“ΕΘΝΙΚΟ ΜΕΤΣΟΒΙΟ ΠΟΛΥΤΕΧΝΕΙΟ”

“ΣΧΟΛΗ ΗΛΕΚΤΡΟΛΟΓΩΝ ΜΗΧΑΝΙΚΩΝ

&

ΜΗΧΑΝΙΚΩΝ ΗΛΕΚΤΡΟΝΙΚΩΝ ΥΠΟΛΟΓΙΣΤΩΝ”

Τεχνητή Νοημοσύνη

Θέμα 2

7ο Εξάμηνο

Ροή Λ

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Τρόπος οργάνωσης & Μοντελοποίησης των Κανόνων

Σκοπός της άσκησης είναι η υλοποίηση ενός expert system για τη διάγνωση συγκεκριμένων βλαβών σχετικά με το σύστημα λίπανσης του κινητήρα **JT9D-7A** της Pratt & Whitney.
Το έμπειρο σύστημα υλοποιείται σε περιβάλλον CLIPS σε λειτουργικό σύστημα Linux και έκδοση Ubuntu 14.04. Οι κατηγορίες βλαβών που θα μας απασχολήσουν είναι οι “Oil Consumption” και “Oil pressure” και συγκεκριμένα οι βλάβες BE,BD,CD,CE σύμφωνα και με τα αναγνωριστικά βλαβών του Fault Isoaltion Manual(FIM). Αρχικά δίνεται στο χρήστη η δυνατότητα να επιλέξει από το αρχικό μενού για ποια γενικότερη κατηγορία βλαβών επιθυμεί να λάβει διάγνωση:

```
CLIPS> (reset)
CLIPS> (run)



*****BOEING 747 FAULT ISOLATION EXPERT SYSTEM*****

MAIN MENU

1 - Oil consumption is high
2 - Oil quantity indicator is malfunctioning
3 - Oil pressure is abnormal or indicator is malfunctioning
4 - Oil filter bypass light is illuminated
5 - Oil temperature is abnormal or indicator is malfunctioning
6 - Breather temperature is high
7 - Engine was shutdown in flight
8 - Unlisted engine oil fault
Which of the above were observed during the flight? >
**************************************************
**************************************************
Note:Our current expert systems resolves only
     Oil Consumption and Oil Pressure Issues
```

Από το οποίο υπενθυμίζεται ότι στο παρόν έμπειρο σύστημα υποστηρίζονται διαγνώσεις σχετικά με την επιλογή `Oil comsuption is high` την οποία ο χρήστης μπορεί να επιλέξει πληκτρολογώντας `1` και την επιλογή `Oil pressure is abnormal or indicator is malfunctioning` την οποία ο χρήστης μπορεί να επιλέξει πληκτρολογώντας `3`.
Για οποιαδήποτε άλλη επιλογή (2,4,5,6,7,8) το πρόγραμμα μας διακόπτει την λειτουργία του και επιστρέφει δηλαδή:

```
CLIPS> (reset)
CLIPS> (run)



*****BOEING 747 FAULT ISOLATION EXPERT SYSTEM*****

MAIN MENU

1 - Oil consumption is high
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Which of the above were observed during the flight? >
**************************************************
**************************************************
Note:Our current expert systems resolves only
     Oil Consumption and Oil Pressure Issues
4

CLIPS>
```

Έπειτα μετά από αυτή την επιλογή ο χρήστης καλείται να απαντήσει ποια από της 0,1,2,3,4 μηχανές έχει το πρόβλημα σύμφωνα και με το παρακάτω κατηγόρημα στον κώδικα μας:

```
(defrule engine-number                ;;MENU TO INDICATE WHICH ENGINE HAS THE PROBLEM
   (menu-op engine-num)
   ?fact <- (menu-op engine-num)
=>
   (printout t "Which engine is malfuctioning? (1,2,3,4,0) >" crlf)
   (assert (engine-num (read)))
   (printout t crlf)
   (retract ?fact)
)
```

Μια συντόμευση για ναι/όχι ερωταπανατήσεις που θα χρησιμοποιηθεί συχνά μέσα στον κώδικα :

```
;;  SHORTCUT FOR QUESTIONS YES-NO

(defrule yes-no-question
   (ask-question yesno)
   ?fact <- (ask-question yesno)
=>
   (printout t "[yes,no] > ")
   (assert (answer (read)))
   (printout t crlf)
   (retract ?fact)
)
```

Το πρόγραμμα μας λοιπόν παίρνει ως είσοδο το ποιά μηχανή έχει το πρόβλημα και τι είδους προβλήμα έχουμε (για μας 1 ή 3) δηλαδή τα inp1,inp2 και ανάλογα με το διάγραμμα ροής έχουμε και τις κατάλληλες τερματικές καταστάσεις για κάθε πρόβλημα οι οποίες συνοδεύονται με εκτύπωση κατάλληλου μηνύματος όπως φαίνεται και στα screenshots.Ανάλογα με τις απαντησεις yes/no έχουμε τις μεταβάσεις απο κανόνα σε κανόνα με τις μεταβλητές step-id number που στον κώδικα επισημαίνονται με κόκκινο ,οπου idnumber το νούμερο που εκφράζει καθε μετάβαση απο κατάσταση σε κατάσταση του expert system όπως ορίζεται στο διάγραμμα ροής που μας δίνεται.
Τα rules είναι στην ουσία τα κατηγορήματα που απλά θέτουν μια μεταβλητή που μας οδηγεί στο επόμενο κανόνα που θα τρέξει.Επίσης με την χρήση του assert που επισημαίνεται με κίτρινο προσθέτουμε γεγονότα στους κανόνες μας.Με την επισήμανση τον step-idnumber μπορούμε να παρακολουθήσουμε τις διαδοχικές μεταβάσεις σύμφωνα και με τα δοθέντα διαγράμματα ροής.Ο κώδικας είναι κατάλληλα γραμμένος για τον σωστό διαχωρισμό των βλαβών αλλά και των επιμέρους κομματιών-ελέγχων για τη διάγνωση κάθε βλάβης.Κάθε ερωταπάντηση γίνεται διαδοχικά διαχωρισμένη από την επόμενη η οποία την ακολουθεί και ανάλογα με τις απαντήσεις που θα πάρουμε εμφανίζουμε κατάλληλα μηνύματα (printout) στην οθόνη.

