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EU-JAPAN DIGITAL WEEK 2025

"Critical Applications of AI in Industry, Healthcare and Other Sectors" Workshop

OT x AI safety approaches in Hitachi

April 7th, 2025

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Contents

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Contents

1-1. Hitachi corporate data

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Corporate Name	Hitachi, Ltd.
Founded	1910
Headquarters	6-6, Marunouchi 1-chome, Chiyoda-ku, Tokyo 100-8280, Japan
Revenues	10,264.6 billion yen (FY2021*1)
Adjusted operating income	738.2 billion yen (FY2021*1)
EBIT (Earnings before interest and taxes)	850.9 billion yen (FY2021*1)
Net income attributable to Hitachi, Ltd. stockholders	583.4 billion yen (FY2021*1)
Number of consolidated employees	368,247 (As of end of FY2021*1)

*1: Based on the financial results for FY2020 ended in March 2021

1-2. Business segment constitution (FY2021)

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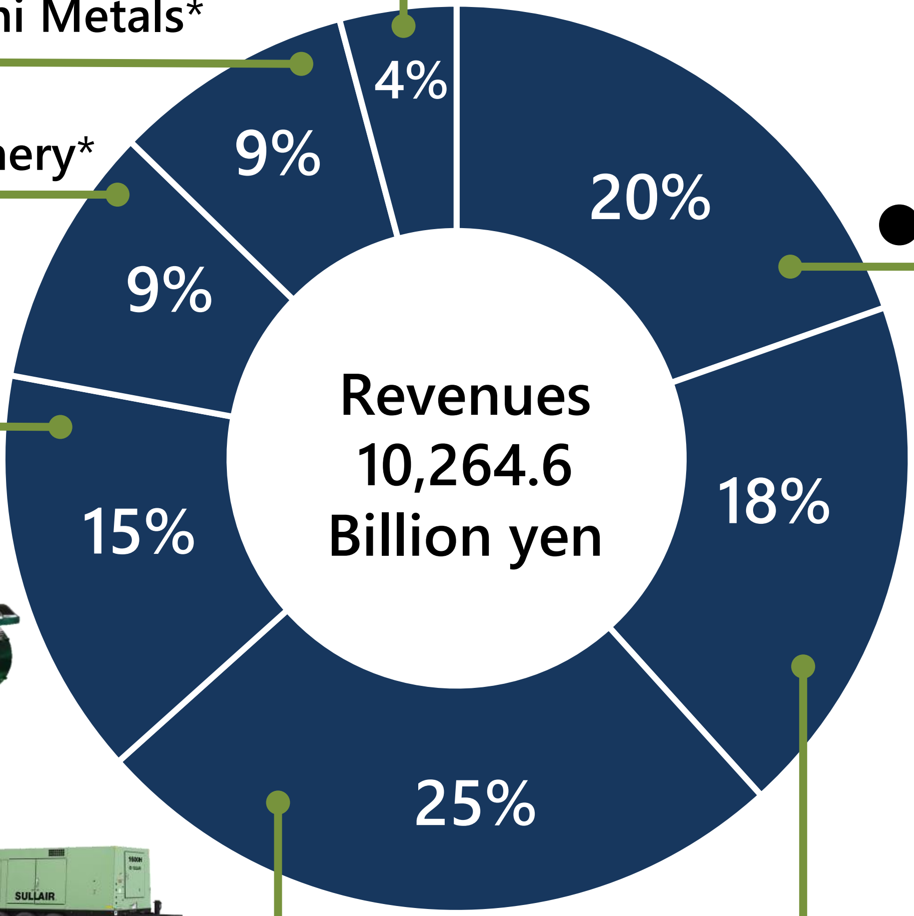
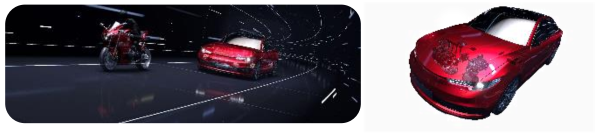
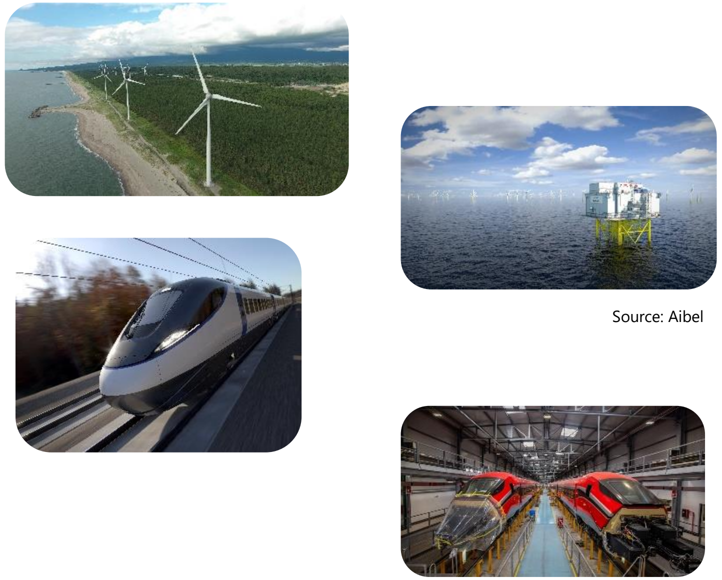




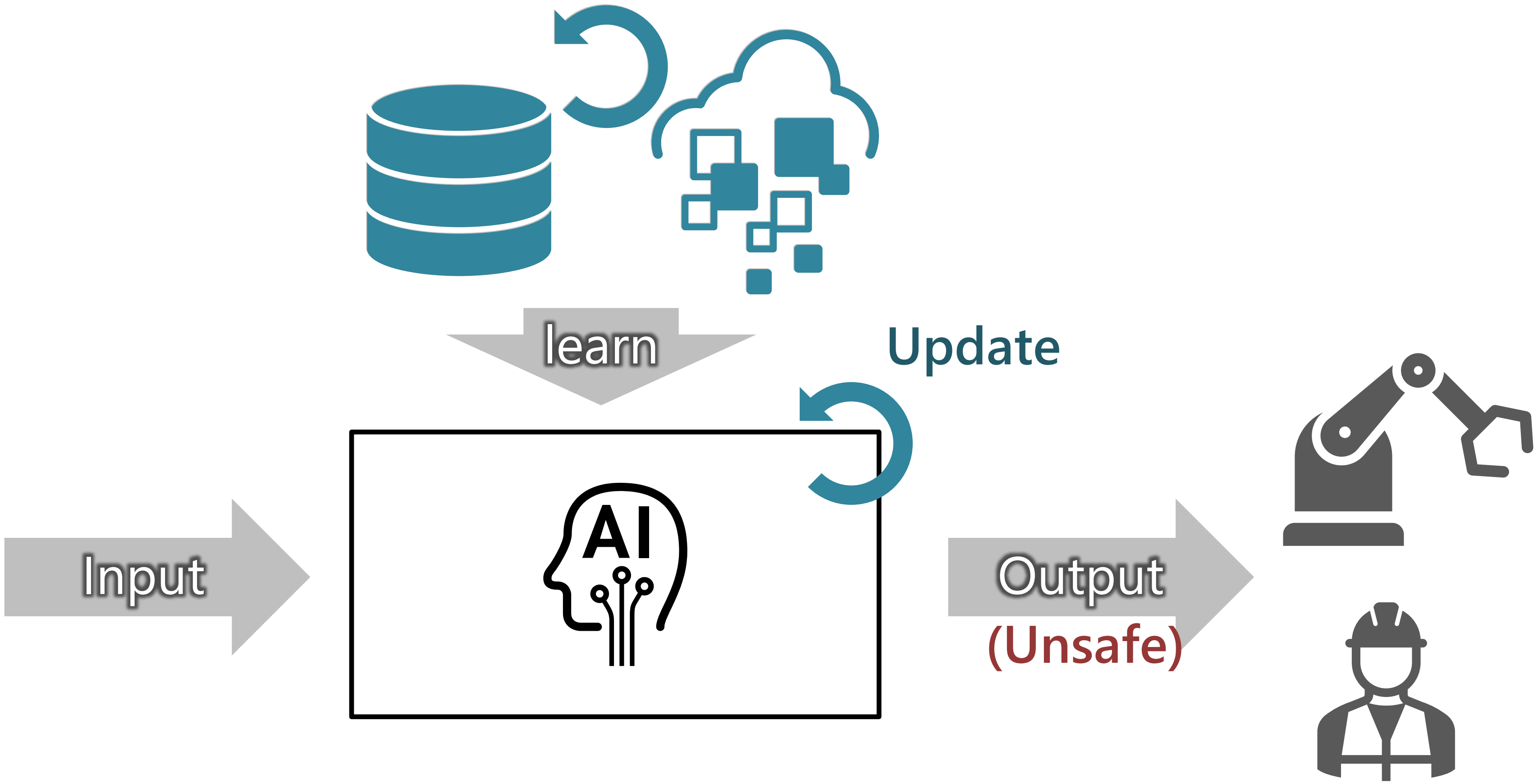


The figures are based on the new segment classifications effective from FY2022.

