

Safety Network Japan第120回定例会



路車協調型モビリティ制御の安全性について

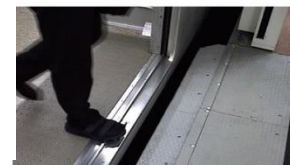
日時: 2025年4月18日(金) 15:00~17:00

会場: 日本大学理工学部駿河台キャンパス(御茶ノ水)

タワー・スコラ6階 S617会議室

株式会社京三製作所 R&Dセンター

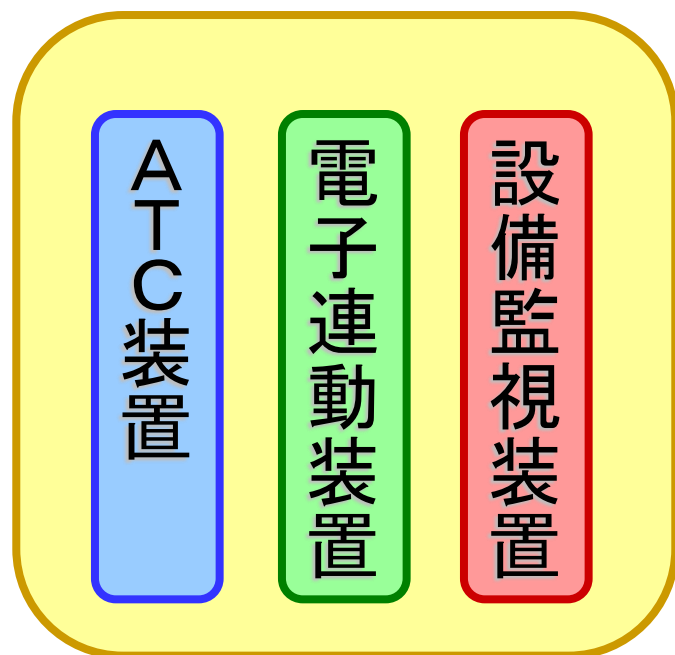
高田哲也



1. はじめに
2. 鉄道:CBTC用連動装置
3. 路面電車:運行制御システム
4. 道路:交差点信号制御
5. 自律運転と路車協調制御
6. おわりに

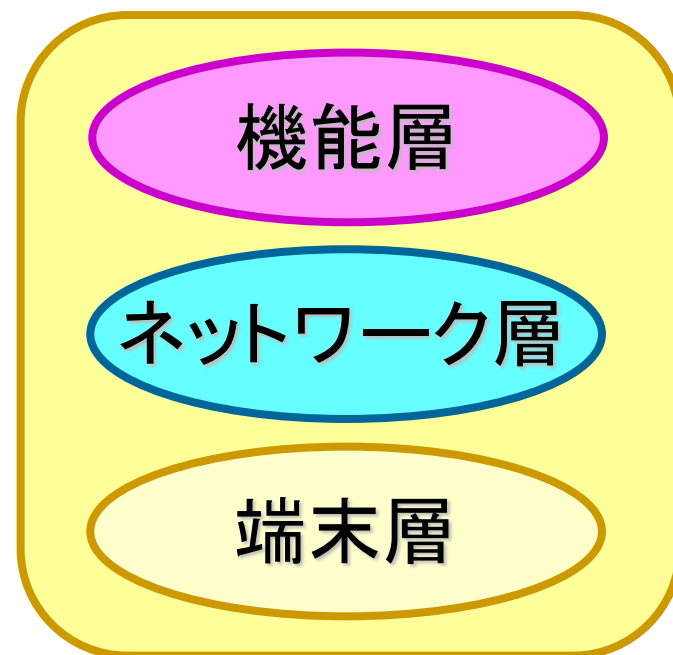
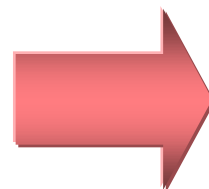
1. はじめに
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従来システム



