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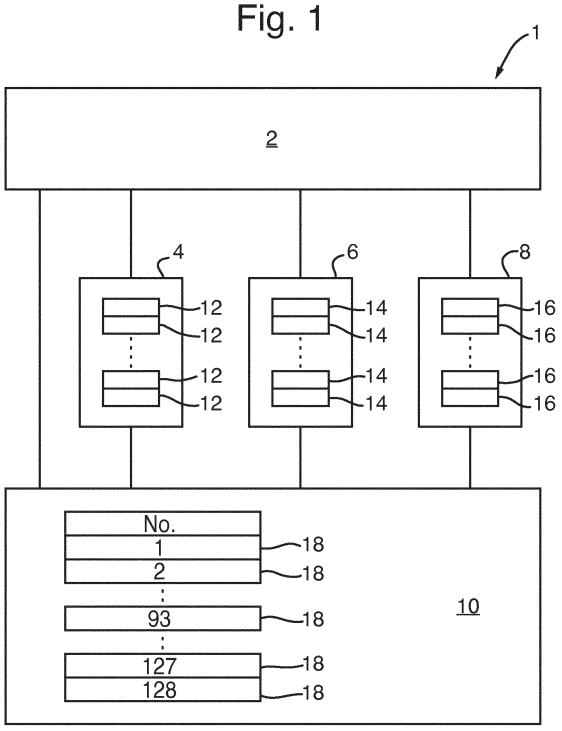
(54) COUNTERMEASURES SYSTEM

(57) A countermeasures method and system, comprising: one or more processors (2), in response to a military threat to a vehicle, selecting a coordinated countermeasures response (18) from a plurality of different responses (18); and implementing the selected response (18) according to its stored specification. The stored specifications of the responses each comprise: a sequence of commands (s1, s2,...s6) and trigger events (t1, t2,...t6), each of the commands comprising one or more sub-commands (12, 14, 16) each specifying an individual response action categorised as one of a plurality of countermeasures response-type categories (4, 6, 8), for example one category (4) is flight manoeuvres, one (6) is deployment of expendables, and one (8) is emission of electronic countermeasures. If a command comprises plural sub-commands (12, 14, 16) then each of the sub-commands (12, 14, 16) of the command (s1, s2,...s6) is from a different category (4, 6, 8).

Fig. 1



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Description

FIELD OF THE INVENTION

[0001] The present invention relates to countermeasures systems and processes, for example, but not limited to, countermeasures systems and processes for vehicles, in particular military vehicles, including, but not limited to, military aircraft, ships, submarines and ground vehicles.

BACKGROUND

[0002] It is known to provide defensive aids, to vehicles, in particular military vehicles, for example military aircraft, ships, submarines, and ground vehicles. For example, a defensive aids subsystem (DASS) may provide one subsystem of a military aircraft's avionics system.

[0003] It is known that countermeasure responses to detected threats may be improved by carrying out two or more defensive responses in combination, including overlapping in time fully or partially. For example, an aircraft may combine any of a change in flight manoeuvre, for example changes in speed and/or direction, release of expendable countermeasures, for example chaff and/or flares, and deployment of one or more electronic countermeasures (ECMs).

[0004] Conventionally, the speed of determination of a suitable combination of countermeasures responses, and the speed of deployment of such combined countermeasures responses, is limited by human response times, for example the response times of an aircraft pilot.

[0005] US Patent Number 7,599,765 describes a dynamic guidance arrangement for close-in manoeuvring air combat.

SUMMARY OF THE INVENTION

[0006] The present inventor has realised that it would be desirable to provide countermeasures systems and processes that can determine a suitable combination of responses and deploy such a combination of responses in a manner that alleviates or removes the dependency on human response times.

[0007] The present inventor has further realised that it would be desirable to provide such countermeasures systems and processes in a manner that is able to efficiently determine from a wide range of possible response combinations whilst alleviating the amount of mission data, for example flight mission data, that needs to be stored and/or processed to provide such a wide range of possibilities. The present inventor has further realised that it would be desirable if such mission data could efficiently and flexibly be updated or replaced. The present inventor has further realised that it would be desirable if the provided countermeasures systems and processes were such that updating or replacing of only selected portions of such mission data could be implemented efficiently and flexibly.

[0008] In a first aspect, the invention provides a countermeasures method, comprising: in response to a military threat to a vehicle, one or more processors selecting a co-ordinated countermeasures response from a plurality of different co-ordinated countermeasures responses whose specifications are stored in a manner accessible to the one or more processors; and implementing the selected co-ordinated countermeasures response according to its stored specification; wherein the stored specifications of the co-ordinated countermeasures responses each comprise: a sequence of commands, each of the commands comprising one or more sub-commands, each sub-command specifying an individual response action categorised as one of a plurality of countermeasures response-type categories, wherein if a command comprises plural sub-commands then each of the sub-commands of the command is from a different countermeasures response-type category.

[0009] The stored specifications of the co-ordinated countermeasures responses may further comprise trigger events defining respective transitions between consecutive commands of the sequence of commands.

[0010] One of the countermeasures response-type categories may comprise flight manoeuvres.

[0011] One of the countermeasures response-type categories may comprise deployment of expendables.

[0012] One of the countermeasures response-type categories may comprise emission of electronic countermeasures.

[0013] At least some of the commands specified by the selected co-ordinated countermeasures response may be implemented automatically by the aircraft's automatic systems without pilot involvement.

[0014] All of the commands specified by the selected co-ordinated countermeasures response may be implemented automatically by the aircraft's automatic systems without pilot involvement.

[0015] In a further aspect, the invention provides a countermeasures system, comprising: one or more processors configured to, in response to a military threat to a vehicle, select a co-ordinated countermeasures response from a plurality of different co-ordinated countermeasures responses whose specifications are stored in a manner accessible to the one or more processors; and implement the selected co-ordinated countermeasures response according to its stored specification; wherein the stored specifications of the co-ordinated countermeasures responses each comprise: a sequence of commands, each of the commands comprising one or more sub-commands, each sub-command specifying an individual response action categorised as one of a plurality of countermeasures response-type categories, wherein if a command comprises plural sub-commands then each of the sub-commands of the command is from a different countermeasures response-type category.

[0016] The stored specifications of the co-ordinated countermeasures responses may further comprise trig-

ger events defining respective transitions between consecutive commands of the sequence of commands.

[0017] One of the countermeasures response-type categories may comprise flight manoeuvres.

[0018] One of the countermeasures response-type categories may comprise deployment of expendables.

[0019] One of the countermeasures response-type categories may comprise emission of electronic countermeasures.

[0020] At least some of the commands specified by the selected co-ordinated countermeasures response may be implemented automatically by the aircraft's automatic systems without pilot involvement.

[0021] All of the commands specified by the selected co-ordinated countermeasures response may be implemented automatically by the aircraft's automatic systems without pilot involvement.

[0022] In a further aspect, the invention provides a program or plurality of programs arranged such that when executed by a computer system or one or more processors it/they cause the computer system or the one or more processors to operate in accordance with the method of the above aspect.

[0023] In a further aspect, the invention provides a machine readable storage medium storing a program or at least one of the plurality of programs according to the above aspect.

