indicates likely vigilance and will cause the count to be increased.

If the count is not adjusted by any of the control inputs and is allowed, say, to reach zero, the vigilance system will advance from an initial quiescent state to one of several alarm states where increased visual and audible warnings prompt the driver to provide a control input. If the driver does not respond to the warnings, the system advances to the emergency brake state.

In the Emergency Brake state, the vigilance system applies emergency train brakes and will not release the brakes until specific conditions are met, such as:

A set time (e.g. 45 seconds) has elapsed;
The indicated vehicle speed is 0km/hr; and,
The driver has acknowledged the emergency brake application.

The warning light and bell are also used to indicate when the vigilance system is applying the emergency brake, and when the driver is permitted to reset the system following the brake application.

A number of enhancements may be incorporated into this general scheme: The control functions may adjust the count according to the train's current speed so that faster vehicle speeds result in lower counts and increased driver warnings. Random values for the counts may be set at the time of resetting to remove predictability from system behaviour, and thereby mitigate sub-conscious driver acknowledgements.

These systems ensure the driver remains sufficiently alert and responsive to their task.

There are also a number of types of danger zones in railroad networks where accidents are more likely to happen. These include:

Speed restrictions;

Turnouts;

Sharp curves;

Level crossings; and,

Any other condition whereby the vehicle's speed must be reduced to pass safely.

Grade separation is the only certain means of preventing collisions between rail and road traffic at level crossings, but is expensive and not practicable in many rail systems. In most urban areas and some suburban areas, rail level crossings are protected against collisions through the use of controllable physical barriers, and active audio and visual warning systems that alert a road user that a train is approaching. Where such systems are in use, a train and road vehicle collision is usually due to road users accidentally or intentionally driving through the level crossing when a train is approaching.

In some rural environments in Australia and other countries, there are many thousands of level crossings where no current active protection is provided. The remoteness of the locations and cost are the major deterrents. A variety of passive mitigation strategies are applied as alternatives, such as level crossing approach road redesign, foliage removal, rumble strips (sections of rough road surface producing characteristic noise audible to vehicle occupants), and static warning signs. Collisions at these intersections typically arise because of failure of road users to notice the oncoming train, miscalculating the time of arrival of the train, or through risk-taking behaviour.

In some jurisdictions the permanent use of headlights is required to assist in train awareness from the front. Ditch lights and side marker lights are also mandated in some jurisdictions to increase train visibility from the side. Ditch lights are typically driver actuated, subject to standing operating procedures

Disclosure of the Invention

The invention is a computerised control unit for a train driver's vigilance system, comprising:

A positioning unit in communication with a positioning system to receive up to date notifications of the current position of the train.

An electronic map of the railroad track, for at least the current journey, wherein the track is divided into sections and each section is associated with a track class.

A set of vigilance system control functions, one set for each track class.

Wherein the control unit is operable to determine the location of the train with respect to the electronic map, including the current section of the track and its track class; and the control unit is further operable to select the set of vigilance system control functions for the current track class for use by the vigilance system.

The control unit operates in conjunction with a train driver's vigilance system. It adds knowledge about the train's location to the vigilance system, and intelligence that automatically alters the vigilance system's control functions according to the class of track upon which the train is currently travelling. This not only improves performance of the vigilance system but is also able to improve safety at danger zones such as level crossings.

There may be a super class overlaid over many sections of track and overriding any conflict that might occur, for instance, where there are closely parallel or crossing tracks of a different class. Alternatively the immediate class history may be used to resolve such a conflict.

The sets of vigilance system control functions may be stored in the vigilance system or in the control unit. In the former case where the sets of control functions are stored in the vigilance system, the control unit selects and instructs the vigilance system which set of control functions to use according to the current track class.

In the alternative where the control unit stores the sets of control functions, it operates to download the appropriate set of control functions to the vigilance unit according to the current track class.

The sets of control functions typically receive signals, interpret those signals and output signals to other devices that issue stimuli to the driver that require a control input.

Different sets of control functions may be designed to receive different signals, to interpret the signals differently, to issue different stimuli or to require a different control inputs; or any combination of these things.

The control functions may receive signals that take account of a range of local track factors, which may be derived from the track class information, including:

Speed restrictions;

Turnouts;

Sharp curves;

Level crossings; and,

Any other condition whereby the vehicle's speed must be reduced to safely pass through the affected area.

The control functions may also receive signals from other train-borne systems, including:

Driver alertness;

Speed (from a speedometer or calculated from changes in position); and,

Over-speed warnings.

