

# **Situation recognition as a step to an intelligent situation-aware crew assistant system**

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**The ICE project**

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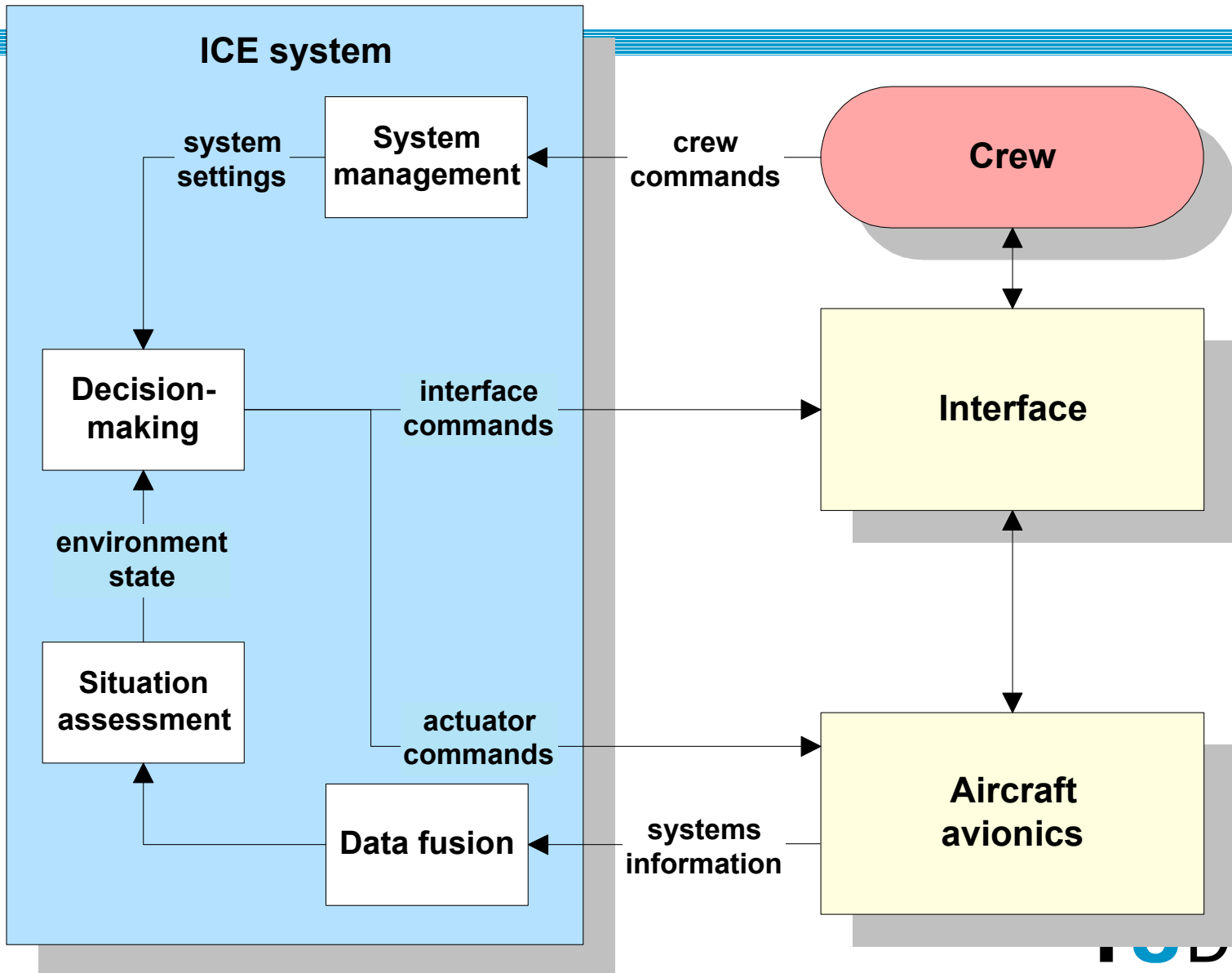
- The ICE project
- Design
- Implementation
- Results
- Conclusions and future work

