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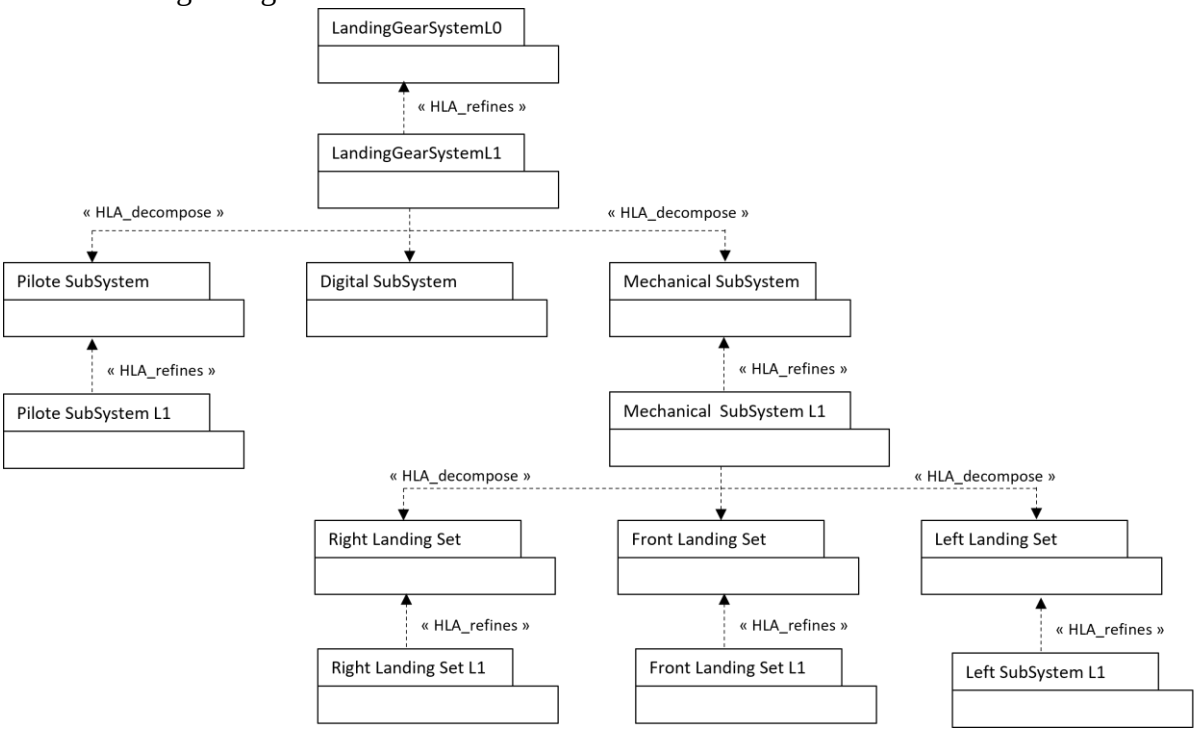
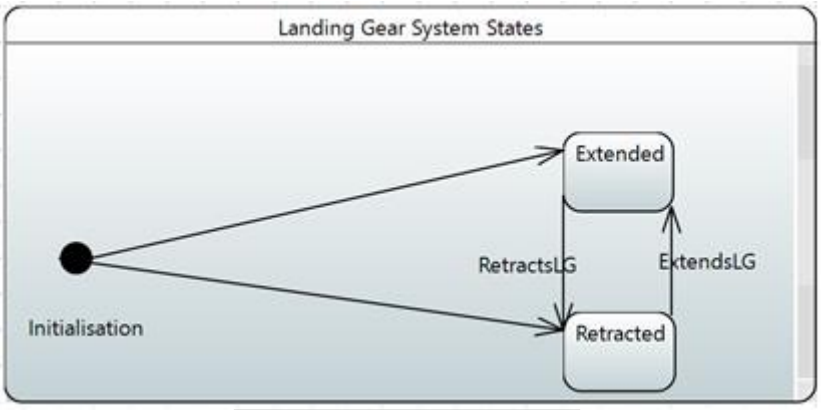
High-Level Architecture

- Package Diagram :

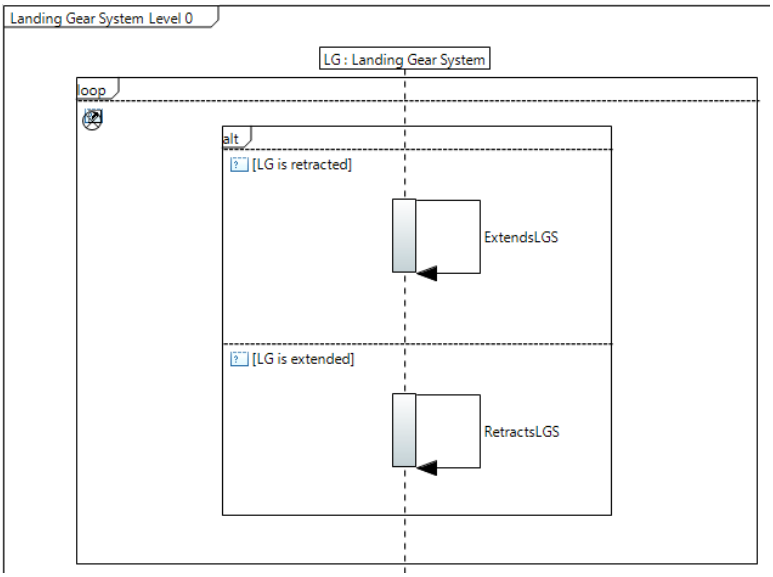


- LandingGearSystemL0 :

Block Definition Diagram



State-Machine Diagram



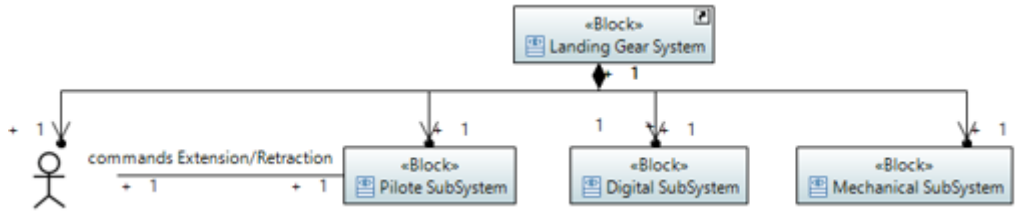
Sequence Diagram

- Event_B specification of LandingGearSystemL0:

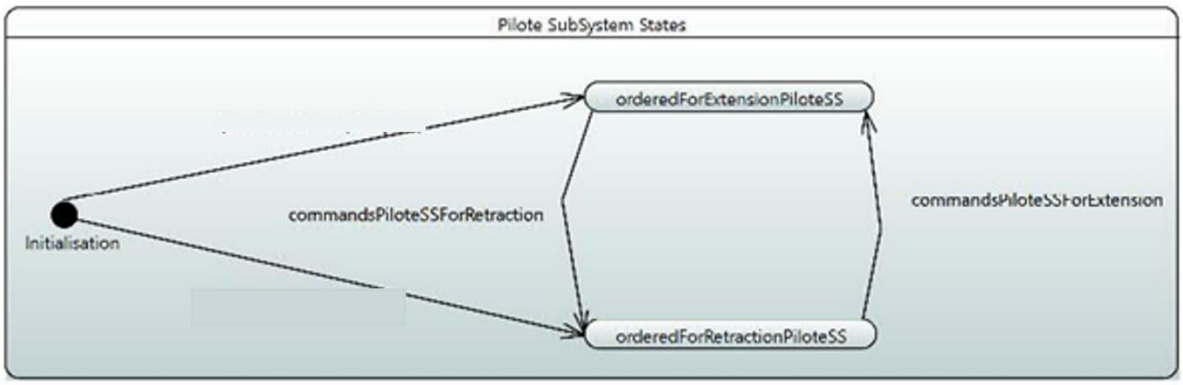
```
SYSTEM
    LandingGearSystemL0_CONT
SETS
    LandingGearSystem;
    LandingGearSystemStates
CONSTANTS
    lg,
    Extended,
    Retracted
PROPERTIES
    lg ∈ LandingGearSystem ∧
    LandingGearSystem ={lg} ∧
    Retracted ∈ LandingGearSystemStates ∧
    Extended ∈ LandingGearSystemStates ∧
    Retracted ≠ Extended ∧
    LandingGearSystemStates ={Extended, Retracted}
END
```

```
SYSTEM
    LandingGearSystemL0
SEES
    LandingGearSystemL0_CONT
VARIABLES
    lgState
INVARIANT
    lgState ∈ LandingGearSystem → LandingGearSystemStates
INITIALISATION
    lgState :∈ {lg} →LandingGearSystemStates
EVENTS
    RetractsLGS =
    SELECT
        lgState(lg)=Extended
    THEN
    lgState(lg):=Retracted
    END;
    ExtendsLGS =
    SELECT
        lgState(lg)=Retracted
    THEN
        lgState(lg):=Extended
    END
END
```

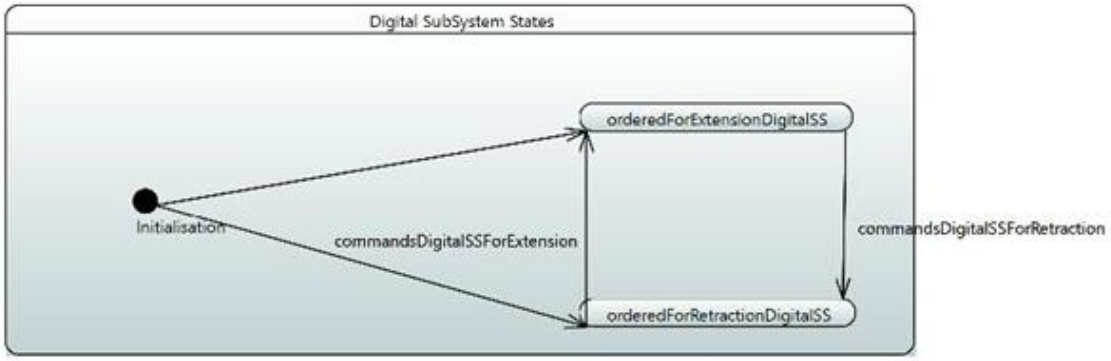
- LandingGearSystemL1:



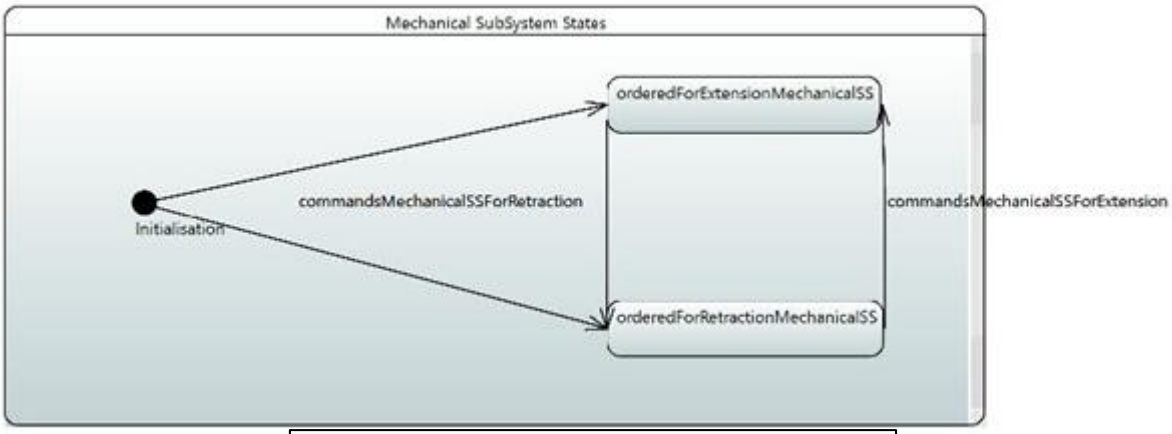
Block Definition Diagram



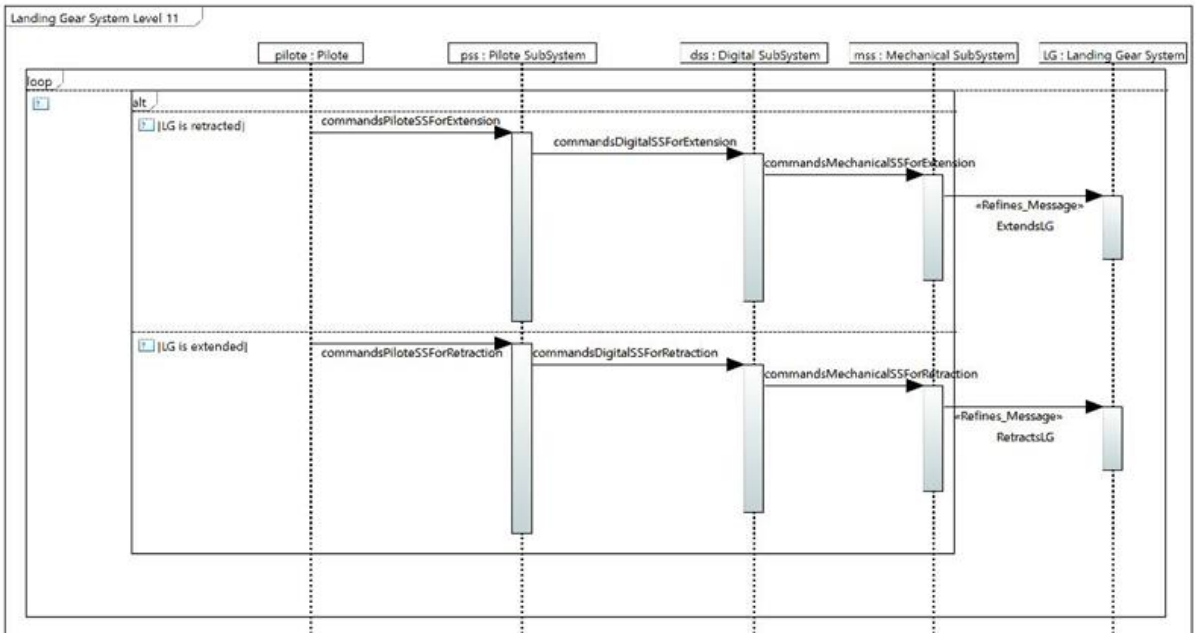
Pilote SubSystem state-machine Diagram



Digital SubSystem state-machine Diagram



Mechanical SubSystem state-machine Diagram



Sequence Diagram of LandingGearSystemL1

- Event_B specification of LandingGearSystemL1:

SYSTEM

LandingGearSystemL1_CONT

SETS

DigitalSubSystem;
MechanicalSubSystem;
PiloteSubSystem;
DigitalSubSystemStates;
PiloteSubSystemStates;
MechanicalSubSystemStates;
PILOT

CONSTANTS

mss,
dss,
pss,
pilot,
orderedForExtensionMechanicalSS,
orderedForRetractionPiloteSS,
orderedForExtensionDigitalSS,
orderedForExtensionPiloteSS,
orderedForRetractionDigitalSS,
orderedForRetractionMechanicalSS,
commandsExtension,
commandsRetraction

PROPERTIES

mss ∈ MechanicalSubSystem ∧
dss ∈ DigitalSubSystem ∧
pss ∈ PiloteSubSystem ∧
pilot ∈ PILOT ∧
PILOT={pilot} ∧
PiloteSubSystem ={pss} ∧
MechanicalSubSystem ={mss} ∧

DigitalSubSystem ={dss} ∧
orderedForRetractionPiloteSS ∈ PiloteSubSystemStates ∧
orderedForExtensionPiloteSS ∈ PiloteSubSystemStates ∧
orderedForExtensionMechanicalSS ∈ MechanicalSubSystemStates ∧
orderedForRetractionDigitalSS ∈ DigitalSubSystemStates ∧
orderedForExtensionDigitalSS ∈ DigitalSubSystemStates ∧
orderedForRetractionMechanicalSS ∈ MechanicalSubSystemStates ∧
orderedForExtensionPiloteSS ≠ orderedForRetractionPiloteSS ∧
orderedForExtensionDigitalSS ≠ orderedForRetractionDigitalSS ∧
orderedForRetractionMechanicalSS ≠ orderedForExtensionMechanicalSS ∧
DigitalSubSystemStates ={orderedForRetractionDigitalSS,
orderedForExtensionDigitalSS} ∧
PiloteSubSystemStates ={orderedForRetractionPiloteSS,
orderedForExtensionPiloteSS} ∧
MechanicalSubSystemStates ={orderedForExtensionMechanicalSS,
orderedForRetractionMechanicalSS} ∧
commandsExtension ∈ {pilot} ↦ {pss} ∧
commandsRetraction ∈ {pilot} ↦ {pss}

END

REFINEMENT

LandingGearSystemL1

REFINES

LandingGearSystemL0

SEES

LandingGearSystemL1_CONT,
LandingGearSystemL0_CONT

VARIABLES

dssState,
mssState,
pssState,
lgState

INVARIANT

dssState ∈ DigitalSubSystem → DigitalSubSystemStates ∧
mssState ∈ MechanicalSubSystem → MechanicalSubSystemStates ∧
pssState ∈ PiloteSubSystem → PiloteSubSystemStates

INITIALISATION

dssState :∈ {dss} →DigitalSubSystemStates ||
mssState :∈ {mss} →MechanicalSubSystemStates ||
pssState :∈ {pss} →PiloteSubSystemStates ||
lgState :∈ {lg} →LandingGearSystemStates

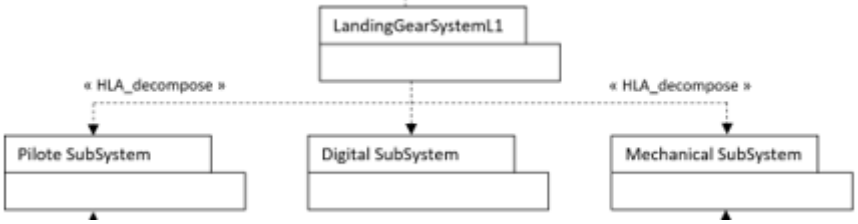
EVENTS

commandsMechanicalSSForRetraction =
SELECT
dssState(dss)=orderedForRetractionDigitalSS ∧
mssState(mss)=orderedForExtensionMechanicalSS
THEN
mssState(mss):=orderedForRetractionMechanicalSS
END;
ExtendsLG ref ExtendsLGS=
SELECT

```
            lgState(lg)=Retracted ∧
            mssState(mss)=orderedForExtensionMechanicalSS
        THEN
            lgState(lg):=Extended
        END;
        commandsMechanicalSSForExtension =
        SELECT
            dssState(dss)=orderedForExtensionDigitalSS ∧
            mssState(mss)=orderedForRetractionMechanicalSS
        THEN
            mssState(mss):=orderedForExtensionMechanicalSS
        END;
        RetractsLG ref RetractsLGS=
        SELECT
            lgState(lg)=Extended ∧
            mssState(mss)=orderedForRetractionMechanicalSS
        THEN
            lgState(lg):=Retracted
        END;
        commandsDigitalSSForRetraction =
        SELECT
            pssState(pss)=orderedForRetractionPiloteSS ∧
            dssState(dss)=orderedForExtensionDigitalSS
        THEN
            dssState(dss):=orderedForRetractionDigitalSS
        END;
        commandsPiloteSSForExtension =
        SELECT
            lgState(lg)=Retracted ∧
            pssState(pss)=orderedForRetractionPiloteSS
        THEN
            pssState(pss):=orderedForExtensionPiloteSS
        END;

        commandsDigitalSSForExtension =
        SELECT
            pssState(pss)=orderedForExtensionPiloteSS ∧
            dssState(dss)=orderedForRetractionDigitalSS
        THEN
            dssState(dss):=orderedForExtensionDigitalSS
        END;
        commandsPiloteSSForRetraction =
        SELECT
            lgState(lg)=Extended ∧
            pssState(pss)=orderedForExtensionPiloteSS
        THEN
            pssState(pss):=orderedForRetractionPiloteSS
        END
END
```

- LandingGearSystemL1 decomposition:



❖ Pilote SubSystem:

- *Event_B specification of PiloteSubSystem_Interface:*

```
SYSTEM
    PiloteSubSystem_Interface
SEES
    LandingGearSystemL1_CONT,
    LandingGearSystemL0_CONT
VARIABLES
    pssState
INVARIANT
    pssState ∈ PiloteSubSystem → PiloteSubSystemStates
INITIALISATION
    pssState :∈ {pss} →PiloteSubSystemStates
EVENTS
    commandsDigitalSSForRetraction =
    SELECT
        pssState(pss)=orderedForRetractionPiloteSS
    THEN
        skip
    END;
    commandsPiloteSSForExtension =
    SELECT
        pssState(pss)=orderedForRetractionPiloteSS
    THEN
        pssState(pss):=orderedForExtensionPiloteSS
    END;
    commandsDigitalSSForExtension =
    SELECT
        pssState(pss)=orderedForExtensionPiloteSS
    THEN
        skip
    END;
    commandsPiloteSSForRetraction =
    SELECT
        pssState(pss)=orderedForExtensionPiloteSS
    THEN
        pssState(pss):=orderedForRetractionPiloteSS
    END
END
```

❖ Digital SubSystem:

- *Event_B specification of DigitalSubSystem_Interface:*

```
SYSTEM
        DigitalSubSystem_Interface
SEES
        LandingGearSystemL1_CONT,
        LandingGearSystemL0_CONT
VARIABLES
        dssState
INVARIANT
        dssState ∈ DigitalSubSystem → DigitalSubSystemStates
INITIALISATION
        dssState :∈ {dss} →DigitalSubSystemStates
EVENTS
        commandsDigitalSSForRetraction =
        SELECT
                dssState(dss)=orderedForExtensionDigitalSS
        THEN
                dssState(dss):=orderedForRetractionDigitalSS
        END ;
        commandsDigitalSSForExtension =
        SELECT
                dssState(dss)=orderedForRetractionDigitalSS
        THEN
                dssState(dss):=orderedForExtensionDigitalSS
        END ;

         commandsMechanicalSSForRetraction =
         SELECT
                 dssState(dss)=orderedForRetractionDigitalSS
         THEN
                 skip
         END ;
         commandsMechanicalSSForExtension =
         SELECT
                 dssState(dss)=orderedForExtensionDigitalSS
         THEN
                 skip
         END
END
```

❖ Mechanical SubSystem:

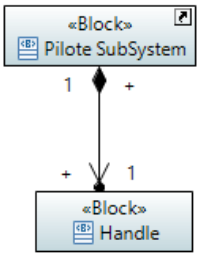
- *Event_B specification of MechanicalSubSystem_Interface:*

```
SYSTEM
    MechanicalSubSystem_Interface
SEES
    LandingGearSystemL1_CONT,
    LandingGearSystemL0_CONT
VARIABLES
    mssState
INVARIANT
    mssState ∈ MechanicalSubSystem → MechanicalSubSystemStates
INITIALISATION
    mssState :∈ {mss} →MechanicalSubSystemStates
EVENTS
    commandsMechanicalSSForRetraction =
    SELECT
        mssState(mss)=orderedForExtensionMechanicalSS
    THEN
        mssState(mss):=orderedForRetractionMechanicalSS
    END;
    ExtendsLG =
    SELECT
        mssState(mss)=orderedForExtensionMechanicalSS
    THEN
        skip
    END;
    commandsMechanicalSSForExtension =
    SELECT
        mssState(mss)=orderedForRetractionMechanicalSS
    THEN
        mssState(mss):=orderedForExtensionMechanicalSS
    END;
    RetractsLG =
    SELECT
        mssState(mss)=orderedForRetractionMechanicalSS
    THEN
        skip
    END
END
```