The control functions may also receive signals from trackside systems, including information about one or more of:

Zone boundary crossings;

Localised speed limits;

Approaches/exits to/from sharp curves, platforms, level crossings, turnouts, depots, baulks, etc;

Temporary track restrictions caused by track work or extreme weather, such as prolonged heat waves; and,

Objects that impede forward vision such as tunnels or buildings.

The control functions may interpret individual factors differently depending on the current combination of other factors; for instance in approaching a level crossing the response may be different depending on the driver's state of alertness.

The control functions may also provide other outputs in addition to the vigilance system outputs to the driver. For instance, the control functions may initiate radio transmissions that will control trackside equipment or even close motor vehicles.

The location information will typically be obtained from a satellite positioning system such as GPS, GLONASS or Galileo. Alternatively, trackside transponders can be used to respond to the train's passing by transmitting a signal to the train containing updated location information. A combination of these techniques may be employed to ensure up to date location information is available when the GPS signal is unavailable.

The control unit can be quickly deployed in rail vehicles without the need for expensive infrastructure or trackside equipment.

In another aspect the invention is a combination vigilance system and control unit.

In a third aspect the invention is a method for controlling a train driver vigilance system, comprising the steps of:

Receiving up to date notifications of the current position of the train.

Storing an electronic map of the railroad track, where the track is divided into sections and each section is associated with a track class.

Storing a set of vigilance system control functions, one for each track class.

Identifying the current section of track and its associated class. And,

Selecting the set of vigilance system control functions for the current class.

In a further aspect the invention is software for performing the method.

Brief Description of the Drawings

An example of the invention will now be described with reference to the accompanying drawings, in which Fig. 1 is a block diagram of a vigilance system together with a computerised in-train control unit exemplifying the invention.

Best Modes of the Invention

The train driver's control cab is equipped with a vigilance system 10, being a state machine that provides programmed responses according to its current logical state, and includes clocks and counters that procure automatic changes of state (from "suppressed "through several "alarm" states to an "emergency braking" state) according to the passage of time and the drivers response to audible and visual alarms. The vigilance system will make use of a number of warning devices, and one or more driver acknowledgement devices in connection with its ordinary operation.

Also there is an electronic map of all the track routes of the rail system, stored in a programmable database 20. In this electronic map 20 each rail line is overlaid along its length with a series of partially overlapping rectangular zones. A suitable shape and size for each zone has been found to be a square of forty metres per side. (This size and shape of these areas has been derived from consideration of the complexity in developing maps and ease of data processing required in the on-train equipment, balanced against the requirement for sufficient spatial resolution.)

Each zone is identified as belonging to one of a multiplicity of track classes. As a result geographical lengths of the track, which may be made up of one, several or many of the zones will belong to a particular class.

A simple classification scheme may operate as follows:

All metropolitan tracks over which the train operates are assigned to a first class.

Freight tracks are assigned to a second class.

Country tracks are assigned to a third class.

Any length of track including an obstacle or hazard is assigned to a fourth class, this is the class requiring the highest vigilance.

A further programmable database 30 contains plural sets of vigilance system control functions; one set for each class.

A Global Positioning System (GPS) receiver 40 is provided for receiving position information from a GPS system 45 to enable the position of the train to be determined in real time.

The control unit operates to identify the class of a zone corresponding to the vehicles current position (and zone) according to the following process:

If poor signal coverage inhibits GPS reception, for instance because the vehicle is in a tunnel, steep cutting. dense cityscape or landscape, underneath large bridges or within a workshop, the control unit will determine the fourth class; which has the strictest timings.

If a GPS signal is present and the vehicle is located on an explicitly zoned track, the control unit will determine the class corresponding to the zone.

If a GPS signal is present and the vehicle is not on an explicitly zoned track but the zone can be inferred, the control unit will determine the class of the inferred zone.

If a GPS signal is present and the vehicle is not on an explicitly zoned track and the zone cannot be inferred, the control unit will determine the fourth class.

If a GPS signal is present and the vehicle is in a hazard zone, the control unit will determine the fourth class.

In general, using the location information the Control Unit 50 is programmed to directly identify the class of the zone in which the train is currently located. Having done so, the Control Unit 50 selects the set of vigilance system control functions applicable to the class of the section of track and invokes their use in the vigilance system. Invocation may take place by mere selection when the sets of control functions are stored in the vigilance system, or by downloading the sets into the system.

As a result the vigilance system operates differently in each class of zone. For instance, when the train enters a zone classified as having track conditions that justify higher than normal levels of driver vigilance, the control unit will invoke a set of control functions in the vigilance system that require the driver to respond to more frequent prompts and may require different responses.