* Hitachi Construction Machinery was deconsolidated on August 23, 2022. Hitachi Metals are scheduled to be deconsolidated in FY2022.

1-3. Challenges for applying AI

AI is a powerful tool. However, there are existing risks, and it cannot be used as it is.



1-4. Existing countermeasure methods (architecture)

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Architecture requirements: safe protection, no loss of efficiency, support for evolution

	Architecture Type (Classification)	Subtype	method	Pros	Cons
A	Making AI system more reliable	AI component protection	・Guardrail [1]	・Protection of unintended output is possible	・Specific output can be suppressed, but unintended outputs are possible
B			・Uncertainty separation [2]	・Accuracy can be improved (Flip uncertain output)	・Zero incorrect output is not possible (Uncertainty of AI itself)
C		AI component redundancy	・AI redundancy (Ensemble [3])	・ (parallel processing)	(
D			・AI diversity (multi-agents) [4]	・Accuracy can be improved (Select good results in parallel processing)	・Zero incorrect output is not possible (Mistake by consultation)
E	Rule-based protection from the outside	Fixed limiter	・Upper and lower limits/limit values [5]	・ Almost reliable protection i	・Performance degradation due to exc
F		Evolutionary support	・MAPE-K [6] ・Dynamic risk assessment, etc. [7]	・ i ・The limiter also evolve according to the situation.	・Di evo

Good to use it to improve accuracy (high reliability).

Essentially, impossible to guarantee the output of AI itself => Insufficient for "OT x AI" safety measures

Safety assurance requires certain protection (rule-based)

The design needs to be able to dynamically change the rules and follow them "correctly" and "efficiently".

1-5. Proposed architecture concept

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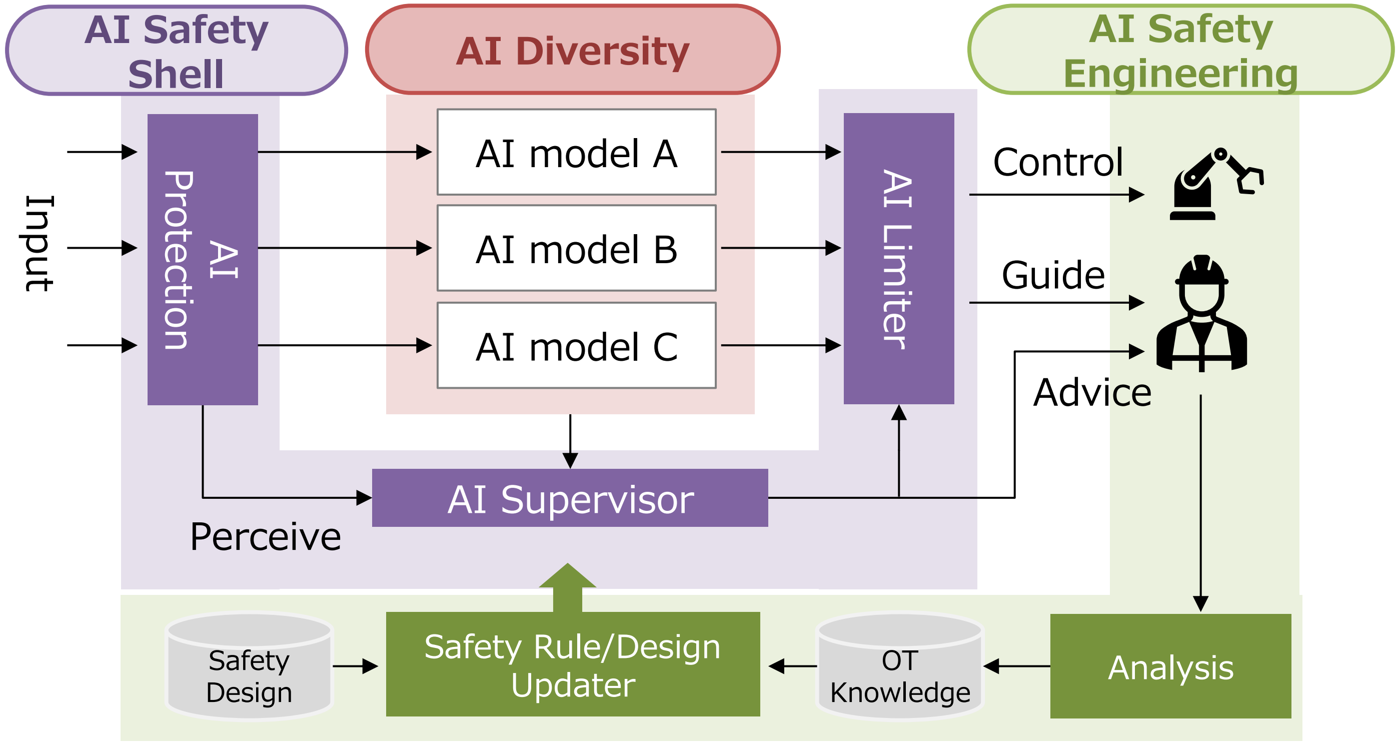
Improving reliability/safety through diversity, AI Safety Shell, and Safety Engineering



①AI Diversity

(Excluded from today's explanation)

- Improvement of reliability/performance

②AISS

- Ensuring safety by making decisions based on rules

③Safety engineering

- Responding to evolving systems

Contents

2-1. AI Safety Shell

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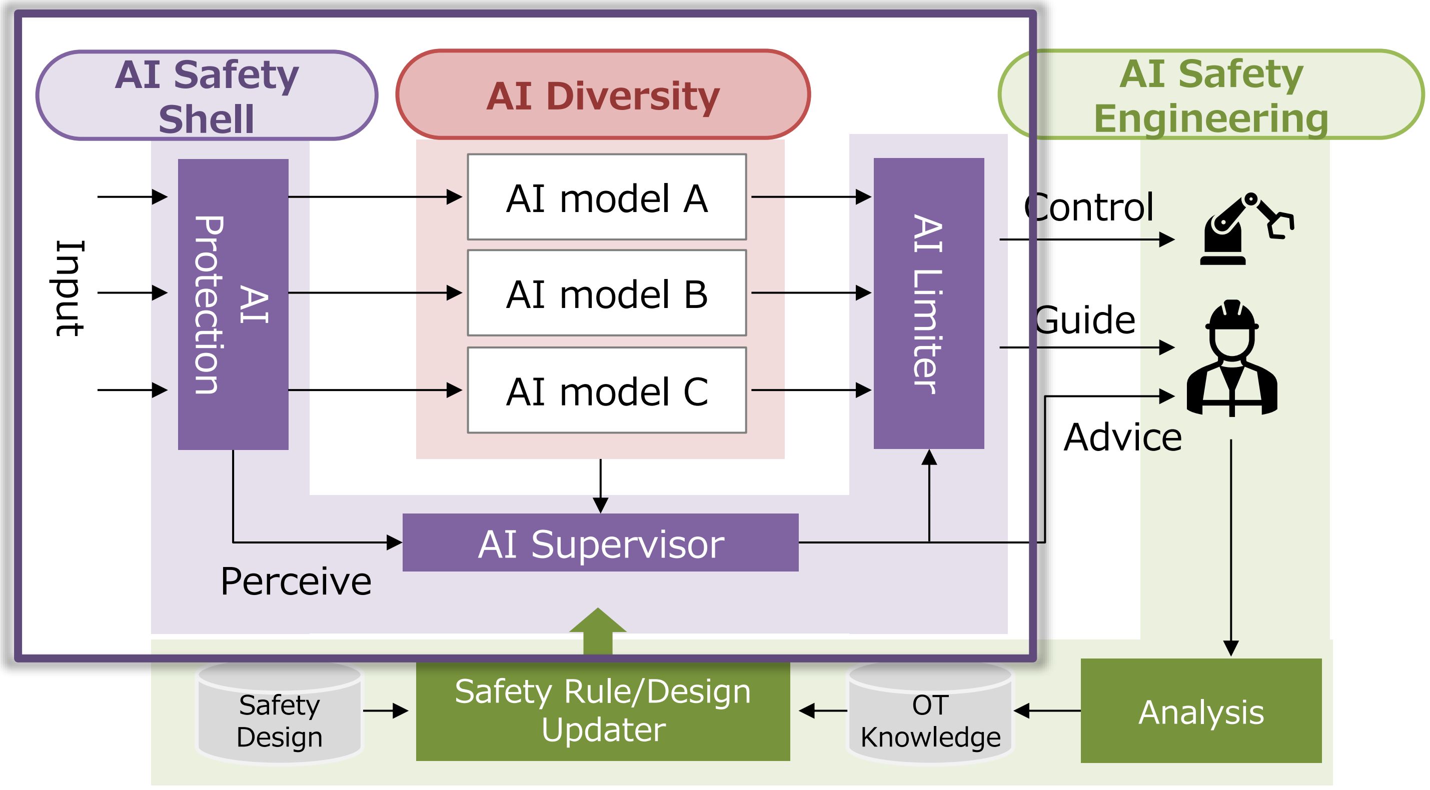
The key is supervision and input/output protection.
The way to protect it differs depending on the application/models/purpose.

