



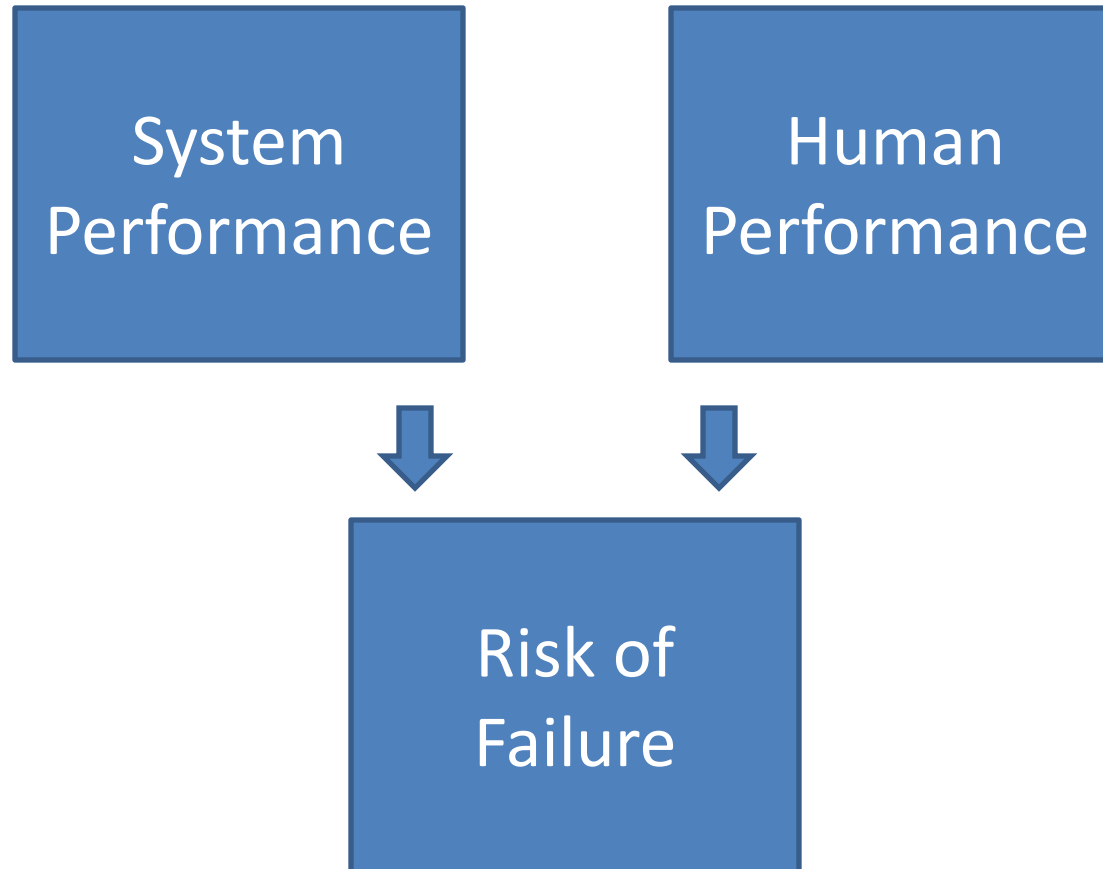
Modeling and Analysis of Context-Based Human-System Interaction

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Research Goal

Integrate a model of human performance with a model of system performance to better understand and estimate the failure risks in complex human-machine systems

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Integrate a model of human performance with a model of system performance to better understand and estimate the failure risks in complex human-machine systems*

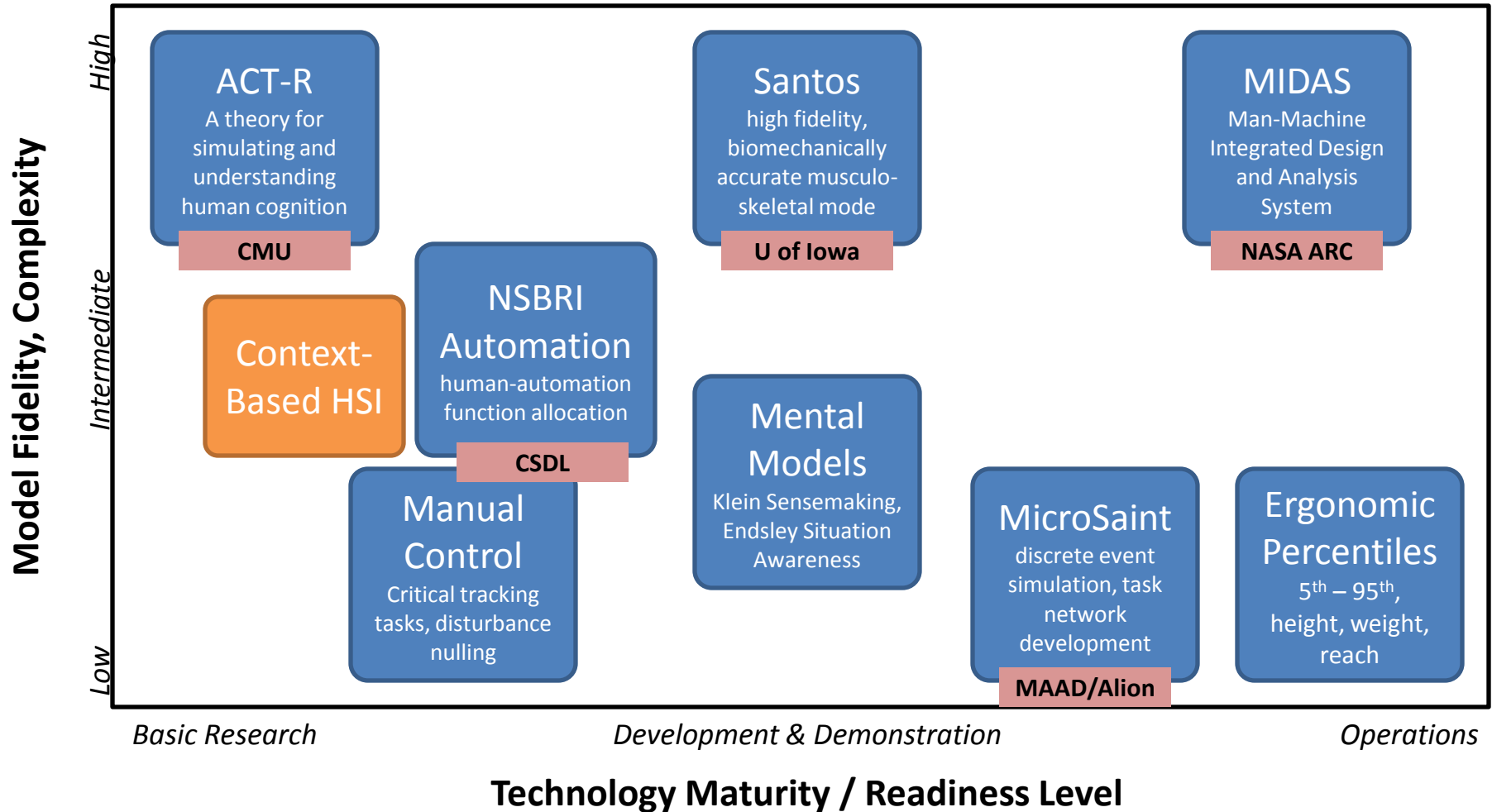
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Integrate a model of human performance with a model of system performance to better understand and estimate the failure risks in complex human-machine systems*