<u>ΠΡΟΒΛΗΜΑ 1</u> (BD/BE)

```
;;  CHOSEN PROBLEM 1: OIL CONSUMPTION

(defrule oil-consumption
```

```
   (observed-problem-number 1)
   ?fact <- (observed-problem-number 1)
=>
   (assert (error-code 79-01-BA-0))
   (assert (menu-op engine-num))
   (retract ?fact)
)


(defrule high-oil-consumption
   (error-code 79-01-BA-0)
=>
   (printout t "Are there any other abnormal oil systems?" crlf)
   (assert (ask-question yesno))
)

(defrule high-oil-consumption-with-abnormal-issues ;;WE COCNLUDE WE HAVE BD PROBLEM
TYPE
   (error-code 79-01-BA-0)
   ?fact-1 <- (error-code 79-01-BA-0)
   (answer yes)
   ?fact-2 <- (answer yes)
=>
   (assert (error-code 79-01-BD-0))
   (assert (high-oil-consumption-question start))
   (retract ?fact-1)
   (retract ?fact-2)
)

(defrule high-oil-consumption-without-abnormal-issues ;;WE CONCLUDE WE HAVE BE PROBLEM
TYPE
   (error-code 79-01-BA-0)
   ?fact-1 <- (error-code 79-01-BA-0)
   (answer no)
   ?fact-2 <- (answer no)
=>
   (assert (error-code 79-01-BE-0))
   (assert (high-oil-consumption-question start))
   (retract ?fact-1)
   (retract ?fact-2)
)


;;;;;;;;;;;;;;;;;;;;;;;;;HIGH OIL CONSUMPTION PROBLEM TROUBLESHOOTING;;;;;;;;;;;;;;;;;;;;;;;;;

(defrule high-oil-consumption-question-start
   (high-oil-consumption-question start)
   ?fact <- (high-oil-consumption-question start)
=>
```

```
   (printout t "Examine turbine exhaust area for evidence of oil loss per Visual Check 1, 79-01-10. Is oil
loss occuring?" crlf)
   (assert (high-oil-consumption-question step-0))
   (assert (ask-question yesno))
   (retract ?fact)
)
;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;; FIRST FIM PAGE WITH BD/BE STARTS HERE ;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;

(defrule high-oil-consumption-question-at-step0-no
   (high-oil-consumption-question step-0)
   ?fact-1 <- (high-oil-consumption-question step-0)
   (answer no)
   ?fact-2 <- (answer no)
=>
   (printout t "Examine main gearbox drains (MM 71-71-00) for leakage.  Is excessive oil present?"
crlf)
   (assert (high-oil-consumption-question step-1))
   (assert (ask-question yesno))
   (retract ?fact-1)
   (retract ?fact-2)
)

(defrule high-oil-consumption-question-at-step0-yes
   (high-oil-consumption-question step-0)
   ?fact-1 <- (high-oil-consumption-question step-0)
   (answer yes)
   ?fact-2 <- (answer yes)
=>
   (printout t "Identify source of oil loss per Visual Check 1, 79-01-10.  Is oil loss due to leakage from
rear cover of No. 4 bearing compartment?" crlf)
   (assert (high-oil-consumption-question step-2))
   (assert (ask-question yesno))
   (retract ?fact-1)
   (retract ?fact-2)
)

(defrule high-oil-consumption-question-at-step1-yes
   (high-oil-consumption-question step-1)
   ?fact-1 <- (high-oil-consumption-question step-1)
   (answer yes)
   ?fact-2 <- (answer yes)
=>
   (printout t "Identify leaking drain line source (MM 71-71-00) Was source of leakage from the fuel/oil
cooler?" crlf)
   (assert (high-oil-consumption-question step-14))
   (assert (ask-question yesno))
   (retract ?fact-1)
   (retract ?fact-2)
)
```

```
(defrule high-oil-consumption-question-at-step1-no
   (high-oil-consumption-question step-1)
   ?fact-1 <- (high-oil-consumption-question step-1)
   (answer no)
   ?fact-2 <- (answer no)
=>
   (printout t "Check that PT3 water drain plug is installed per Visual Check 9, 71-01-10. Is plug
missing?" crlf)
   (assert (high-oil-consumption-question step-15))
   (assert (ask-question yesno))
   (retract ?fact-1)
   (retract ?fact-2)
)

(defrule high-oil-consumption-question-at-step2-no
   (high-oil-consumption-question step-2)
   ?fact-1 <- (high-oil-consumption-question step-2)
   (answer no)
   ?fact-2 <- (answer no)
=>
   (printout t "Is oil loss due to leakage from oil pressure supply line or oil scavenge line of No. 4
bearing compartment?" crlf)
   (assert (high-oil-consumption-question step-3))
   (assert (ask-question yesno))
   (retract ?fact-1)
   (retract ?fact-2)
)

(defrule high-oil-consumption-question-at-step2-yes
   (high-oil-consumption-question step-2)
   ?fact-1 <- (high-oil-consumption-question step-2)
   (answer yes)
   ?fact-2 <- (answer yes)
=>
   (printout t "Replace engine. MM 71-00-02" crlf)
   (assert (high-oil-consumption-question diagnosis))
   (retract ?fact-1)
   (retract ?fact-2)
)

(defrule high-oil-consumption-question-at-step3-yes
   (high-oil-consumption-question step-3)
   ?fact-1 <- (high-oil-consumption-question step-3)
   (answer yes)
   ?fact-2 <- (answer yes)
=>
   (printout t "Remove and clean or replace oil pressure supply tube and/or oil scavenge tube as
required.  MM 72-53-00" crlf)
```

```
    (assert (high-oil-consumption-question diagnosis))
    (retract ?fact-1)
    (retract ?fact-2)
)

(defrule high-oil-consumption-question-at-step3-no
    (high-oil-consumption-question case-3)
    ?fact-1 <- (high-oil-consumption-question case-3)
    (answer no)
    ?fact-2 <- (answer no)
=>
    (printout t "Is oil loss due to a clogged or loose oil scavenge line or a failed scavenge pump?" crlf)
    (assert (high-oil-consumption-question step-6))
    (assert (ask-question yesno))
    (retract ?fact-1)
    (retract ?fact-2)
)

(defrule high-oil-consumption-question-at-step6-yes
    (high-oil-consumption-question step-6)
    ?fact-1 <- (high-oil-consumption-question step-6)
    (answer yes)
    ?fact-2 <- (answer yes)
=>
    (printout t "Remove and clean or replace oil scavenge tube as necessary.  MM 72-53-00.  Replace
scavenge pump if required.  MM 72-61-21" crlf)
    (assert (high-oil-consumption-question diagnosis))
    (retract ?fact-1)
    (retract ?fact-2)
)

(defrule high-oil-consumption-question-at-step6-no
    (high-oil-consumption-question step-6)
    ?fact-1 <- (high-oil-consumption-question step-6)
    (answer no)
    ?fact-2 <- (answer no)
=>
    (printout t "Replace engine. MM 71-00-02" crlf)
    (assert (high-oil-consumption-question diagnosis))
    (retract ?fact-1)
    (retract ?fact-2)
)
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(defrule high-oil-consumption-question-at-step14-yes
```

```
   (high-oil-consumption-question step-14)
   ?fact-1 <- (high-oil-consumption-question step-14)
   (answer yes)
   ?fact-2 <- (answer yes)
=>
   (printout t "Replace fuel/oil cooler (MM 79-21-01)" crlf)
   (assert (high-oil-consumption-question diagnosis))
   (retract ?fact-1)
   (retract ?fact-2)
)

(defrule high-oil-consumption-question-at-step14-no
   (high-oil-consumption-question step-14)
   ?fact-1 <- (high-oil-consumption-question step-14)
   (answer no)
   ?fact-2 <- (answer no)
=>
   (printout t "Remove applicable component and check both component and drive pad seal." crlf)
   (printout t "Replace component and/or drive seal as follows:" crlf)
   (printout t "         Component          Seal Replacement Ref" crlf)
   (printout t "         ---------          --------------------" crlf)
   (printout t "  Generator (MM 24-21-01)        MM 72-61-08    " crlf)
   (printout t "  Fuel Pump (MM 73-11-01)        MM 72-61-11    " crlf)
   (printout t "Hydraulic Pump (MM 29-11-05)      MM 72-61-09    " crlf)
   (printout t "   Starter (MM 80-11-01)         MM 72-61-06    " crlf)
   (printout t "   Constant Speed Drive          MM 72-61-07    " crlf)
   (printout t "(MM 24-11-01)" crlf)
   (assert (high-oil-consumption-question diagnosis))
   (retract ?fact-1)
   (retract ?fact-2)
)

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;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;; THIRD FIM PAGE WITH BD/BE STARTS HERE ;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;

(defrule high-oil-consumption-question-at-step15-yes
   (high-oil-consumption-question step-15)
   ?fact-1 <- (high-oil-consumption-question step-15)
   (answer yes)
   ?fact-2 <- (answer yes)
=>
   (printout t "Install drain plug" crlf)
   (assert (high-oil-consumption-question diagnosis))
   (retract ?fact-1)
   (retract ?fact-2)
)

(defrule high-oil-consumption-question-at-step15-no
```

```
   (high-oil-consumption-question step-15)
   ?fact-1 <- (high-oil-consumption-question step-15)
   (answer no)
   ?fact-2 <- (answer no)
=>
   (printout t "Examine external plumbing, main gearbox and angle gearbox for obvious leakage per
Visual Check 2, 79-01-10.  Is obvious leakage present?" crlf)
   (assert (high-oil-consumption-question step-19))
   (assert (ask-question yesno))
   (retract ?fact-1)
   (retract ?fact-2)
)

(defrule high-oil-consumption-question-at-step19-yes
   (high-oil-consumption-question step-19)
   ?fact-1 <- (high-oil-consumption-question step-19)
   (answer yes)
   ?fact-2 <- (answer yes)
=>
   (printout t "Is leakage from oil pressure and/or oil scavenge lines?" crlf)
   (assert (high-oil-consumption-question step-20))
   (assert (ask-question yesno))
   (retract ?fact-1)
   (retract ?fact-2)
)

(defrule high-oil-consumption-question-at-step19-no
   (high-oil-consumption-question step-19)
   ?fact-1 <- (high-oil-consumption-question step-19)
   (answer no)
   ?fact-2 <- (answer no)
=>
   (printout t "Perform oil system static leak check per Engine Check 1, 79-01-20 and/or oil system
monitoring leak check per Engine Check 2, 79-01-20.  Was source of leakage found?" crlf)
   (assert (high-oil-consumption-question step-21))
   (assert (ask-question yesno))
   (retract ?fact-1)
   (retract ?fact-2)
)

(defrule high-oil-consumption-question-at-step20-yes
   (high-oil-consumption-question step-20)
   ?fact-1 <- (high-oil-consumption-question step-20)
   (answer yes)
   ?fact-2 <- (answer yes)
=>
   (printout t "Is leakage from No. 3 bearing oil scavenge tube connections?" crlf)
   (assert (high-oil-consumption-question step-22))
   (assert (ask-question yesno))
```

```
    (retract ?fact-1)
    (retract ?fact-2)
)

(defrule high-oil-consumption-question-at-step20-no
    (high-oil-consumption-question step-20)
    ?fact-1 <- (high-oil-consumption-question step-20)
    (answer no)
    ?fact-2 <- (answer no)
=>
    (printout t "Is leakage from breather lines?" crlf)
    (assert (high-oil-consumption-question step-23))
    (assert (ask-question yesno))
    (retract ?fact-1)
    (retract ?fact-2)
)

(defrule high-oil-consumption-question-at-step21-yes
    (high-oil-consumption-question step-21)
    ?fact-1 <- (high-oil-consumption-question step-21)
    (answer yes)
    ?fact-2 <- (answer yes)
=>
    (printout t "Refer to Engine Check 1 and/or engine check 2 for corrective action." crlf)
    (assert (high-oil-consumption-question diagnosis))
    (retract ?fact-1)
    (retract ?fact-2)
)

(defrule high-oil-consumption-question-at-step21-no
    (high-oil-consumption-question step-21)
    ?fact-1 <- (high-oil-consumption-question step-21)
    (answer no)
    ?fact-2 <- (answer no)
=>
    (printout t "Check fuel pump hydraulic stage pressure per Engine Check 2, 71-01-20. Is pressure
within limits?" crlf)
    (assert (high-oil-consumption-question step-46))
    (assert (ask-question yesno))
    (retract ?fact-1)
    (retract ?fact-2)
)

(defrule high-oil-consumption-question-at-step22-yes
    (high-oil-consumption-question step-22)
    ?fact-1 <- (high-oil-consumption-question step-22)
    (answer yes)
    ?fact-2 <- (answer yes)
=>
```

```
   (printout t "Repair No. 3 bearing oil scavenge tube connections as required. MM 79-21-03 AR")
   (assert (high-oil-consumption-question diagnosis))
   (retract ?fact-1)
   (retract ?fact-2)
)

(defrule high-oil-consumption-question-at-step22-no
   (high-oil-consumption-question step-22)
   ?fact-1 <- (high-oil-consumption-question step-22)
   (answer no)
   ?fact-2 <- (answer no)
=>
   (printout t "Replace Engine.  MM 71-00-02" crlf)
   (assert (high-oil-consumption-question diagnosis))
   (retract ?fact-1)
   (retract ?fact-2)
)

(defrule high-oil-consumption-question-at-step23-yes
   (high-oil-consumption-question step-23)
   ?fact-1 <- (high-oil-consumption-question step-23)
   (answer yes)
   ?fact-2 <- (answer yes)
=>
   (printout t "Is leakage from No. 1 and 2 bearing breather manifold and/or No. 3 bearing breather
manifold?" crlf)
   (assert (high-oil-consumption-question step-28))
   (assert (ask-question yesno))
   (retract ?fact-1)
   (retract ?fact-2)
)

(defrule high-oil-consumption-question-at-step23-no
   (high-oil-consumption-question step-23)
   ?fact-1 <- (high-oil-consumption-question step-23)
   (answer no)
   ?fact-2 <- (answer no)
=>
   (printout t "Is leakage from oil instrumentation lines?" crlf)
   (assert (high-oil-consumption-question step-29))
   (assert (ask-question yesno))
   (retract ?fact-1)
   (retract ?fact-2)
)

(defrule high-oil-consumption-question-at-step28-yes
   (high-oil-consumption-question step-28)
   ?fact-1 <- (high-oil-consumption-question step-28)
   (answer yes)
```

```
   ?fact-2 <- (answer yes)
=>
   (printout t "Replace No. 1 and 2 bearing breather manifold and/or No. 3 bearing breather manifold as
required. MM 79-21-04 R/I" crlf)
   (assert (high-oil-consumption-question diagnosis))
   (retract ?fact-1)
   (retract ?fact-2)
)

(defrule high-oil-consumption-question-at-step28-no
   (high-oil-consumption-question step-28)
   ?fact-1 <- (high-oil-consumption-question step-28)
   (answer no)
   ?fact-2 <- (answer no)
=>
   (printout t "Replace engine. MM 71-00-02" crlf)
   (assert (high-oil-consumption-question diagnosis))
   (retract ?fact-1)
   (retract ?fact-2)
)


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(defrule high-oil-consumption-question-at-step29-yes
   (high-oil-consumption-question step-29)
   ?fact-1 <- (high-oil-consumption-question step-29)
   (answer yes)
   ?fact-2 <- (answer yes)
=>
   (printout t "Replace engine. MM 71-00-02" crlf)
   (assert (high-oil-consumption-question diagnosis))
   (retract ?fact-1)
   (retract ?fact-2)
)

(defrule high-oil-consumption-question-at-step29-no
   (high-oil-consumption-question step-29)
   ?fact-1 <- (high-oil-consumption-question step-29)
   (answer no)
   ?fact-2 <- (answer no)
=>
   (printout t "Is leakage from N2 manual crank pad on main gearbox?" crlf)
   (assert (high-oil-consumption-question step-34))
   (assert (ask-question yesno))
   (retract ?fact-1)
```

```
    (retract ?fact-2)
)

(defrule high-oil-consumption-question-at-step34-yes
    (high-oil-consumption-question step-34)
    ?fact-1 <- (high-oil-consumption-question step-34)
    (answer yes)
    ?fact-2 <- (answer yes)
=>
    (printout t "Remove N2 manual crank pad and install new o-ring and gasket (if applicable). MM 72-
00-00 MP" crlf)
    (assert (high-oil-consumption-question diagnosis))
    (retract ?fact-1)
    (retract ?fact-2)
)

(defrule high-oil-consumption-question-at-step34-no
    (high-oil-consumption-question step-34)
    ?fact-1 <- (high-oil-consumption-question step-34)
    (answer no)
    ?fact-2 <- (answer no)
=>
    (printout t "Is leakage from angle gearbox?" crlf)
    (assert (high-oil-consumption-question step-36))
    (assert (ask-question yesno))
    (retract ?fact-1)
    (retract ?fact-2)
)

(defrule high-oil-consumption-question-at-step36-yes
    (high-oil-consumption-question step-36)
    ?fact-1 <- (high-oil-consumption-question step-36)
    (answer yes)
    ?fact-2 <- (answer yes)
=>
    (printout t "Replace angle gearbox.  MM 72-61-01 R/I.")
    (assert (high-oil-consumption-question diagnosis))
    (retract ?fact-1)
    (retract ?fact-2)
)

(defrule high-oil-consumption-question-at-step36-no
    (high-oil-consumption-question step-36)
    ?fact-1 <- (high-oil-consumption-question step-36)
    (answer no)
    ?fact-2 <- (answer no)
=>
    (printout t "Is leakage from main gearbox?" crlf)
    (assert (high-oil-consumption-question step-39))
```

```
   (assert (ask-question yesno))
   (retract ?fact-1)
   (retract ?fact-2)
)

(defrule high-oil-consumption-question-at-step39-yes
   (high-oil-consumption-question step-39)
   ?fact-1 <- (high-oil-consumption-question step-39)
   (answer yes)
   ?fact-2 <- (answer yes)
=>
   (printout t "Replace main gearbox.  MM 72-61-02 R/I.")
   (assert (high-oil-consumption-question diagnosis))
   (retract ?fact-1)
   (retract ?fact-2)
)

(defrule high-oil-consumption-question-at-step39-no
   (high-oil-consumption-question step-39)
   ?fact-1 <- (high-oil-consumption-question step-39)
   (answer no)
   ?fact-2 <- (answer no)
=>
   (printout t "Replace engine. MM 71-00-02" crlf)
   (assert (high-oil-consumption-question diagnosis))
   (retract ?fact-1)
   (retract ?fact-2)
)

;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;; FOURTH FIM PAGE WITH BE/BD ENDS HERE ;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;

;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;; FIFTH AND LAST FIM PAGE WITH BD/BE STARTS
HERE ;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;

(defrule high-oil-consumption-question-at-step46-no
   (high-oil-consumption-question step-46)
   ?fact-1 <- (high-oil-consumption-question step-46)
   (answer no)
   ?fact-2 <- (answer no)
=>
   (printout t "Replace fuel pump. MM 73-11-01" crlf)
   (assert (high-oil-consumption-question diagnosis))
   (retract ?fact-1)
   (retract ?fact-2)
)

(defrule high-oil-consumption-question-at-step46-yes
   (high-oil-consumption-question step-46)
   ?fact-1 <- (high-oil-consumption-question step-46)
```

```
   (answer yes)
   ?fact-2 <- (answer yes)
=>
   (printout t "Check ground idle speed. MM 71-00-00 A/T, Test No. 9. Is ground idle speed low?" crlf)
   (assert (high-oil-consumption-question step-49))
   (assert (ask-question yesno))
   (retract ?fact-1)
   (retract ?fact-2)
)

(defrule high-oil-consumption-question-at-step49-yes
   (high-oil-consumption-question step-49)
   ?fact-1 <- (high-oil-consumption-question step-49)
   (answer yes)
   ?fact-2 <- (answer yes)
=>
   (printout t "Adjust ground idle speed. MM 71-00-00 A/T, Test No. 9." crlf)
   (assert (high-oil-consumption-question diagnosis))
   (retract ?fact-1)
   (retract ?fact-2)
)

(defrule high-oil-consumption-question-at-step49-no
   (high-oil-consumption-question step-49)
   ?fact-1 <- (high-oil-consumption-question step-49)
   (answer no)
   ?fact-2 <- (answer no)
=>
   (printout t "From idle power, advance thrust level slowly to increase N2 RPM by 10%.  Did N1
increase at least 10% also?" crlf)
   (assert (high-oil-consumption-question step-52))
   (assert (ask-question yesno))
   (retract ?fact-1)
   (retract ?fact-2)
)

(defrule high-oil-consumption-question-at-step52-no
   (high-oil-consumption-question step-52)
   ?fact-1 <- (high-oil-consumption-question step-52)
   (answer no)
   ?fact-2 <- (answer no)
=>
   (printout t "Replace Evc. MM 75-31-01" crlf)
   (assert (high-oil-consumption-question diagnosis))
   (retract ?fact-1)
   (retract ?fact-2)
)

(defrule high-oil-consumption-question-at-step52-yes
```

```
   (high-oil-consumption-question step-52)
   ?fact-1 <- (high-oil-consumption-question step-52)
   (answer yes)
   ?fact-2 <- (answer yes)
=>
   (printout t "The following are infrequent causes of this fault:" crlf)
   (printout t " 1. Faulty main gearbox deaerator          Ref Engine Check 3, 79-01-20 for resolution"
crlf)
   (printout t " 2. PT3 manifold leaks                    Ref Visual Check 8, 71-01-10 for resolution" crlf)
   (printout t " 3. No. 1 and 2 bearing compartment leaks  Replace Engine (MM 71-00-02)" crlf)
   (assert (high-oil-consumption-question diagnosis))
   (retract ?fact-1)
   (retract ?fact-2)
)

(defrule high-oil-consumption-question-diagnosis
   (high-oil-consumption-question diagnosis)
   ?fact-1 <- (high-oil-consumption-question diagnosis)
   (error-code ?inp1)
   ?fact-2 <- (error-code ?inp1)
   (engine-num ?inp2)
   ?fact-3 <- (engine-num ?inp2)
=>
   (printout t crlf)
   (printout t "----THANKS TO US THE PROBLEM IS SOLVED----" crlf)
   (printout t "========END OF " ?inp1 ?inp2 " PROBLEMS=======" crlf)
   (printout t "----------THANK GOD WE ARE SAFE-----------" crlf)
   (retract ?fact-1)
   (retract ?fact-2)
   (retract ?fact-3)
)


;;;;;;;;;;;;;;;;;;;;;;;;; END OF FIFTH AND LAST PAGE OF FIM FOR OIL CONSUMPTION... THANK
GOD;;;;;;;;;;;;;;;;;;;;;
```