# ICE: the project

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- Ultimate goal: artificial co-pilot
  - Take over tasks
  - Provide useful information
- Main focus on reasoning

# ICE: architecture

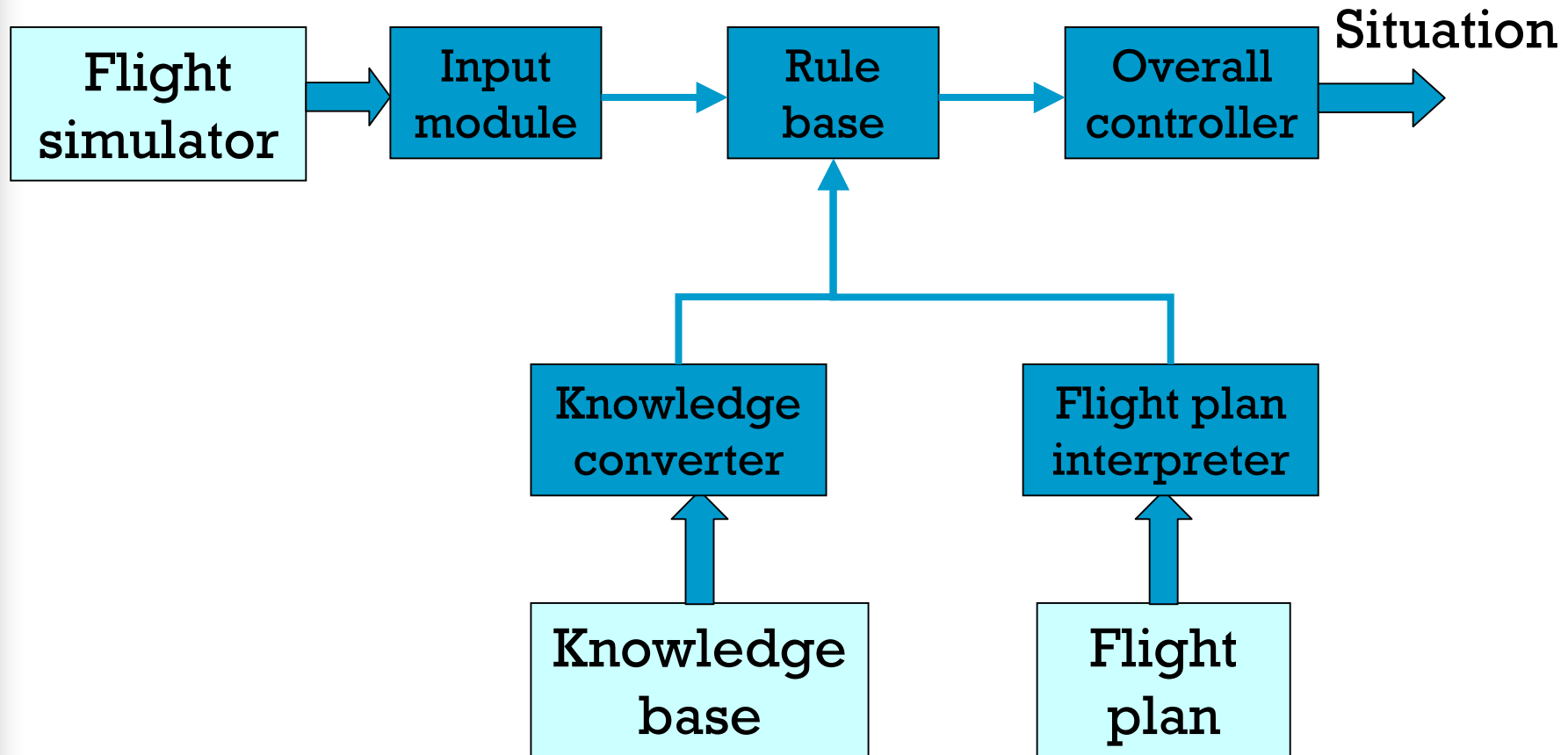