***WIP**

Human Performance Models

How we represent the human in complex systems

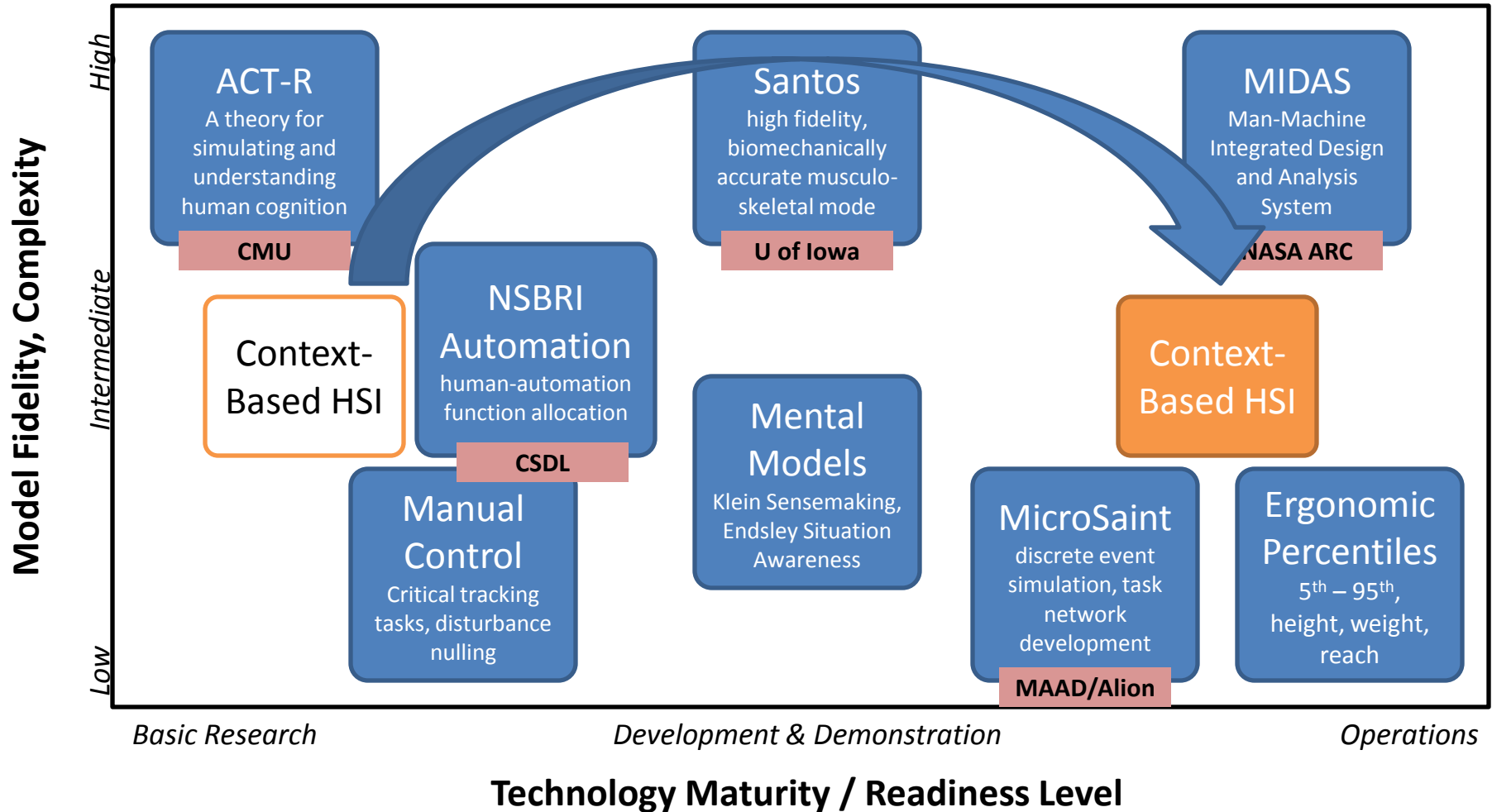


Technology Maturity / Readiness Level

Note: Not all solutions require a high technology maturity and high model fidelity