ΠΡΟΒΛΗΜΑ 2 (CD/CE)

```
;;;;;;;;;;;;;;;;;;;;;;;;;;;;OIL PRESSURE PROBLEM TROUBLESHOOTING;;;;;;;;;;;;;;;;;;;;;;;;;;

;;  CHOSEN PROBLEM 3: OIL PRESSURE

(defrule oil-pressure
   (observed-problem-number 3)
   ?fact <- (observed-problem-number 3)
=>
   (assert (error-code 79-01-CA-0))
   (assert (menu-op engine-num))
```

```
   (retract ?fact)
)

(defrule abnormal-oil-pressure
   (error-code 79-01-CA-0)
=>
   (printout t "Change thrust setting & check oil press. Did oil press follow thrust change?" crlf)
   (assert (ask-question yesno))
)

(defrule abnormal-oil-pressure-CD ;;WE CONCLUDE THAT WE HAVE A CD OIL PRESSURE PROBLEM
   (error-code 79-01-CA-0)
   ?fact-1 <- (error-code 79-01-CA-0)
   (answer no)
   ?fact-2 <- (answer no)
=>
   (assert (error-code 79-01-CD-0))
   (assert (abnormal-oil-pressure-CD-question start))
   (retract ?fact-1)
   (retract ?fact-2)
)
;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;; FIM PAGE WITH CD STARTS HERE ;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;
(defrule abnormal-oil-pressure-CD-question-start
   (abnormal-oil-pressure-CD-question start)
   ?fact <- (abnormal-oil-pressure-CD-question start)
=>
   (printout t "Connect line for air pressure to elbow of oil pressure transmitter, T422. Apply 45 PSI. Does indicator read 40 to 45 PSI?" crlf)
   (assert (abnormal-oil-pressure-CD-question step-0))
   (assert (ask-question yesno))
   (retract ?fact)
)

(defrule abnormal-oil-pressure-CD-question-at-step0-yes
   (abnormal-oil-pressure-CD-question step-0)
   ?fact-1 <- (abnormal-oil-pressure-CD-question step-0)
   (answer yes)
   ?fact-2 <- (answer yes)
=>
   (printout t "Adjust oil pressure.  MM 71-00-00 A/T, Test No. 7.  Observe oil pressure indicator. Is oil pressure within limits?" crlf)
   (assert (abnormal-oil-pressure-CD-question step-1))
   (assert (ask-question yesno))
   (retract ?fact-1)
   (retract ?fact-2)
)

(defrule abnormal-oil-pressure-CD-question-at-step0-no
```

```
   (abnormal-oil-pressure-CD-question step-0)
   ?fact-1 <- (abnormal-oil-pressure-CD-question step-0)
   (answer no)
   ?fact-2 <- (answer no)
=>
   (printout t "Exchange oil pressure indicators, N30, N31, N32, or N33.  MM 79-32-03." crlf)
   (printout t "Apply 40 to 45 PSI to transmitter. Does indicator read 40 to 45 PSI?" crlf)
   (assert (abnormal-oil-pressure-CD-question step-2))
   (assert (ask-question yesno))
   (retract ?fact-1)
   (retract ?fact-2)
)

(defrule abnormal-oil-pressure-CD-question-at-step1-no
   (abnormal-oil-pressure-CD-question step-1)
   ?fact-1 <- (abnormal-oil-pressure-CD-question step-1)
   (answer no)
   ?fact-2 <- (answer no)
=>
   (printout t "Replace oil pressure regulating valve. MM 72-61-03." crlf)
   (assert (abnormal-oil-pressure-CD-question diagnosis))
   (retract ?fact-1)
   (retract ?fact-2)
)

(defrule abnormal-oil-pressure-CD-question-at-step1-yes
   (abnormal-oil-pressure-CD-question step-1)
   ?fact-1 <- (abnormal-oil-pressure-CD-question step-1)
   (answer yes)
   ?fact-2 <- (answer yes)
=>
   (printout t "The following item may be an infrequent cause of abnormal oil pressure:" crlf)
   (printout t "     COMPONENT           CORRECTIVE ACTION" crlf)
   (printout t "     ---------           -----------------" crlf)
   (printout t "   Main Oil Pump   Replace main oil pump (MM 72-61-17)" crlf)
   (assert (abnormal-oil-pressure-CD-question diagnosis))
   (retract ?fact-1)
   (retract ?fact-2)
)

(defrule abnormal-oil-pressure-CD-question-at-step2-yes
   (abnormal-oil-pressure-CD-question step-2)
   ?fact-1 <- (abnormal-oil-pressure-CD-question step-2)
   (answer yes)
   ?fact-2 <- (answer yes)
=>
   (printout t "Replace indicator. MM 79-32-03" crlf)
   (assert (abnormal-oil-pressure-CD-question diagnosis))
   (retract ?fact-1)
```

```
   (retract ?fact-2)
)

(defrule abnormal-oil-pressure-CD-question-at-step2-no
   (abnormal-oil-pressure-CD-question step-2)
   ?fact-1 <- (abnormal-oil-pressure-CD-question step-2)
   (answer no)
   ?fact-2 <- (answer no)
=>
   (printout t "Replace engine oil pressure transmitter, T422. MM 79-32-01." crlf)
   (assert (abnormal-oil-pressure-CD-question diagnosis))
   (retract ?fact-1)
   (retract ?fact-2)
)

(defrule abnormal-oil-pressure-CD-question-diagnosis
   (abnormal-oil-pressure-CD-question diagnosis)
   ?fact-1 <- (abnormal-oil-pressure-CD-question diagnosis)
   (error-code ?inp1)
   ?fact-2 <- (error-code ?inp1)
   (engine-num ?inp2)
   ?fact-3 <- (engine-num ?inp2)
=>
   (printout t crlf)
   (printout t "----THANKS TO US THE PROBLEM IS SOLVED----" crlf)
   (printout t "========END OF " ?inp1 ?inp2 " PROBLEMS=======" crlf)
   (printout t "----------THANK GOD WE ARE SAFE----------" crlf)
   (retract ?fact-1)
   (retract ?fact-2)
   (retract ?fact-3)
)
;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;; FIM PAGE WITH CD ENDS HERE ;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;
;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;; FIM PAGE WITH CE STARTS HERE ;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;
(defrule abnormal-oil-pressure-CE  ;;WE COCNCLUDE THAT WE HAVE A CE OIL PRESSURE
PROBLEM
   (error-code 79-01-CA-0)
   ?fact-1 <- (error-code 79-01-CA-0)
   (answer yes)
   ?fact-2 <- (answer yes)
=>
   (assert (error-code 79-01-CE-0))
   (assert (abnormal-oil-pressure-CE-question start))
   (retract ?fact-1)
   (retract ?fact-2)
)
(defrule abnormal-oil-pressure-CE-question-start
   (abnormal-oil-pressure-CE-question start)
   ?fact <- (abnormal-oil-pressure-CE-question start)
=>
```

```
   (printout t "Examine magnetic chip detectors and main oil strainer per Engine Check 18, 71-01-20. Was contamination abnormal?" crlf)
   (assert (abnormal-oil-pressure-CE-question step-0))
   (assert (ask-question yesno))
   (retract ?fact)
)
(defrule abnormal-oil-pressure-CE-question-at-step0-yes
   (abnormal-oil-pressure-CE-question step-0)
   ?fact-1 <- (abnormal-oil-pressure-CE-question step-0)
   (answer yes)
   ?fact-2 <- (answer yes)
=>
   (printout t "Replace main oil strainer.  MM 72-61-05. Replace main oil pressure regulating valve. MM 72-61-03.  Perform oil system contamination inspection.  MM 72-00-00 I/C." crlf)
   (assert (abnormal-oil-pressure-CE-question diagnosis))
   (retract ?fact-1)
   (retract ?fact-2)
)
(defrule abnormal-oil-pressure-CE-question-at-step0-no
   (abnormal-oil-pressure-CE-question step-0)
   ?fact-1 <- (abnormal-oil-pressure-CE-question step-0)
   (answer no)
   ?fact-2 <- (answer no)
=>
   (printout t "Exchange oil pressure indicators, N30, N31, N32, or N33.  MM 79-32-03. Connect air pressure source to elbow on oil pressure transmitter, T422. Apply 45 PSI.  Observe oil pressure indication.  Does indicator read 40-45 PSI?" crlf)
   (assert (abnormal-oil-pressure-CE-question step-2))
   (assert (ask-question yesno))
   (retract ?fact-1)
   (retract ?fact-2)
)
(defrule abnormal-oil-pressure-CE-question-at-step2-yes
   (abnormal-oil-pressure-CE-question step-2)
   ?fact-1 <- (abnormal-oil-pressure-CE-question step-2)
   (answer yes)
   ?fact-2 <- (answer yes)
=>
   (printout t "Replace indicator. MM 79-32-03" crlf)
   (assert (abnormal-oil-pressure-CE-question diagnosis))
   (retract ?fact-1)
   (retract ?fact-2)
)
(defrule abnormal-oil-pressure-CE-question-at-step2-no
   (abnormal-oil-pressure-CE-question step-2)
   ?fact-1 <- (abnormal-oil-pressure-CE-question step-2)
   (answer no)
   ?fact-2 <- (answer no)
=>
```

```
    (printout t "Replace engine oil pressure transmitter, T422. MM 79-32-01" crlf)
    (assert (abnormal-oil-pressure-CE-question diagnosis))
    (retract ?fact-1)
    (retract ?fact-2)
)
(defrule abnormal-oil-pressure-CE-question-end
    (abnormal-oil-pressure-CE-question diagnosis)
    ?fact-1 <- (abnormal-oil-pressure-CE-question diagnosis)
    (error-code ?inp1)
    ?fact-2 <- (error-code ?inp1)
    (engine-num ?inp2)
    ?fact-3 <- (engine-num ?inp2)
=>
    (printout t crlf)
    (printout t "----THANKS TO US THE PROBLEM IS SOLVED----" crlf)
    (printout t "========END OF " ?inp1 ?inp2 " PROBLEMS=======" crlf)
    (printout t "----------THANK GOD WE ARE SAFE----------" crlf)
    (retract ?fact-1)
    (retract ?fact-2)
    (retract ?fact-3)
)
```