■AISS:

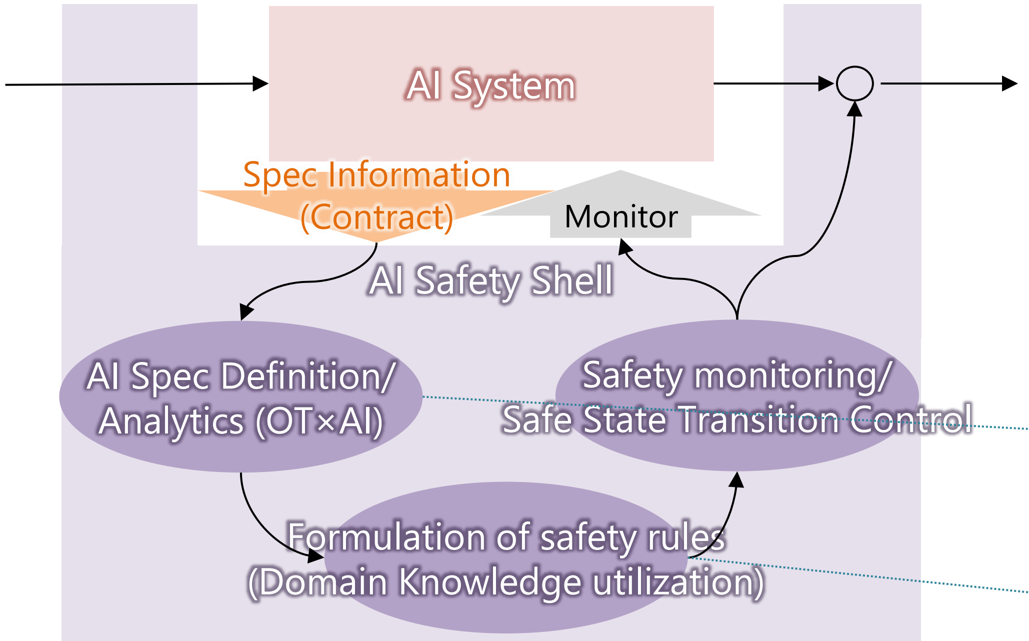
1. **Protection by safety rules**
   (When it is easy to define)
2. **Risk-based protection**
   (for mission-critical systems)



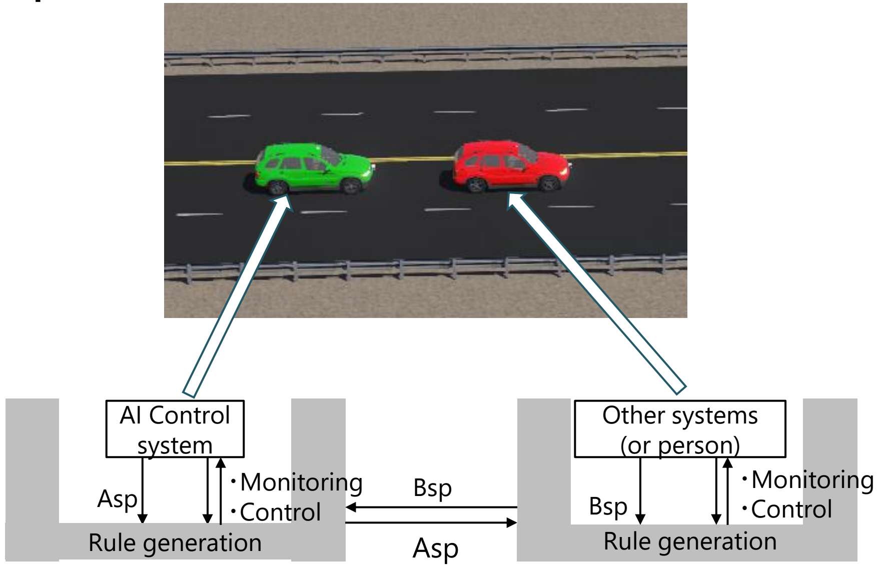
2-2. Safety rule (contract) based safeguard

If the requirements for cooperation can be defined and AI based on safety rules, this approach is possible
The output of AI can be appropriately constrained by contract. Even if it is broken, AISS can protect the system

〇Structure



〇Example



〇AI performance information

$$A_{sp} = (a_{a\_min\_brake}, a_{a\_max\_accel})$$

$$B_{sp} = (a_{b\_max\_brake})$$

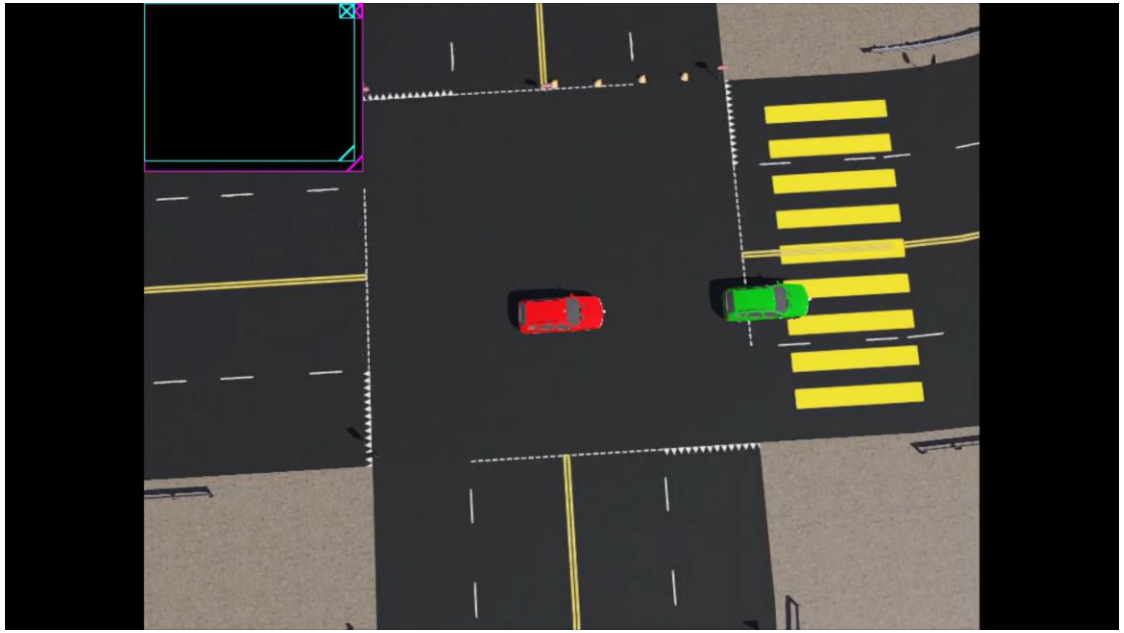
〇 Safety rules

$$d_{min} = \left[v_a\rho + \frac{1}{2} a_{a\_max\_accel}\rho^2 + \frac{(v_a + \rho a_{a\_max\_accel})^2}{2a_{a\_min\_brake}} - \frac{v_b^2}{2a_{b\_max\_brake}} \right]$$