Human Performance Models

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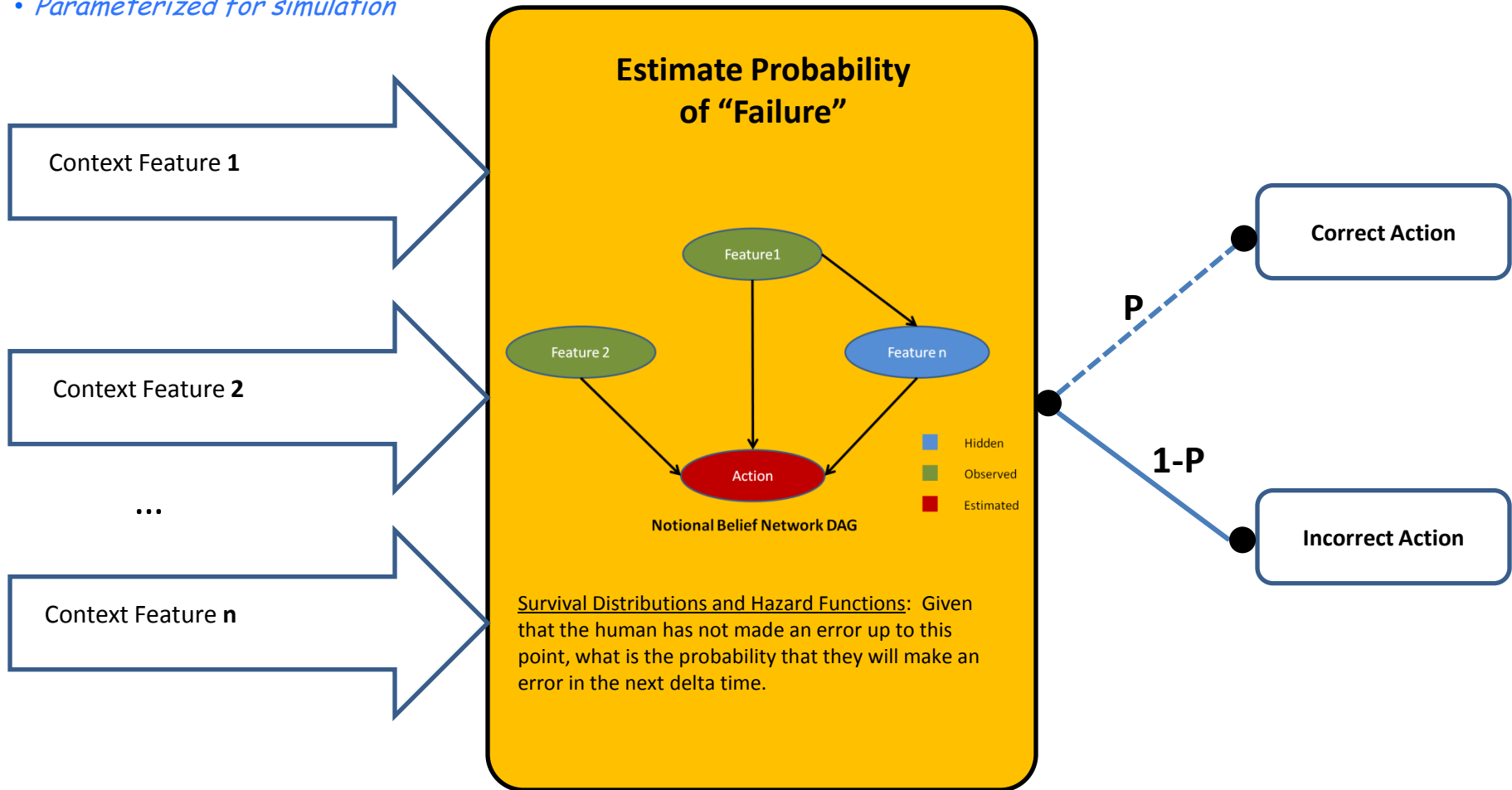
Human Operator Context

- Our current approach focuses on human operator context, and how this context ultimately leads to operator performance.
- Contextual features (such as weather, hours of rest, and pilot experience) are more easily observable than internal features (such as fatigue, confidence, and distraction) for many modeling approaches.
- Through the use of Bayesian Belief Networks, we relate these observable contextual features to unobservable internal features and ultimately onto estimations of operator performance.