Traces για κάθε πιθανή βλάβη

Βλάβη BE/BD.Παρατίθενται δύο διαφορετικά στιγμιότυπα για κάθεμια από τις δύο βλάβες :

Trace 1(Βλάβη BE)

```
CLIPS> (reset)
CLIPS> (run)



*****BOEING 747 FAULT ISOLATION EXPERT SYSTEM*****

MAIN MENU

1 - Oil consumption is high
2 - Oil quantity indicator is malfunctioning
3 - Oil pressure is abnormal or indicator is malfunctioning
4 - Oil filter bypass light is illuminated
5 - Oil temperature is abnormal or indicator is malfunctioning
6 - Breather temperature is high
7 - Engine was shutdown in flight
8 - Unlisted engine oil fault
Which of the above were observed during the flight? >
**************************************************
**************************************************
Note:Our current expert systems resolves only
     Oil Consumption and Oil Pressure Issues
1

Which engine is malfuctioning? (1,2,3,4,0) >
1

Are there any other abnormal oil systems?
[yes,no] > yes

Examine turbine exhaust area for evidence of oil loss per Visual Check 1, 79-01-10. Is oil loss occuring?
[yes,no] > no

Examine main gearbox drains (MM 71-71-00) for leakage.  Is excessive oil present?
[yes,no] > yes

Identify leaking drain line source (MM 71-71-00) Was source of leakage from the fuel/oil cooler?
[yes,no] > no
```

```
4 - Oil filter bypass light is illuminated
5 - Oil temperature is abnormal or indicator is malfunctioning
6 - Breather temperature is high
7 - Engine was shutdown in flight
8 - Unlisted engine oil fault
Which of the above were observed during the flight? >
**************************************************
**************************************************
Note:Our current expert systems resolves only
     Oil Consumption and Oil Pressure Issues
1

Which engine is malfuctioning? (1,2,3,4,0) >
1

Are there any other abnormal oil systems?
[yes,no] > yes

Examine turbine exhaust area for evidence of oil loss per Visual Check 1, 79-01-10. Is oil loss occuring?
[yes,no] > no

Examine main gearbox drains (MM 71-71-00) for leakage.  Is excessive oil present?
[yes,no] > yes

Identify leaking drain line source (MM 71-71-00) Was source of leakage from the fuel/oil cooler?
[yes,no] > no

Remove applicable component and check both component and drive pad seal.
Replace component and/or drive seal as follows:
         Component          Seal Replacement Ref
         ---------          --------------------
   Generator (MM 24-21-01)        MM 72-61-08
   Fuel Pump (MM 73-11-01)        MM 72-61-11
Hydraulic Pump (MM 29-11-05)      MM 72-61-09
    Starter (MM 80-11-01)         MM 72-61-06
    Constant Speed Drive          MM 72-61-07
(MM 24-11-01)

----THANKS TO US THE PROBLEM IS SOLVED----
========END OF 79-01-BD-01 PROBLEMS=======
----------THANK GOD WE ARE SAFE----------
```

Trace 2(Βλάβη BD)

```
CLIPS> (reset)
CLIPS> (run)



*****BOEING 747 FAULT ISOLATION EXPERT SYSTEM*****

MAIN MENU

1 - Oil consumption is high
2 - Oil quantity indicator is malfunctioning
3 - Oil pressure is abnormal or indicator is malfunctioning
4 - Oil filter bypass light is illuminated
5 - Oil temperature is abnormal or indicator is malfunctioning
6 - Breather temperature is high
7 - Engine was shutdown in flight
8 - Unlisted engine oil fault
Which of the above were observed during the flight? >
**************************************************
**************************************************
Note:Our current expert systems resolves only
     Oil Consumption and Oil Pressure Issues
1

Which engine is malfuctioning? (1,2,3,4,0) >
3

Are there any other abnormal oil systems?
[yes,no] > no

Examine turbine exhaust area for evidence of oil loss per Visual Check 1, 79-01-
10. Is oil loss occuring?
[yes,no] > no

Examine main gearbox drains (MM 71-71-00) for leakage.  Is excessive oil present
?
[yes,no] > no
Check that PT3 water drain plug is installed per Visual Check 9, 71-01-10. Is pl
ug missing?
[yes,no] > no

Examine external plumbing, main gearbox and angle gearbox for obvious leakage pe
r Visual Check 2, 79-01-10.  Is obvious leakage present?
[yes,no] > yes

Is leakage from oil pressure and/or oil scavenge lines?
[yes,no] > no

Is leakage from breather lines?
[yes,no] > no

Is leakage from oil instrumentation lines?
[yes,no] > no

Is leakage from N2 manual crank pad on main gearbox?
[yes,no] > no

Is leakage from angle gearbox?
[yes,no] > no

Is leakage from main gearbox?
[yes,no] > no

Replace engine. MM 71-00-02

----THANKS TO US THE PROBLEM IS SOLVED----
========END OF 79-01-BE-03 PROBLEMS=======
----------THANK GOD WE ARE SAFE-----------
```