BRIEF DESCRIPTION OF THE DRAWINGS

[0024]

Figure 1 is a schematic block diagram of an embodiment of a countermeasures system;

Figure 2 is a schematic block diagram showing details of a manoeuvres programs module 4, an expendables programs module 6, and an ECM programs module 8 of the countermeasures system of Figure 1;

Figure 3 is a schematic block diagram showing details of a manoeuvres program, by way of example the manoeuvres program with unique identity number thirty-one;

Figure 4 is a schematic block diagram showing details of an expendables program, by way of example the expendables program with unique identity number twenty-five;

Figure 5 is a schematic block diagram showing details of another expendables program, by way of example the expendables program with unique identity number twenty-six;

Figure 6 is a schematic block diagram showing details of an ECM program, by way of example the ECM program with unique identity number fifty-four;

Figure 7 is a schematic block diagram showing details of a co-ordinated program, by way of example the co-ordinated program with unique identity number ninety-three; and

Figure 8 is a schematic representation of the implementation of a countermeasures process specified (or defined) by a co-ordinated program, in this example the co-ordinated program number ninety-three.

DETAILED DESCRIPTION

[0025] Figure 1 is a schematic block diagram of an embodiment of a countermeasures system 1. In this embodiment the countermeasures system 1 is for use as part of a defensive aids subsystem (DASS) of a military aircraft's avionics system, and is located within the aircraft

[0026] The countermeasures system 1 comprises a processor 2 (or plural processors 2), a manoeuvres programs module 4, an expendables programs module 6, an electronic countermeasure (ECM) programs module 8, and a co-ordinated programs module 10.

[0027] The processor 2 is operatively coupled to the manoeuvres programs module 4, the expendables programs module 6, the ECM programs module 8, and the co-ordinated programs module 10. The co-ordinated programs module 10 is further operatively coupled to the manoeuvres programs module 4, the expendables programs module 6, and the ECM programs module 8.

[0028] The manoeuvres programs module 4 comprises a plurality of different manoeuvres programs 12. The expendable programs module 6 comprises a plurality of different expendables programs 14. The ECM programs module 8 comprises a plurality of different ECM programs 16. For each type of program each case the terminology "program" may also be understood as meaning a subcommand, a command or an instruction.

[0029] The co-ordinated programs module 10 comprises a plurality of different co-ordinated programs 18. The terminology "program" may also be understood as meaning a command or an instruction. Each co-ordinated program 18 has a unique identity. In this embodiment there are one hundred and twenty-eight (128) different co-ordinated programs and they are identified as co-ordinated program numbers one to one hundred and twenty-eight respectively. Further details of the co-ordinated programs 18 will be described later below, including with reference to Figure 7.

[0030] Figure 2 is a schematic block diagram showing further details of the manoeuvres programs module 4, the expendables programs module 6, and the ECM programs module 8.

[0031] As mentioned above with reference to Figure 1, the manoeuvres programs module 4 comprises a plurality of different manoeuvres programs 12. Each ma-

noeuvres program 12 has a unique identity. In this embodiment there are thirty-two different manoeuvres programs and they are identified as manoeuvres program numbers one to thirty-two respectively. In this embodiment each also has a program name. Further details of the manoeuvres programs 12 will be described later below with reference to Figure 3.

[0032] As mentioned above with reference to Figure 1, the expendable programs module 6 comprises a plurality of different expendables programs 14. Each expendables program 14 has a unique identity. In this embodiment there are thirty-two different expendables programs and they are identified as expendables program numbers one to thirty-two respectively. In this embodiment each also has a program name. In this embodiment each expendables program 14 has a value of the number of chaff packs that will be ejected by implementation of the respective expendables program 14 and a value of the number of flares that will be ejected by implementation of the respective expendables program 14. Further details of the expendables programs 14 will be described later below with reference to Figures 4 and 5.

[0033] As mentioned above with reference to Figure 1, the ECM programs module 8 comprises a plurality of different ECM programs 16. Each ECM program 16 has a unique identity. In this embodiment there are sixty-four different ECM programs and they are identified as ECM programs numbers one to sixty-four respectively. In this embodiment each also has a program name. Further details of the ECM programs 16 will be described later below with reference to Figure 6.

[0034] Figure 3 is a schematic block diagram showing further details of one of the manoeuvres programs 12, by way of example the manoeuvres program with unique identity number thirty-one. In this embodiment, the manoeuvres program number thirty-one specifies (or defines) a flight path change by specifying (or defining) four steps. The first step specifies (or defines) a first turn. The second step specifies (or defines) a second turn. The third step specifies (or defines) a third turn. The fourth step specifies (or defines) an exit trajectory. Each step may be specified (or defined) in any suitable manner, according to the specifics of the aircraft and other flight mission data specification formats. For example, in this embodiment the steps are specified (or defined) as a series of changes of azimuth and elevation with limits and periods of no change required.

[0035] Turning now to the expendables programs 14, in this embodiment, some of the expendables programs 14 are allocated as chaff only, some of the remaining expendables programs 14 are allocated as flare only, and the remaining expendables programs 14 are allocated as mixed chaff and flare.

[0036] Figure 4 is a schematic block diagram showing further details of one of the expendables programs 14, by way of example the expendables program with unique identity number twenty-five. In this embodiment, the expendables program number twenty-five is chaff only. In this embodiment, the expendables program number twenty-five specifies (or defines) the quantity of chaff salvos, which in this example equals two, and the quantity of flare ejections (which, with this expendables program being chaff only, equals zero). For each specified (or defined) occurrence of expendable, i.e. in this example for each of the two specified (or defined) chaff salvos, information related to the characteristics of the expendable and its implementation details is specified (or defined). This may be specified (or defined) in any suitable manner, according to the specifics of the aircraft and other flight mission data specification formats. For example, in this embodiment each chaff salvo is specified (or defined) in terms of (i) an inter-salvo time, (ii) the number of chaff packs to be fired in the salvo, (iii) the spacing i.e. the time between each chaff packet, and (iv) the salvo time.

[0037] Figure 5 is a schematic block diagram showing further details of another one of the expendables programs 14, by way of example the expendables program with unique identity number twenty-six. In this embodiment, the expendables program number twenty-six is mixed chaff and flare. In this embodiment, the expendables program number twenty-six specifies (or defines) the quantity of chaff salvos, which in this example equals two, and the quantity of flare ejections, which in this example equals two. For each specified (or defined) occurrence of expendable, i.e. in this example for each of the two specified (or defined) chaff salvos and each of the two specified (or defined) flare ejections, information related to the characteristics of the expendable and its implementation details is specified (or defined). This may be specified (or defined) in any suitable manner, according to the specifics of the aircraft and other flight mission data specification formats. For example, in this embodiment each chaff salvo is specified (or defined) as described in the preceding paragraph with reference to Figure 4. Further for example, in this embodiment each flare ejection is specified (or defined) in terms of (i) an inter-ejection time, (ii) a flare type identification, and (iii) the ejection time.

[0038] Turning now to the ECM programs 16, in this embodiment each ECM program 16 specifies (or defines) either a single emission step, or a plurality of emission steps that will be implemented sequentially (either immediately after each other or a gap between). In this embodiment different emission types are available to be specified (or defined), different durations of emission step are available to be specified (or defined), and different emission directions are available to be specified (or defined).