Context-Based Human-System Interaction

Context Modeling Framework

- Extensible to multiple features / domains
- Parameterized for simulation



Context-Based Human-System Interaction



Attitude Direction Indicator

Context-Based Human-System Interaction



Attitude Direction Indicator



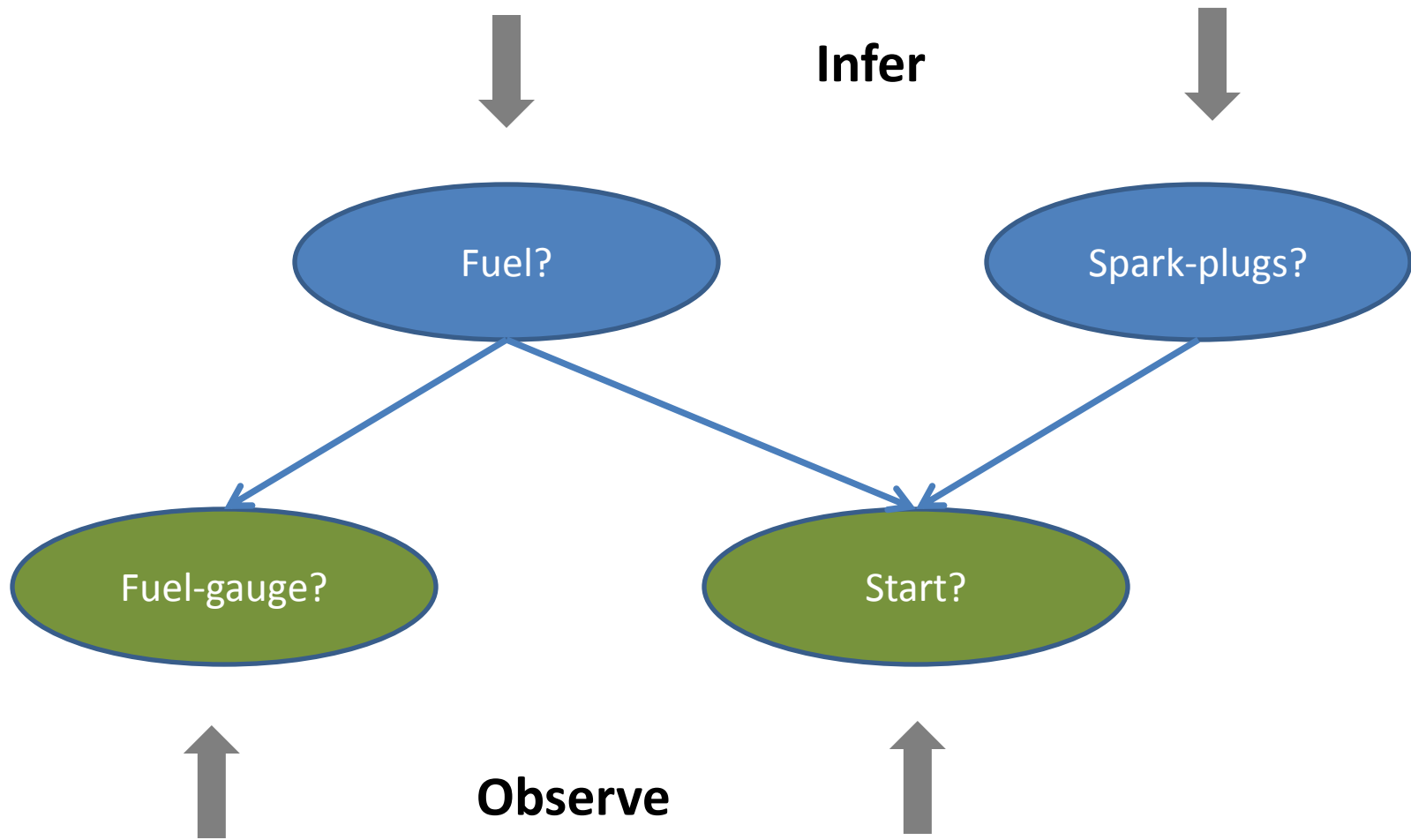
Some Contextual Cues

- Temperature
- Weather
 - Visibility
 - Wind
 - Rain
 - Snow
 - Pressure
 - Fog
 - Waves
 - Lightning
 - Forecast
- Sunlight & glare
- Fatigue
- Noise
- Vibration
- Isolation
- Threat of failure
- Threat of injury to self/others
- Time pressure
- Confidence
- Training
- Experience
- Intelligence
- Motivation
- Group pressure
- Communication skills
- Location (work, home, etc.)
- Time of day
- Day of week
- Day of month
- Mood
- Humidity

Bayesian Belief Networks

- Why BBN?
 - Powerful
 - Human understandable predictions
 - Verification
 - Trust
 - Can be built by experts without training data
 - (relatively) easy to add and remove nodes