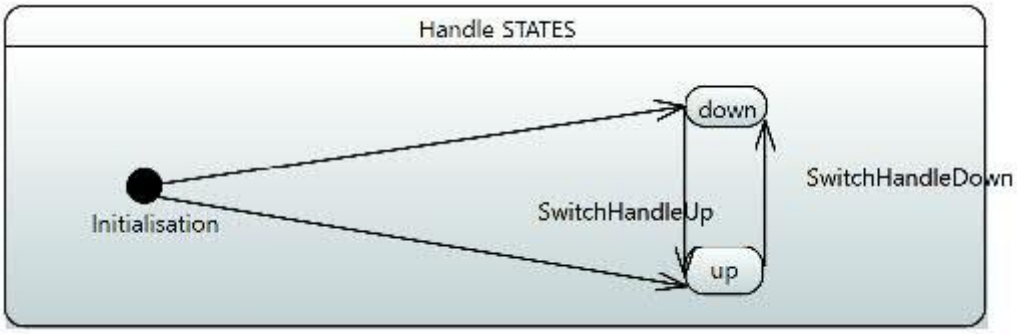
- *LandingGearSystemL1_Refinement_Interface:*

```
SYSTEM
    LandingGearSystemL1_Refinement_Interface
SEES
    LandingGearSystemL1_CONT,
    LandingGearSystemL0_CONT
VARIABLES
    lgState
INVARIANT
    lgState ∈ LandingGearSystem → LandingGearSystemStates
INITIALISATION
    lgState :∈ {lg} →LandingGearSystemStates
EVENTS
    ExtendsLG =
    SELECT
        lgState(lg)=Retracted
    THEN
        lgState(lg):=Extended
    END;
    RetractsLG =
    SELECT
        lgState(lg)=Extended
    THEN
        lgState(lg):=Retracted
    END;
    commandsPiloteSSForExtension =
    SELECT
        lgState(lg)=Retracted
    THEN
        skip
    END;
    commandsPiloteSSForRetraction =
    SELECT
        lgState(lg)=Extended
    THEN
        skip
    END
END
```

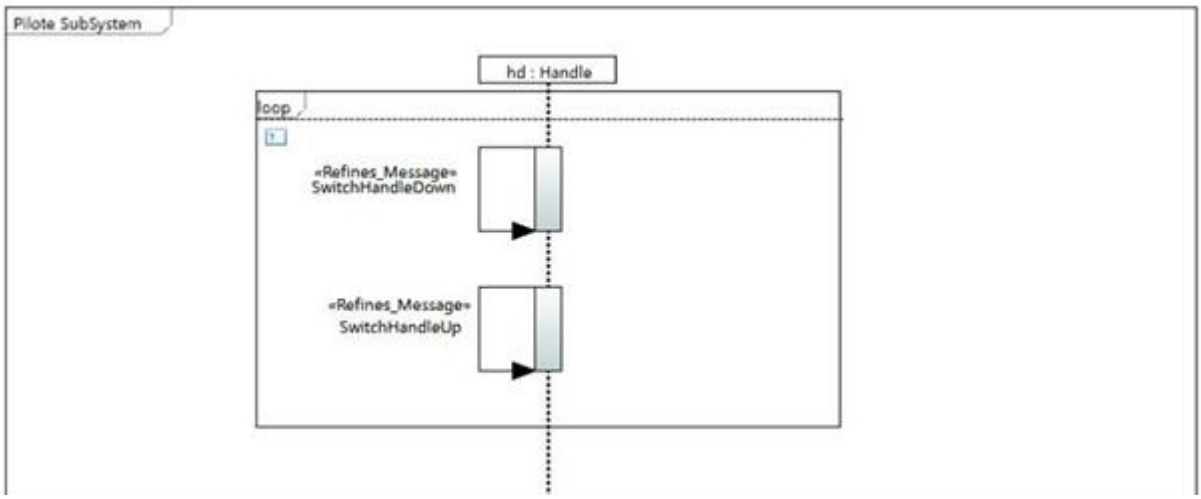
- PiloteSubSystemL1:



Block Definition Diagram of PiloteSubSystemL1



State-machine Diagram of Handle



Sequence Diagram of PiloteSubSystemL1

- Event_B specification of PiloteSubSystemL1:

SYSTEM

PiloteSubSystem_CONT

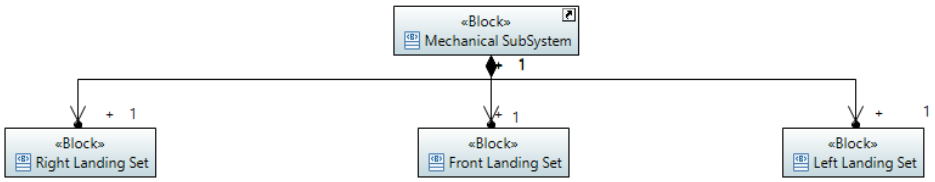
SETS

Handle;

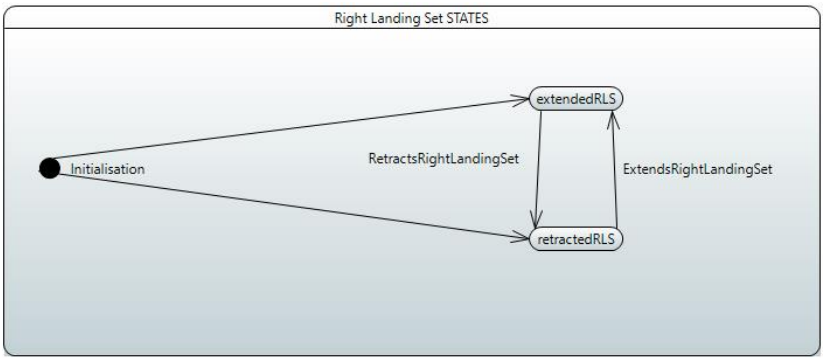
HandleSTATES
CONSTANTS
hd,
down,
up
PROPERTIES
hd ∈ Handle ∧
Handle ={hd} ∧
down ∈ HandleSTATES ∧
up ∈ HandleSTATES ∧
up ≠ down ∧
HandleSTATES ={down, up}
END

REFINEMENT
PiloteSubSystemL1
REFINES
PiloteSubSystem_Interface
SEES
PiloteSubSystem_CONT,
LandingGearSystemL1_CONT,
LandingGearSystemL0_CONT
VARIABLES
hdState,
pssState
INVARIANT
hdState ∈ Handle → HandleSTATES
INITIALISATION
hdState :∈ {hd} →HandleSTATES ||
pssState :∈ {pss} →PiloteSubSystemStates
EVENTS
SwitchHandleUp ref commandsPiloteSSForRetraction=
SELECT
hdState(hd)=down ∧
pssState(pss)=orderedForExtensionPiloteSS
THEN
hdState(hd):=up ||
pssState(pss):=orderedForRetractionPiloteSS
END;
SwitchHandleDown ref commandsPiloteSSForExtension=
SELECT
hdState(hd)=up ∧
pssState(pss)=orderedForRetractionPiloteSS
THEN
hdState(hd):=down ||
pssState(pss):=orderedForExtensionPiloteSS
END
END

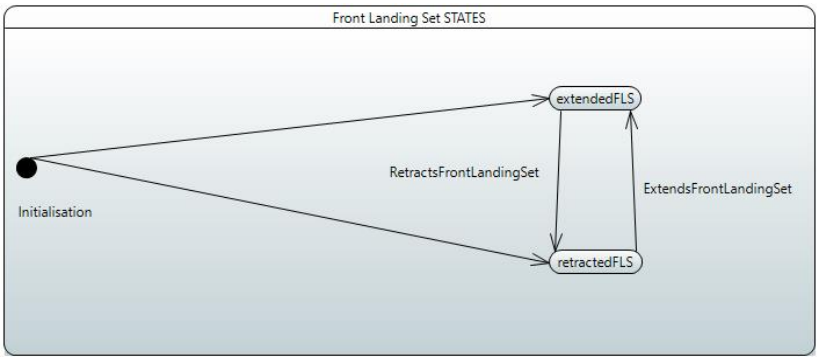
- MechanicalSubSystemL1:



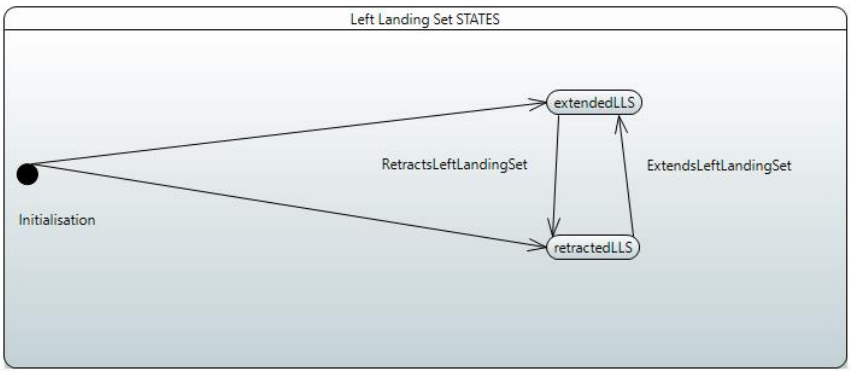
Block Definition Diagram of MechanicalSubSystemL1