[0039] Figure 6 is a schematic block diagram showing further details of one of the ECM programs 12, by way of example the ECM program with unique identity number fifty-four. In this embodiment, the ECM program number fifty-four specifies (or defines) the ECM emissions in terms of two immediately sequential emission steps. In this embodiment, each emission step is specified (or defined) in terms of (i) a duration, (ii) an emission type iden-

tification, and (iii) emission direction (in this example, forward, aft or towed decoy). In this embodiment, the different emission types may include, for example, any conventional jamming approach, such as single frequency radio jamming signal, spot jamming, sweep jamming, barrage jamming, base jamming, pulse jamming, cover pulse jamming, digital radio frequency memory jamming, repeater jamming, and so on.

[0040] Further details will now be described, with reference to Figures 7 and 8, of the co-ordinated programs 18. Each of the one hundred and twenty-eight co-ordinated programs 18 of this embodiment is a respective available program for specifying (or defining) and implementing a countermeasures process in response to the detection of a threat. In this embodiment each co-ordinated program 18 consists of a co-ordinated combination of one or more of any of the individual programs described above, i.e. any of the manoeuvres programs 12 and/or any of the expendables programs 14 and/or any of the ECM programs 16.

[0041] Figure 7 is a schematic block diagram showing further details of one of the co-ordinated programs 18, by way of example the co-ordinated program with unique identity number ninety-three. In this embodiment, the co-ordinated program number ninety-three comprises at least one of each of the types of constituent programs, namely manoeuvers programs 12, expendables programs 14, and ECM programs 16, and specifications (or definitions) in terms of entries of each of these are included in the co-ordinated program number ninety-three. The co-ordinated program comprises identification/specification of these respective constituent program entries to provide a co-ordinated sequence of steps s1-s7, with trigger events specifying (or defining) the progress from one sequential step to the next.

[0042] Figure 8 is a schematic representation of the implementation of a countermeasures process specified (or defined) by a co-ordinated program 18, in this example the co-ordinated program number ninety-three. The representation includes a schematic plan of the flight trajectory 30 of the aircraft as implemented during the countermeasures process. At pertinent points on the flight trajectory 30, the points where each step s1-s7 starts are indicated, and also the points where each step's respective trigger event (specifying the end of that step and the move on to the next step) t1-t7 occurs are indicated.

[0043] In overview, the co-ordinated program specifies (or defines) command information for each step and the respective triggers to the next step. Again in overview, for the co-ordinated program number ninety-three of this example, and referring to Figures 7 and 8, the commands and triggers are as follows:

- start manoeuvre program no. 31 (step s1) → when turn completed (trigger t1) →
- start expendables program no. 25 (step s2) → when expendables program no. 25 completed (trigger t2) →
- perform next turn (step s3) → when vertical velocity goes up through 0 (trigger t3) →
- start 1st part of expendables program no. 26 (step s4) → when time delay reaches 10 (trigger t4) →
- perform next turn and start 2nd part of expendables program no. 26 (step s5) → when vertical velocity goes down through 0 (trigger t5) →
- start ECM program no. 54 (step s6) → when ECM program no. 54 complete (trigger t6) →
- perform exit of manoeuvre program no. 31 (step s7).

[0044] In more detail, again referring to Figures 7 and 8, for the case of the example of co-ordinated program number ninety-three, the first step s1 of the co-ordinated sequence is specified (or defined) in terms of manoeuvre program number thirty-one (which was described above with reference to Figure 3). The first step s1 of the co-ordinated sequence is accordingly specified (or defined) by starting and then implementing the earlier described step number 1 of the manoeuvre program number thirty-one, namely the 1st turn of the manoeuvre program number thirty-one. In this example, step s1 does not comprise any ECM command or expendables command. However, further specified (or defined) as part of step s1 of the co-ordinated program is the trigger event that constitutes the end of step s1 and the requirement to move on to the next step, i.e. step s2. In this example the trigger event of step s1 is completion of the 1st turn.

[0045] The second step s2 of the co-ordinated sequence is specified (or defined) by starting and then implementing the whole of the expendables program number twenty-five (which was described above with reference to Figure 4). In other words, the whole of expendables program number twenty-five is implemented before any further stage of the manoeuvre program number thirty-one is implemented (which can be contrasted with steps s4 and s5 to be described later below). In other words step s2 does not comprise any manoeuvre command or ECM command. However, further specified (or defined) as part of step s2 of the co-ordinated program is the trigger event that constitutes the end of step s2 and the requirement to move on to the next step, i.e. step s3. In this example the trigger event of step s2 is completion of the relevant expendable items used by implementing expendables program number twenty-five, i.e. in this example the two chaff salvos.

[0046] As was also the case with above described first step s1, the third step s3 of the co-ordinated sequence is specified (or defined) in terms of manoeuvre program number thirty-one. The third step s3 of the co-ordinated sequence is specified (or defined) by starting and then implementing the earlier described step number 2 of the

manoeuvre program number thirty-one, namely the 2nd turn of the manoeuvre program number thirty-one. In this example, step s3 does not comprise any ECM command or expendables command. Further specified (or defined) as part of step s3 of the co-ordinated program is the trigger event that constitutes the end of step s3 and the requirement to move on to the next step, i.e. step s4. In this example the trigger event of step s3 is the parameter "vertical velocity up" reaching a pre-defined trigger value, which in this example is 0.0.

[0047] The fourth step s4 of the co-ordinated sequence is specified (or defined) by starting and then implementing the chaff salvos parts of the expendables program number twenty-six (which was described above with reference to Figure 5). In other words, as will be described in more detail below, only a first part of expendables program number twenty-six is implemented without a further stage of the manoeuvre program number thirty-one being implemented (which can be contrasted with step s2 described earlier above). Step s4 does not comprise any manoeuvre command or ECM command. However, further specified (or defined) as part of step s4 of the co-ordinated program is the trigger event that constitutes the end of step s4 and the requirement to move on to the next step, i.e. step s5. In this example the trigger event of step s4 is the parameter "time delay expired" reaching a pre-defined trigger value, which in this example is 10.0.

[0048] The fifth step s5 of the co-ordinated sequence is specified (or defined) in terms of both the manoeuvre program number thirty-one and the expendables program number twenty-six. The manoeuvre program number thirty-one part of the fifth step s5 is specified (or defined) by both starting and then implementing the earlier described step number 3 of the manoeuvre program number thirty-one, namely the 3rd turn of the manoeuvre program number thirty-one. The expendables program number twenty-six part of the fifth step s5 is specified (or defined) by starting and then implementing the flare ejections parts of the expendables program number twenty-six. In other words, in step s5 a second part of expendables program number twenty-six is implemented simultaneously, or at least partially temporally overlapping, with a part of the manoeuvre program number thirty-one. In this example, step s5 does not comprise any ECM command. Further specified (or defined) as part of step s5 of the co-ordinated program is the trigger event that constitutes the end of step s5 and the requirement to move on to the next step, i.e. step s6. In this example the trigger event of step s5 is the parameter "vertical velocity down" reaching a pre-defined trigger value, which in this example is 0.0.

[0049] The sixth step s6 of the co-ordinated sequence is specified (or defined) by starting and then implementing the whole of the ECM program number fifty-four (which was described above with reference to Figure 6). In other words, the whole of ECM program number fifty-four is implemented before any further stage of the manoeuvre program number thirty-one is implemented. In other words step s6 does not comprise any manoeuvre command or expendables command. However, further specified (or defined) as part of step s6 of the co-ordinated program is the trigger event that constitutes the end of step s6 and the requirement to move on to the next step, i.e. step s7. In this example the trigger event of step s6 is completion of the relevant ECM emissions performed by implementing ECM program number fifty-four, i.e. in this example the two emission types described with reference to Figure 6.