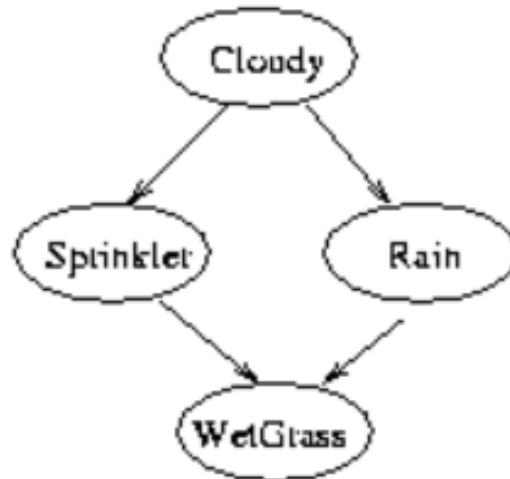
Bayesian Belief Networks



Computational Example

$P(C=F)$ $P(C=T)$

0.5 0.5

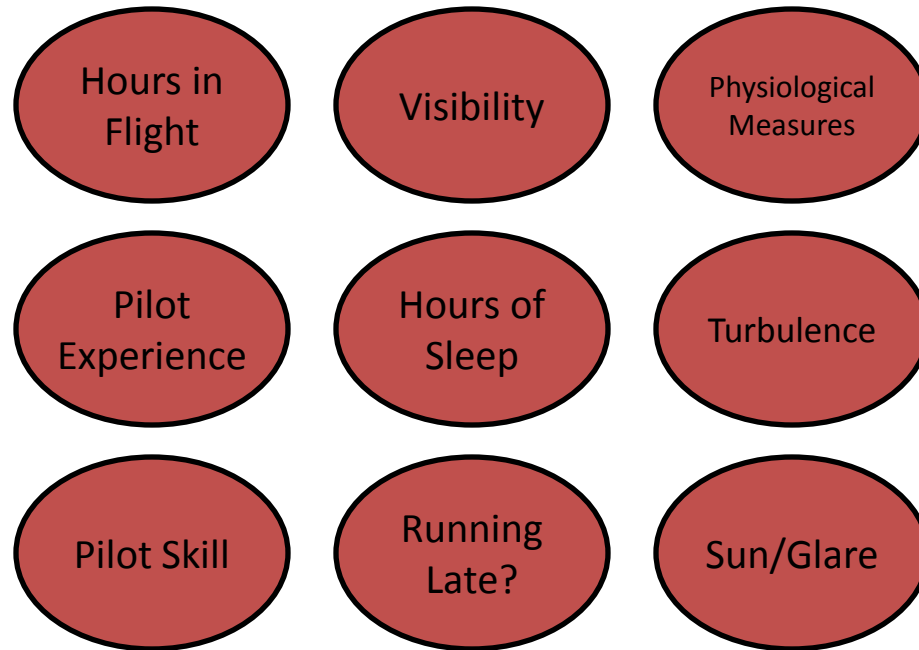


C	$P(S=F)$	$P(S=T)$
F	0.5	0.5
T	0.9	0.1

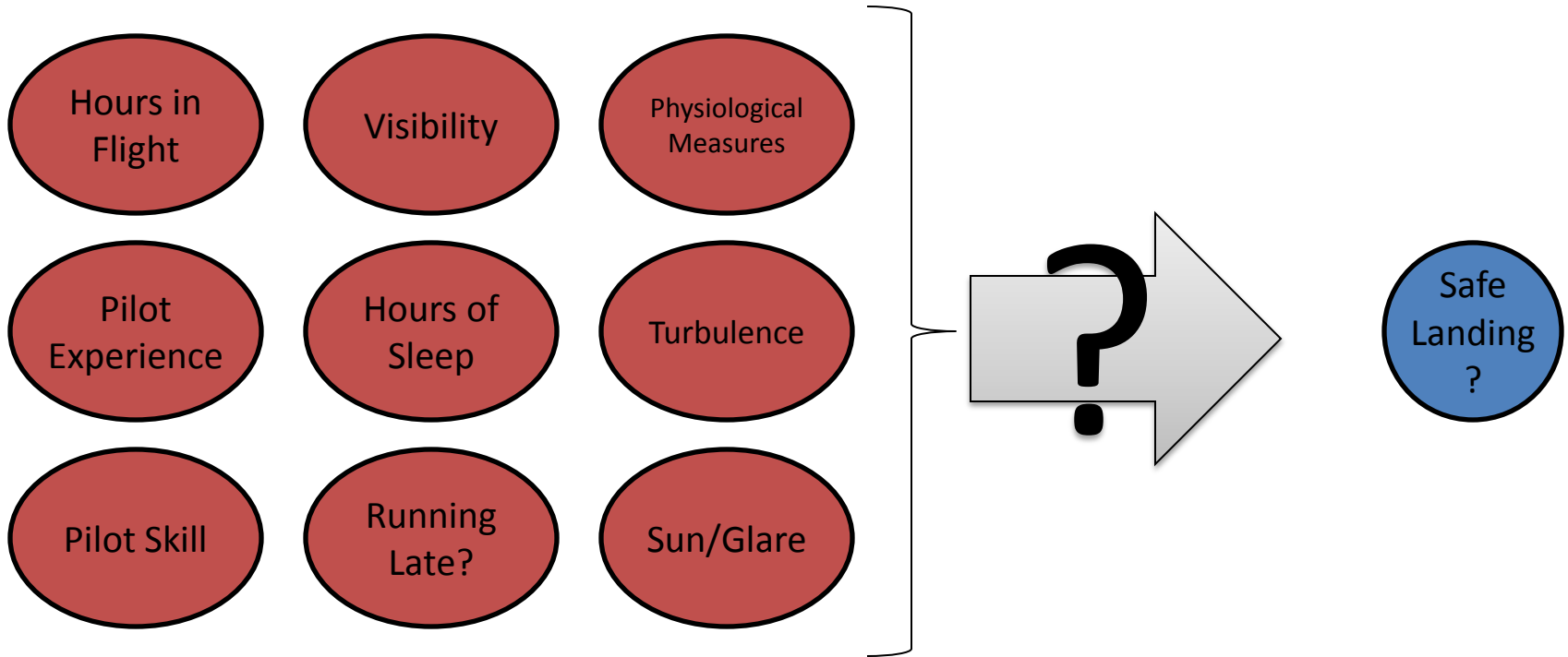