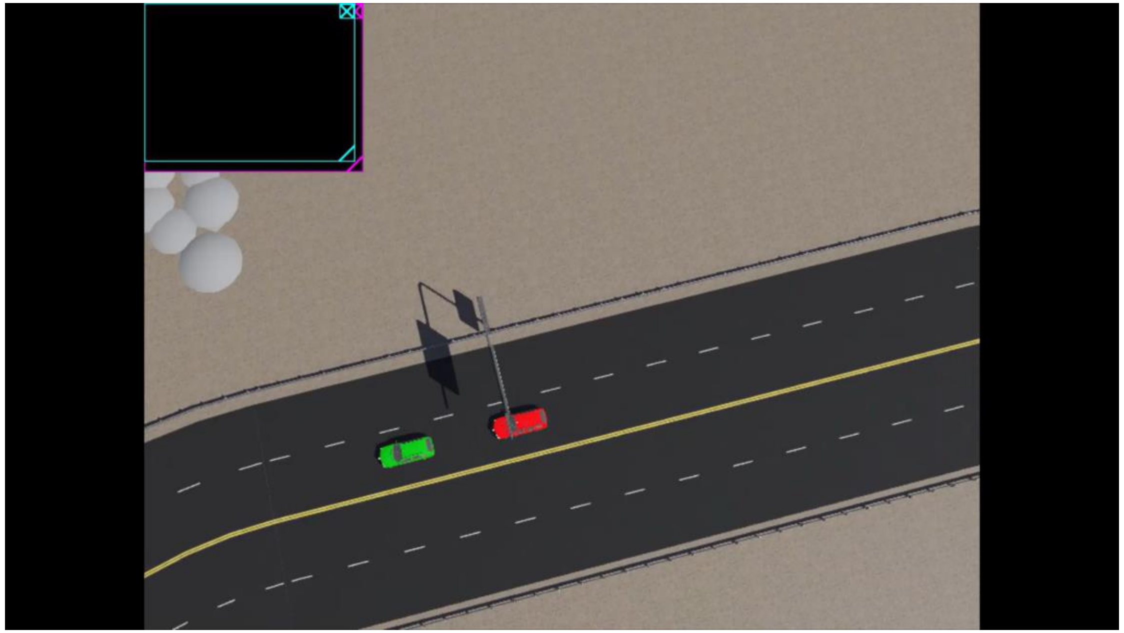
2-3. Experimental result

Even if the AI breaks the rules, it can be controlled safely
When updating, just update the rules

AISS off



AISS on



*While it's easy to notice and stop when a vehicle suddenly accelerates, it can be difficult to notice when a vehicle sometimes doesn't slow down, and it can be too late.

2-4. Risk-based guardrails

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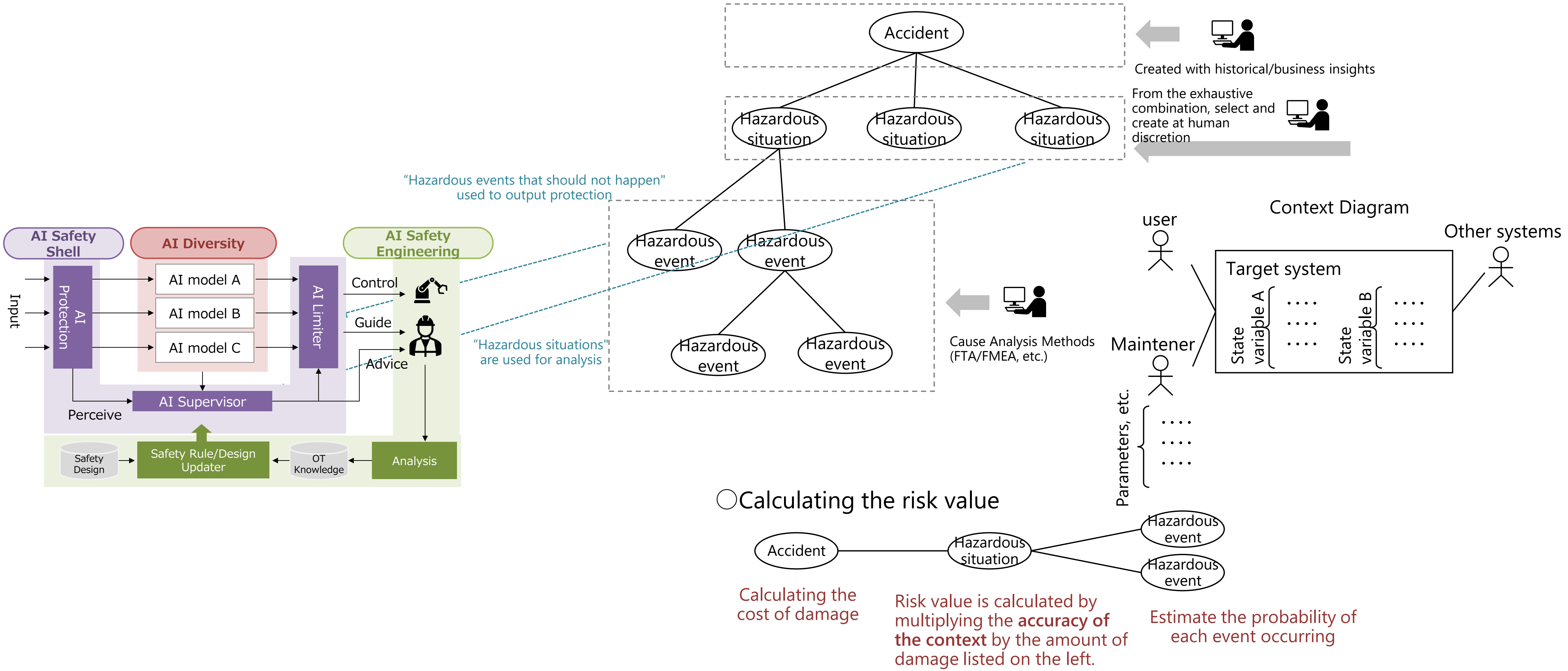
Protect outputs according to risk (for mission-critical systems)
The key is context. Protect outputs by correctly understanding the current situation.



2-5. Prototyping (Risk-based guardrails)

*Presentation Only

Contents

3-1. AI Safety Engineering

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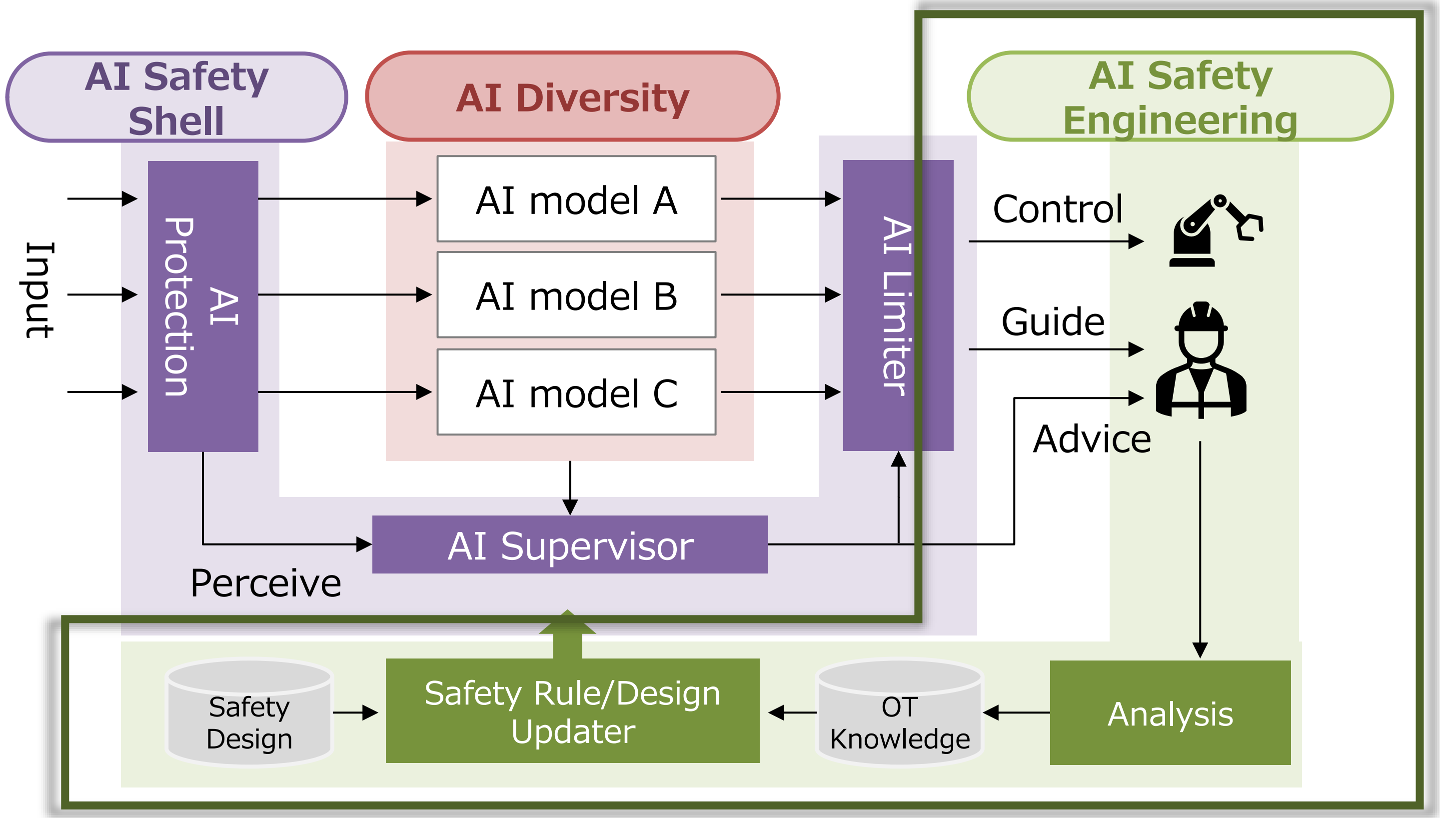
AI evolves through data-driven methods. Corresponding safety engineering methods are required