Βλάβη CE/CD.Παρατίθενται δύο διαφορετικά στιγμιότυπα για κάθεμια από τις δύο βλάβες :

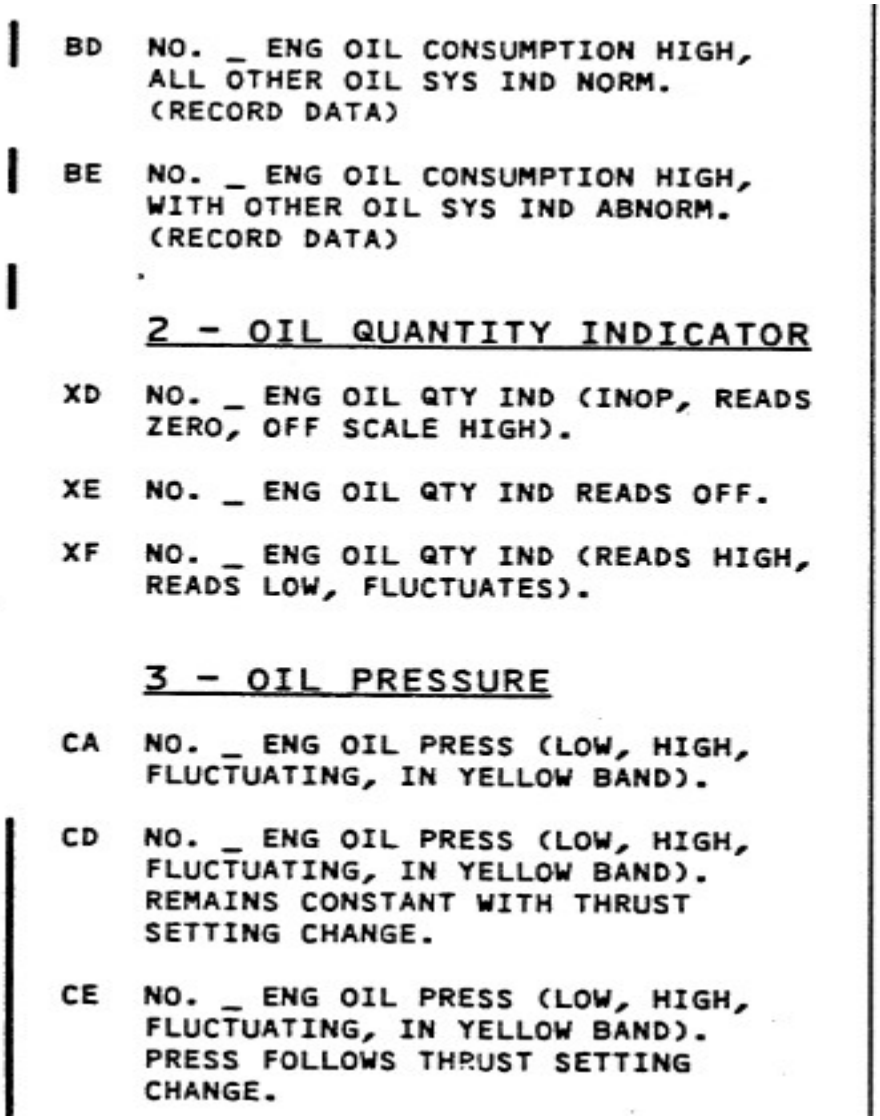
Trace 3(Βλάβη CD)

```
*****BOEING 747 FAULT ISOLATION EXPERT SYSTEM*****

MAIN MENU

1 - Oil consumption is high
2 - Oil quantity indicator is malfunctioning
3 - Oil pressure is abnormal or indicator is malfunctioning
4 - Oil filter bypass light is illuminated
5 - Oil temperature is abnormal or indicator is malfunctioning
6 - Breather temperature is high
7 - Engine was shutdown in flight
8 - Unlisted engine oil fault
Which of the above were observed during the flight? >
**************************************************
**************************************************
Note:Our current expert systems resolves only
     Oil Consumption and Oil Pressure Issues
3

Which engine is malfuctioning? (1,2,3,4,0) >
4

Change thrust setting & check oil press. Did oil press follow thrust change?
[yes,no] > no

Connect line for air pressure to elbow of oil pressure transmitter, T422. Apply 45 PSI.  Does indicator re
[yes,no] > yes

Adjust oil pressure.  MM 71-00-00 A/T, Test No. 7.  Observe oil pressure indicator. Is oil pressure within
[yes,no] > yes

The following item may be an infrequent cause of abnormal oil pressure:
     COMPONENT           CORRECTIVE ACTION
     ---------           ----------------
   Main Oil Pump   Replace main oil pump (MM 72-61-17)

----THANKS TO US THE PROBLEM IS SOLVED----
========END OF 79-01-CD-04 PROBLEMS=======
----------THANK GOD WE ARE SAFE----------
```

Trace 4(Βλάβη CE)

```
*****BOEING 747 FAULT ISOLATION EXPERT SYSTEM*****

MAIN MENU

1 - Oil consumption is high
2 - Oil quantity indicator is malfunctioning
3 - Oil pressure is abnormal or indicator is malfunctioning
4 - Oil filter bypass light is illuminated
5 - Oil temperature is abnormal or indicator is malfunctioning
6 - Breather temperature is high
7 - Engine was shutdown in flight
8 - Unlisted engine oil fault
Which of the above were observed during the flight? >
**************************************************
**************************************************
Note:Our current expert systems resolves only
     Oil Consumption and Oil Pressure Issues
3

Which engine is malfuctioning? (1,2,3,4,0) >
3

Change thrust setting & check oil press. Did oil press follow thrust change?
[yes,no] > yes

Examine magnetic chip detectors and main oil strainer per Engine Check 18, 71-01-20. Was contamination abnormal?
[yes,no] > no

Exchange oil pressure indicators, N30, N31, N32, or N33.  MM 79-32-03. Connect air pressure source to elbow on oil pressure transmitter, T422. A
pply 45 PSI.  Observe oil pressure indication.  Does indicator read 40-45 PSI?
[yes,no] > yes

Replace indicator. MM 79-32-03

----THANKS TO US THE PROBLEM IS SOLVED----
========END OF 79-01-CE-03 PROBLEMS=======
----------THANK GOD WE ARE SAFE----------
```

Επίσης παρατίθενται ένα στιγμιότυπο του FIM το οποίο βοήθησε στον παραπάνω διαχωρισμό των βλαβών ανάλογα με την ομαλότητα η όχι των υπόλοιπων ενδείξεων αν επιλεγεί το 1(διαχωρισμός βλαβών BE/BD) ή με το αν ακολουθεί ή όχι τις αλλαγές στην ώση του αεροπλάνου (βλάβες CD/CE) αν επιλεγεί το 3.



BD NO. _ ENG OIL CONSUMPTION HIGH, ALL OTHER OIL SYS IND NORM. (RECORD DATA)

BE NO. _ ENG OIL CONSUMPTION HIGH, WITH OTHER OIL SYS IND ABNORM. (RECORD DATA)

2 - OIL QUANTITY INDICATOR

XD NO. _ ENG OIL QTY IND (INOP, READS ZERO, OFF SCALE HIGH).

XE NO. _ ENG OIL QTY IND READS OFF.

XF NO. _ ENG OIL QTY IND (READS HIGH, READS LOW, FLUCTUATES).

3 - OIL PRESSURE

CA NO. _ ENG OIL PRESS (LOW, HIGH, FLUCTUATING, IN YELLOW BAND).

CD NO. _ ENG OIL PRESS (LOW, HIGH, FLUCTUATING, IN YELLOW BAND). REMAINS CONSTANT WITH THRUST SETTING CHANGE.

CE NO. _ ENG OIL PRESS (LOW, HIGH, FLUCTUATING, IN YELLOW BAND). PRESS FOLLOWS THRUST SETTING CHANGE.

Στην συνέχεια παρατίθεται ολόκληρος ο κώδικας σε τελική ολοκληρωμένη μορφή με σχόλια επεξηγηματικά σχετικά με τη ροή του προγράμματος αλλά και διαχωριστικά σημεία για κάθε βλάβη ο οποίος επίσης επισυνάπτεται και στο *.zip αρχείο μαζί με την αναφορά:

Κώδικας

```
(deffacts startup (menu-op start))

(member-of possible-main-menu-selections 1 2 3 4 5 6 7 8)

(defrule main-menu              ;;MENU TO CHOOSE WHICH TROUBLE YOU HAVE
```

```
   (menu-op start)              ;;POSSIBLE VALID CHOICES FOR OUR EXPERT SYSTEM ARE 1
AND 3
   ?fact <- (menu-op start)
=>
   (printout t t t t "*****BOEING 747 FAULT ISOLATION EXPERT SYSTEM*****" crlf)
   (printout t t "MAIN MENU" t crlf)
   (printout t "1 - Oil consumption is high" crlf)
   (printout t "2 - Oil quantity indicator is malfunctioning" crlf)
   (printout t "3 - Oil pressure is abnormal or indicator is malfunctioning" crlf)
   (printout t "4 - Oil filter bypass light is illuminated" crlf)
   (printout t "5 - Oil temperature is abnormal or indicator is malfunctioning" crlf)
   (printout t "6 - Breather temperature is high" crlf)
   (printout t "7 - Engine was shutdown in flight" crlf)
   (printout t "8 - Unlisted engine oil fault" crlf)
   (printout t "Which of the above were observed during the flight? >" crlf)
   (printout t "**************************************************" crlf)
   (printout t "**************************************************" crlf)
   (printout t "Note:Our current expert systems resolves only "crlf)
   (printout t "     Oil Consumption and Oil Pressure Issues "crlf)
   (assert (observed-problem-number (read)) )
   (printout t crlf)
   (retract ?fact)
)

;; CODE EXPLANATION:
;; First we check the oil consumption problem (BD/BE)
;; and we solve it step by step as shown in the manual
;; Then we check for oil pressure problem (CD/CE)
;; and we solve it step by step as shown in the manual
;; There are clarification marks at each point of our
;; source code so as to be easily understood by
;; everyone, as any expert system should be.


(defrule engine-number              ;;MENU TO INDICATE WHICH ENGINE HAS THE
PROBLEM
   (menu-op engine-num)
   ?fact <- (menu-op engine-num)
=>
   (printout t "Which engine is malfuctioning? (1,2,3,4,0) >" crlf)
   (assert (engine-num (read)))
   (printout t crlf)
   (retract ?fact)
)

;;  SHORTCUT FOR QUESTIONS YES-NO

(defrule yes-no-question
   (ask-question yesno)
```

```
   ?fact <- (ask-question yesno)
=>
   (printout t "[yes,no] > ")
   (assert (answer (read)))
   (printout t crlf)
   (retract ?fact)
)

;;  CHOSEN PROBLEM 1: OIL CONSUMPTION

(defrule oil-consumption
   (observed-problem-number 1)
   ?fact <- (observed-problem-number 1)
=>
   (assert (error-code 79-01-BA-0))
   (assert (menu-op engine-num))
   (retract ?fact)
)


(defrule high-oil-consumption
   (error-code 79-01-BA-0)
=>
   (printout t "Are there any other abnormal oil systems?" crlf)
   (assert (ask-question yesno))
)

(defrule high-oil-consumption-with-abnormal-issues ;;WE COCNLUDE WE HAVE BD PROBLEM
TYPE
   (error-code 79-01-BA-0)
   ?fact-1 <- (error-code 79-01-BA-0)
   (answer yes)
   ?fact-2 <- (answer yes)
=>
   (assert (error-code 79-01-BD-0))
   (assert (high-oil-consumption-question start))
   (retract ?fact-1)
   (retract ?fact-2)
)

(defrule high-oil-consumption-without-abnormal-issues ;;WE CONCLUDE WE HAVE BE PROBLEM
TYPE
   (error-code 79-01-BA-0)
   ?fact-1 <- (error-code 79-01-BA-0)
   (answer no)
   ?fact-2 <- (answer no)
=>
   (assert (error-code 79-01-BE-0))
   (assert (high-oil-consumption-question start))
```

```
    (retract ?fact-1)
    (retract ?fact-2)
)


;;;;;;;;;;;;;;;;;;;;;;;;;;HIGH OIL CONSUMPTION PROBLEM TROUBLESHOOTING;;;;;;;;;;;;;;;;;;;;;;;;;;

(defrule high-oil-consumption-question-start
    (high-oil-consumption-question start)
    ?fact <- (high-oil-consumption-question start)
=>
   (printout t "Examine turbine exhaust area for evidence of oil loss per Visual Check 1, 79-01-10. Is oil
loss occuring?" crlf)
   (assert (high-oil-consumption-question step-0))
   (assert (ask-question yesno))
   (retract ?fact)
)
;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;; FIRST FIM PAGE WITH BD/BE STARTS HERE ;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;

(defrule high-oil-consumption-question-at-step0-no
    (high-oil-consumption-question step-0)
    ?fact-1 <- (high-oil-consumption-question step-0)
    (answer no)
    ?fact-2 <- (answer no)
=>
    (printout t "Examine main gearbox drains (MM 71-71-00) for leakage.  Is excessive oil present?"
crlf)
    (assert (high-oil-consumption-question step-1))
    (assert (ask-question yesno))
    (retract ?fact-1)
    (retract ?fact-2)
)

(defrule high-oil-consumption-question-at-step0-yes
    (high-oil-consumption-question step-0)
    ?fact-1 <- (high-oil-consumption-question step-0)
    (answer yes)
    ?fact-2 <- (answer yes)
=>
    (printout t "Identify source of oil loss per Visual Check 1, 79-01-10.  Is oil loss due to leakage from
rear cover of No. 4 bearing compartment?" crlf)
    (assert (high-oil-consumption-question step-2))
    (assert (ask-question yesno))
    (retract ?fact-1)
    (retract ?fact-2)
)

(defrule high-oil-consumption-question-at-step1-yes
    (high-oil-consumption-question step-1)
```

```
   ?fact-1 <- (high-oil-consumption-question step-1)
   (answer yes)
   ?fact-2 <- (answer yes)
=>
   (printout t "Identify leaking drain line source (MM 71-71-00) Was source of leakage from the fuel/oil
cooler?" crlf)
   (assert (high-oil-consumption-question step-14))
   (assert (ask-question yesno))
   (retract ?fact-1)
   (retract ?fact-2)
)

(defrule high-oil-consumption-question-at-step1-no
   (high-oil-consumption-question step-1)
   ?fact-1 <- (high-oil-consumption-question step-1)
   (answer no)
   ?fact-2 <- (answer no)
=>
   (printout t "Check that PT3 water drain plug is installed per Visual Check 9, 71-01-10. Is plug
missing?" crlf)
   (assert (high-oil-consumption-question step-15))
   (assert (ask-question yesno))
   (retract ?fact-1)
   (retract ?fact-2)
)

(defrule high-oil-consumption-question-at-step2-no
   (high-oil-consumption-question step-2)
   ?fact-1 <- (high-oil-consumption-question step-2)
   (answer no)
   ?fact-2 <- (answer no)
=>
   (printout t "Is oil loss due to leakage from oil pressure supply line or oil scavenge line of No. 4
bearing compartment?" crlf)
   (assert (high-oil-consumption-question step-3))
   (assert (ask-question yesno))
   (retract ?fact-1)
   (retract ?fact-2)
)

(defrule high-oil-consumption-question-at-step2-yes
   (high-oil-consumption-question step-2)
   ?fact-1 <- (high-oil-consumption-question step-2)
   (answer yes)
   ?fact-2 <- (answer yes)
=>
   (printout t "Replace engine. MM 71-00-02" crlf)
   (assert (high-oil-consumption-question diagnosis))
   (retract ?fact-1)
```

```
    (retract ?fact-2)
)

(defrule high-oil-consumption-question-at-step3-yes
    (high-oil-consumption-question step-3)
    ?fact-1 <- (high-oil-consumption-question step-3)
    (answer yes)
    ?fact-2 <- (answer yes)
=>
    (printout t "Remove and clean or replace oil pressure supply tube and/or oil scavenge tube as
required.  MM 72-53-00" crlf)
    (assert (high-oil-consumption-question diagnosis))
    (retract ?fact-1)
    (retract ?fact-2)
)

(defrule high-oil-consumption-question-at-step3-no
    (high-oil-consumption-question case-3)
    ?fact-1 <- (high-oil-consumption-question case-3)
    (answer no)
    ?fact-2 <- (answer no)
=>
    (printout t "Is oil loss due to a clogged or loose oil scavenge line or a failed scavenge pump?" crlf)
    (assert (high-oil-consumption-question step-6))
    (assert (ask-question yesno))
    (retract ?fact-1)
    (retract ?fact-2)
)

(defrule high-oil-consumption-question-at-step6-yes
    (high-oil-consumption-question step-6)
    ?fact-1 <- (high-oil-consumption-question step-6)
    (answer yes)
    ?fact-2 <- (answer yes)
=>
    (printout t "Remove and clean or replace oil scavenge tube as necessary.  MM 72-53-00.  Replace
scavenge pump if required.  MM 72-61-21" crlf)
    (assert (high-oil-consumption-question diagnosis))
    (retract ?fact-1)
    (retract ?fact-2)
)

(defrule high-oil-consumption-question-at-step6-no
    (high-oil-consumption-question step-6)
    ?fact-1 <- (high-oil-consumption-question step-6)
    (answer no)
    ?fact-2 <- (answer no)
=>
    (printout t "Replace engine. MM 71-00-02" crlf)
```

```
   (assert (high-oil-consumption-question diagnosis))
   (retract ?fact-1)
   (retract ?fact-2)
)
;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;; FIRST FIM PAGE WITH BE/BD ENDS HERE ;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;


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(defrule high-oil-consumption-question-at-step14-yes
   (high-oil-consumption-question step-14)
   ?fact-1 <- (high-oil-consumption-question step-14)
   (answer yes)
   ?fact-2 <- (answer yes)
=>
   (printout t "Replace fuel/oil cooler (MM 79-21-01)" crlf)
   (assert (high-oil-consumption-question diagnosis))
   (retract ?fact-1)
   (retract ?fact-2)
)

(defrule high-oil-consumption-question-at-step14-no
   (high-oil-consumption-question step-14)
   ?fact-1 <- (high-oil-consumption-question step-14)
   (answer no)
   ?fact-2 <- (answer no)
=>
   (printout t "Remove applicable component and check both component and drive pad seal." crlf)
   (printout t "Replace component and/or drive seal as follows:" crlf)
   (printout t "         Component          Seal Replacement Ref" crlf)
   (printout t "         ---------          --------------------" crlf)
   (printout t "   Generator (MM 24-21-01)         MM 72-61-08    " crlf)
   (printout t "   Fuel Pump (MM 73-11-01)         MM 72-61-11    " crlf)
   (printout t "Hydraulic Pump (MM 29-11-05)       MM 72-61-09    " crlf)
   (printout t "    Starter (MM 80-11-01)          MM 72-61-06    " crlf)
   (printout t "    Constant Speed Drive           MM 72-61-07    " crlf)
   (printout t "(MM 24-11-01)" crlf)
   (assert (high-oil-consumption-question diagnosis))
   (retract ?fact-1)
   (retract ?fact-2)
)

;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;; SECOND FIM PAGE WITH BE/BD ENDS HERE ;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;

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(defrule high-oil-consumption-question-at-step15-yes
   (high-oil-consumption-question step-15)
```

```
   ?fact-1 <- (high-oil-consumption-question step-15)
   (answer yes)
   ?fact-2 <- (answer yes)
=>