[0050] The seventh step s7 of the co-ordinated sequence is specified (or defined) in terms of manoeuvre program number thirty-one. The seventh step s7 of the co-ordinated sequence is specified (or defined) by starting and then implementing the earlier described step number 4 of the manoeuvre program number thirty-one, namely the exit from the manoeuvre program number thirty-one. In this example, step s7 does not comprise any ECM command or expendables command. This also constitutes the end of, and the exit from, the co-ordinated sequence specified (or defined) the co-ordinated program number ninety-three, and accordingly step s7 does not include a trigger event for moving on to any next step.

[0051] In further embodiments, in addition to the elements described above with reference to Figures 1 to 8, the co-ordinated programs 18 further comprise program entry conditions allocated to the respective co-ordinated program 18. In one example of such a further embodiment, the entry conditions are specified (or defined) in terms of allowable flight direction sectors, an allowable altitude range, and an allowable aircraft speed range. The entry conditions specify (or define) criteria that must currently be met by the aircraft's flight characteristics for the particular co-ordinated program to be selected as a response to the particular detected threat.

[0052] In yet further embodiments, as an alternative to the entry conditions described in the preceding paragraph, and in addition to the elements described earlier above with reference to Figures 1 to 8, the co-ordinated programs 18 further comprise a separate specification (or definition) of the resource requirements pertinent to the respective co-ordinated program 18. In one example of such a further embodiment, the resource requirements are specified (or defined) in terms of specifying (or defining) which of the following resources are required by the respective co-ordinated program 18: ECM forward, ECM aft, ECM TD, expendables, manoeuvre. The resource requirements specify (or define) resources that must currently be available on the aircraft for the particular co-ordinated program to be selected as a response to the particular detected threat.

[0053] In yet further embodiments, in addition to the elements described above with reference to Figures 1 to 8, the co-ordinated programs 18 further comprise both: (i) program entry conditions allocated to the respective co-ordinated program 18 as described in the last paragraph but one, and also (ii) a separate specification (or definition) of the resource requirements pertinent to the

respective co-ordinated program 18 as described in the preceding paragraph.

[0054] In the above embodiments, the countermeasures system 1 is for use as part of a defensive aids subsystem (DASS) of a military aircraft's avionics system. However, this need not be the case, and in other embodiments the countermeasures system may be for use as part of, or in addition to, any other suitable system and/or other type f vehicle, e.g. a sea vessel or land vehicle.

[0055] In the above embodiments, the countermeasures system 1 comprises a processor 2 (or plural processors 2), a manoeuvres programs module 4, an expendables programs module 6, an electronic countermeasure (ECM) programs module 8, and a co-ordinated programs module 10. However, this need not be the case, and in other embodiments one or more of these modules (and their resulting functionality) may be omitted, and/or one or more other modules providing other types of functionality or options may be provided in addition or instead.

[0056] In the above embodiments, the processor 2 is operatively coupled to the manoeuvres programs module 4, the expendables programs module 6, the ECM programs module 8, and the co-ordinated programs module 10. The co-ordinated programs module 10 is further operatively coupled to the manoeuvres programs module 4, the expendables programs module 6, and the ECM programs module 8. However, this need not be the case, and in other embodiments other operative coupling arrangements may be implemented.

[0057] In the above embodiments, there are one hundred and twenty-eight different co-ordinated programs. However, this need not be the case, and in other embodiments there may be other numbers of co-ordinated programs.

[0058] In the above embodiments, there are thirty-two different manoeuvres programs. However, this need not be the case, and in other embodiments there may be other numbers of manoeuvres programs, including the possibility of only a single one.

[0059] In the above embodiments, there are thirty-two different expendables programs. However, this need not be the case, and in other embodiments there may be other numbers of expendables programs, including the possibility of only a single one.

[0060] In the above embodiments, there are sixty-four different ECM programs. However, this need not be the case, and in other embodiments there may be other numbers of ECM programs, including the possibility of only a single one.

[0061] In the above embodiments, the exemplary manoeuvres program number thirty-one specifies (or defines) a flight path change as described above. However, other example manoeuvres program numbers in the above embodiments may be specified in other ways. This is also the case for some or all of any manoeuvres programs in other embodiments. For example definitions need not be in terms of turns as such, and also need not be in terms of changes of azimuth and elevation, and so on. Also, more generally, the flight trajectory may be specified in various ways, for example in terms of changes relative to a current trajectory, or in some other relative localised manner, or in absolute terms.

[0062] In the above embodiments, some of the expendables programs 14 are allocated as chaff only, some of the remaining expendables programs 14 are allocated as flare only, and the remaining expendables programs 14 are allocated as mixed chaff and flare. However, this need not be the case, and in other embodiments there may be chaff only or flare only, in other embodiments there may be chaff only or mixed chaff and flare (but not flare only), and in other embodiments there may be flare only or mixed chaff and flare (but not chaff only). In yet further embodiments, the array of combinations available may include, instead of or on addition to chaff and/or flares, types of expendables other than chaff or flares. In yet further embodiments, there may only be one type of expendable used by the different expendables programs, be that chaff, flare, or some other type of expendable. In yet further embodiments, different types of expendables may be deployed overlapping partially or fully temporally.

[0063] In the above embodiments, each ECM program 16 specifies (or defines) either a single emission step, or a plurality of emission steps that will be implemented sequentially (either immediately after each other or a gap between). However, this need not be the case, and in other embodiments only one or two of these possibilities may be included. Also, for example, plural emission steps may be implemented sequentially but with gaps between one or more next emissions, or further for example, with plural emissions overlapping partially or fully temporally

[0064] In the above embodiments, different emission types are available to be specified (or defined), different durations of emission step are available to be specified (or defined), and different emission directions are available to be specified (or defined). However, this need not be the case, and in other embodiments any other suitable possibilities may be specified (or defined).

[0065] In the above embodiments, each co-ordinated program 18 consists of a co-ordinated combination of one or more of any of the individual programs described above, i.e. any of the manoeuvres programs 12 and/or any of the expendables programs 14 and/or any of the ECM programs 16. However, this need not be the case, and in other embodiments each co-ordinated program 18 may consist of a co-ordinated combination of a more restricted allowable set of the individual programs available in the different modules of the particular embodiment of the countermeasures system.

[0066] In the above embodiments, the co-ordinated programs include trigger events specifying (or defining) the progress from one sequential step to the next. However, this need not be the case, and in other embodiments, mechanisms other than trigger events may be used to specify (or define) progress from one step to another. Returning to those embodiments where trigger events are employed, in addition to or instead of the trig-

ger events described above, other types of trigger events may be specified (or defined).

[0067] In the above embodiments the different co-ordinated programs are individually specified, and the choice of which of these programs to include in the co-ordinated programs module 10 is made, as follows. The co-ordinated programs 18 are pre-defined in a mission planning stage on the ground. For example, the tactics to be employed against one or more particular threat emitters may be generated by an air force using the countermeasures system 1. Furthermore, two or more mission data sets may be loaded into the system, in a manner such that they are swappable in flight. In other embodiments the aspects descried in this paragraph may be implemented in other ways.