# Design: situation recognition

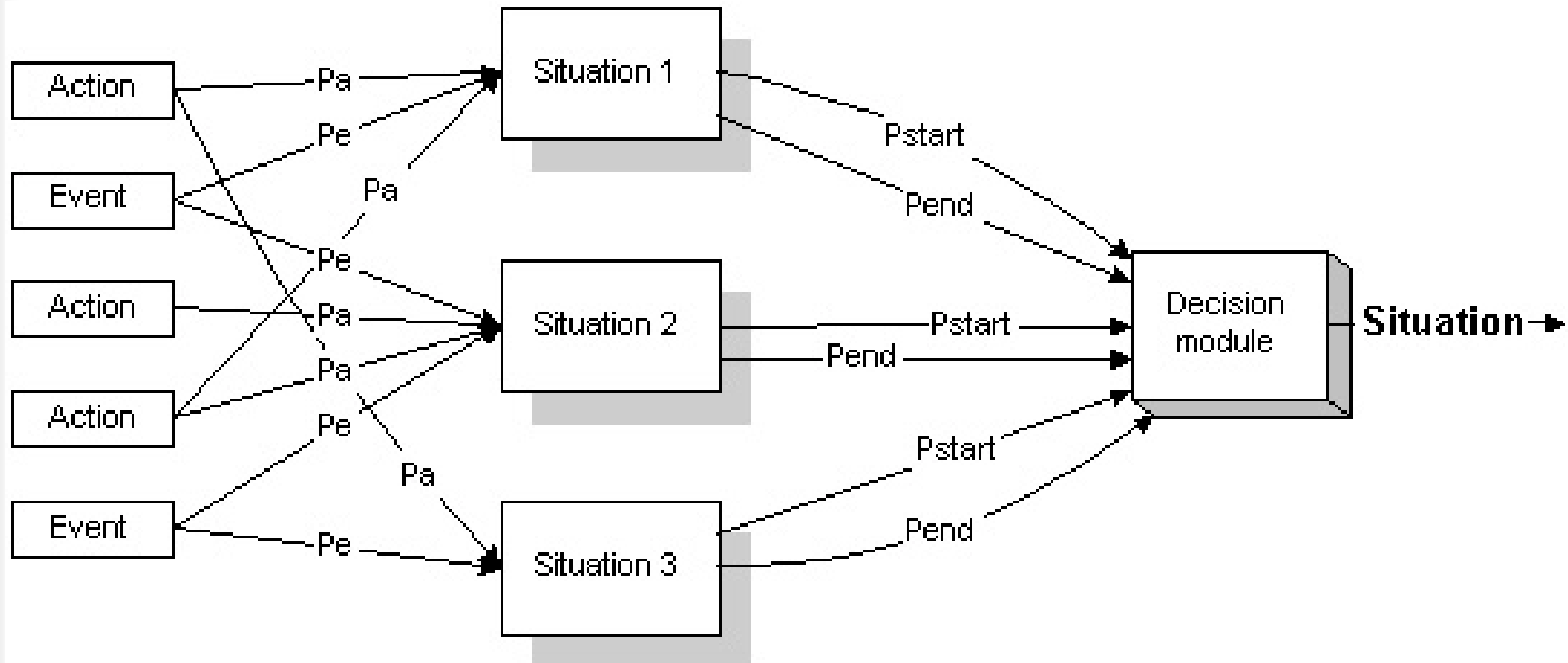
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- Detect current situation based on data from simulator
  - Aircraft status
  - Pilot actions
  - Environment
- Probabilistic approach