In one example, one or more contiguous zones along a stretch of track may be classed as containing a level crossing. The set of vigilance system control functions applicable to a level crossing class are automatically invoked when the train enters this stretch. As we have discussed above the control functions generally include requirements for the driver to acknowledge the vigilance system by taking an action, such as pressing a button or possibly sounding a horn.

In this specific case the control functions will require the driver to demonstrate heightened vigilance. The required degree of vigilance may be dependent on other factors whether or not related to the class of the zone, such as the speed of the train, the degree of curve, quality of visibility, weather conditions, the drivers state of vigilance and many other factors.

The vigilance system control functions for a level crossing zone will also contain programmed decision logic that determines time to arrival of the train to the crossing. And at either a set distance from the level crossing, or a selected time before arrival at the level crossing the control functions will activate relays to flash lights on the front of the train, preferably red lights, or red and blue alternating lights, and also automatically actuate ditch lights (flashing white lights along the side of the locomotive).

The control functions also cause transmission of a coded radio signal receivable by a radio in any nearby motor vehicle equipped to produce audio and (or visual) signals within the vehicle to advise the driver of that vehicle about the approaching level crossing. Alternatively, or in addition, the radio signal may be able to work co operatively with motor vehicle controls to reduce vehicle speed when a vehicle is approaching the level crossing. The radio path may be direct from train to motor

vehicle, via repeaters, or through a wide area network attached to a computerised central administration function controlling communication with many trains and many vehicles.

The radio signal can also be coded to control a warning process, such as flashing lights, at the crossing, or roadside warning signals some distance in advance of the crossing.

Parts of such a train-borne warning system is able to be operated with no additional trackside works or maintenance, where all equipment is locomotive or train mounted. Further equipment, such as motor vehicle carried warning devices or level crossing or roadside warnings can be added to the train-borne system electively and progressively.

The control unit 50 also provides inputs to one or more event recorders 60, including image records, and may be used to initiate the commencement of a real time record such as CCTV of events at or near the crossing, in front of the train, or in the train driver's cab. The event recorder will log the time and location, provided GPS reception is available, of emergency brake applications

Although the invention has been described with reference to a particular example, it should be appreciated that it could be exemplified in many other forms and in combination with other features not mentioned above. For instance, further logical inputs can be added to the system, such as a measure of driver drowsiness obtained by a suitably objective biometric process, to further condition the control functions.

The control unit may be incorporated into a programmable device such as a field programmable gate array (FPGA) or a complex programmable logic device (CPLD).

Multiple electronic maps may be pre-loaded into the control units. Each map may contain an 'effective date' specifying the date and time on which the map is to become effective. Pre-loading zone maps into a fleet of control units allows simultaneous reconfiguration of the fleet when the effective date is reached.

Secure authentication may be employed to allow only approved maps to be loaded in-field. A PDA or laptop is used to upload the map to the control unit.

A multi-line display in the driver's control cab may be used to display the active zone map, the next zone map scheduled to take effect, the firmware version and the current track zone. Emergency brake application logs may be displayed on the screen by pressing a 'select' button.

The control units may be automatically configured at installation for use on different vehicles. This ensures a single control unit can be fitted to different vehicle classes, even if each class requires different vigilance system and interfaces. A universal mounting arrangement also allow fitment of the control units to different vehicle classes while providing easy viewing of the screen. A display associated with the control unit will operates in portrait or landscape mode depending on mounting arrangement.

The control unit can be configured to notify train control, via activation of an emergency radio, if a driver has not responded to an emergency brake application within a set time (indicating possible incapacitation). This allows train control to contact the driver to establish the extent of the incident and arrange further assistance if required.

The majority of issues arising from signal loss can be overcome with the use of a dead-reckoning system. Dead-reckoning systems infer vehicle position by observing the vehicles acceleration in two dimensions while also considering the distance travelled by the vehicle during times when the GPS signal is unavailable.

Claims

1. A computerised control unit for a train driver's vigilance system, comprising:

a positioning unit in communication with a positioning system to receive up to date notifications of the current position of the train;

an electronic map of the railroad track, for at least the current journey, wherein the track is divided into sections and each section is associated with a track class;

a set of vigilance system control functions, one set for each track class;

wherein the control unit is operable to determine the location of the train with respect to the electronic map, including the current section of the track and its track class; and the control unit is further operable to select the set of vigilance system control functions for the current track class for use by the vigilance system.