C	$P(R=F)$	$P(R=T)$
F	0.8	0.2
T	0.2	0.8

S	R	$P(W=F)$	$P(W=T)$
F	F	1.0	0.0
T	F	0.1	0.9
F	T	0.1	0.9
T	T	0.01	0.99

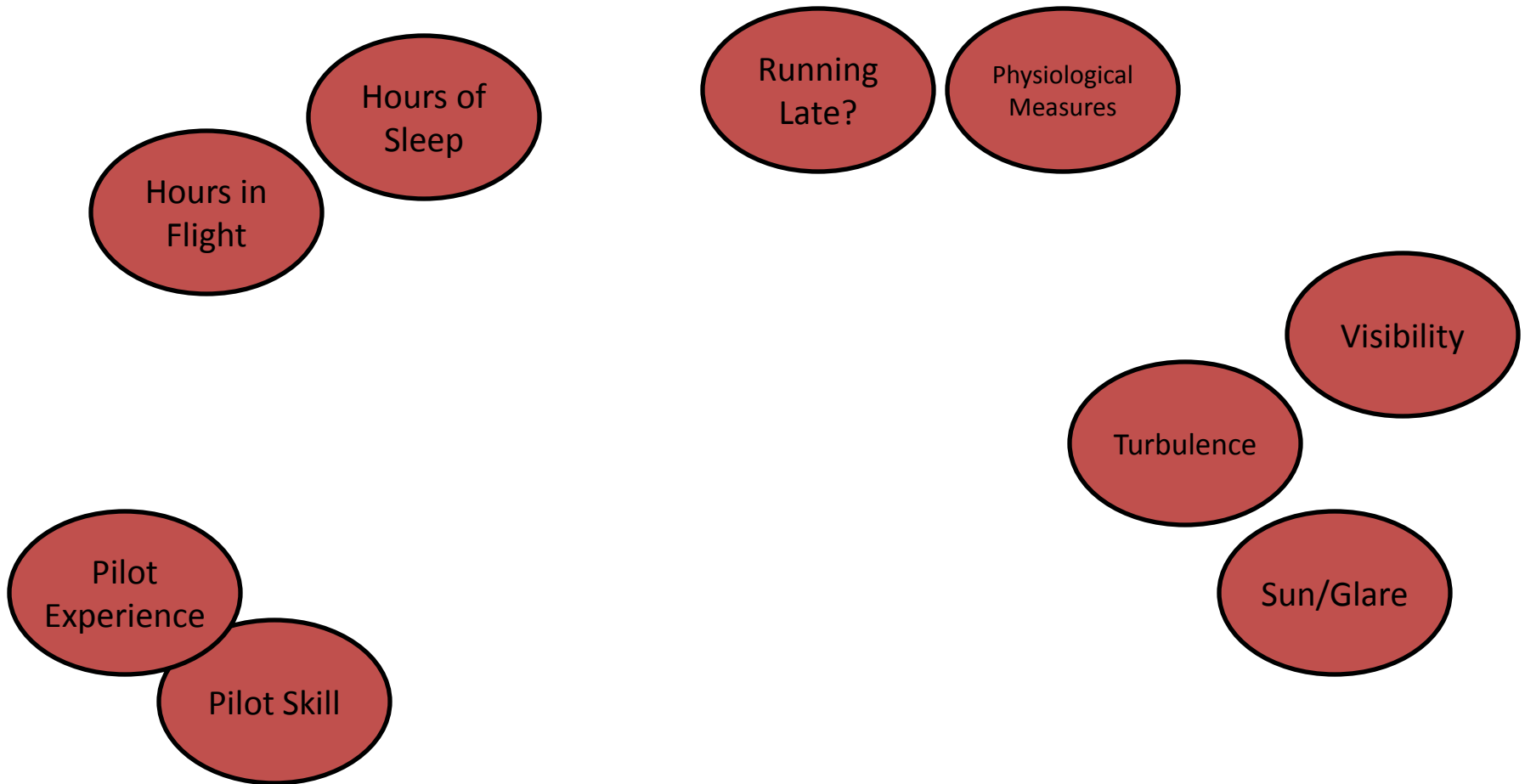
Simple Safe Landing BBN



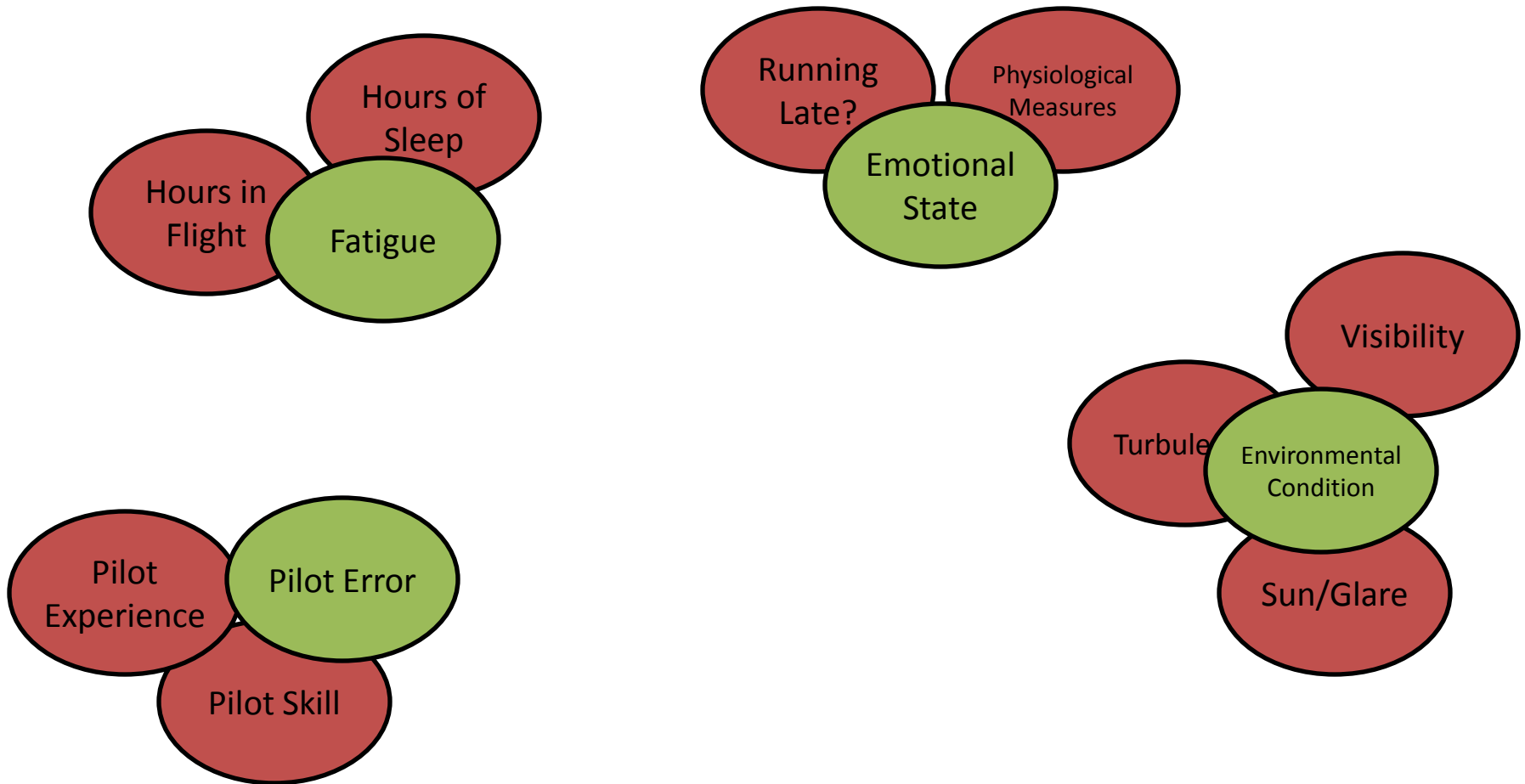