■Safety engineering

- Dynamic risk assessment in response to evolution
- Methods for updating safety rules
- etc.



3-2. Safety engineering method overview

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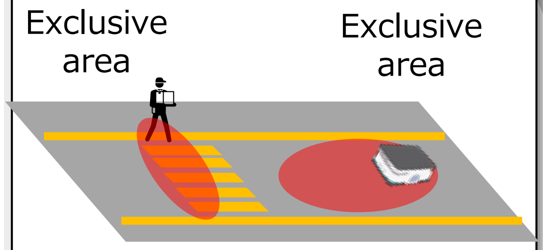
Evolve the system to adapt human-evolution (co-evolutional control) with guaranteed safety

Symbiotic safety (basis) [8]

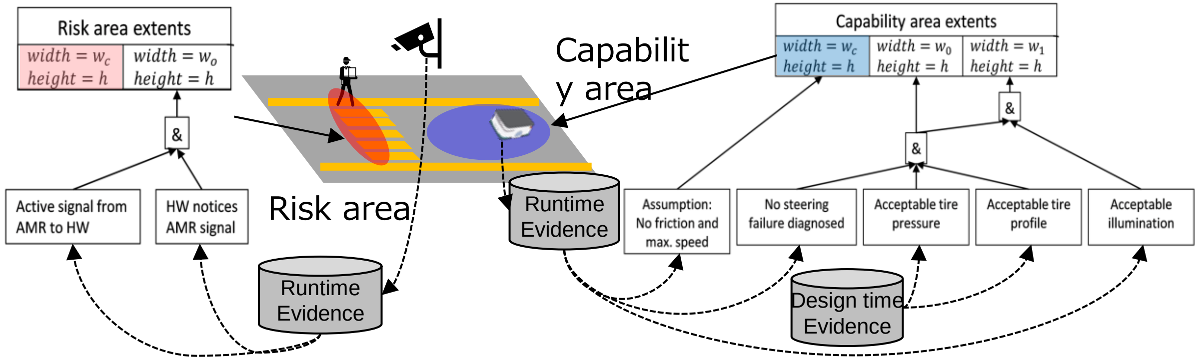


Area exclusive control

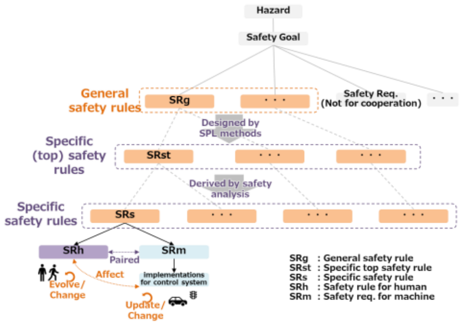
Fraunhofer IKS

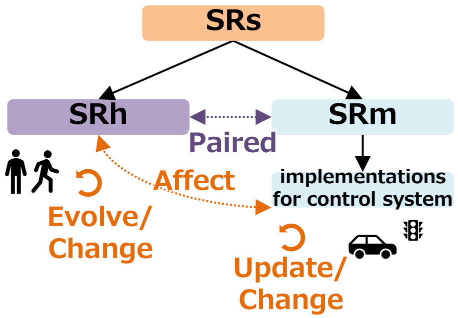
Dynamic risk and capability assessment [9]

Fraunhofer IESE



Paired safety rule structure [10]





Shorten the safety design time to apply the system to other use-cases or domains

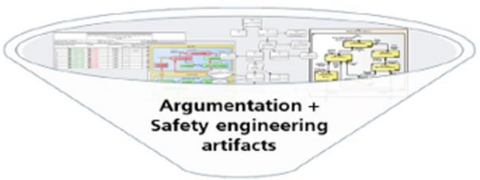
Environment metamodel [11]

Fraunhofer IESE

Safety engineering artifact

Reusable

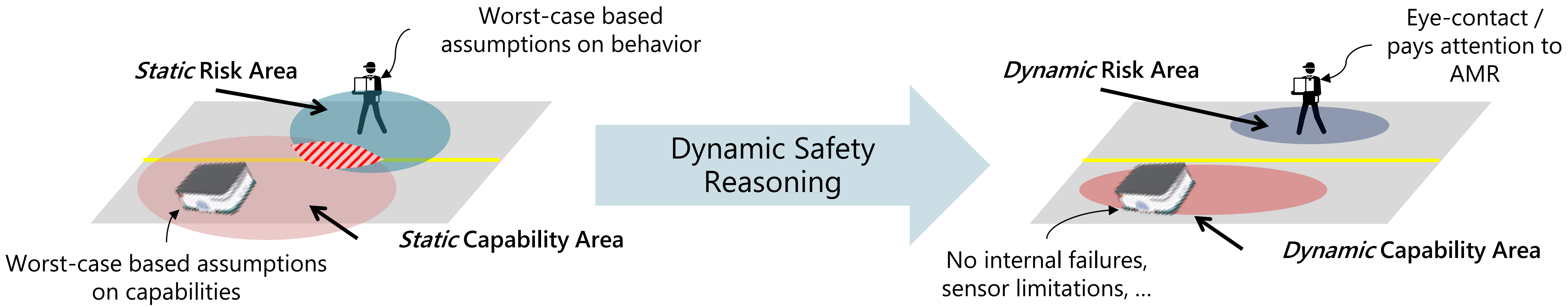
New design



DDI

3-3. Dynamic risk and capability assessment

Dynamic Risk and Capability Areas Can Enhance Efficiency Compared to Using Worst-Case Assumptions

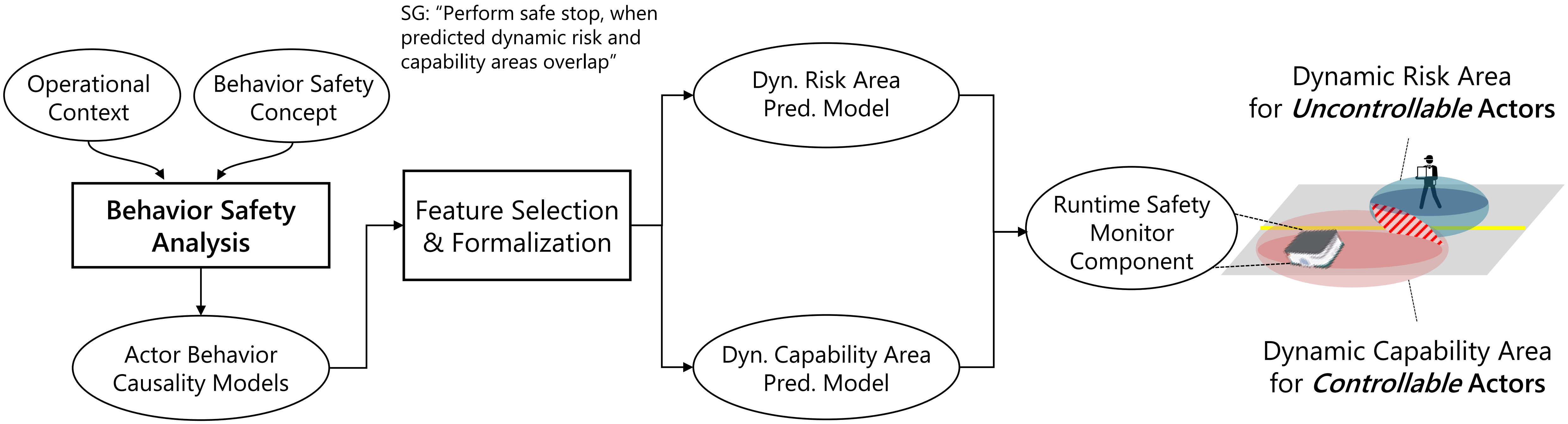


- Replace static worst-case assumptions with dynamic safety reasoning capabilities
- Detecting low-risk situations and reducing risk/capability area extents
- Requires models that allow a dynamic assessment of:
  - risk of operational situation for human worker
  - safety-related capabilities of the AMR