[0068] In the above embodiments, when a threat is detected, the process for selecting a particular co-ordinated program as a function of the detected threat is as follows. The processor 2 selects a particular co-ordinated program 18 from among the co-ordinated programs 18 available in the co-ordinated programs module 10 dependent upon the instantaneous threat engagement scenario. When a threat is detected, factors that may be taken into account may include, for example, one or more of the following:

(i) relative threat position;

(ii) the aircraft's own speed and vector;

(iii) the current allocation of resources and prioritisation of threat in relation to other threats emitters;

(iv) the number and type of expendables and other resources required to be consumed when performing a given co-ordinated program; and

(v) the serviceability of the resources required to be consumed or used when performing a given co-ordinated program.

[0069] Any suitable selection algorithm may be employed. Irrespective of which selection algorithm is employed for selecting a particular co-ordinated program as a function of the detected threat, an advantage that tends to occur with the above embodiments is that selection need only be performed relative to a given number of available co-ordinated programs 18 (i.e. those that are present in the co-ordinated programs module 10), which choices nevertheless contain a cross-spectrum or selection of the different manoeuvres programs 4, expendables programs 6 and ECM programs 8. Also, by virtue of the differing combinations, a wide variety of overall response combination effects may be achieved from a relatively small number of stored different manoeuvres programs 4, expendables programs 6 and ECM programs 8 respectively.

[0070] Another advantage that tends to occur with the above embodiments is that wide-ranging changes can be relatively easily made to the simplified structure in which the differing manoeuvres programs 4, expendables programs 6 and ECM programs 8 are stored in the countersystems system 1.

[0071] As described earlier above, each of the co-ordinated programs 18 of the above embodiments is a respective available program for specifying (or defining) and implementing a countermeasures process in response to the detection of a threat. Once selected, the selected co-ordinated program 18 may be implemented or made use of in any appropriate manner. For example, one possibility is that all the actions specified by the selected co-ordinated program 18 are implemented automatically by the aircraft's automatic systems, i.e. without pilot involvement. In such implementations, the aircraft flight controls and weapon systems may for example be deployed under direct control of the selected co-ordinated program 18, or alternatively may be used to specify instructions or other input into one or more separate flight and/or countermeasures control systems. Another possibility is that only some the actions specified by the selected co-ordinated program 18 are implemented automatically by the aircraft's automatic systems in the manner described above in this paragraph, with the remaining actions being performed by, or in response to, pilot involvement. In such cases the actions performed by, or in response to, pilot involvement are preferably indicated by the countermeasures system 1 to the pilot, as requiring to be performed. In such cases, the indication may be a visual indication and/or audio indication. The indication may further involve (or may only involve) an indication of the existence of a next step, or may include some or all details of the next step, to be implemented, and may be presented in a manner by which one simple action by the pilot implements the inputting of the instruction for that next step to be performed. Yet another possibility is that all the actions specified by the selected co-ordinated program 18 are performed by, or in response to, pilot involvement in the manner described immediately above in this paragraph.

[0072] Apparatus, including the processor or processors 2, the manoeuvres programs module 4, the expendables programs module 6, the electronic countermeasure (ECM) programs module 8, and the co-ordinated programs module 10, for implementing the above arrangements and systems, may be provided by configuring or adapting any suitable apparatus, for example one or more computers or other processing apparatus or processors, and/or providing additional modules. The apparatus may comprise a computer, a network of computers, or one or more processors, for implementing instructions and using data, including instructions and data in the form of a computer program or plurality of computer programs stored in or on a machine readable storage medium such as computer memory, a computer disk, ROM, PROM etc., or any combination of these or other storage media.

Claims

1. A countermeasures method, comprising:

   in response to a military threat to a vehicle, one or more processors (2) selecting a co-ordinated countermeasures response (18) from a plurality of different co-ordinated countermeasures responses (18) whose specifications are stored in a manner accessible to the one or more processors (2); and
   implementing the selected co-ordinated countermeasures response (18) according to its stored specification;
   wherein the stored specifications of the co-ordinated countermeasures responses each comprise:

      a sequence of commands (s1, s2,...s6), each of the commands comprising one or more sub-commands (12, 14, 16), each sub-command (12, 14, 16) specifying an individual response action categorised as one of a plurality of countermeasures response-type categories (4, 6, 8), wherein if a command comprises plural sub-commands (12, 14, 16) then each of the sub-commands (12, 14, 16) of the command (s1, s2,...s6) is from a different countermeasures response-type category (4, 6, 8).

2. A countermeasures method according to claim 1, wherein the stored specifications of the co-ordinated countermeasures responses (18) further comprise trigger events (t1, t2,...t6) defining respective transitions between consecutive commands (s1, s2,...s6) of the sequence of commands.

3. A countermeasures method according to claim 1 or claim 2, wherein one (4) of the countermeasures response-type categories (4, 6, 8) comprises flight manoeuvres.

4. A countermeasures method according to any of claims 1 to 3, wherein one (6) of the countermeasures response-type categories (4, 6, 8) comprises deployment of expendables.

5. A countermeasures method according to any of claims 1 to 4, wherein one (8) of the countermeasures response-type categories (4, 6, 8) comprises emission of electronic countermeasures.

6. A countermeasures method according to any of claims 1 to 5, wherein at least some of the commands (s1, s2,...s6) specified by the selected co-ordinated countermeasures response (18) are implemented automatically by the aircraft's automatic systems without pilot involvement.

7. A countermeasures method according to claim 6, wherein all of the commands (s1, s2,...s6) specified by the selected co-ordinated countermeasures response (18) are implemented automatically by the aircraft's automatic systems without pilot involvement.

8. A countermeasures system, comprising:

   one or more processors (2) configured to, in response to a military threat to a vehicle, select a co-ordinated countermeasures response (18) from a plurality of different co-ordinated countermeasures responses (18) whose specifications are stored in a manner accessible to the one or more processors (2); and
   implement the selected co-ordinated countermeasures response (18) according to its stored specification;
   wherein the stored specifications of the co-ordinated countermeasures responses each comprise:

      a sequence of commands (s1, s2,...s6), each of the commands comprising one or more sub-commands (12, 14, 16), each sub-command (12, 14, 16) specifying an individual response action categorised as one of a plurality of countermeasures response-type categories (4, 6, 8), wherein if a command comprises plural sub-commands (12, 14, 16) then each of the sub-commands (12, 14, 16) of the command (s1, s2,...s6) is from a different countermeasures response-type category (4, 6, 8).

9. A countermeasures system according to claim 8, wherein the stored specifications of the co-ordinated countermeasures responses (18) further comprise trigger events (t1, t2,...t6) defining respective transitions between consecutive commands (s1, s2,...s6) of the sequence of commands.

10. A countermeasures system according to claim 8 or claim 9, wherein one (4) of the countermeasures response-type categories (4, 6, 8) comprises flight manoeuvres.

11. A countermeasures system according to any of claims 8 to 10, wherein one (6) of the countermeasures response-type categories (4, 6, 8) comprises deployment of expendables.