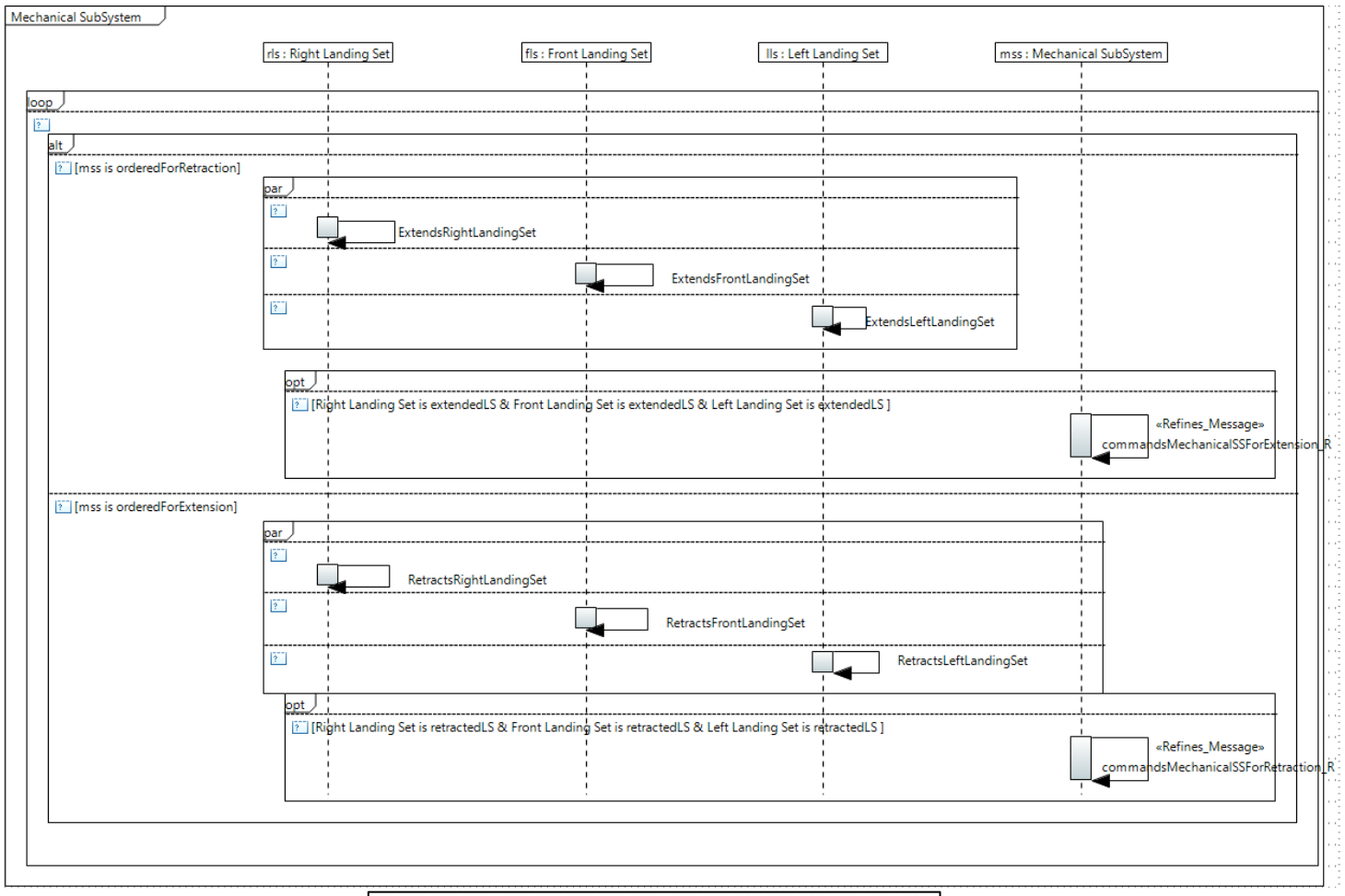
State-machine Diagram of Right Landing Set



State-machine Diagram of Front Landing Set



State-machine Diagram of Left Landing Set



Sequence Diagram of Mechanical SubSystem L1

- Event_B specification of MechanicalSubSystemL1:

SYSTEM

MechanicalSubSystem_CONT

SETS

LeftLandingSet;
FrontLandingSet;
RightLandingSet;
LeftLandingSetSTATES;
FrontLandingSetSTATES;
RightLandingSetSTATES

CONSTANTS

fls,
lls,
rls,
extendedRLS,
retractedRLS,
extendedFLS,
retractedFLS,
retractedLLS,
extendedLLS

PROPERTIES

rls ∈ RightLandingSet ∧
fls ∈ FrontLandingSet ∧
lls ∈ LeftLandingSet ∧
FrontLandingSet ={fls} ∧

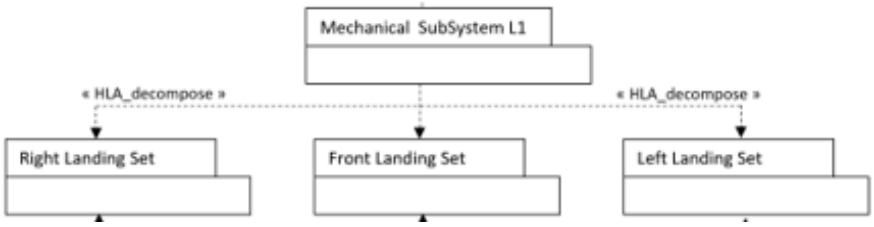
LeftLandingSet ={lls} ∧
RightLandingSet ={rls} ∧
extendedLLS ∈ LeftLandingSetSTATES ∧
retractedLLS ∈ LeftLandingSetSTATES ∧
extendedRLS ∈ RightLandingSetSTATES ∧
retractedFLS ∈ FrontLandingSetSTATES ∧
retractedRLS ∈ RightLandingSetSTATES ∧
extendedFLS ∈ FrontLandingSetSTATES ∧
extendedRLS ≠ retractedRLS ∧
extendedFLS ≠ retractedFLS ∧
extendedLLS ≠ retractedLLS ∧
LeftLandingSetSTATES ={extendedLLS, retractedLLS} ∧
FrontLandingSetSTATES ={retractedFLS, extendedFLS} ∧
RightLandingSetSTATES ={retractedRLS, extendedRLS}

END

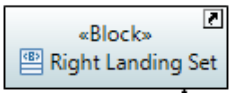
REFINEMENT
MechanicalSubSystemL1
REFINES
MechanicalSubSystem_Interface
SEES
MechanicalSubSystem_CONT,
LandingGearSystemL1_CONT,
LandingGearSystemL0_CONT
VARIABLES
flsState,
llsState,
rlsState,
mssState
INVARIANT
flsState ∈ FrontLandingSet → FrontLandingSetSTATES ∧
llsState ∈ LeftLandingSet → LeftLandingSetSTATES ∧
rlsState ∈ RightLandingSet → RightLandingSetSTATES
INITIALISATION
flsState :∈ {fls} →FrontLandingSetSTATES ||
llsState :∈ {lls} →LeftLandingSetSTATES ||
rlsState :∈ {rls} →RightLandingSetSTATES ||
mssState :∈ {mss} →MechanicalSubSystemStates
EVENTS
ExtendsRightLandingSet =
SELECT
rlsState(rls)=retractedRLS ∧
mssState(mss)= orderedForRetractionMechanicalSS
THEN
rlsState(rls):=extendedRLS
END;
RetractsFrontLandingSet =
SELECT
flsState(fls)=extendedFLS ∧
mssState(mss)= orderedForExtensionMechanicalSS
THEN

```
            flsState(fls):=retractedFLS
        END;
        ExtendsLeftLandingSet =
        SELECT
            llsState(lls)=retractedLLS ∧
            mssState(mss)= orderedForRetractionMechanicalSS
        THEN
            llsState(lls):=extendedLLS
        END;
        CommandsMechanicalSSForExtension_R ref CommandsMechanicalSSForExtension=
        SELECT
            rlsState(rls)=extendedRLS ∧
            flsState(fls)=extendedFLS ∧
            llsState(lls)=extendedLLS ∧
            mssState(mss)= orderedForRetractionMechanicalSS
        THEN
            mssState(mss):= orderedForExtensionMechanicalSS
             END;
        commandsMechanicalSSForRetraction_R ref commandsMechanicalSSForRetraction=
        SELECT
            rlsState(rls)=retractedRLS ∧
            flsState(fls)=retractedFLS ∧
            llsState(lls)=retractedLLS ∧
            mssState(mss)= orderedForExtensionMechanicalSS
        THEN
            mssState(mss):=orderedForRetractionMechanicalSS END;
        ExtendsFrontLandingSet =
        SELECT
            flsState(fls)=retractedFLS ∧
            mssState(mss)= orderedForRetractionMechanicalSS
        THEN
            flsState(fls):=extendedFLS
        END;
        RetractsRightLandingSet =
        SELECT
            rlsState(rls)=extendedRLS ∧
            mssState(mss)= orderedForExtensionMechanicalSS
        THEN
            rlsState(rls):=retractedRLS
        END;
        RetractsLeftLandingSet =
        SELECT
            llsState(lls)=extendedLLS ∧
            mssState(mss)= orderedForExtensionMechanicalSS
        THEN
            llsState(lls):=retractedLLS
        END
END
```

- MechanicalSubSystemL1 decomposition:



❖ Right Landing Set:



- *Event_B specification of RightLandingSet_Interface:*

SYSTEM
RightLandingSet_Interface
SEES
MechanicalSubSystem_CONT,
LandingGearSystemL1_CONT,
LandingGearSystemL0_CONT
VARIABLES
rlsState
INVARIANT
rlsState ∈ RightLandingSet → RightLandingSetSTATES
INITIALISATION
rlsState :∈ {rls} →RightLandingSetSTATES
EVENTS
ExtendsRightLandingSet =
SELECT
rlsState(rls)=retractedRLS
THEN
rlsState(rls):=extendedRLS
END;
ExtendsLGSS =
SELECT
rlsState(rls)=extendedRLS
THEN
skip
END;
RetractsLGSS =
SELECT
rlsState(rls)=retractedRLS
THEN
skip
END;
RetractsRightLandingSet =
SELECT
rlsState(rls)=extendedRLS
THEN

```
        rlsState(rls):=retractedRLS
    END
END
```

❖ Front Landing Set:

- *Event_B specification of FrontLandingSet_Interface:*

```
SYSTEM
    FrontLandingSet_Interface
SEES
    MechanicalSubSystem_CONT,
    LandingGearSystemL1_CONT,
    LandingGearSystemL0_CONT
VARIABLES
    flsState
INVARIANT
    flsState ∈ FrontLandingSet → FrontLandingSetSTATES
INITIALISATION
    flsState :∈ {fls} →FrontLandingSetSTATES
EVENTS
    RetractsFrontLandingSet =
    SELECT
        flsState(fls)=extendedFLS
    THEN
        flsState(fls):=retractedFLS
    END;
    ExtendsLG =
    SELECT
        flsState(fls)=extendedFLS
    THEN
        skip END;
    RetractsLG =
    SELECT
        flsState(fls)=retractedFLS
    THEN
        skip END;
    ExtendsFrontLandingSet =
    SELECT
        flsState(fls)=retractedFLS
    THEN
        flsState(fls):=extendedFLS
    END
END
```

❖ Left Landing Set:

- *Event_B specification of LeftLandingSet_Interface:*

```
SYSTEM
    LeftLandingSet_Interface
SEES
    MechanicalSubSystem_CONT,
    LandingGearSystemL1_CONT,
    LandingGearSystemL0_CONT
VARIABLES
    llsState
INVARIANT
    llsState ∈ LeftLandingSet → LeftLandingSetSTATES
INITIALISATION
    llsState :∈ {lls} →LeftLandingSetSTATES
EVENTS
    ExtendsLeftLandingSet =
    SELECT
        llsState(lls)=retractedLLS
    THEN
        llsState(lls):=extendedLLS
    END;
    ExtendsLG =
    SELECT
        llsState(lls)=extendedLLS
    THEN
        skip END;
    RetractsLG =
    SELECT
        llsState(lls)=retractedLLS
    THEN
        skip END;
    RetractsLeftLandingSet =
    SELECT
        llsState(lls)=extendedLLS
    THEN
        llsState(lls):=retractedLLS
    END
END
```

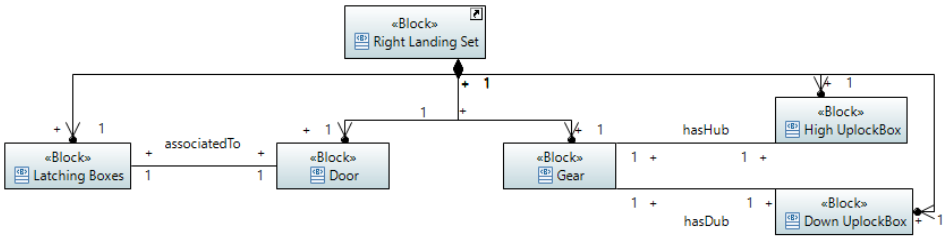
- *MechanicalSubSystem_Refinement_Interface:*

```
SYSTEM
    MechanicalSubSystem_Refinement_Interface
SEES
    MechanicalSubSystem_CONT,
    LandingGearSystemL1_CONT,
    LandingGearSystemL0_CONT
VARIABLES
    mssState
INVARIANT
```