AMR: Autonomous Mobile Robot

3-4. Method overview

Engineering Runtime Safety Monitors Requires a Systematic Method for Dynamic Model Creation



3-5. Method overview

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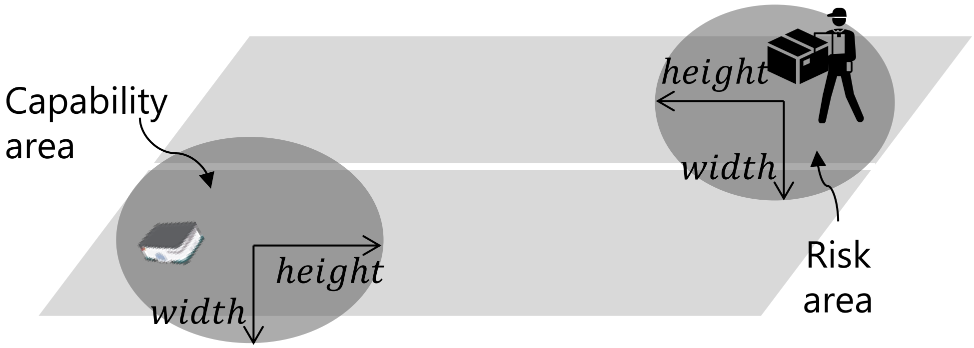
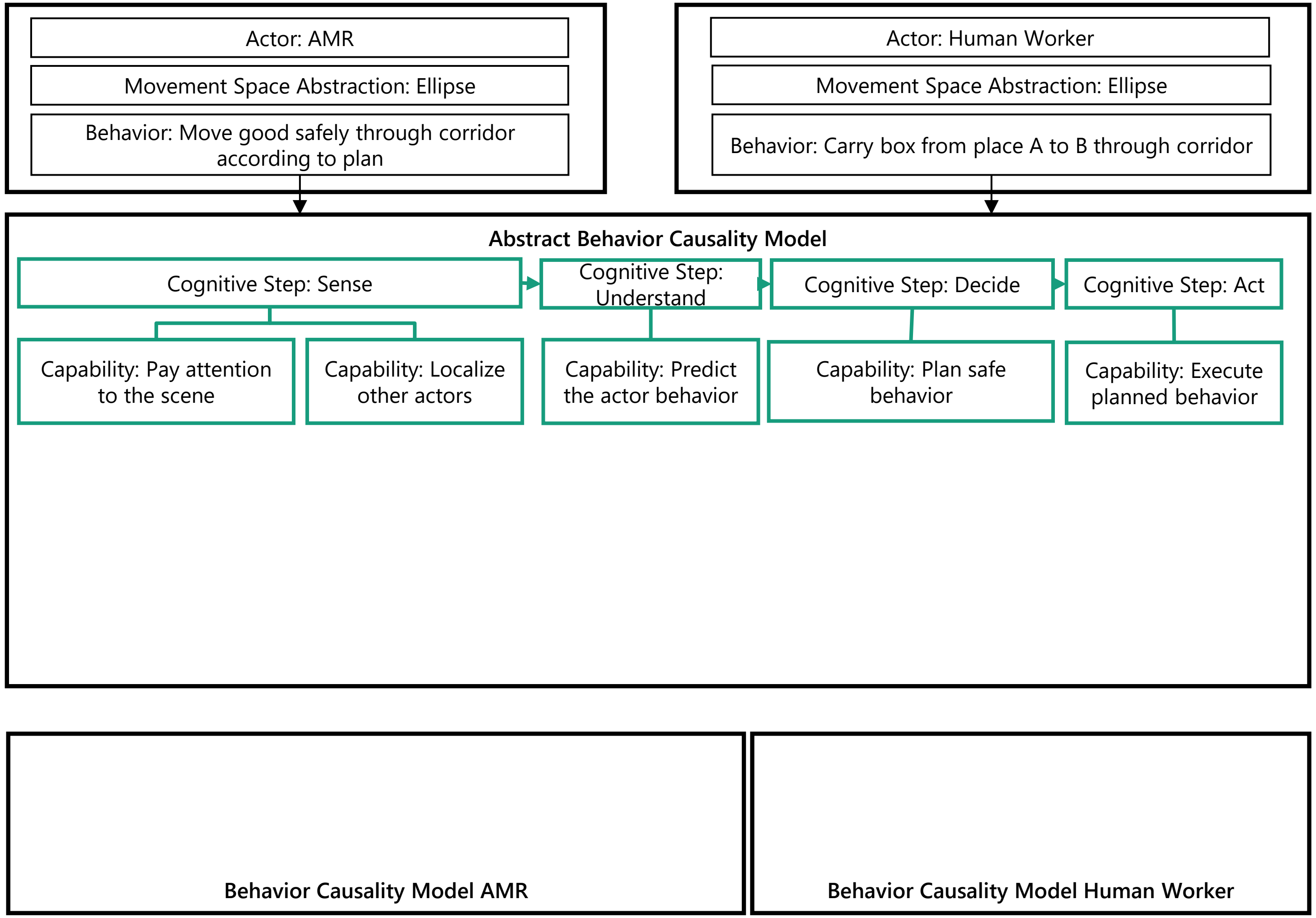
Movement Space is Modelled based on SUDA and its Capability Decomposition