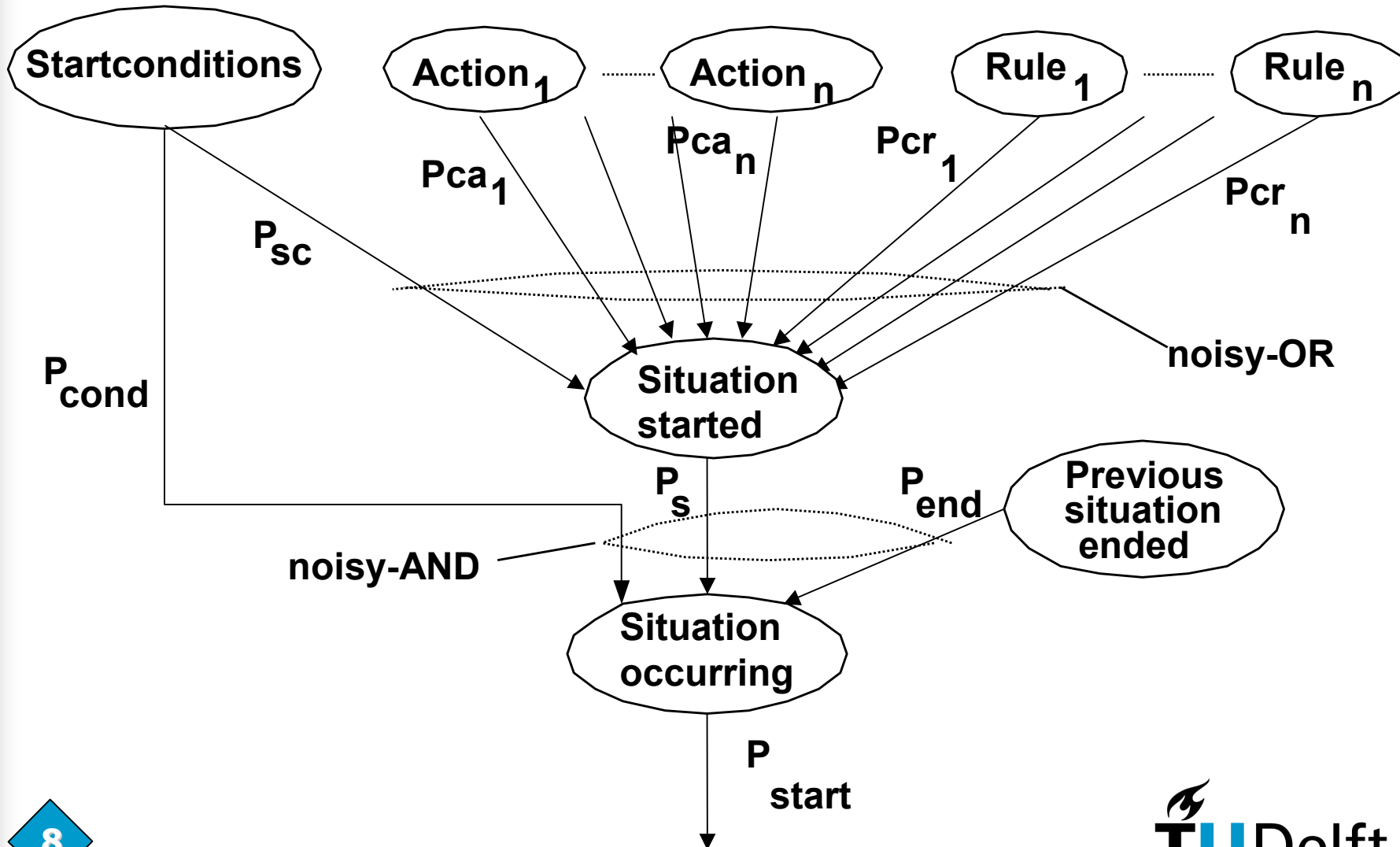
# Design: architecture



# Design: overall controller

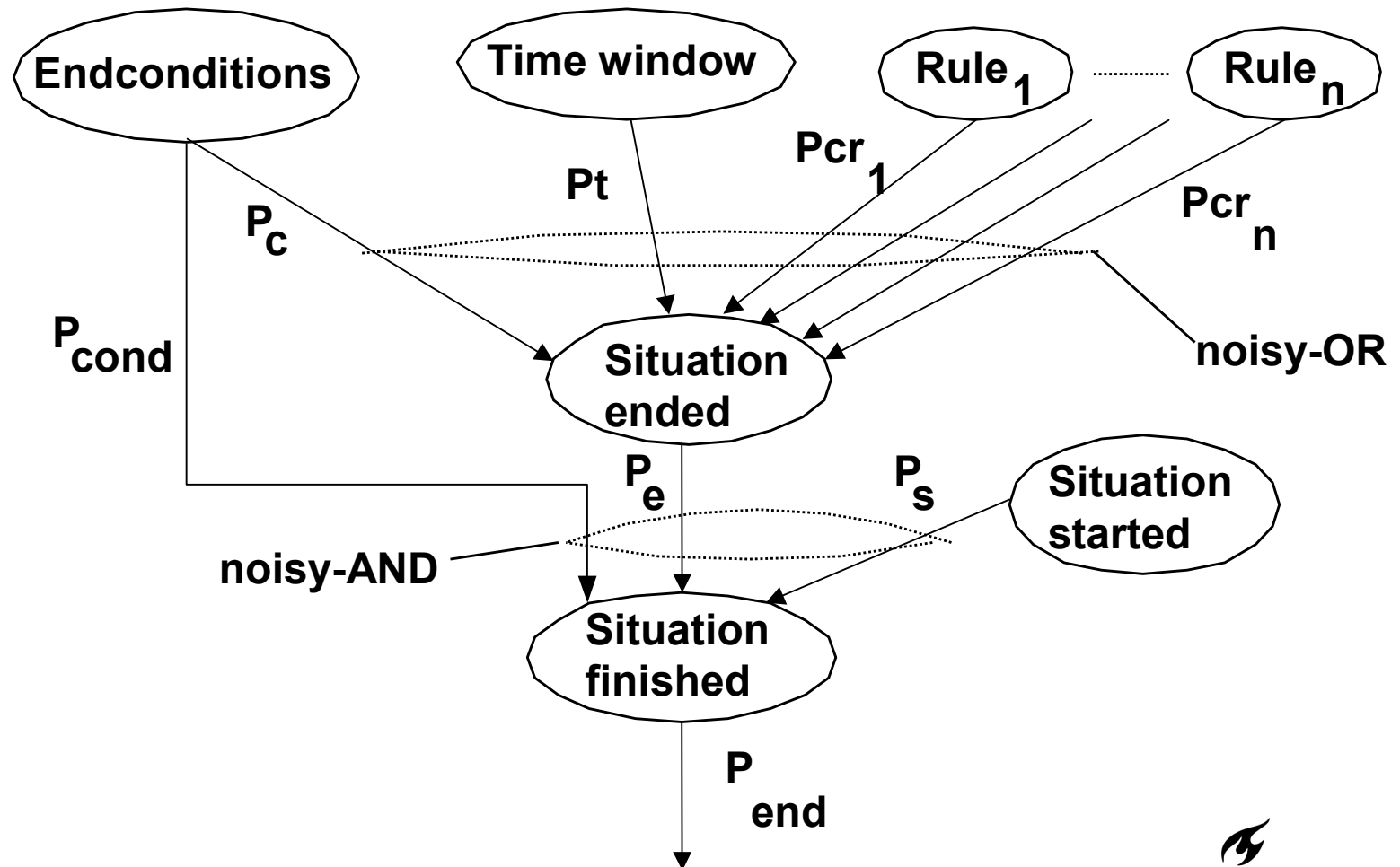


# Design: start probabilities





# Design: end probabilities



# Implementation

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- Java
- MSFS 2002 Simulator
  
- Rule-based system JESS
- Knowledge base for Cessna and F-16
- Hard-coded probabilistic reasoning

# Results: example experiment (1)

An attack on a ground target:

<b>Situation</b>	<b>Time started (s)</b>	<b>Time detected (s)</b>
Startup	0	0
Taxiing to runway	10	12
Taking off	14	15
Normal flight	43	34
Navigating	83	83
Normal flight	91	91
Navigating	123	123

# Results: example experiment (2)

An attack on a ground target:

<b>Situation</b>	<b>Time started (s)</b>	<b>Time detected (s)</b>
Normal flight	128	128
Visual attack	186	193
Normal flight	221	221
Landing	361	366
Aborting landing	-	410
Taxiing from runway	409	410
Shutdown	427	427

# Conclusions

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- Probabilistic model performs fairly well
- Few mistakes, able to correct
- Recognize situations in real-time for Cessna and F-16
- First step towards situation-awareness system