2. A computerised control unit according to claim 1, wherein the control unit is integrated into a train driver's vigilance system.

3. A computerised control unit according to claim 1 or 2, wherein the sets of control functions are stored in the vigilance system, in which case the control unit not only selects but also instructs the vigilance system which set of control functions to use according to the current track class.

4. A computerised control unit according to claim 1 or 2, wherein the sets of control functions are stored in the control unit, in which case the control unit not only selects but also downloads the appropriate set of control functions to the vigilance unit according to the current track class.

5. A computerised control unit according to claim 1, wherein the sets of control functions receive signals, interpret those signals and output signals to other devices that issue stimuli to the driver that require a control input.

6. A computerised control unit according to claim 5, wherein the control functions receive signals that take account of local track factors, including:

speed restrictions;

turnouts;

sharp curves;

level crossings; and,

any other condition whereby the vehicle's speed must be reduced to safely pass through the affected area.

7. A computerised control unit according to claim 5 or 6, wherein the control functions receive signals from other train-borne systems, including:

driver alertness;

speed (from a speedometer or calculated from changes in position); and,

over-speed warnings.

8. A computerised control unit according to claim 5, 6 or 7, wherein the control functions receive signals from trackside systems, including information about one or more of:

zone boundary crossings;

localised speed limits;

approaches/exits to/from sharp curves, platforms, level crossings, turnouts, depots and baulks;

temporary track restrictions caused by track work or extreme weather, such as prolonged heat waves; and,

objects that impede forward vision such as tunnels or buildings.

9. A computerised control unit according to any one of claims 5 to 8, wherein the control functions interpret individual factors differently depending on the current combination of other factors.

10. A computerised control unit according to claim 5, wherein the control functions provide other outputs in addition to the vigilance system outputs to the driver.

11. A computerised control unit according to claim 10, wherein the control functions initiate radio transmissions that will control train -borne or trackside equipment including motor vehicles.

12. A computerised control unit according to claim 11, wherein the equipment that will be controlled includes warning devices.

13. A computerised control unit according to claim 10, wherein the equipment is external warning lights.

14. A computerised control unit according to claim 1, wherein location information is obtained from a satellite positioning system.

15. A computerised control unit according to any preceding claim, wherein location information is obtained from a trackside transponders.

16. A computerised control unit according to any preceding claim, wherein location information is also obtained by dead reckoning.

17. A computerised control unit according to claim 1, in combination with a train driver's vigilance system.

18. A method for controlling a train driver vigilance system, comprising the steps of:
receiving up to date notifications of the current position of the train;
storing an electronic map of the railroad track, where the track is divided into sections and each section is associated with a track class;
storing a set of vigilance system control functions, one for each track class;
identifying the current section of track and its associated class; and,
selecting the set of vigilance system control functions for the current class.