SUDA: Sense-Understand-Decide-Act

3-6. Method overview

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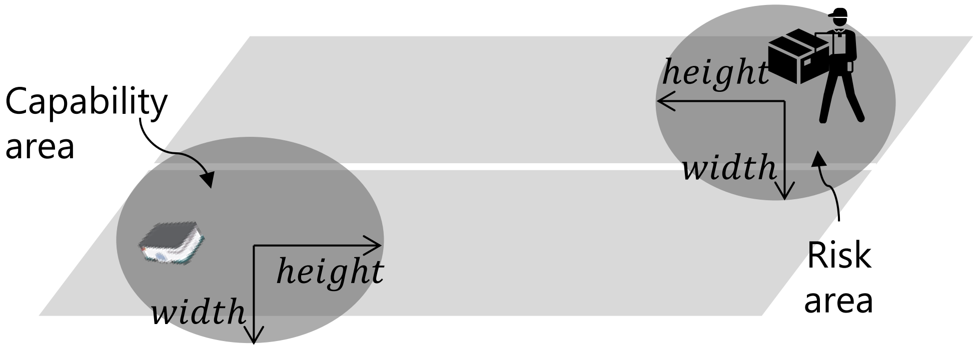
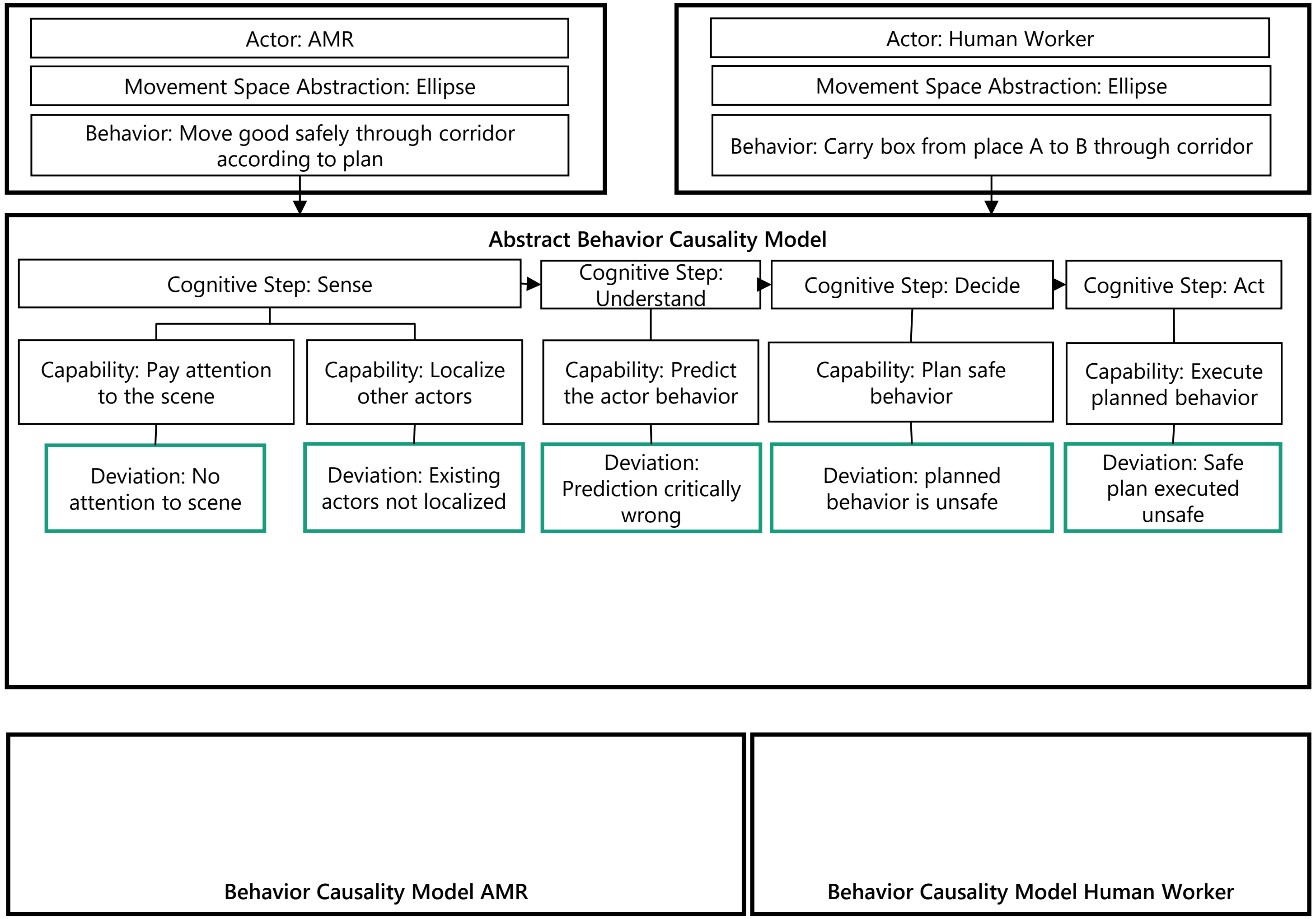
Potential Capability Deviations impact the likelihood of Behaviors





3-7. Method overview

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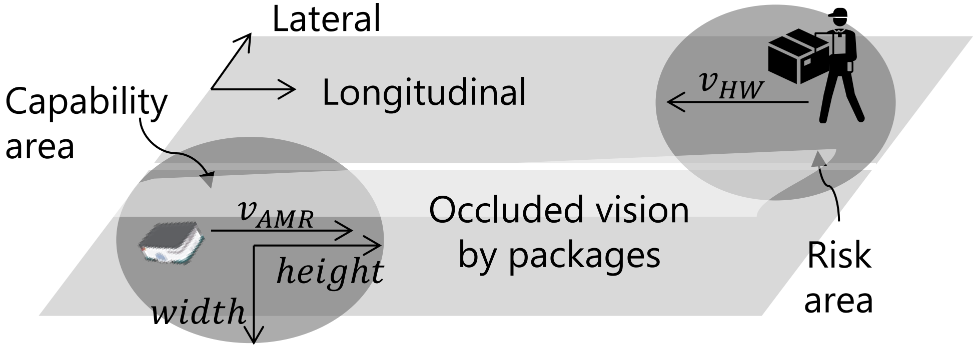
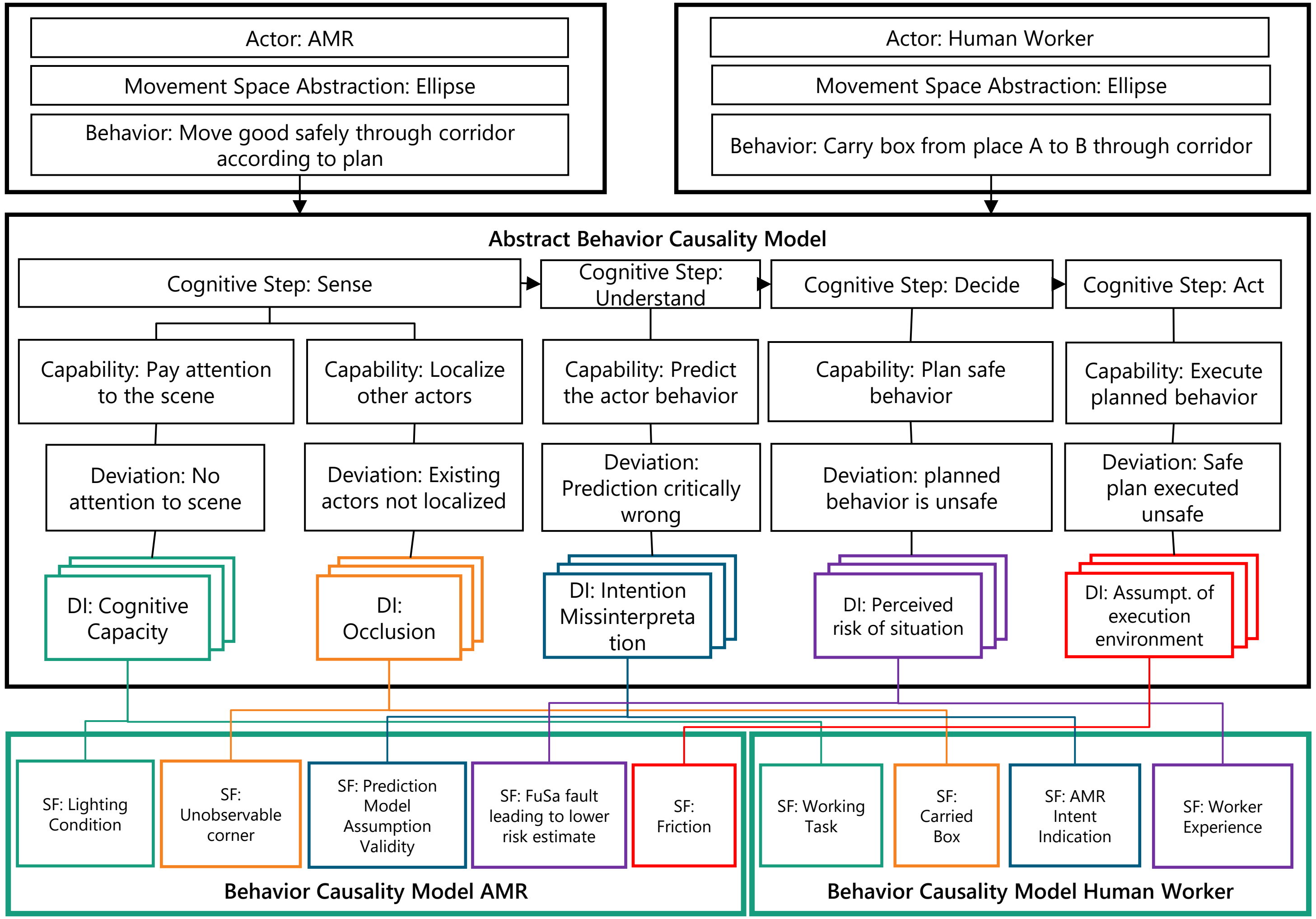
Situation Features concretize abstract Deviations for particular Actors