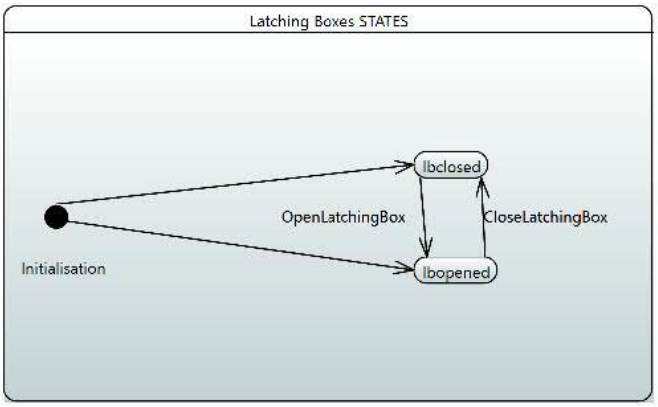
```
        mssState ∈ MechanicalSubSystem → MechanicalSubSystemStates
INITIALISATION
        mssState :∈ {mss} →MechanicalSubSystemStates
EVENTS
        ExtendsRightLandingSet =
        SELECT
                mssState(mss)=orderedForExtensionMechanicalSS
        THEN
                skip END;
        RetractsFrontLandingSet =
        SELECT
                mssState(mss)=orderedForRetractionMechanicalSS
        THEN
                skip END;
        ExtendsLeftLandingSet =
        SELECT
                mssState(mss)=orderedForExtensionMechanicalSS
        THEN
                skip END;
        ExtendsLG =
        SELECT
                mssState(mss)=orderedForExtensionMechanicalSS
        THEN
                skip END;
        RetractsLG =
        SELECT
                mssState(mss)=orderedForRetractionMechanicalSS
        THEN
                skip END;
        ExtendsFrontLandingSet =
        SELECT
                mssState(mss)=orderedForExtensionMechanicalSS
        THEN
                skip END;
        RetractsRightLandingSet =
        SELECT
                mssState(mss)=orderedForRetractionMechanicalSS
        THEN
                skip END;

        RetractsLeftLandingSet =
        SELECT
                mssState(mss)=orderedForRetractionMechanicalSS
        THEN
                skip END
END
```

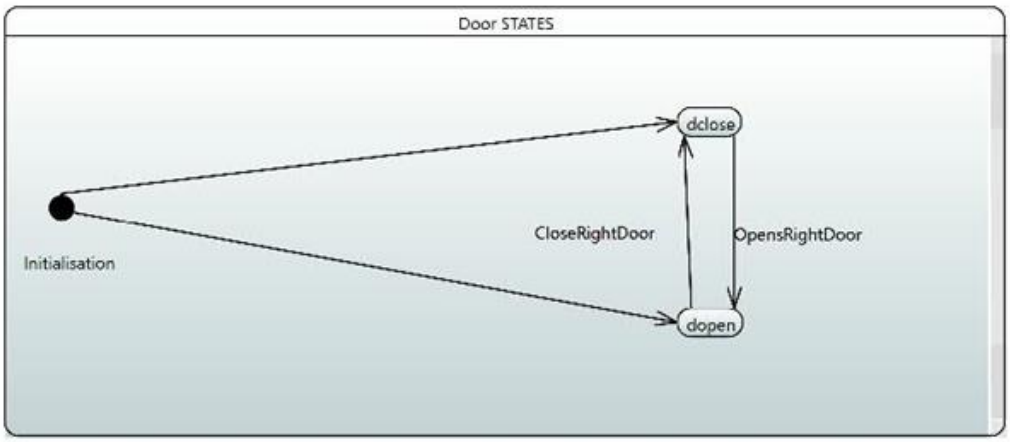
- Right Landing Set L1:



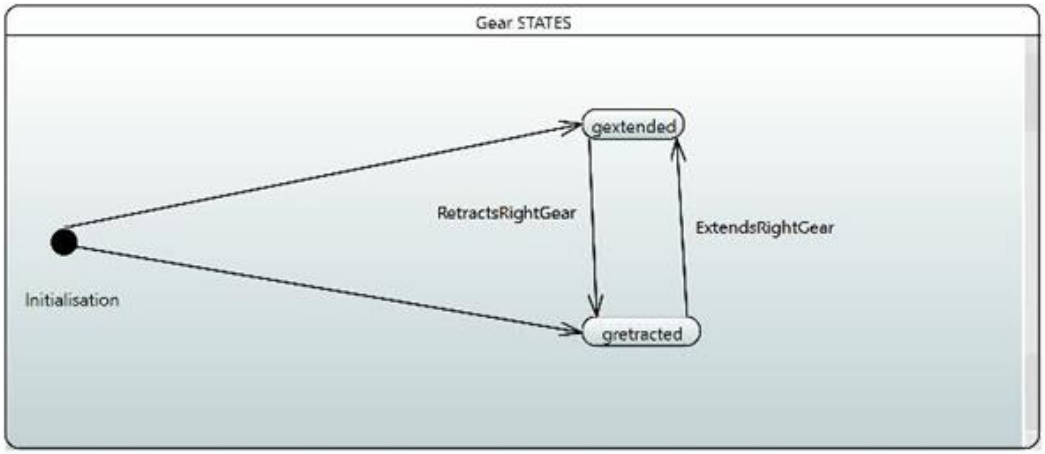
Block Definition Diagram of RightLandingSetL1



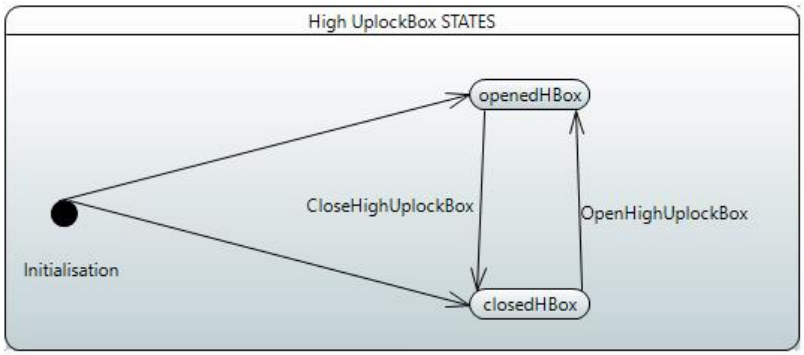
State-machine Diagram of Latching Boxes



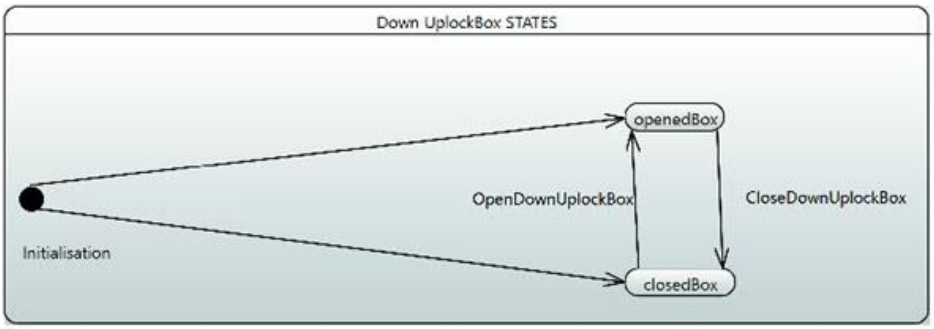
State-machine Diagram of Right Door



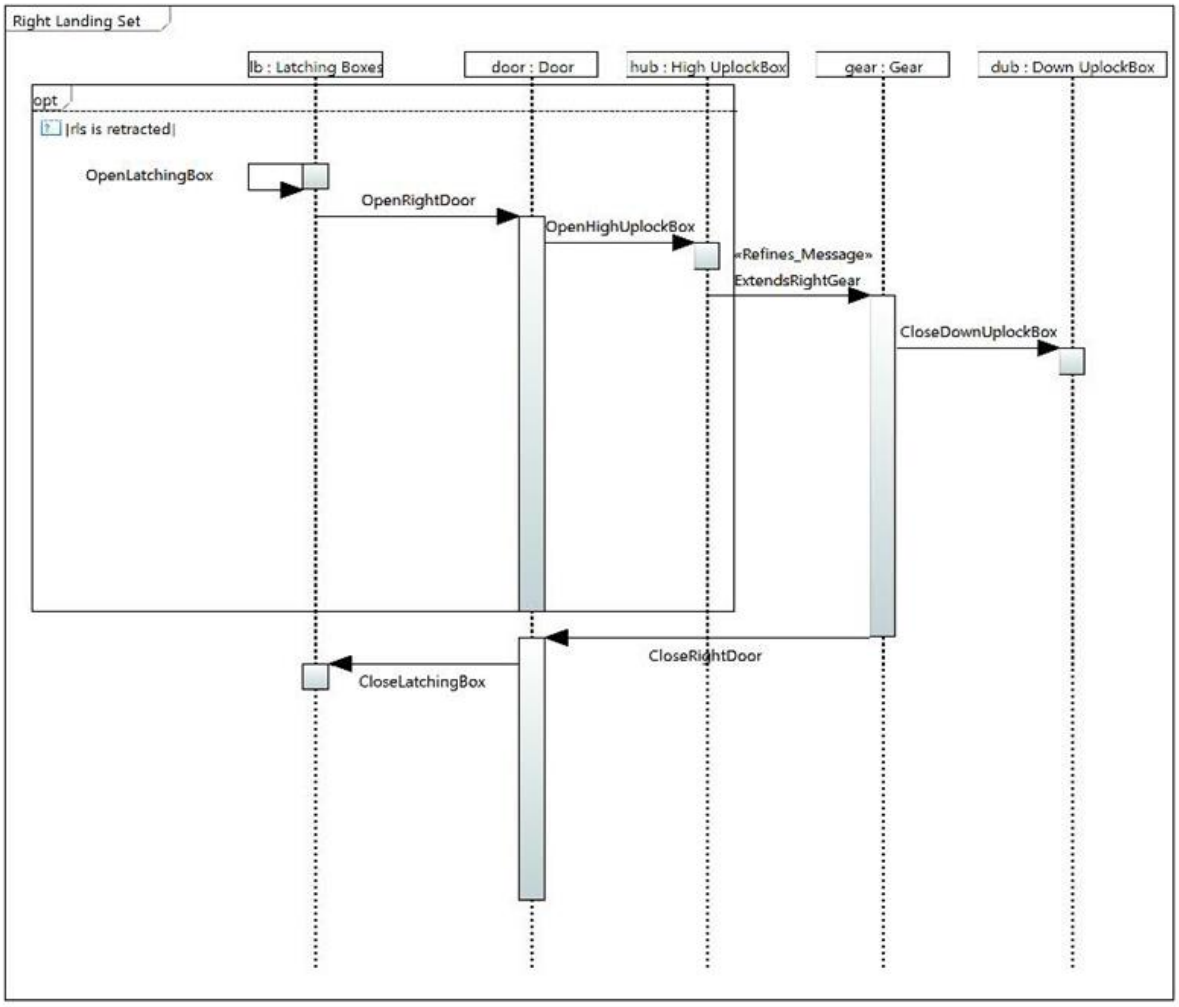
State-machine Diagram of Right Gear



State-machine Diagram of High UplockBox



State-machine Diagram of Down UplockBox



Sequence Diagram of RightLandingSetL1

- Event_B specification of RightLandingSetL1:

SYSTEM
RightLandingSet_CONT
SETS
HighUplockBox;
DownUplockBox;
Gear;
LatchingBoxes;
Door;
DoorSTATES;
HighUplockBoxSTATES;
DownUplockBoxSTATES;
GearSTATES;
LatchingBoxesSTATES
CONSTANTS
gear,
lb,
hub,
dub,
door,
openedHBox,
openedDBox,
closedHBox,
dclose,
gextended,
lbclosed,
dopen,
gretracted,
lbopened,
closedDBox,
hasHub,
hasDub,
associatedTo
PROPERTIES
dub ∈ DownUplockBox ∧
lb ∈ LatchingBoxes ∧
hub ∈ HighUplockBox ∧
door ∈ Door ∧
gear ∈ Gear ∧
HighUplockBox ={hub} ∧
DownUplockBox ={dub} ∧
Gear ={gear} ∧
Door ={door} ∧
LatchingBoxes ={lb} ∧
closedHBox ∈ HighUplockBoxSTATES ∧
dopen ∈ DoorSTATES ∧
openedDBox ∈ DownUplockBoxSTATES ∧
openedHBox ∈ HighUplockBoxSTATES ∧
lbopened ∈ LatchingBoxesSTATES ∧
closedDBox ∈ DownUplockBoxSTATES ∧

gretracted ∈ GearSTATES ∧
lbclosed ∈ LatchingBoxesSTATES ∧
gextended ∈ GearSTATES ∧
dclose ∈ DoorSTATES ∧
gretracted ≠ gextended ∧
dclose ≠ dopen ∧
lbopened ≠ lbclosed ∧
openedHBox ≠ closedHBox ∧
openedDBox ≠ closedDBox ∧
GearSTATES ={gextended, gretracted} ∧
DownUplockBoxSTATES ={closedDBox, openedDBox} ∧
LatchingBoxesSTATES ={lbclosed, lbopened} ∧
HighUplockBoxSTATES ={closedHBox, openedHBox} ∧
DoorSTATES ={dopen, dclose} ∧
hasHub ∈ {gear} ↦ {hub} ∧
hasDub ∈ {gear} ↦{dub} ∧
associatedTo ∈ {lb} ↦ {door}

END

REFINEMENT
RightLandingSetL1

REFINES
RightLandingSet_Interface

SEES
RightLandingSet_CONT,
MechanicalSubSystem_CONT,
LandingGearSystemL1_CONT,
LandingGearSystemL0_CONT

VARIABLES
doorState,
dubState,
gearState,
hubState,
lbState,
rlsState

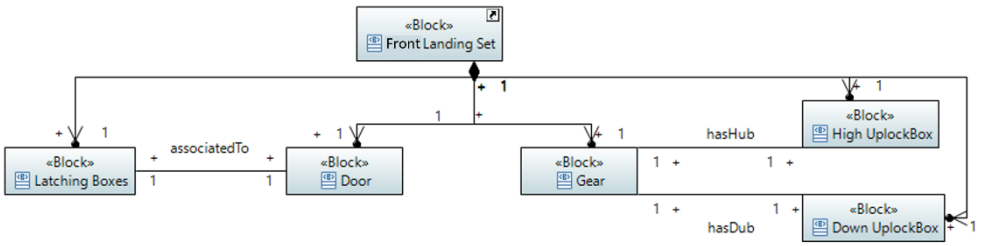
INVARIANT
doorState ∈ Door → DoorSTATES ∧
dubState ∈ DownUplockBox → DownUplockBoxSTATES ∧
gearState ∈ Gear → GearSTATES ∧
hubState ∈ HighUplockBox → HighUplockBoxSTATES ∧
lbState ∈ LatchingBoxes → LatchingBoxesSTATES

INITIALISATION
doorState :∈ {door} →DoorSTATES ||
dubState :∈ {dub} →DownUplockBoxSTATES ||
gearState :∈ {gear} →GearSTATES ||
hubState :∈ {hub} →HighUplockBoxSTATES ||
lbState :∈ {lb} →LatchingBoxesSTATES ||
rlsState :∈ {rls} →RightLandingSetSTATES

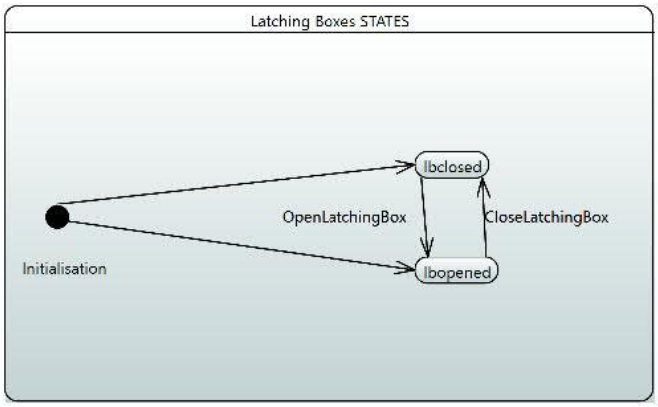
EVENTS
OpenRightDoor =

```
        SELECT
                lbState(lb)=lbopened ∧
                doorState(door)=dclose
        THEN
                doorState(door):=dopen
        END;
        CloseLatchingBox =
        SELECT
                doorState(door)=dclose ∧
                lbState(lb)=lbopened
        THEN
                lbState(lb):=lbclosed
        END;
        ExtendsRightGear ref ExtendsRightLandingSet=
        SELECT
                hubState(hub)=openedHBox ∧
                gearState(gear)=gretracted ∧
                rlsState(rls)=retractedRLS
        THEN
                gearState(gear):=gextended ||
                rlsState(rls):=extendedRLS
        END;
        OpenHighUplockBox =
        SELECT
                doorState(door)=dopen ∧
                hubState(hub)=closedHBox
        THEN
                hubState(hub):=openedHBox
        END;
        OpenLatchingBox =
        SELECT
                lbState(lb)=lbclosed
        THEN
                lbState(lb):=lbopened
        END;
        CloseRightDoor =
        SELECT
                dubState(dub)=closedDBox ∧
                doorState(door)=dopen
        THEN
                doorState(door):=dclose
        END;
        CloseDownUplockBox =
        SELECT
                gearState(gear)=gextended ∧
                dubState(dub)=openedDBox
        THEN
                dubState(dub):=closedDBox
        END
END
```

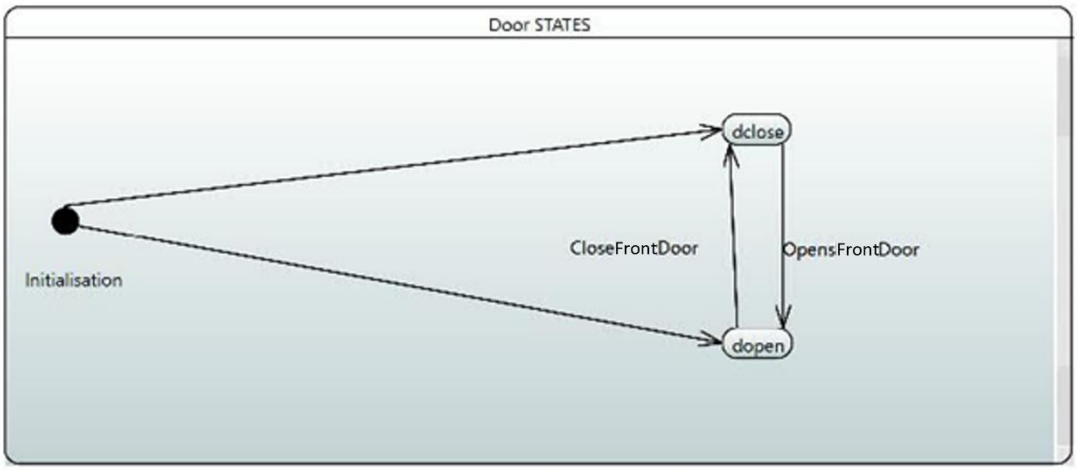
- Front Landing Set L1:



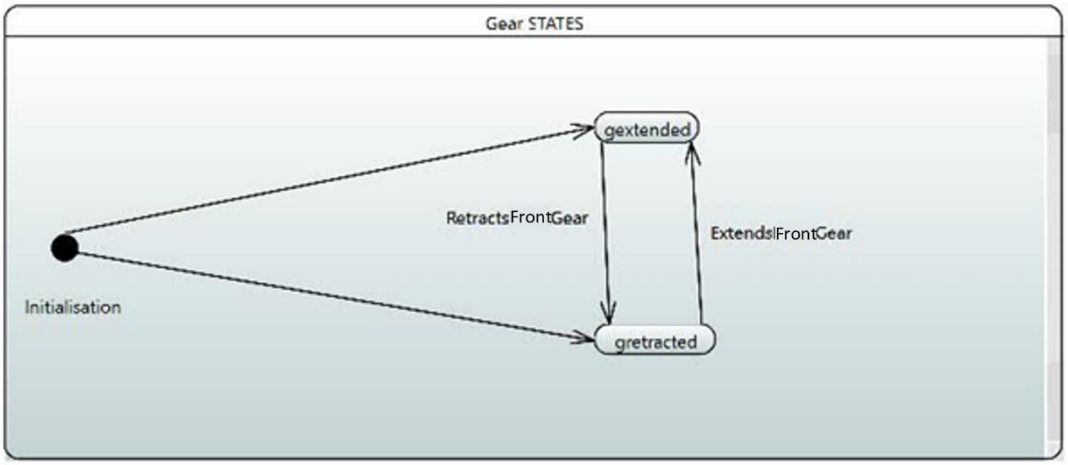
Block Definition Diagram of FrontLandingSetL1