19. Software for performing the method of claim 18

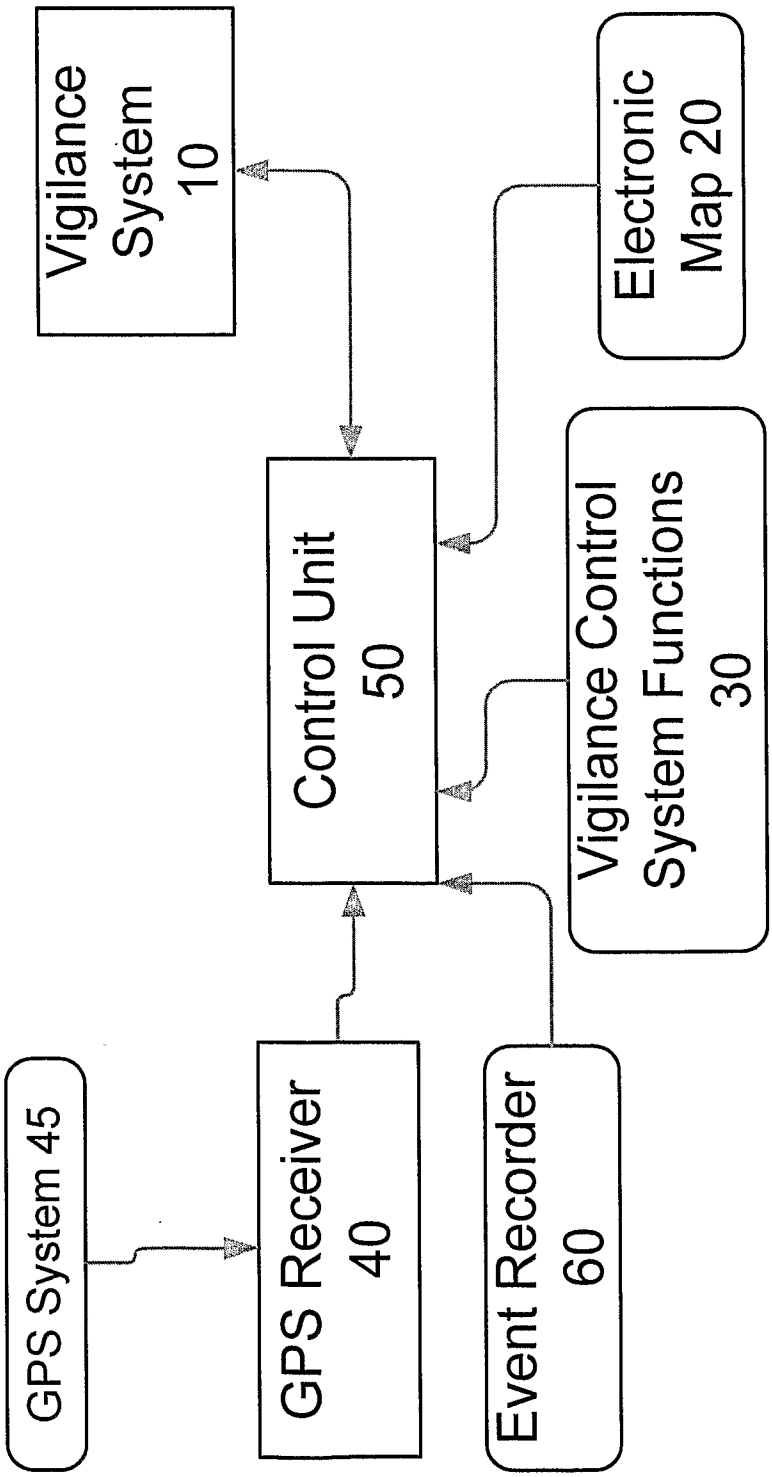

Vigilance System 10
Electronic Map 20
Control Unit 50
Vigilance Control System Functions 30
GPS System 45
GPS Receiver 40
Event Recorder 60

Fig. 1

INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU2008/001472

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl.

B61L 25/02 (2006.01) ***B61L 23/20*** (2006.01)

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPODOC, WPI: B61L/ic & keywords [(TRAIN?, LOCOMOTIVE?); (TRACK, SECTION?, ZONE? , SEGMENT?, CLASS) ; (MAP, LOCATION, POSITION, GPS); (COMPUT+, CONTROL?, TRANSMIT+) ;(VIGILANCE , SURVEILLANCE , WARNING , DRIVER)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2005/0110628 A1 (Kernwein et al) 26 May 2005 Abstract , paragraphs 0003, 0011, 0020-0022, 0026-0027 and 0029-0031 & figures 1-4	1-10, 13-19
X	WO 1989/005255 A1 (The Secretary of State for Defence in her Britannic Majesty's Government of the United Kingdom of Great Britain and Northern Ireland) 15 June 1989 Abstract, Pages 1-3 & figures 1-2	1-10, 13-19
A	DE 4406721 A1 (Siemens AG) 31 August 1995 Abstract	1-19

[X] Further documents are listed in the continuation of Box C [X] See patent family annex

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
25 November 2008	05 DEC 2008
Name and mailing address of the ISA/AU AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA E-mail address: pct@ipaustralia.gov.au Facsimile No. +61 2 6283 7999	Authorized officer **RIJU JACOB** AUSTRALIAN PATENT OFFICE (ISO 9001 Quality Certified Service) Telephone No : +61 2 6283 2220

INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU2008/001472

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	DE 102005042218 A1 (Deutches Zentrum fur Luft-und Raumfahrt e.V.) 08 March 2007. Abstract	1-19
A	WO 2001/076928 A1 (Central Research Laboratories Limited) 18 October 2001. Whole document	1-19
A	WO 2003/081514 A1 (Nahla) 2 October 2003. Abstract, Pages 14-18,21-32 & figures 1-8,12,14	1-19

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/AU2008/001472

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report		Patent Family Member					
US	2005110628	US	7398140	US	2004230354		
WO	8905255	GB	2230885				
DE	4406721	NONE					
DE	102005042218	NONE					
WO	0176928	AU	89316/01				
WO	03081514	AU	2002100286	AU	2003209857	CN	1656524
		EP	1540564	US	7317987	US	2005107954

Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001.

END OF ANNEX