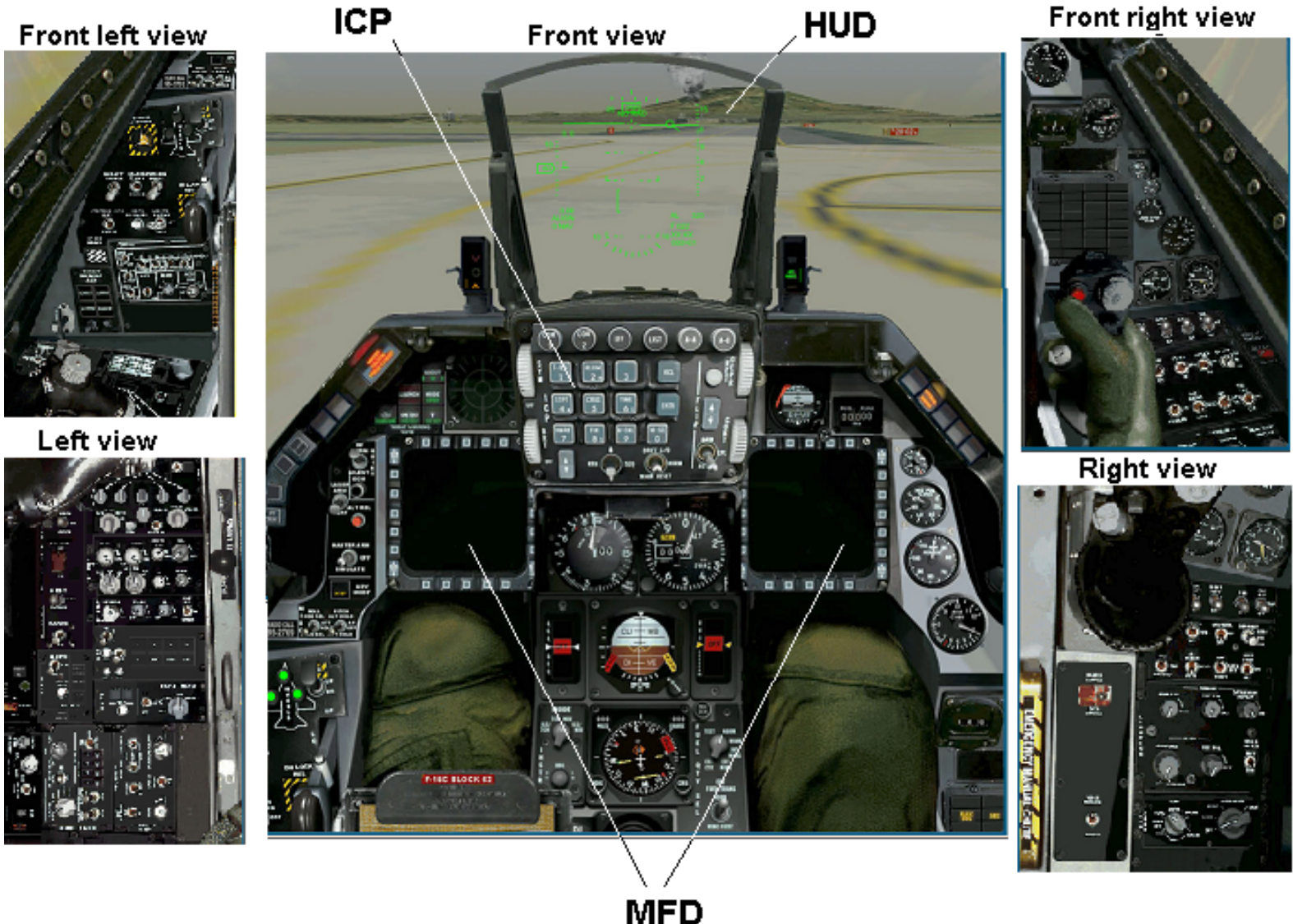
# Future work

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- Compare with other approaches
- Feedback from flight plan
- Add other causal relationships