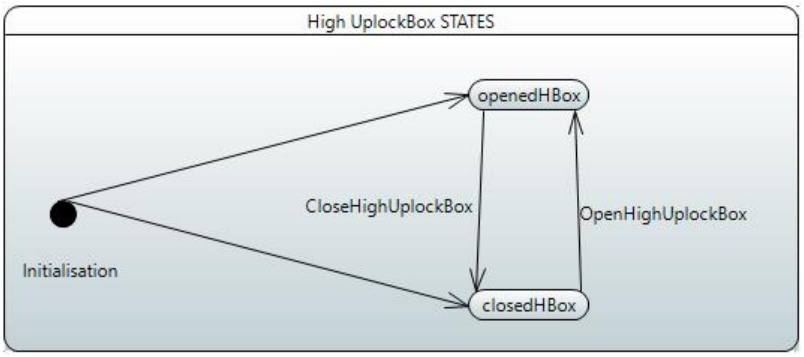
State-machine Diagram of Latching Boxes



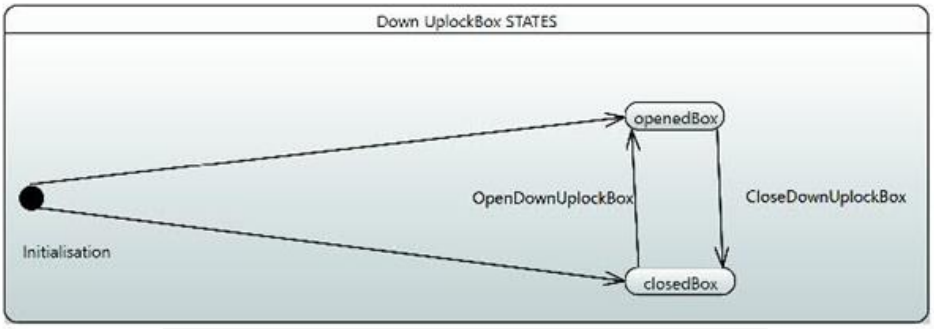
State-machine Diagram of Front Door



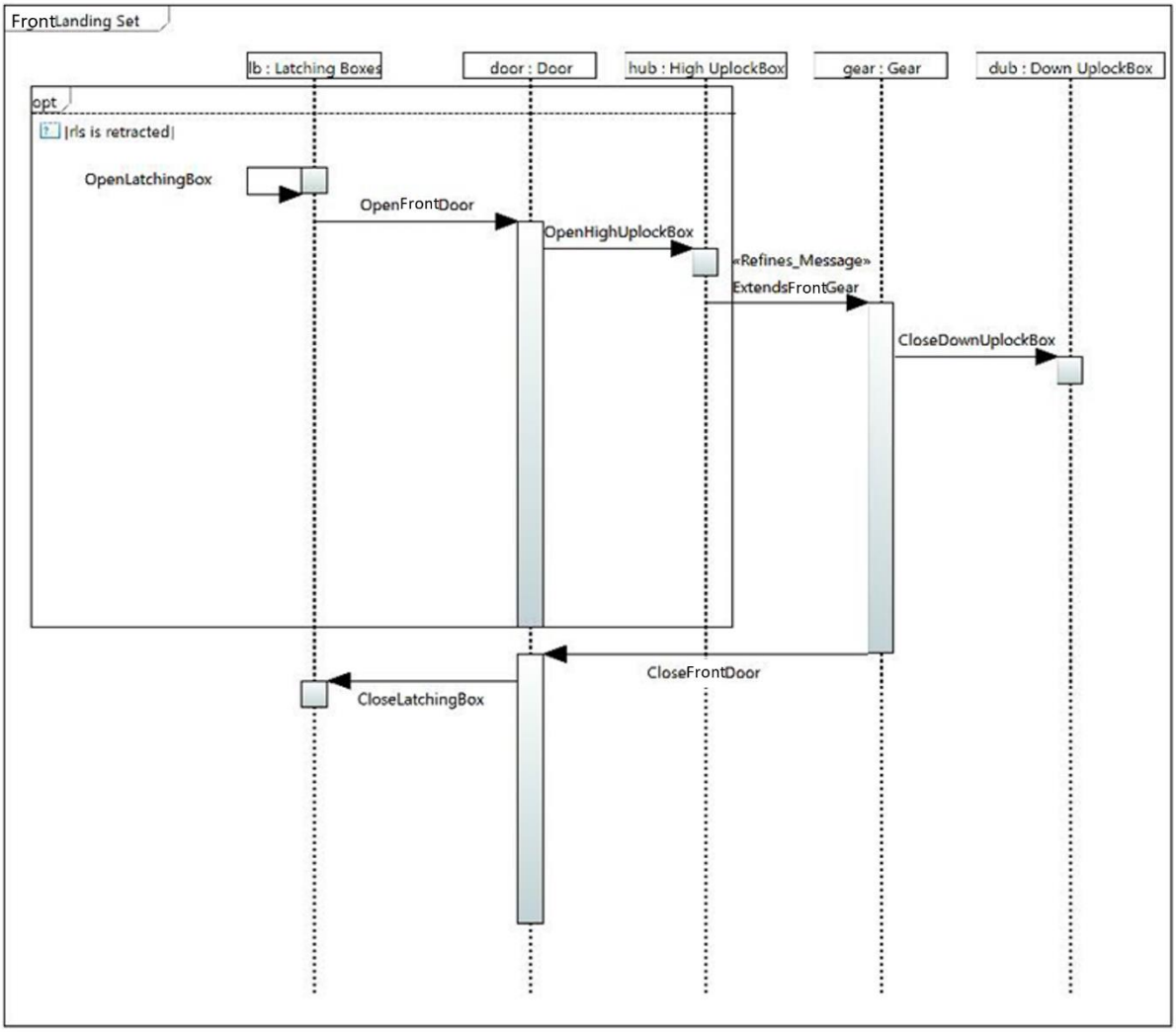
State-machine Diagram of Front Gear



State-machine Diagram of High UplockBox



State-machine Diagram of Down UplockBox



Sequence Diagram of FrontLandingSetL1

- Event_B specification of FrontLandingSetL1:

SYSTEM

FrontLandingSet_CONT

SETS

HighUplockBox;
LatchingBoxes;
Gear;
Door;
DownUplockBox;
GearSTATES;
LatchingBoxesSTATES;
HighUplockBoxSTATES;

DownUplockBoxSTATES;
DoorSTATES

CONSTANTS

hub,
door,
lb,
dub,
gear,
openedHBox,
openedDBox,
closedHBox,
dclose,
gextended,
lbopened,
gretracted,
lbclosed,
dopen,
closedDBox,
hasHub,
hasDub,
associatedTo

PROPERTIES

dub ∈ DownUplockBox ∧
lb ∈ LatchingBoxes ∧
hub ∈ HighUplockBox ∧
door ∈ Door ∧
gear ∈ Gear ∧
HighUplockBox ={hub} ∧
DownUplockBox ={dub} ∧
Gear ={gear} ∧
Door ={door} ∧
LatchingBoxes ={lb} ∧
closedHBox ∈ HighUplockBoxSTATES ∧
dopen ∈ DoorSTATES ∧
openedDBox ∈ DownUplockBoxSTATES ∧
openedHBox ∈ HighUplockBoxSTATES ∧
lbopened ∈ LatchingBoxesSTATES ∧
closedDBox ∈ DownUplockBoxSTATES ∧
gretracted ∈ GearSTATES ∧
lbclosed ∈ LatchingBoxesSTATES ∧
gextended ∈ GearSTATES ∧
dclose ∈ DoorSTATES ∧
gretracted ≠ gextended ∧
dclose ≠ dopen ∧
lbopened ≠ lbclosed ∧
openedHBox ≠ closedHBox ∧
openedDBox ≠ closedDBox ∧
GearSTATES ={gextended, gretracted} ∧
DownUplockBoxSTATES ={closedDBox, openedDBox} ∧
LatchingBoxesSTATES ={lbclosed, lbopened} ∧

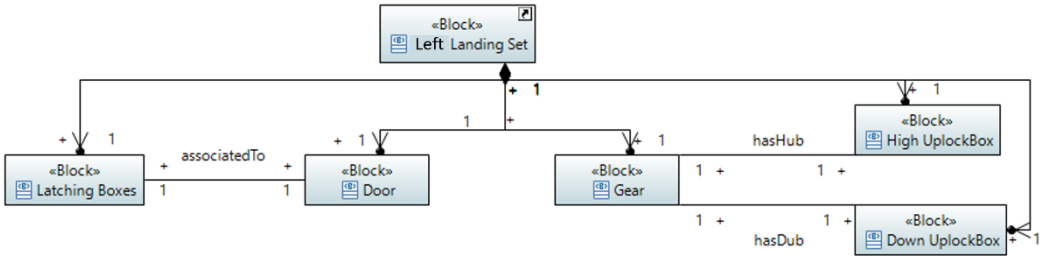
HighUplockBoxSTATES ={closedHBox, openedHBox} ∧
DoorSTATES ={dopen, dclose} ∧
hasHub ∈ {gear} ↦ {hub} ∧
hasDub ∈ {gear} ↦{dub} ∧
associatedTo ∈ {lb} ↦ {door}

END

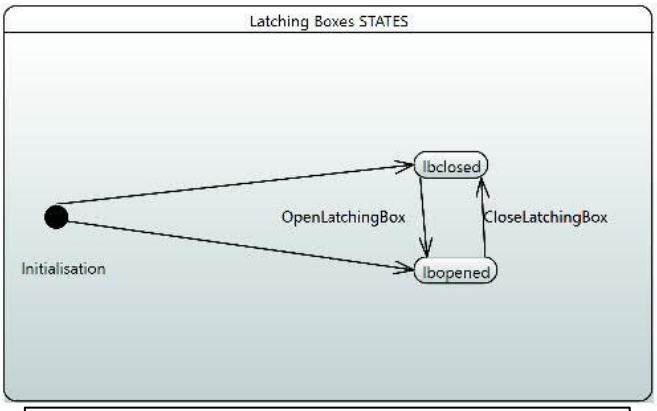
REFINEMENT
FrontLandingSetL1
REFINES
FrontLandingSet_Interface
SEES
FrontLandingSet_CONT,
MechanicalSubSystem_CONT,
LandingGearSystemL1_CONT,
LandingGearSystemL0_CONT
VARIABLES
doorState,
dubState,
gearState,
hubState,
lbState,
flsState
INVARIANT
doorState ∈ Door → DoorSTATES ∧
dubState ∈ DownUplockBox → DownUplockBoxSTATES ∧
gearState ∈ Gear → GearSTATES ∧
hubState ∈ HighUplockBox → HighUplockBoxSTATES ∧
lbState ∈ LatchingBoxes → LatchingBoxesSTATES
INITIALISATION
doorState :∈ {door} →DoorSTATES ||
dubState :∈ {dub} →DownUplockBoxSTATES ||
gearState :∈ {gear} →GearSTATES ||
hubState :∈ {hub} →HighUplockBoxSTATES ||
lbState :∈ {lb} →LatchingBoxesSTATES ||
flsState :∈ {fls} →FrontLandingSetSTATES
EVENTS
CloseDownUplockBox =
SELECT
gearState(gear)=gextended ∧
dubState(dub)=openedDBox
THEN
dubState(dub):=closedDBox
END;
CloseFrontDoor =
SELECT
dubState(dub)=closedDBox ∧
doorState(door)=dopen
THEN
doorState(door):=dclose
END;

```
        OpenFrontDoor =
        SELECT
                lbState(lb)=lbopened ∧
                doorState(door)=dclose
        THEN
                doorState(door):=dopen
        END;
        CloseLatchingBox =
        SELECT
                doorState(door)=dclose ∧
                lbState(lb)=lbopened
        THEN
                lbState(lb):=lbclosed
        END;
        OpenLatchingBox =
        SELECT
                lbState(lb)=lbclosed
        THEN
                lbState(lb):=lbopened
        END;
        OpenHighUplockBox =
        SELECT
                doorState(door)=dopen ∧
                hubState(hub)=closedHBox
        THEN
                hubState(hub):=openedHBox
        END;
        ExtendsFrontGear ref ExtendsFrontLandingSet=
        SELECT
                hubState(hub)=openedHBox ∧
                gearState(gear)=gretracted ∧
                flsState(fls)=retractedFLS
        THEN
                gearState(gear):=gextended ||
                flsState(fls):=extendedFLS
        END
END
```

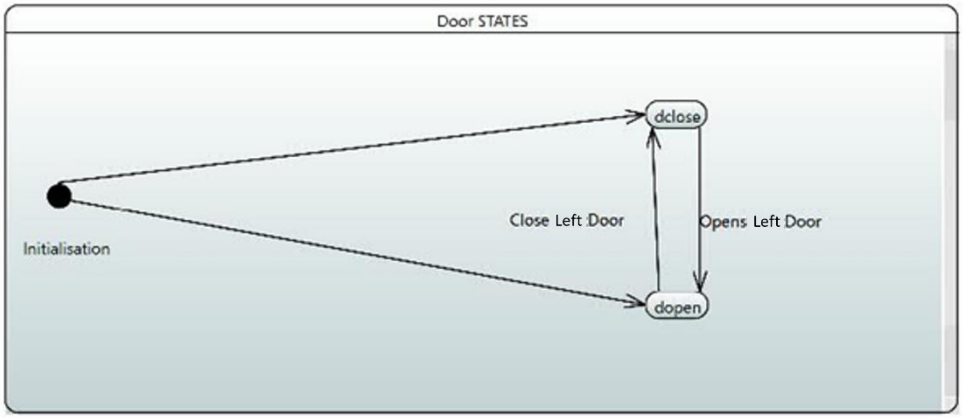
- Left Landing Set L1:



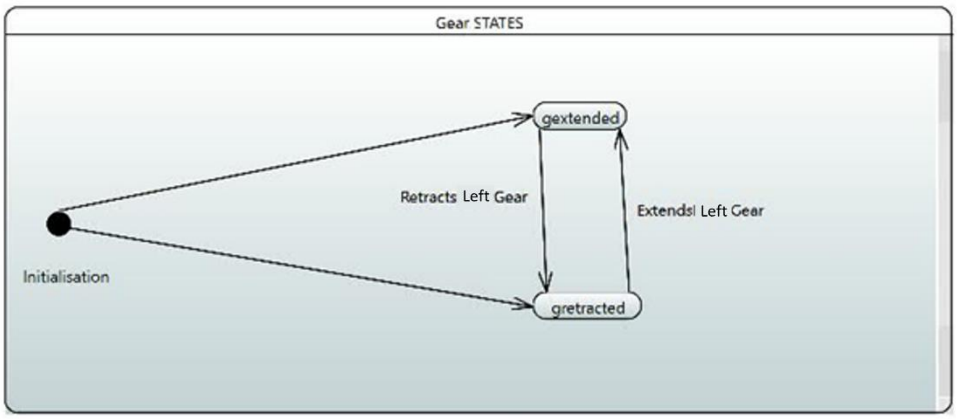
Block Definition Diagram of LeftLandingSetL1



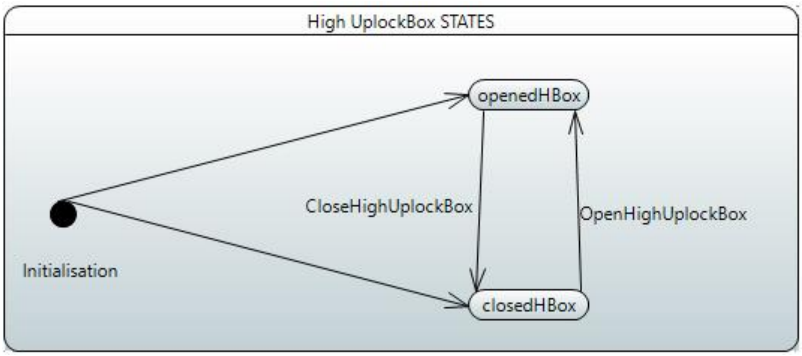
State-machine Diagram of Latching Boxes



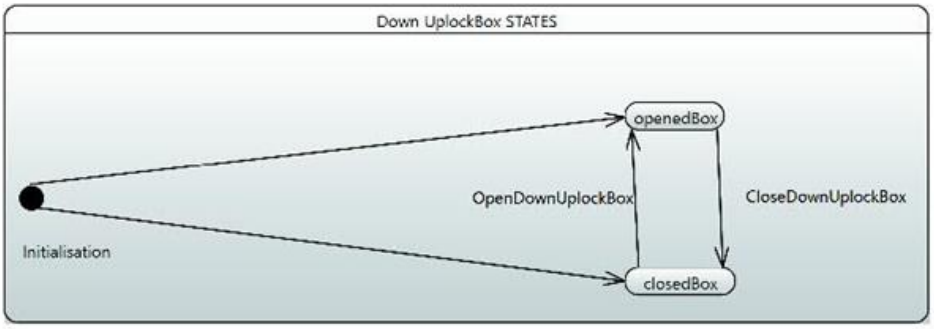
State-machine Diagram of Left Door



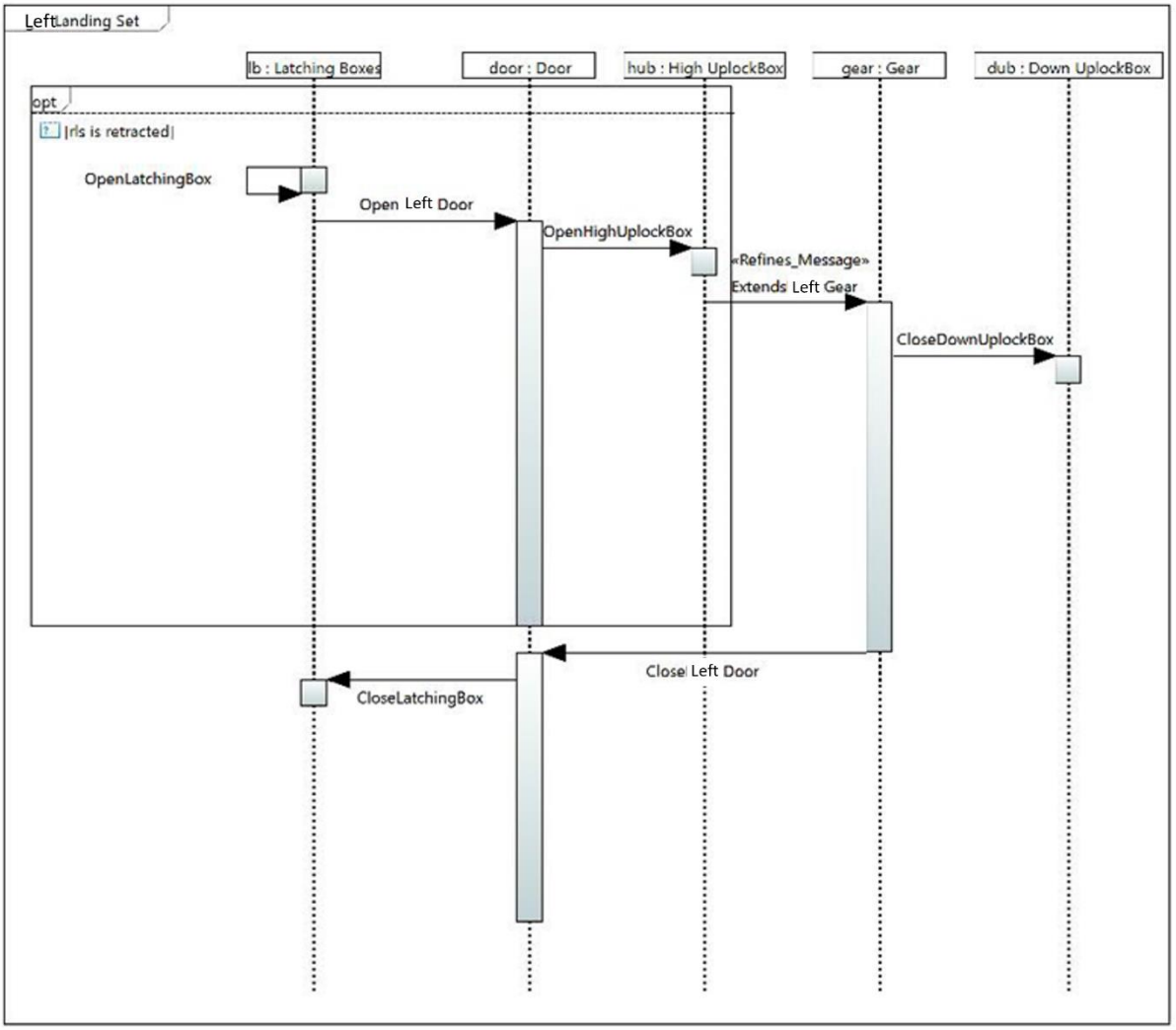
State-machine Diagram of Left Gear



State-machine Diagram of High UplockBox



State-machine Diagram of Down UplockBox



Sequence Diagram of LeftLandingSetL1

- Event_B specification of LeftLandingSetL1:

SYSTEM
LeftLandingSet_CONT
SETS
Gear;
LatchingBoxes;
Door;
HighUplockBox;
DownUplockBox;
HighUplockBoxSTATES;
DoorSTATES;
DownUplockBoxSTATES;
LatchingBoxesSTATES;
GearSTATES
CONSTANTS
hub,
door,
lb,
dub,
gear,
openedHBox,
openedDBox,
closedHBox,
dclose,
gextended,
lbopened,
gretracted,
lbclosed,
dopen,
closedDBox,
hasHub,
hasDub,
associatedTo
PROPERTIES
dub ∈ DownUplockBox ∧
lb ∈ LatchingBoxes ∧
hub ∈ HighUplockBox ∧
door ∈ Door ∧
gear ∈ Gear ∧
HighUplockBox ={hub} ∧
DownUplockBox ={dub} ∧
Gear ={gear} ∧
Door ={door} ∧
LatchingBoxes ={lb} ∧
closedHBox ∈ HighUplockBoxSTATES ∧
dopen ∈ DoorSTATES ∧
openedDBox ∈ DownUplockBoxSTATES ∧
openedHBox ∈ HighUplockBoxSTATES ∧

lbopened ∈ LatchingBoxesSTATES ∧
closedDBox ∈ DownUplockBoxSTATES ∧
gretracted ∈ GearSTATES ∧
lbclosed ∈ LatchingBoxesSTATES ∧
gextended ∈ GearSTATES ∧
dclose ∈ DoorSTATES ∧
gretracted ≠ gextended ∧
dclose ≠ dopen ∧
lbopened ≠ lbclosed ∧
openedHBox ≠ closedHBox ∧
openedDBox ≠ closedDBox ∧
GearSTATES ={gextended, gretracted} ∧
DownUplockBoxSTATES ={closedDBox, openedDBox} ∧
LatchingBoxesSTATES ={lbclosed, lbopened} ∧
HighUplockBoxSTATES ={closedHBox, openedHBox} ∧
DoorSTATES ={dopen, dclose} ∧
hasHub ∈ {gear} ↦ {hub} ∧
hasDub ∈ {gear} ↦{dub} ∧
associatedTo ∈ {lb} ↦ {door}

END

REFINEMENT

LeftLandingSetL1

REFINES

LeftLandingSet_Interface

SEES

LeftLandingSet_CONT,
MechanicalSubSystem_CONT,
LandingGearSystemL1_CONT,
LandingGearSystemL0_CONT

VARIABLES

doorState,
dubState,
gearState,
hubState,
lbState,
llsState

INVARIANT

doorState ∈ Door → DoorSTATES ∧
dubState ∈ DownUplockBox → DownUplockBoxSTATES ∧
gearState ∈ Gear → GearSTATES ∧
hubState ∈ HighUplockBox → HighUplockBoxSTATES ∧
lbState ∈ LatchingBoxes → LatchingBoxesSTATES

INITIALISATION

doorState :∈ {door} →DoorSTATES ||
dubState :∈ {dub} →DownUplockBoxSTATES ||
gearState :∈ {gear} →GearSTATES ||
hubState :∈ {hub} →HighUplockBoxSTATES ||
lbState :∈ {lb} →LatchingBoxesSTATES ||
llsState :∈ {lls} →LeftLandingSetSTATES

```
        EVENTS
        OpenLatchingBox =
        SELECT
                lbState(lb)=lbclosed
        THEN
                lbState(lb):=lbopened END;
        CloseLeftDoor =
        SELECT
                dubState(dub)=closedDBox ∧
                doorState(door)=dopen
        THEN
                doorState(door):=dclose END;
        OpenHighUplockBox =
        SELECT
                doorState(door)=dopen ∧
                hubState(hub)=closedHBox
        THEN
                hubState(hub):=openedHBox END;
        ExtendsLeftGear ref ExtendsLeftLandingSet=
        SELECT
                hubState(hub)=openedHBox ∧
                gearState(gear)=gretracted ∧
                llsState(lls)=retractedLLS
        THEN
                gearState(gear):=gextended ||
                llsState(lls) :=extendedLLS
        END;
        OpenLeftDoor =
        SELECT
                lbState(lb)=lbopened ∧
                doorState(door)=dclose
        THEN
                doorState(door):=dopen
        END;
        CloseLatchingBox =
        SELECT
                doorState(door)=dclose ∧
                lbState(lb)=lbopened
        THEN
                lbState(lb):=lbclosed
        END;
        CloseDownUplockBox =
        SELECT
                gearState(gear)=gextended ∧
                dubState(dub)=openedDBox
        THEN
                dubState(dub):=closedDBox
        END
END
```