12. A countermeasures system according to any of claims 8 to 11, wherein one (8) of the countermeasures response-type categories (4, 6, 8) comprises

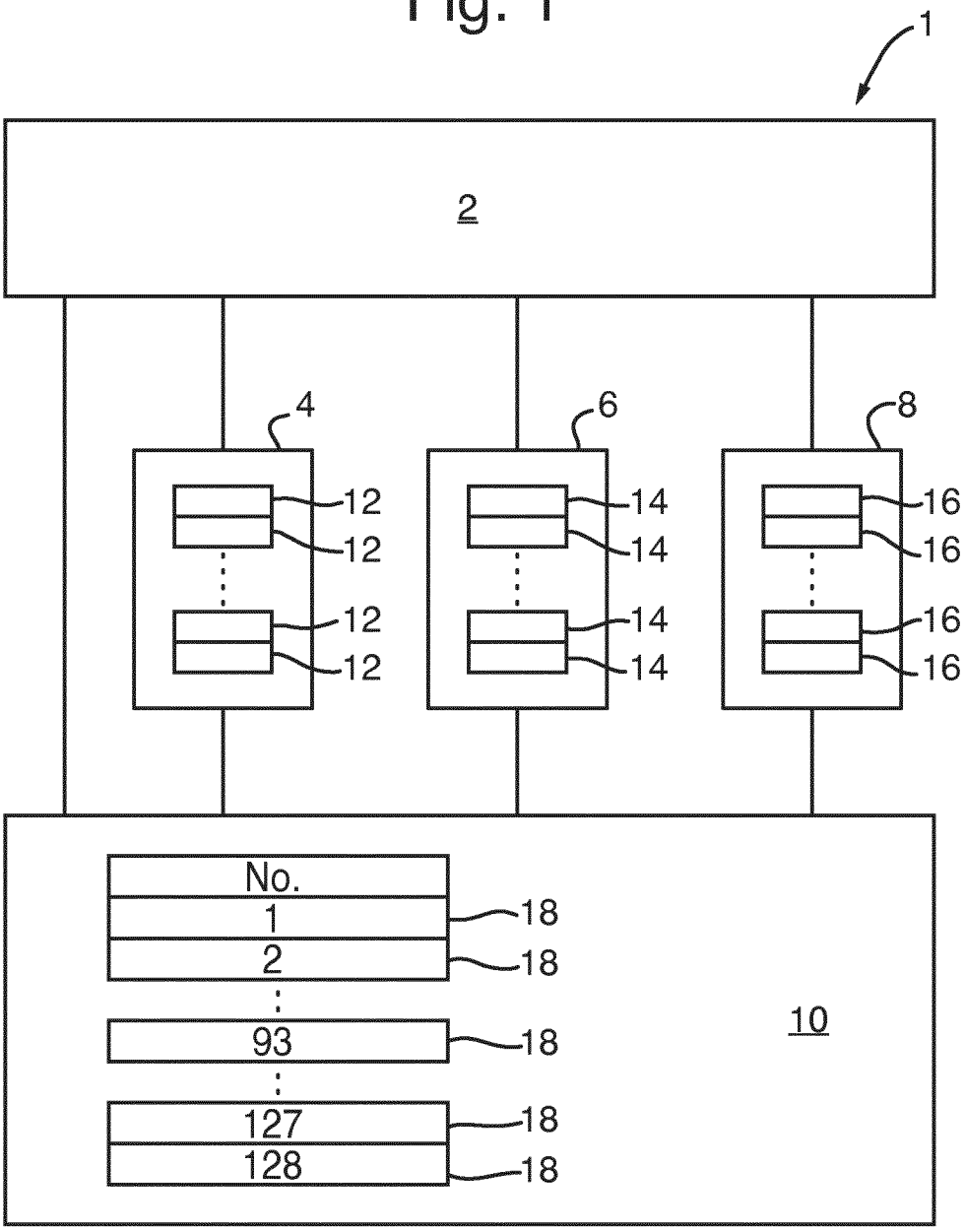
emission of electronic countermeasures.

13. A countermeasures system according to any of claims 8 to 12, wherein at least some of the commands (s1, s2,...s6) specified by the selected coordinated countermeasures response (18) are implementable automatically by the aircraft's automatic systems without pilot involvement.

14. A program or plurality of programs arranged such that when executed by a computer system or one or more processors it/they cause the computer system or the one or more processors to operate in accordance with the method of any of claims 1 to 7.

15. A machine readable storage medium storing a program or at least one of the plurality of programs according to claim 14.

Fig. 1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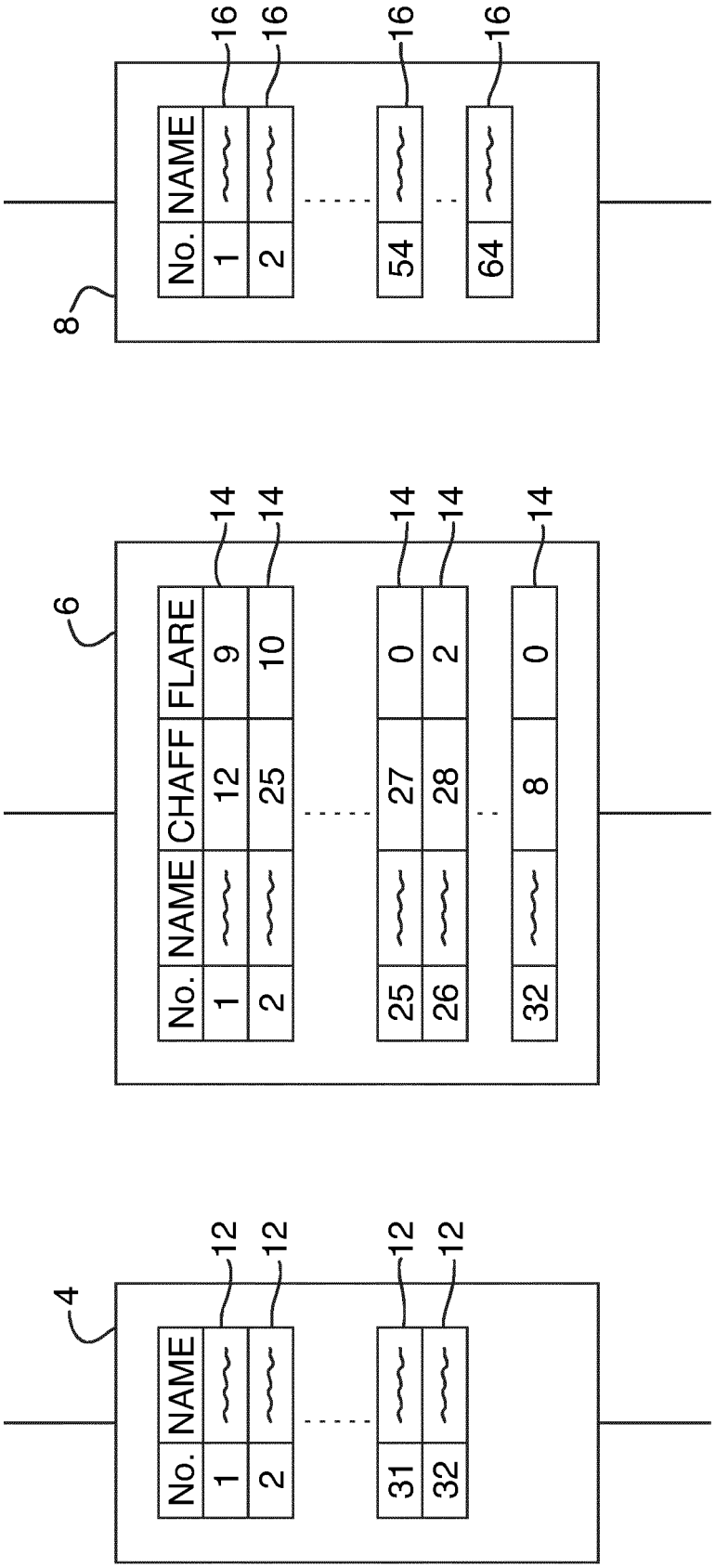
18
10