Simple Safe Landing BBN



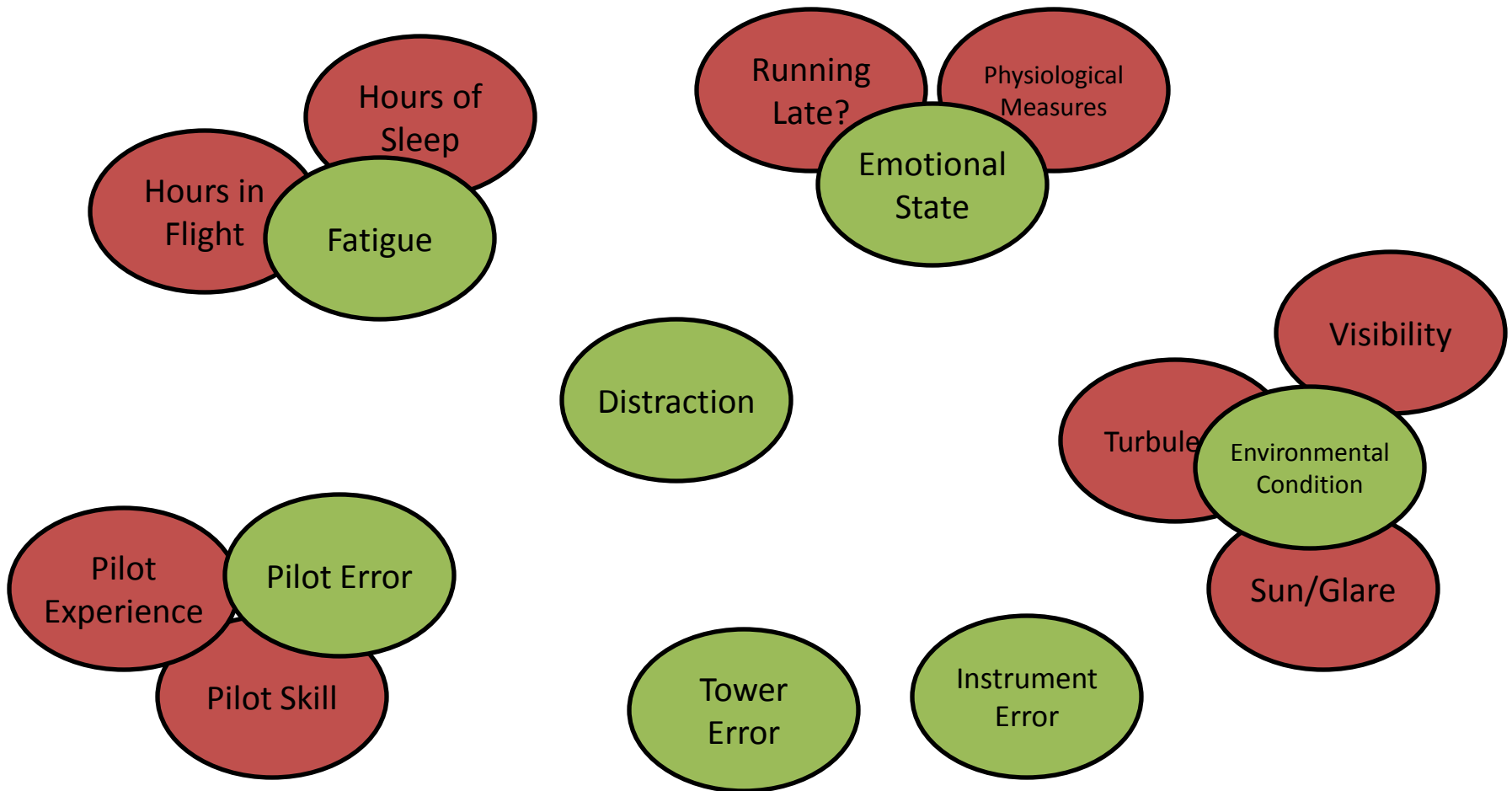
Simple Safe Landing BBN



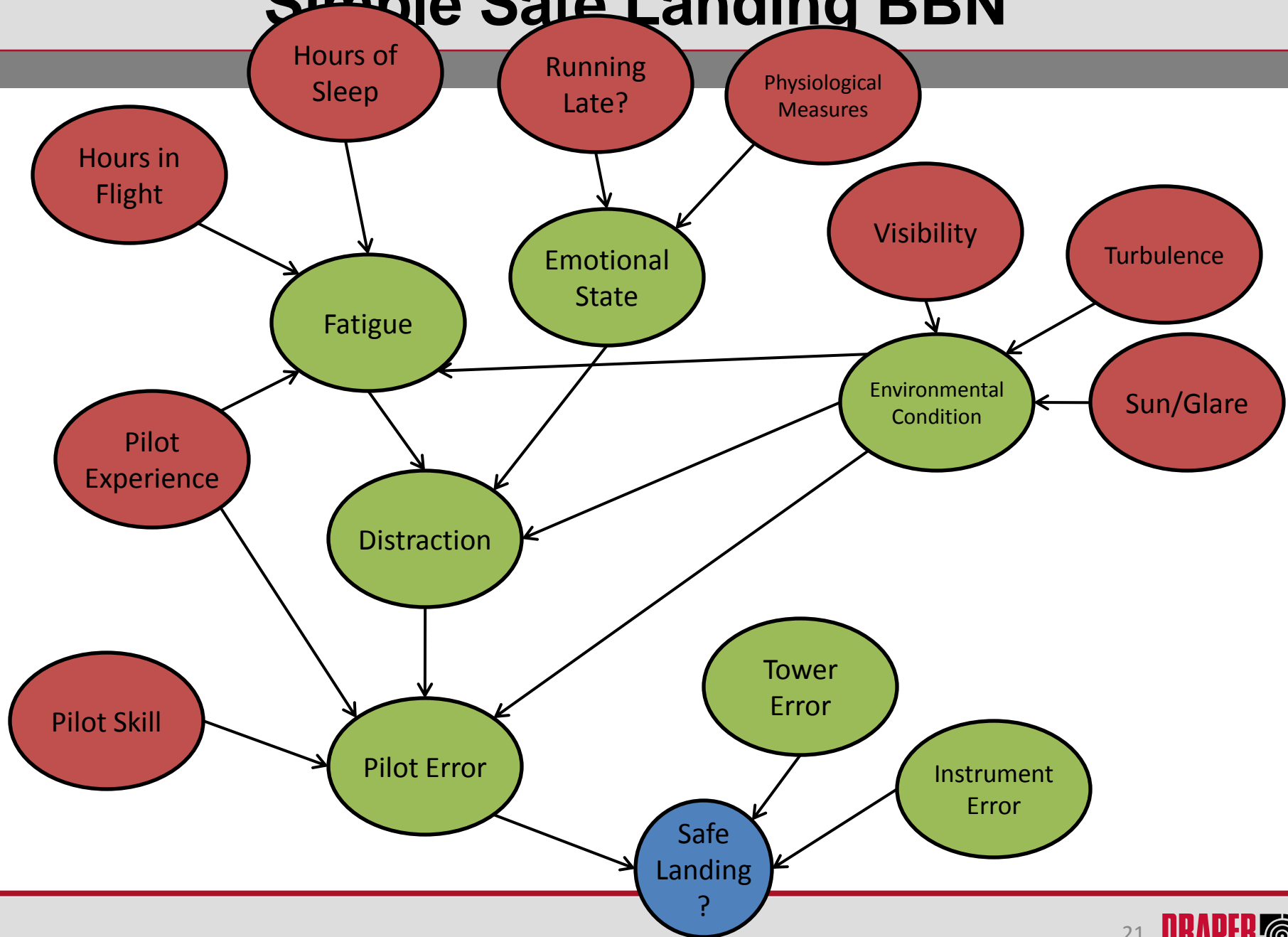
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Simple Safe Landing BBN