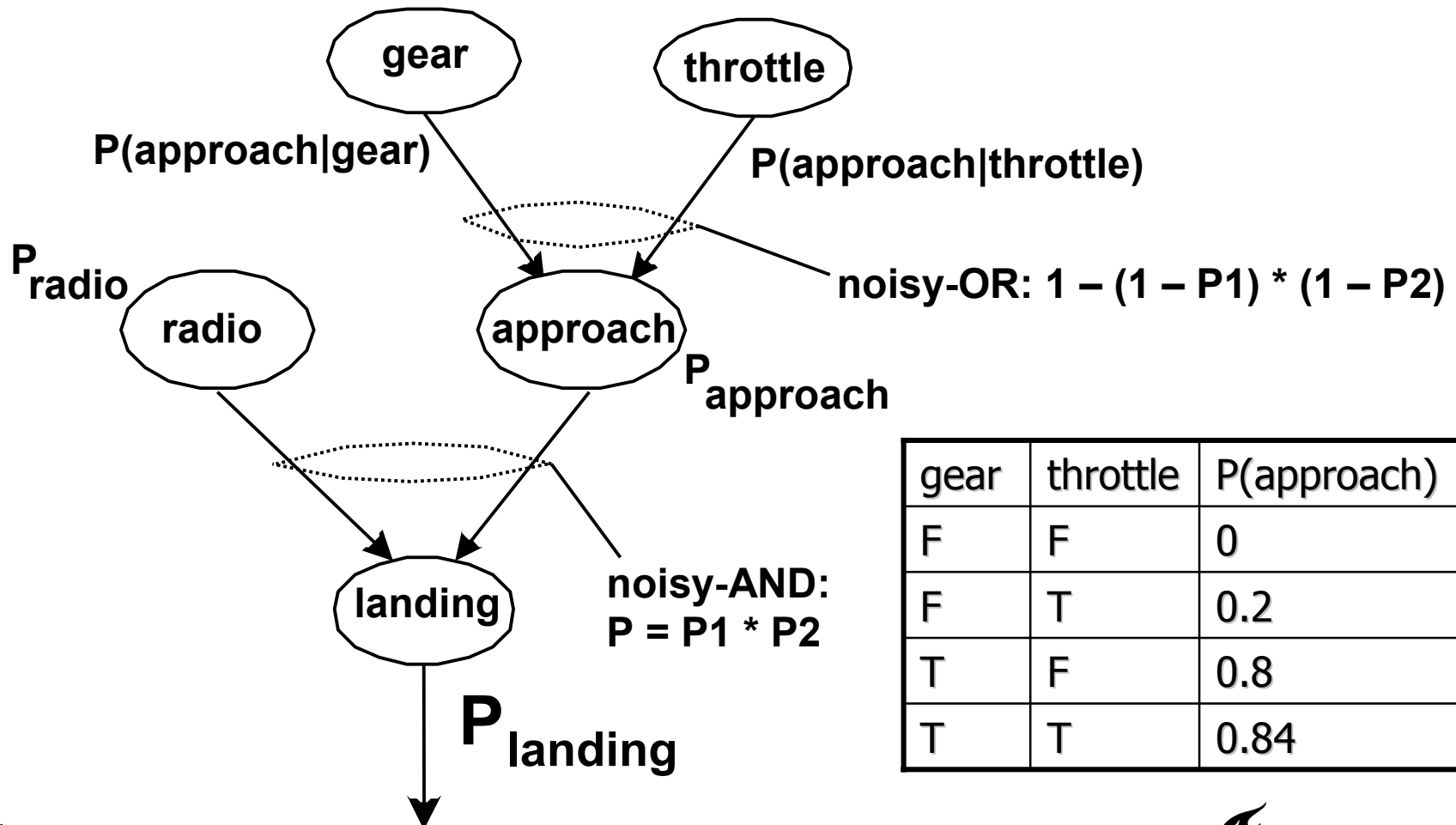


# The F-16 cockpit





# Design: probabilistic network



gear	throttle	P(approach)
F	F	0
F	T	0.2
T	F	0.8
T	T	0.84

# Implementation: XML file F-16

```
<situation name="Taxiing to runway" timewindow="5">
  <nextsituations>
    <nextsituation>Taking off</nextsituation>
  </nextsituations>

  <actions>
    <phase name="taxiing">
      <action name="parking brakes" priority="1" probability="MP">&OFF;</action>
      <action name="throttle" priority="1" probability="SP">>&IDLE;</action>
      <action name="throttle" priority="0.4" probability="SP">&IDLE;</action>
    </phase>
    <phase name="time independent">
      <action name="wheel brakes" priority="0.6" probability="MP">&ON;</action>
      <action name="MPO" priority="1" probability="MP">&NORMAL;</action>
    </phase>
  </actions>

  <visualChecks>
    <instrument name="speed brakes" repetitive="no" priority="0.3"/>
    <instrument name="caution panel" repetitive="no" priority="0.8"/>
    .....
  </visualChecks>

  <constraints startProbability="MP" endProbability="BP">
    <constraint name="parking brakes" start="&ON;" end="&OFF;"/>
    <constraint name="wheel brakes" start="&OFF;"/>
    .....
  </constraints>

  <additionalrules>
    <rule name="altitude" end=">0" probability="1" />
    <rule name="roll" end=">0" probability="1" />
    .....
  </additionalrules>
</situation>
```

# Results: overview

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- Error rate:  $\text{time wrong} / \text{total time}$
- 4 flights
  - Average: error rate 0.08
  - Lowest: error rate 0.05
  - Highest: error rate 0.11

**Situation Recognizer**

File Program

Current situation: Taking off