Fig. 2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12
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NAME
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NAME
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FLARE
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25
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25
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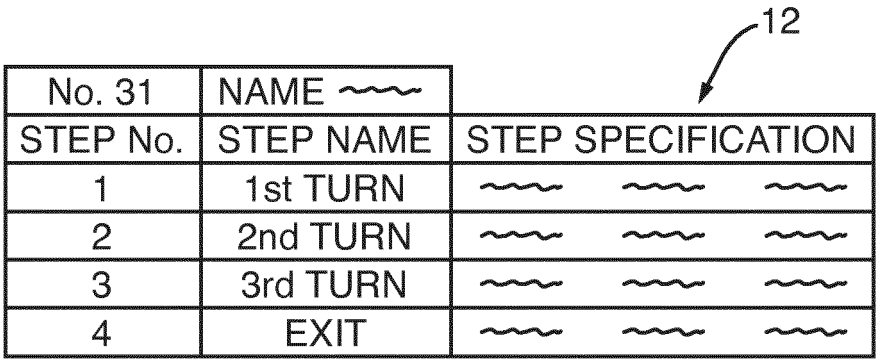
Fig. 3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STEP No.
STEP NAME
STEP SPECIFICATION
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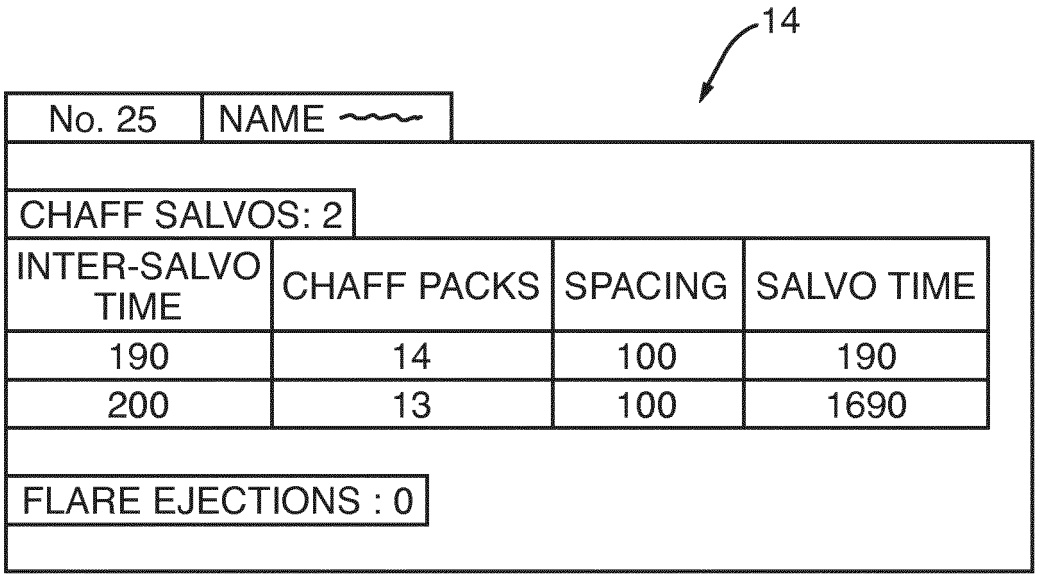
1st TURN
2
2nd TURN
3
3rd TURN
4
EXIT

Fig. 4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No. 25
NAME
CHAFF SALVOS: 2
INTER-SALVO TIME
CHAFF PACKS
SPACING
SALVO TIME
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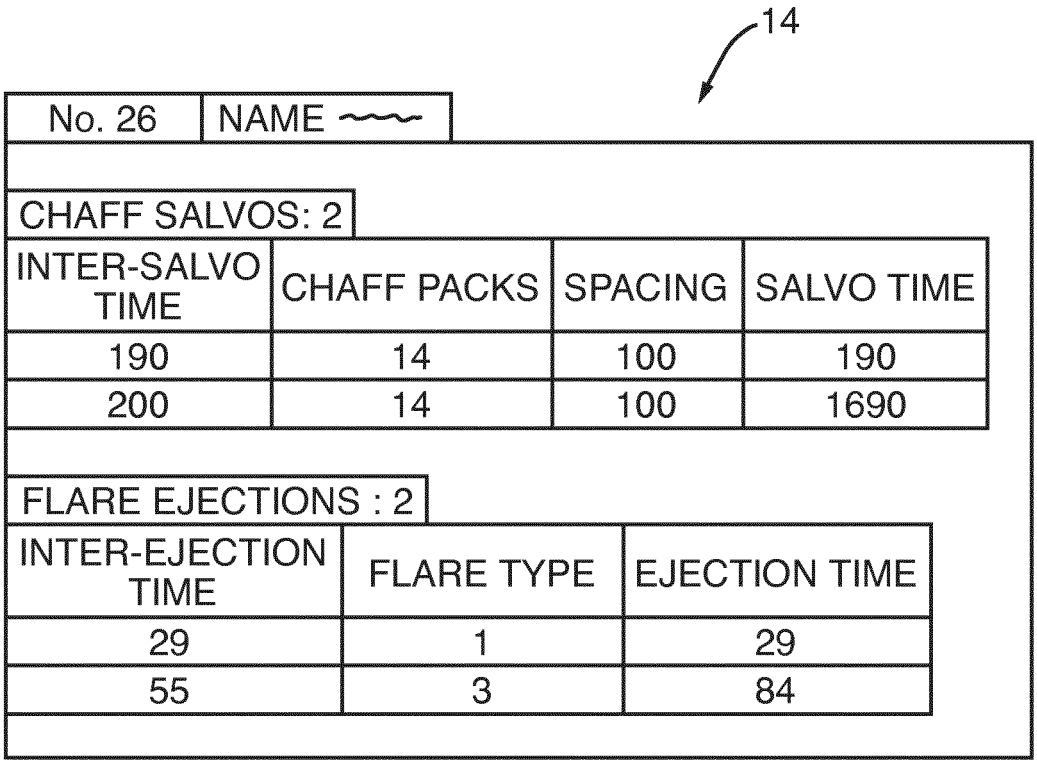
14
100
190
200
13
100
1690
FLARE EJECTIONS : 0

Fig. 5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INTER-EJECTION TIME
FLARE TYPE
EJECTION TIME
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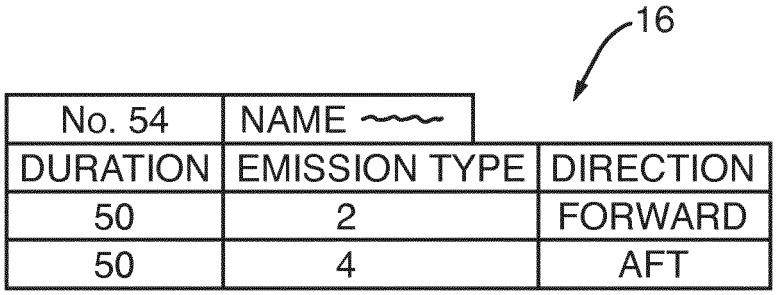
29
55
3
84