   (printout t "Install drain plug" crlf)
   (assert (high-oil-consumption-question diagnosis))
   (retract ?fact-1)
   (retract ?fact-2)
)

(defrule high-oil-consumption-question-at-step15-no
   (high-oil-consumption-question step-15)
   ?fact-1 <- (high-oil-consumption-question step-15)
   (answer no)
   ?fact-2 <- (answer no)
=>
   (printout t "Examine external plumbing, main gearbox and angle gearbox for obvious leakage per
Visual Check 2, 79-01-10.  Is obvious leakage present?" crlf)
   (assert (high-oil-consumption-question step-19))
   (assert (ask-question yesno))
   (retract ?fact-1)
   (retract ?fact-2)
)

(defrule high-oil-consumption-question-at-step19-yes
   (high-oil-consumption-question step-19)
   ?fact-1 <- (high-oil-consumption-question step-19)
   (answer yes)
   ?fact-2 <- (answer yes)
=>
   (printout t "Is leakage from oil pressure and/or oil scavenge lines?" crlf)
   (assert (high-oil-consumption-question step-20))
   (assert (ask-question yesno))
   (retract ?fact-1)
   (retract ?fact-2)
)

(defrule high-oil-consumption-question-at-step19-no
   (high-oil-consumption-question step-19)
   ?fact-1 <- (high-oil-consumption-question step-19)
   (answer no)
   ?fact-2 <- (answer no)
=>
   (printout t "Perform oil system static leak check per Engine Check 1, 79-01-20 and/or oil system
monitoring leak check per Engine Check 2, 79-01-20.  Was source of leakage found?" crlf)
   (assert (high-oil-consumption-question step-21))
   (assert (ask-question yesno))
   (retract ?fact-1)
   (retract ?fact-2)
```

```
)

(defrule high-oil-consumption-question-at-step20-yes
   (high-oil-consumption-question step-20)
   ?fact-1 <- (high-oil-consumption-question step-20)
   (answer yes)
   ?fact-2 <- (answer yes)
=>
   (printout t "Is leakage from No. 3 bearing oil scavenge tube connections?" crlf)
   (assert (high-oil-consumption-question step-22))
   (assert (ask-question yesno))
   (retract ?fact-1)
   (retract ?fact-2)
)

(defrule high-oil-consumption-question-at-step20-no
   (high-oil-consumption-question step-20)
   ?fact-1 <- (high-oil-consumption-question step-20)
   (answer no)
   ?fact-2 <- (answer no)
=>
   (printout t "Is leakage from breather lines?" crlf)
   (assert (high-oil-consumption-question step-23))
   (assert (ask-question yesno))
   (retract ?fact-1)
   (retract ?fact-2)
)

(defrule high-oil-consumption-question-at-step21-yes
   (high-oil-consumption-question step-21)
   ?fact-1 <- (high-oil-consumption-question step-21)
   (answer yes)
   ?fact-2 <- (answer yes)
=>
   (printout t "Refer to Engine Check 1 and/or engine check 2 for corrective action." crlf)
   (assert (high-oil-consumption-question diagnosis))
   (retract ?fact-1)
   (retract ?fact-2)
)

(defrule high-oil-consumption-question-at-step21-no
   (high-oil-consumption-question step-21)
   ?fact-1 <- (high-oil-consumption-question step-21)
   (answer no)
   ?fact-2 <- (answer no)
=>
   (printout t "Check fuel pump hydraulic stage pressure per Engine Check 2, 71-01-20. Is pressure
within limits?" crlf)
   (assert (high-oil-consumption-question step-46))
```

```
   (assert (ask-question yesno))
   (retract ?fact-1)
   (retract ?fact-2)
)

(defrule high-oil-consumption-question-at-step22-yes
   (high-oil-consumption-question step-22)
   ?fact-1 <- (high-oil-consumption-question step-22)
   (answer yes)
   ?fact-2 <- (answer yes)
=>
   (printout t "Repair No. 3 bearing oil scavenge tube connections as required. MM 79-21-03 AR")
   (assert (high-oil-consumption-question diagnosis))
   (retract ?fact-1)
   (retract ?fact-2)
)

(defrule high-oil-consumption-question-at-step22-no
   (high-oil-consumption-question step-22)
   ?fact-1 <- (high-oil-consumption-question step-22)
   (answer no)
   ?fact-2 <- (answer no)
=>
   (printout t "Replace Engine.  MM 71-00-02" crlf)
   (assert (high-oil-consumption-question diagnosis))
   (retract ?fact-1)
   (retract ?fact-2)
)

(defrule high-oil-consumption-question-at-step23-yes
   (high-oil-consumption-question step-23)
   ?fact-1 <- (high-oil-consumption-question step-23)
   (answer yes)
   ?fact-2 <- (answer yes)
=>
   (printout t "Is leakage from No. 1 and 2 bearing breather manifold and/or No. 3 bearing breather
manifold?" crlf)
   (assert (high-oil-consumption-question step-28))
   (assert (ask-question yesno))
   (retract ?fact-1)
   (retract ?fact-2)
)

(defrule high-oil-consumption-question-at-step23-no
   (high-oil-consumption-question step-23)
   ?fact-1 <- (high-oil-consumption-question step-23)
   (answer no)
   ?fact-2 <- (answer no)
=>
```

```
   (printout t "Is leakage from oil instrumentation lines?" crlf)
   (assert (high-oil-consumption-question step-29))
   (assert (ask-question yesno))
   (retract ?fact-1)
   (retract ?fact-2)
)

(defrule high-oil-consumption-question-at-step28-yes
   (high-oil-consumption-question step-28)
   ?fact-1 <- (high-oil-consumption-question step-28)
   (answer yes)
   ?fact-2 <- (answer yes)
=>
   (printout t "Replace No. 1 and 2 bearing breather manifold and/or No. 3 bearing breather manifold as
required. MM 79-21-04 R/I" crlf)
   (assert (high-oil-consumption-question diagnosis))
   (retract ?fact-1)
   (retract ?fact-2)
)

(defrule high-oil-consumption-question-at-step28-no
   (high-oil-consumption-question step-28)
   ?fact-1 <- (high-oil-consumption-question step-28)
   (answer no)
   ?fact-2 <- (answer no)
=>
   (printout t "Replace engine. MM 71-00-02" crlf)
   (assert (high-oil-consumption-question diagnosis))
   (retract ?fact-1)
   (retract ?fact-2)
)


;;;;;;;;;;;;;;;;;;;;;;;;;;;; THIRD FIM PAGE WITH BE/BD ENDS HERE ;;;;;;;;;;;;;;;;;;;;;;;;;;;;

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(defrule high-oil-consumption-question-at-step29-yes
   (high-oil-consumption-question step-29)
   ?fact-1 <- (high-oil-consumption-question step-29)
   (answer yes)
   ?fact-2 <- (answer yes)
=>
   (printout t "Replace engine. MM 71-00-02" crlf)
   (assert (high-oil-consumption-question diagnosis))
   (retract ?fact-1)
   (retract ?fact-2)
)
```

```
(defrule high-oil-consumption-question-at-step29-no
   (high-oil-consumption-question step-29)
   ?fact-1 <- (high-oil-consumption-question step-29)
   (answer no)
   ?fact-2 <- (answer no)
=>
   (printout t "Is leakage from N2 manual crank pad on main gearbox?" crlf)
   (assert (high-oil-consumption-question step-34))
   (assert (ask-question yesno))
   (retract ?fact-1)
   (retract ?fact-2)
)

(defrule high-oil-consumption-question-at-step34-yes
   (high-oil-consumption-question step-34)
   ?fact-1 <- (high-oil-consumption-question step-34)
   (answer yes)
   ?fact-2 <- (answer yes)
=>
   (printout t "Remove N2 manual crank pad and install new o-ring and gasket (if applicable). MM 72-
00-00 MP" crlf)
   (assert (high-oil-consumption-question diagnosis))
   (retract ?fact-1)
   (retract ?fact-2)
)

(defrule high-oil-consumption-question-at-step34-no
   (high-oil-consumption-question step-34)
   ?fact-1 <- (high-oil-consumption-question step-34)
   (answer no)
   ?fact-2 <- (answer no)
=>
   (printout t "Is leakage from angle gearbox?" crlf)
   (assert (high-oil-consumption-question step-36))
   (assert (ask-question yesno))
   (retract ?fact-1)
   (retract ?fact-2)
)

(defrule high-oil-consumption-question-at-step36-yes
   (high-oil-consumption-question step-36)
   ?fact-1 <- (high-oil-consumption-question step-36)
   (answer yes)
   ?fact-2 <- (answer yes)
=>
   (printout t "Replace angle gearbox.  MM 72-61-01 R/I.")
   (assert (high-oil-consumption-question diagnosis))
   (retract ?fact-1)
```

```
    (retract ?fact-2)
)

(defrule high-oil-consumption-question-at-step36-no
    (high-oil-consumption-question step-36)
    ?fact-1 <- (high-oil-consumption-question step-36)
    (answer no)
    ?fact-2 <- (answer no)
=>
    (printout t "Is leakage from main gearbox?" crlf)
    (assert (high-oil-consumption-question step-39))
    (assert (ask-question yesno))
    (retract ?fact-1)
    (retract ?fact-2)
)

(defrule high-oil-consumption-question-at-step39-yes
    (high-oil-consumption-question step-39)
    ?fact-1 <- (high-oil-consumption-question step-39)
    (answer yes)
    ?fact-2 <- (answer yes)
=>
    (printout t "Replace main gearbox.  MM 72-61-02 R/I.")
    (assert (high-oil-consumption-question diagnosis))
    (retract ?fact-1)
    (retract ?fact-2)
)

(defrule high-oil-consumption-question-at-step39-no
    (high-oil-consumption-question step-39)
    ?fact-1 <- (high-oil-consumption-question step-39)
    (answer no)
    ?fact-2 <- (answer no)
=>
    (printout t "Replace engine. MM 71-00-02" crlf)
    (assert (high-oil-consumption-question diagnosis))
    (retract ?fact-1)
    (retract ?fact-2)
)

;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;; FOURTH FIM PAGE WITH BE/BD ENDS HERE ;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;

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HERE ;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;

(defrule high-oil-consumption-question-at-step46-no
    (high-oil-consumption-question step-46)
    ?fact-1 <- (high-oil-consumption-question step-46)
    (answer no)
```

```
   ?fact-2 <- (answer no)
=>
   (printout t "Replace fuel pump. MM 73-11-01" crlf)
   (assert (high-oil-consumption-question diagnosis))
   (retract ?fact-1)
   (retract ?fact-2)
)

(defrule high-oil-consumption-question-at-step46-yes
   (high-oil-consumption-question step-46)
   ?fact-1 <- (high-oil-consumption-question step-46)
   (answer yes)
   ?fact-2 <- (answer yes)
=>
   (printout t "Check ground idle speed. MM 71-00-00 A/T, Test No. 9. Is ground idle speed low?" crlf)
   (assert (high-oil-consumption-question step-49))
   (assert (ask-question yesno))
   (retract ?fact-1)
   (retract ?fact-2)
)

(defrule high-oil-consumption-question-at-step49-yes
   (high-oil-consumption-question step-49)
   ?fact-1 <- (high-oil-consumption-question step-49)
   (answer yes)
   ?fact-2 <- (answer yes)
=>
   (printout t "Adjust ground idle speed. MM 71-00-00 A/T, Test No. 9." crlf)
   (assert (high-oil-consumption-question diagnosis))
   (retract ?fact-1)
   (retract ?fact-2)
)

(defrule high-oil-consumption-question-at-step49-no
   (high-oil-consumption-question step-49)
   ?fact-1 <- (high-oil-consumption-question step-49)
   (answer no)