name	start	end
Taking evasive action	0.03	0.0
Guided attack	0.0	0.0
Taxiing from runway	0.38	0.0
Aborting takeoff	0.22	0.0
Air refueling	0.0	0.0
Dogfight	0.17	0.0
Taxiing to runway	0.0	0.0
Deep stall	0.0	0.0
Taking off	0.99	0.27
Aborting a landing	0.37	0.0
Navigating	0.0	0.0
Shutting down	0.27	0.0
Startup	0.22	0.0
HARM attack	0.0	0.0
Visual attack	0.0	0.0
Normal flight	0.0	0.0
Flame out landing	0.03	0.0
Landing	0.03	0.0
Nonvisual attack	0.0	0.0

**The variables**

airspeed	233.49583	239.81555	243.4982	245.68245	249.5501
elevator t...	-1.83505...	-1.83505...	-1.83505...	-1.83505...	-1.83505...
iff	ON	ON	ON	ON	ON
jettison s...	0	0	0	0	0
wheel br...	0.0	0.0	0.0	0.0	0.0
parachute	0	0	0	0	0
hook	RAISED	RAISED	RAISED	RAISED	RAISED
pitch	0	0	0	0	0
roll	0	0	0	0	0
F-ACK	0	0	0	0	0
air refuel...	0	0	0	0	0
ground s...	116.8397	116.8397	126.28	126.28	130.6788
A-LOW	0	0	0	0	0
designate	0	0	0	0	0
pickle	0	0	0	0	0
master a...	OFF	OFF	OFF	OFF	OFF
throttle	3	3	3	3	3
climbing ...	615.0	781.0	972.0	1002.0	1364.0
master ...	NAV	NAV	NAV	NAV	NAV
rudder	-0.00211...	-7.35698...	-3.11130...	-6.79106...	-0.00331...
elevator	0.03494...	0.03423...	0.03505...	0.04427...	0.06881...
master li...	ON	ON	ON	ON	ON
chaff/flar...	0	0	0	0	0

**Jess viewer**

Content

name	value
*currentSituation*	"Taking off"
*Taking_evasive_action_canStart*	"true"
*Taking_evasive_action_canEnd*	"false"
*Taking_evasive_action_action0*	"unperformed"
*Taking_evasive_action_action1*	"unperformed"
*Taking_evasive_action_action2*	"unperformed"
*Taking_evasive_action_endrule0_fired*	"false"
*Taking_evasive_action_endrule1_fired*	"false"
*Taking_evasive_action_startrule2_fired*	"false"
*Guided_attack_canStart*	"false"

facts rules **globals**