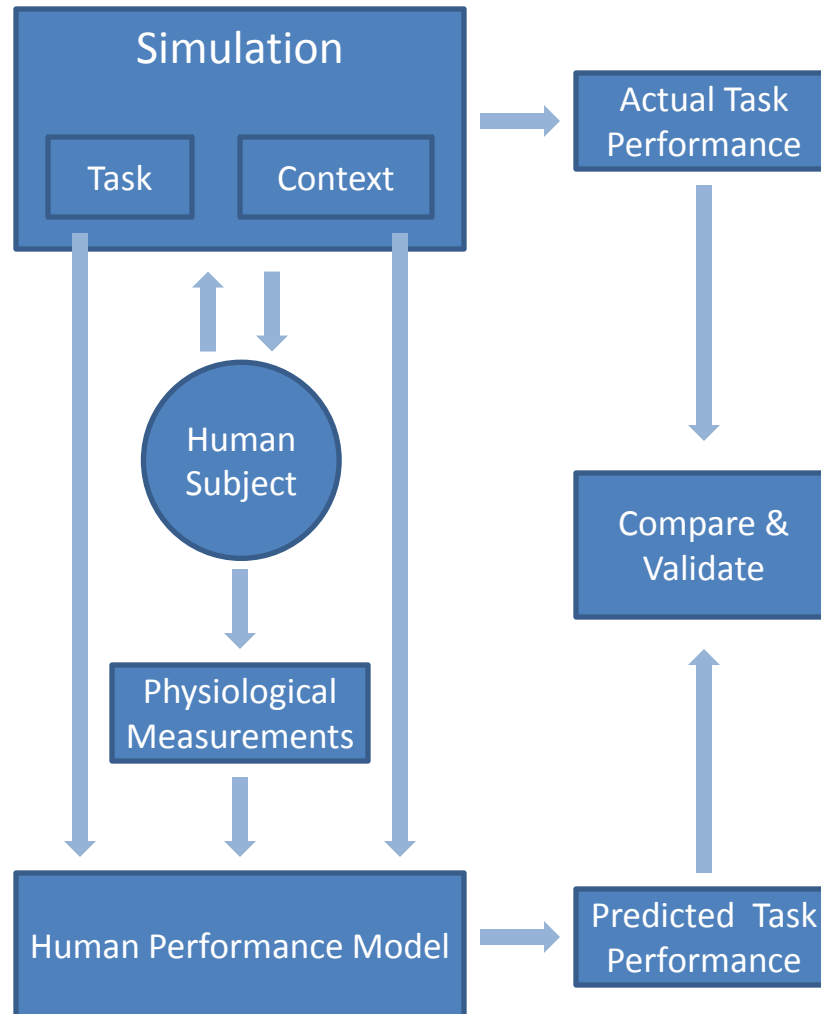


Simple Safe Landing BBN



Evaluation Architecture

Human Performance

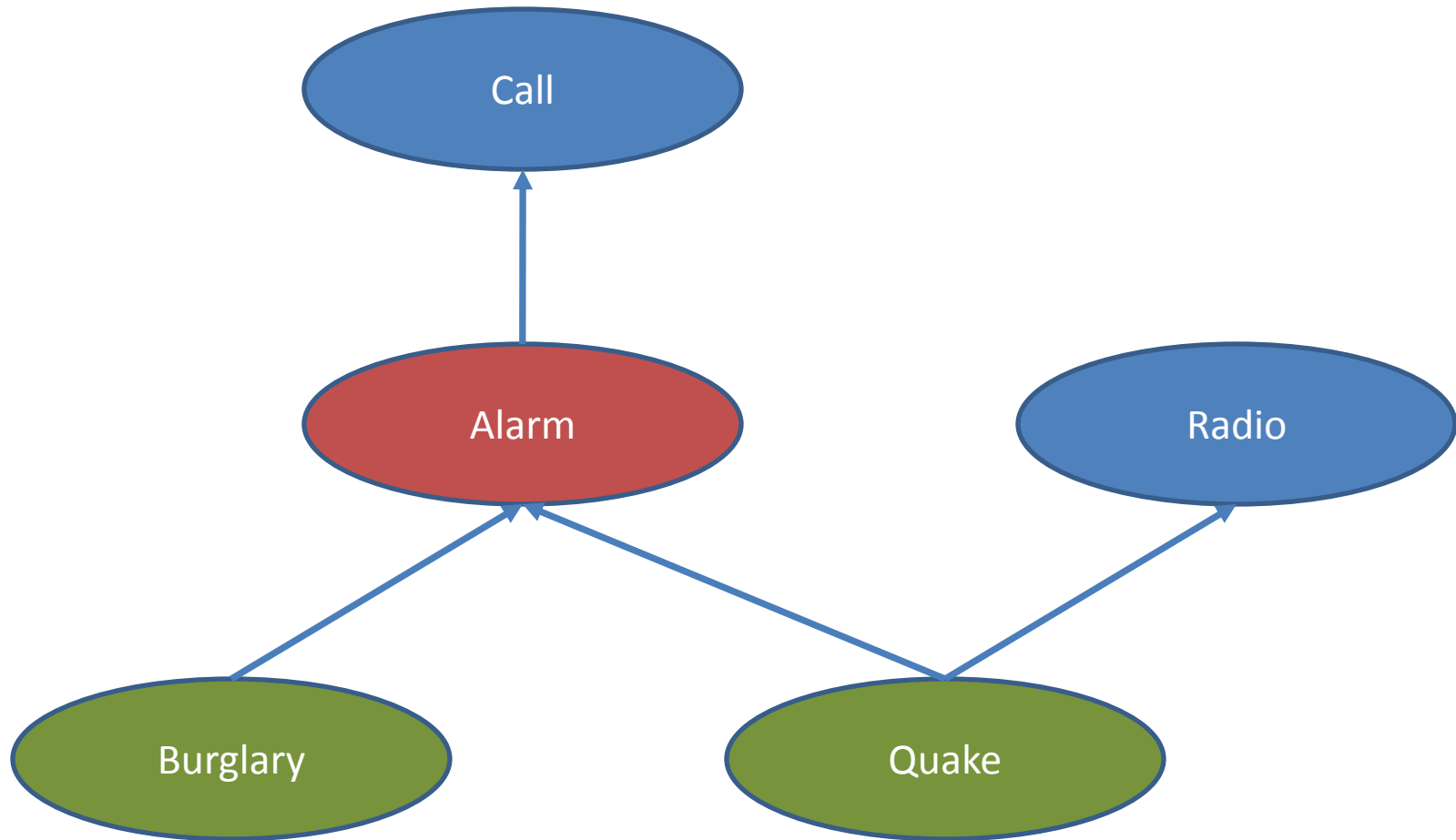


Concluding Remarks

- Operator context should play an important role in HPM and combined HSM
- Contextual features are relatively easy to measure
- BBNs have several advantages over other ML techniques for incorporating context into model
- Validation of HSM not always possible, and in this case human-understandable modeling is important

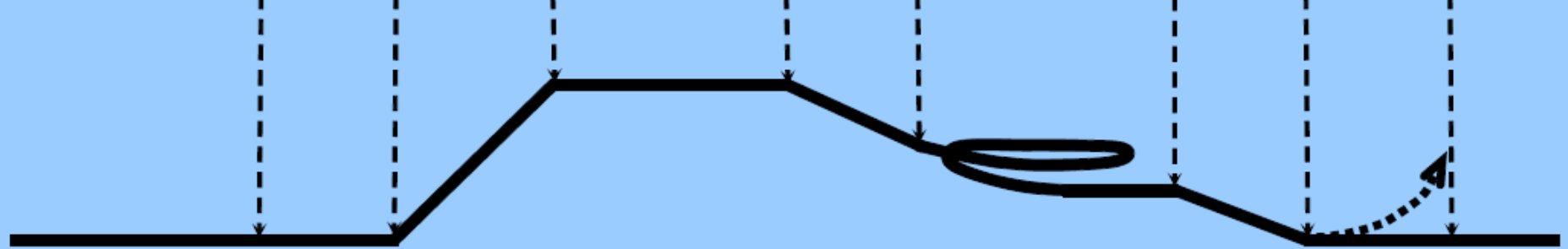
Thank you
Contact: cforlines@draper.com

More Complicated Example



Accident Aircraft Phase of Flight During First Occurrence, 2005

Standing/Taxi/Other	Takeoff	Climb	Cruise	Descent	Maneuver/Hover	Approach	Go-Around	Landing
4.0%	18.7%	3.2%	15.2%	3.0%	12.3%	10.9%	2.1%	30.7%
(2.3%)	(17.8%)	(5.5%)	(19.7%)	(2.9%)	(27.5%)	(17.8%)	(2.3%)	(4.2%)



1,663 accident aircraft with phase of flight data