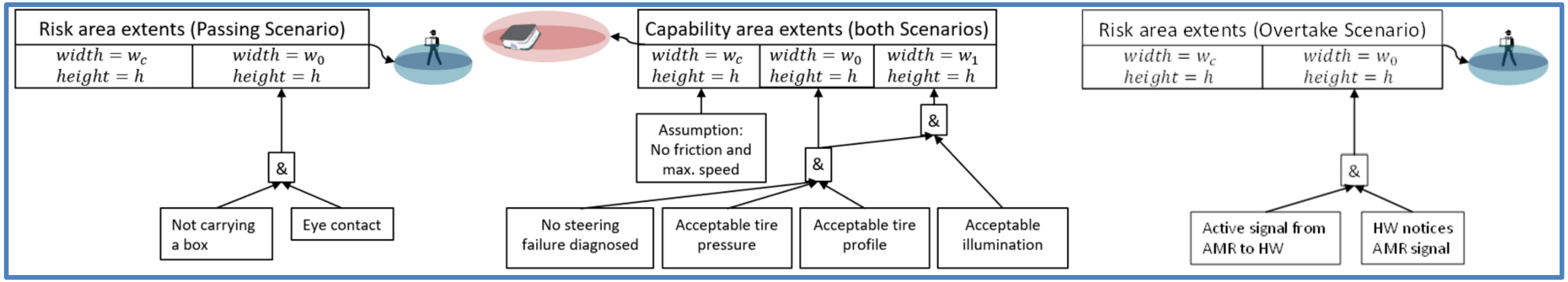




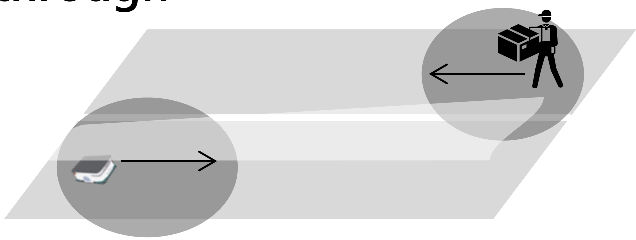
DI: Deviation Influence, SF: Situation features

3-7. Evaluation result

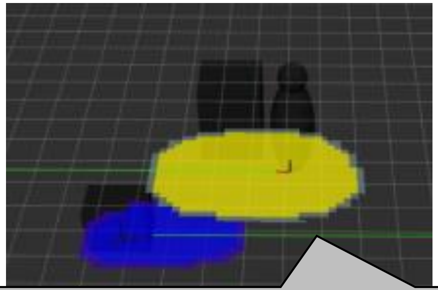
Integration of Dynamic Risk and Capability Models by ConSert



Passing through

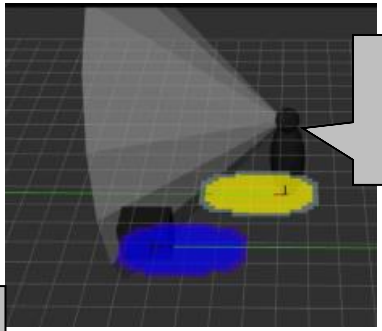


Carrying a box



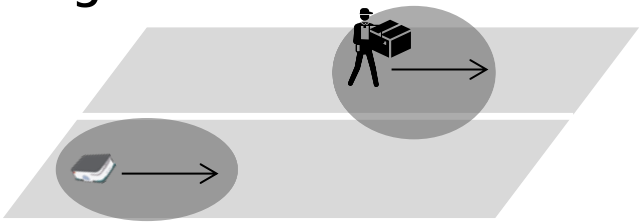
If the worker is carrying a box, risk area is set to large
(he cannot see the AMR)

Not carrying a box & eye contact

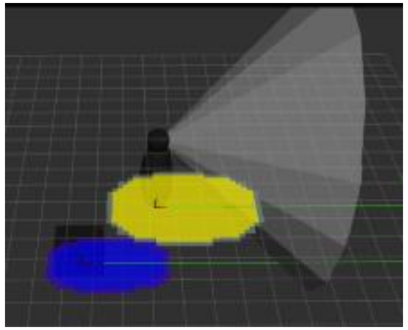


Once the system detects worker's eye contact,
Risk area is set to small

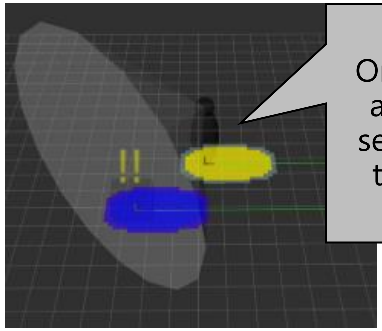
Overtaking



If HW is not aware of AMR,
AMR doesn't overtake



If HW is aware of AMR,
AMR overtakes the HW



Once the system detects awareness, Risk area is set to small and thereby the AMR can overtake

Contents

4-1. AI x Symbiotic safety

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4-2. Collaboration result with Fraunhofer

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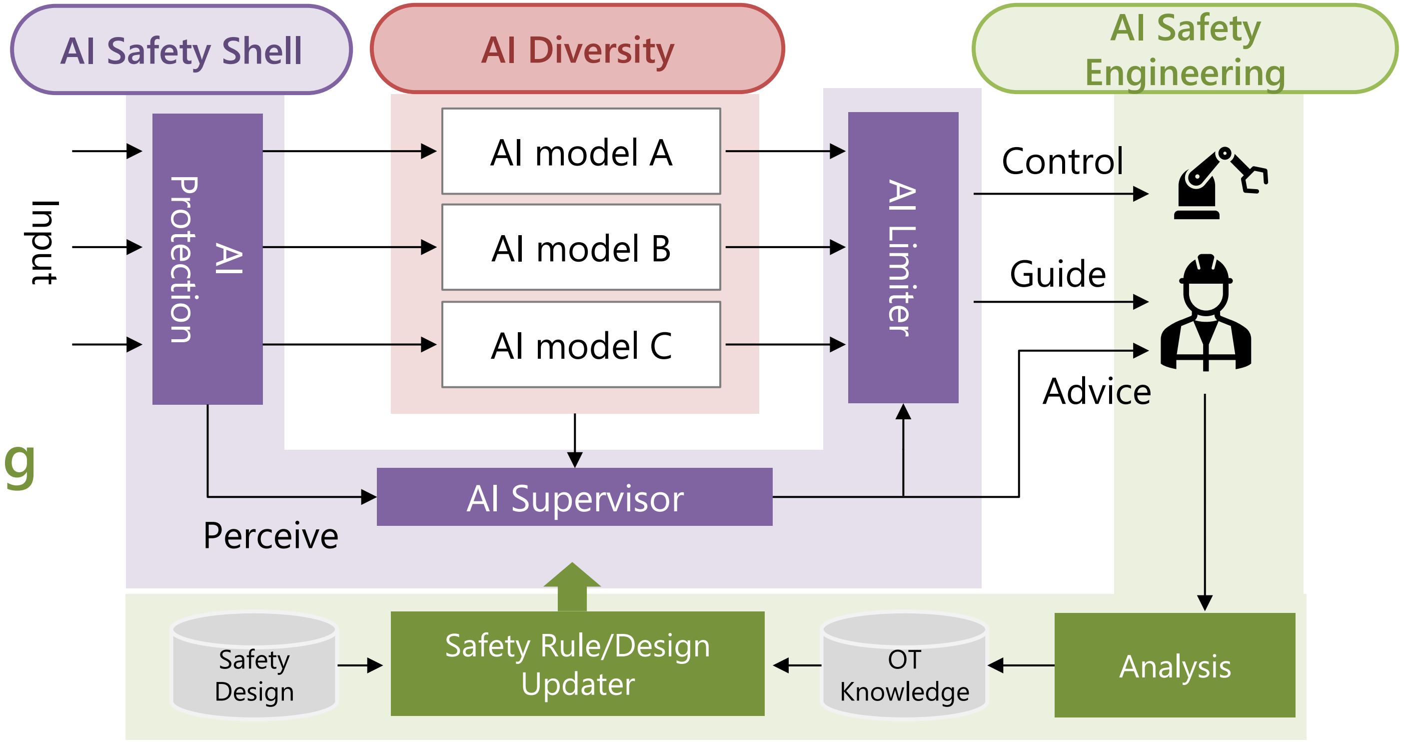
These contents are still being updated through the collaboration with Fraunhofer

■Specific implementation for AISS

- Definition of AI risk
- Protection/Supervisor/Limiter

■Updated version of Safety Engineering (by AI/ for AI)



Contents

5-1. Conclusion

- **Introduction of Hitachi's AI Safety activities**
  - Hitachi try to apply AI to Mission-critical systems (in the OT field)

- **Implementation of the AISS concept/architecture**
  - Two approaches: rule-based, risk-based assessment

- **Safety engineering process** that can respond to dynamic changes

- **Further activities**
  - Evaluation of implementation in control systems
  - Collaboration with Fraunhofer

5-2. References

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