Fig. 6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DURATION
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FORWARD
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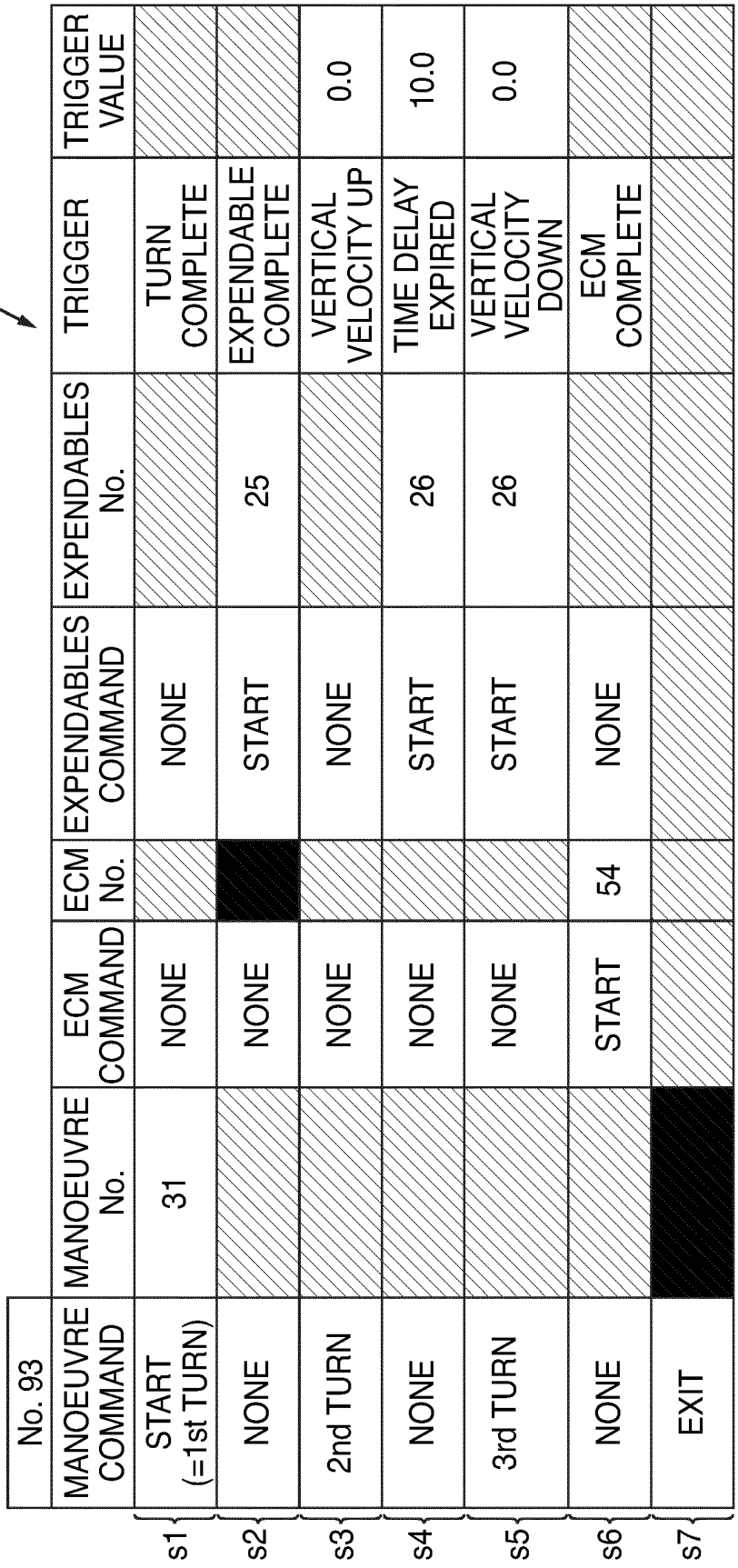
4
AFT

Fig. 7


18
No. 93
MANOEUVRE COMMAND
MANOEUVRE No.
ECM COMMAND
ECM No.
EXPENDABLES COMMAND
EXPENDABLES No.
TRIGGER
TRIGGER VALUE
s1
START (=1st TURN)
31
NONE
NONE
START
TURN COMPLETE
s2
NONE
NONE
NONE
25
START
EXPENDABLE COMPLETE
s3
2nd TURN
NONE
NONE
NONE
VERTICAL VELOCITY UP
0.0
s4
NONE
NONE
NONE
START
26
START
TIME DELAY EXPIRED
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s5
3rd TURN
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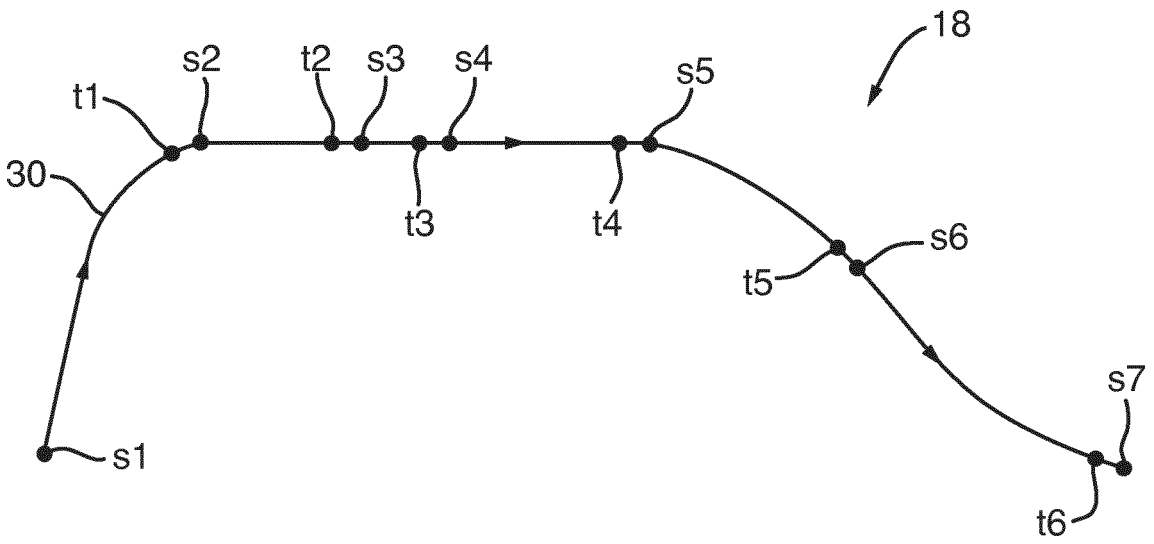
54
NONE
ECM COMPLETE
s7
EXIT

Fig. 8



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EUROPEAN SEARCH REPORT

Application Number
EP 14 27 5044

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 2012/210855 A1 (CLARK DENNIS R [US] ET AL) 23 August 2012 (2012-08-23) * abstract; figures 3,5 * * paragraph [0020] - paragraph [0033] * -----	1-15	INV. F41G7/22 F41H11/02 F41G9/00 G05D1/00
X	US 2007/034071 A1 (GREENE LEONARD M [US]) 15 February 2007 (2007-02-15) * abstract; figure 6 * * paragraph [0038] - paragraph [0049] * -----	1-15	
A	US 2011/196551 A1 (LEES THILO [DE] ET AL) 11 August 2011 (2011-08-11) * abstract * -----	1-15	

TECHNICAL FIELDS SEARCHED (IPC)

F41G
F41H
G05D
B64D
G01S

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	26 September 2014	Vial, Antoine

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26-09-2014

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