   ?fact-2 <- (answer no)
=>
   (printout t "From idle power, advance thrust level slowly to increase N2 RPM by 10%.  Did N1
increase at least 10% also?" crlf)
   (assert (high-oil-consumption-question step-52))
   (assert (ask-question yesno))
   (retract ?fact-1)
   (retract ?fact-2)
)

(defrule high-oil-consumption-question-at-step52-no
   (high-oil-consumption-question step-52)
```

```
   ?fact-1 <- (high-oil-consumption-question step-52)
   (answer no)
   ?fact-2 <- (answer no)
=>
   (printout t "Replace Evc. MM 75-31-01" crlf)
   (assert (high-oil-consumption-question diagnosis))
   (retract ?fact-1)
   (retract ?fact-2)
)

(defrule high-oil-consumption-question-at-step52-yes
   (high-oil-consumption-question step-52)
   ?fact-1 <- (high-oil-consumption-question step-52)
   (answer yes)
   ?fact-2 <- (answer yes)
=>
   (printout t "The following are infrequent causes of this fault:" crlf)
   (printout t " 1. Faulty main gearbox deaerator          Ref Engine Check 3, 79-01-20 for resolution"
crlf)
   (printout t " 2. PT3 manifold leaks                    Ref Visual Check 8, 71-01-10 for resolution" crlf)
   (printout t " 3. No. 1 and 2 bearing compartment leaks  Replace Engine (MM 71-00-02)" crlf)
   (assert (high-oil-consumption-question diagnosis))
   (retract ?fact-1)
   (retract ?fact-2)
)

(defrule high-oil-consumption-question-diagnosis
   (high-oil-consumption-question diagnosis)
   ?fact-1 <- (high-oil-consumption-question diagnosis)
   (error-code ?inp1)
   ?fact-2 <- (error-code ?inp1)
   (engine-num ?inp2)
   ?fact-3 <- (engine-num ?inp2)
=>
   (printout t crlf)
   (printout t "----THANKS TO US THE PROBLEM IS SOLVED----" crlf)
   (printout t "========END OF " ?inp1 ?inp2 " PROBLEMS=======" crlf)
   (printout t "----------THANK GOD WE ARE SAFE----------" crlf)
   (retract ?fact-1)
   (retract ?fact-2)
   (retract ?fact-3)
)


;;;;;;;;;;;;;;;;;;;;;;;;; END OF FIFTH AND LAST PAGE OF FIM FOR OIL CONSUMPTION... THANK
GOD;;;;;;;;;;;;;;;;;;;;;;


;;;;;;;;;;;;;;;;;;;;;;;;;OIL PRESSURE PROBLEM TROUBLESHOOTING;;;;;;;;;;;;;;;;;;;;;;;;;
```

```
;;  CHOSEN PROBLEM 3: OIL PRESSURE

(defrule oil-pressure
   (observed-problem-number 3)
   ?fact <- (observed-problem-number 3)
=>
   (assert (error-code 79-01-CA-0))
   (assert (menu-op engine-num))
   (retract ?fact)
)

(defrule abnormal-oil-pressure
   (error-code 79-01-CA-0)
=>
   (printout t "Change thrust setting & check oil press. Did oil press follow thrust change?" crlf)
   (assert (ask-question yesno))
)

(defrule abnormal-oil-pressure-CD ;;WE CONCLUDE THAT WE HAVE A CD OIL PRESSURE
PROBLEM
   (error-code 79-01-CA-0)
   ?fact-1 <- (error-code 79-01-CA-0)
   (answer no)
   ?fact-2 <- (answer no)
=>
   (assert (error-code 79-01-CD-0))
   (assert (abnormal-oil-pressure-CD-question start))
   (retract ?fact-1)
   (retract ?fact-2)
)


;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;; FIM PAGE WITH CD STARTS HERE ;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;


(defrule abnormal-oil-pressure-CD-question-start
   (abnormal-oil-pressure-CD-question start)
   ?fact <- (abnormal-oil-pressure-CD-question start)
=>
   (printout t "Connect line for air pressure to elbow of oil pressure transmitter, T422. Apply 45 PSI.
Does indicator read 40 to 45 PSI?" crlf)
   (assert (abnormal-oil-pressure-CD-question step-0))
   (assert (ask-question yesno))
   (retract ?fact)
)

(defrule abnormal-oil-pressure-CD-question-at-step0-yes
   (abnormal-oil-pressure-CD-question step-0)
```

```
   ?fact-1 <- (abnormal-oil-pressure-CD-question step-0)
   (answer yes)
   ?fact-2 <- (answer yes)
=>
   (printout t "Adjust oil pressure.  MM 71-00-00 A/T, Test No. 7.  Observe oil pressure indicator. Is oil
pressure within limits?" crlf)
   (assert (abnormal-oil-pressure-CD-question step-1))
   (assert (ask-question yesno))
   (retract ?fact-1)
   (retract ?fact-2)
)

(defrule abnormal-oil-pressure-CD-question-at-step0-no
   (abnormal-oil-pressure-CD-question step-0)
   ?fact-1 <- (abnormal-oil-pressure-CD-question step-0)
   (answer no)
   ?fact-2 <- (answer no)
=>
   (printout t "Exchange oil pressure indicators, N30, N31, N32, or N33.  MM 79-32-03." crlf)
   (printout t "Apply 40 to 45 PSI to transmitter. Does indicator read 40 to 45 PSI?" crlf)
   (assert (abnormal-oil-pressure-CD-question step-2))
   (assert (ask-question yesno))
   (retract ?fact-1)
   (retract ?fact-2)
)

(defrule abnormal-oil-pressure-CD-question-at-step1-no
   (abnormal-oil-pressure-CD-question step-1)
   ?fact-1 <- (abnormal-oil-pressure-CD-question step-1)
   (answer no)
   ?fact-2 <- (answer no)
=>
   (printout t "Replace oil pressure regulating valve. MM 72-61-03." crlf)
   (assert (abnormal-oil-pressure-CD-question diagnosis))
   (retract ?fact-1)
   (retract ?fact-2)
)

(defrule abnormal-oil-pressure-CD-question-at-step1-yes
   (abnormal-oil-pressure-CD-question step-1)
   ?fact-1 <- (abnormal-oil-pressure-CD-question step-1)
   (answer yes)
   ?fact-2 <- (answer yes)
=>
   (printout t "The following item may be an infrequent cause of abnormal oil pressure:" crlf)
   (printout t "     COMPONENT          CORRECTIVE ACTION" crlf)
   (printout t "     ---------          -----------------" crlf)
   (printout t "   Main Oil Pump   Replace main oil pump (MM 72-61-17)" crlf)
   (assert (abnormal-oil-pressure-CD-question diagnosis))
```

```
   (retract ?fact-1)
   (retract ?fact-2)
)

(defrule abnormal-oil-pressure-CD-question-at-step2-yes
   (abnormal-oil-pressure-CD-question step-2)
   ?fact-1 <- (abnormal-oil-pressure-CD-question step-2)
   (answer yes)
   ?fact-2 <- (answer yes)
=>
   (printout t "Replace indicator. MM 79-32-03" crlf)
   (assert (abnormal-oil-pressure-CD-question diagnosis))
   (retract ?fact-1)
   (retract ?fact-2)
)

(defrule abnormal-oil-pressure-CD-question-at-step2-no
   (abnormal-oil-pressure-CD-question step-2)
   ?fact-1 <- (abnormal-oil-pressure-CD-question step-2)
   (answer no)
   ?fact-2 <- (answer no)
=>
   (printout t "Replace engine oil pressure transmitter, T422. MM 79-32-01." crlf)
   (assert (abnormal-oil-pressure-CD-question diagnosis))
   (retract ?fact-1)
   (retract ?fact-2)
)

(defrule abnormal-oil-pressure-CD-question-diagnosis
   (abnormal-oil-pressure-CD-question diagnosis)
   ?fact-1 <- (abnormal-oil-pressure-CD-question diagnosis)
   (error-code ?inp1)
   ?fact-2 <- (error-code ?inp1)
   (engine-num ?inp2)
   ?fact-3 <- (engine-num ?inp2)
=>
   (printout t crlf)
   (printout t "----THANKS TO US THE PROBLEM IS SOLVED----" crlf)
   (printout t "========END OF " ?inp1 ?inp2 " PROBLEMS=======" crlf)
   (printout t "----------THANK GOD WE ARE SAFE----------" crlf)
   (retract ?fact-1)
   (retract ?fact-2)
   (retract ?fact-3)
)

;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;; FIM PAGE WITH CD ENDS HERE ;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;

;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;; FIM PAGE WITH CE STARTS HERE ;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;
```

```
(defrule abnormal-oil-pressure-CE  ;;WE COCNCLUDE THAT WE HAVE A CE OIL PRESSURE
PROBLEM
   (error-code 79-01-CA-0)
   ?fact-1 <- (error-code 79-01-CA-0)
   (answer yes)
   ?fact-2 <- (answer yes)
=>
   (assert (error-code 79-01-CE-0))
   (assert (abnormal-oil-pressure-CE-question start))
   (retract ?fact-1)
   (retract ?fact-2)
)

(defrule abnormal-oil-pressure-CE-question-start
   (abnormal-oil-pressure-CE-question start)
   ?fact <- (abnormal-oil-pressure-CE-question start)
=>
   (printout t "Examine magnetic chip detectors and main oil strainer per Engine Check 18, 71-01-20.
Was contamination abnormal?" crlf)
   (assert (abnormal-oil-pressure-CE-question step-0))
   (assert (ask-question yesno))
   (retract ?fact)
)

(defrule abnormal-oil-pressure-CE-question-at-step0-yes
   (abnormal-oil-pressure-CE-question step-0)
   ?fact-1 <- (abnormal-oil-pressure-CE-question step-0)
   (answer yes)
   ?fact-2 <- (answer yes)
=>
   (printout t "Replace main oil strainer.  MM 72-61-05. Replace main oil pressure regulating valve.
MM 72-61-03.  Perform oil system contamination inspection.  MM 72-00-00 I/C." crlf)
   (assert (abnormal-oil-pressure-CE-question diagnosis))
   (retract ?fact-1)
   (retract ?fact-2)
)

(defrule abnormal-oil-pressure-CE-question-at-step0-no
   (abnormal-oil-pressure-CE-question step-0)
   ?fact-1 <- (abnormal-oil-pressure-CE-question step-0)
   (answer no)
   ?fact-2 <- (answer no)
=>
   (printout t "Exchange oil pressure indicators, N30, N31, N32, or N33.  MM 79-32-03. Connect air
pressure source to elbow on oil pressure transmitter, T422. Apply 45 PSI.  Observe oil pressure
indication.  Does indicator read 40-45 PSI?" crlf)
   (assert (abnormal-oil-pressure-CE-question step-2))
   (assert (ask-question yesno))
   (retract ?fact-1)
```

```
    (retract ?fact-2)
)

(defrule abnormal-oil-pressure-CE-question-at-step2-yes
    (abnormal-oil-pressure-CE-question step-2)
    ?fact-1 <- (abnormal-oil-pressure-CE-question step-2)
    (answer yes)
    ?fact-2 <- (answer yes)
=>
    (printout t "Replace indicator. MM 79-32-03" crlf)
    (assert (abnormal-oil-pressure-CE-question diagnosis))
    (retract ?fact-1)
    (retract ?fact-2)
)

(defrule abnormal-oil-pressure-CE-question-at-step2-no
    (abnormal-oil-pressure-CE-question step-2)
    ?fact-1 <- (abnormal-oil-pressure-CE-question step-2)
    (answer no)
    ?fact-2 <- (answer no)
=>
    (printout t "Replace engine oil pressure transmitter, T422. MM 79-32-01" crlf)
    (assert (abnormal-oil-pressure-CE-question diagnosis))
    (retract ?fact-1)
    (retract ?fact-2)
)

(defrule abnormal-oil-pressure-CE-question-end
    (abnormal-oil-pressure-CE-question diagnosis)
    ?fact-1 <- (abnormal-oil-pressure-CE-question diagnosis)
    (error-code ?inp1)
    ?fact-2 <- (error-code ?inp1)
    (engine-num ?inp2)
    ?fact-3 <- (engine-num ?inp2)
=>
    (printout t crlf)
    (printout t "----THANKS TO US THE PROBLEM IS SOLVED----" crlf)
    (printout t "========END OF " ?inp1 ?inp2 " PROBLEMS=======" crlf)
    (printout t "----------THANK GOD WE ARE SAFE-----------" crlf)
    (retract ?fact-1)
    (retract ?fact-2)
    (retract ?fact-3)
)


;;;;;;;;;;;;;;;;;;;;;;;;;;;;;; FIM PAGE WITH CE ENDS HERE ;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;
```