縦割りの“独立構成”から

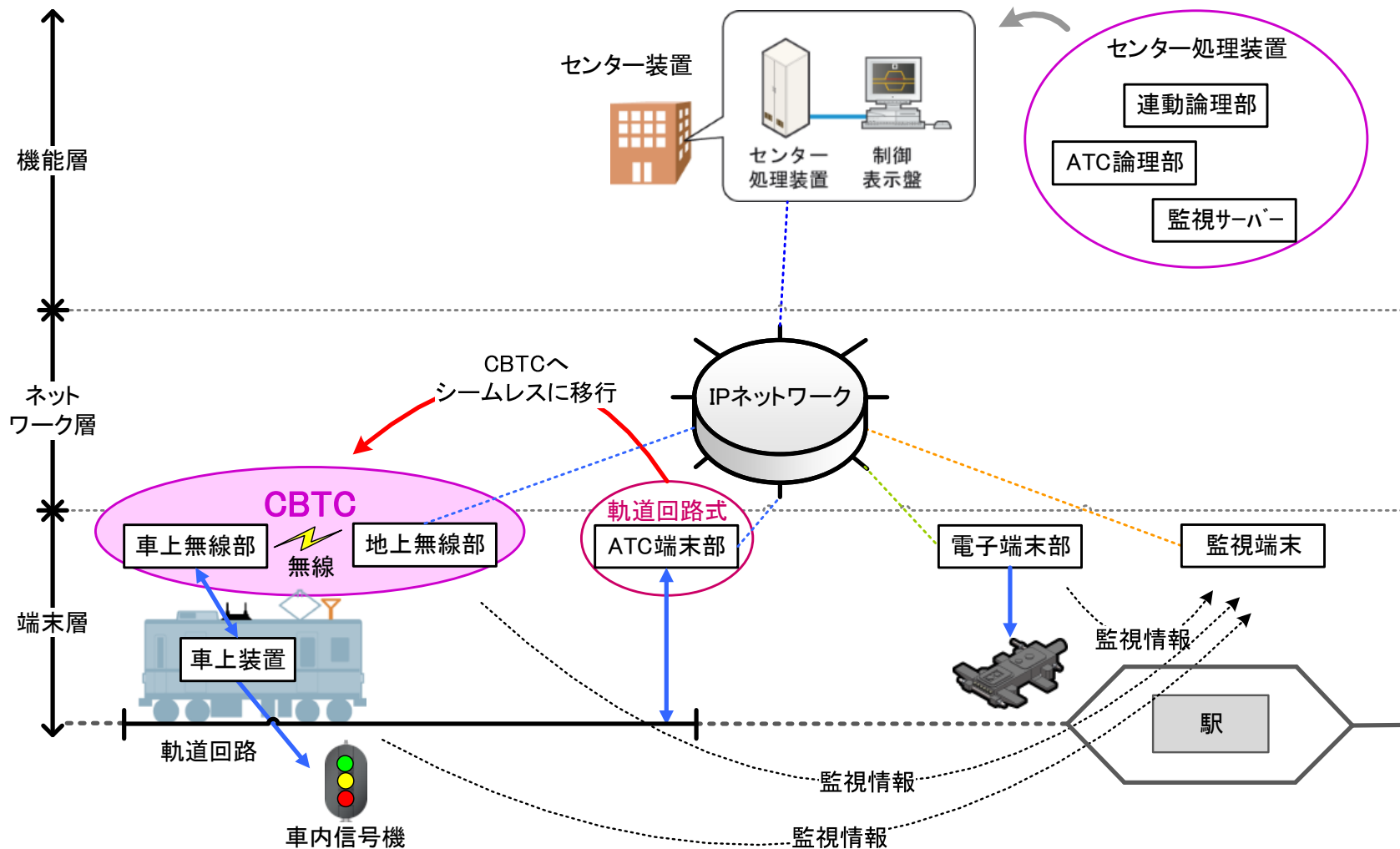
統合型列車制御システム



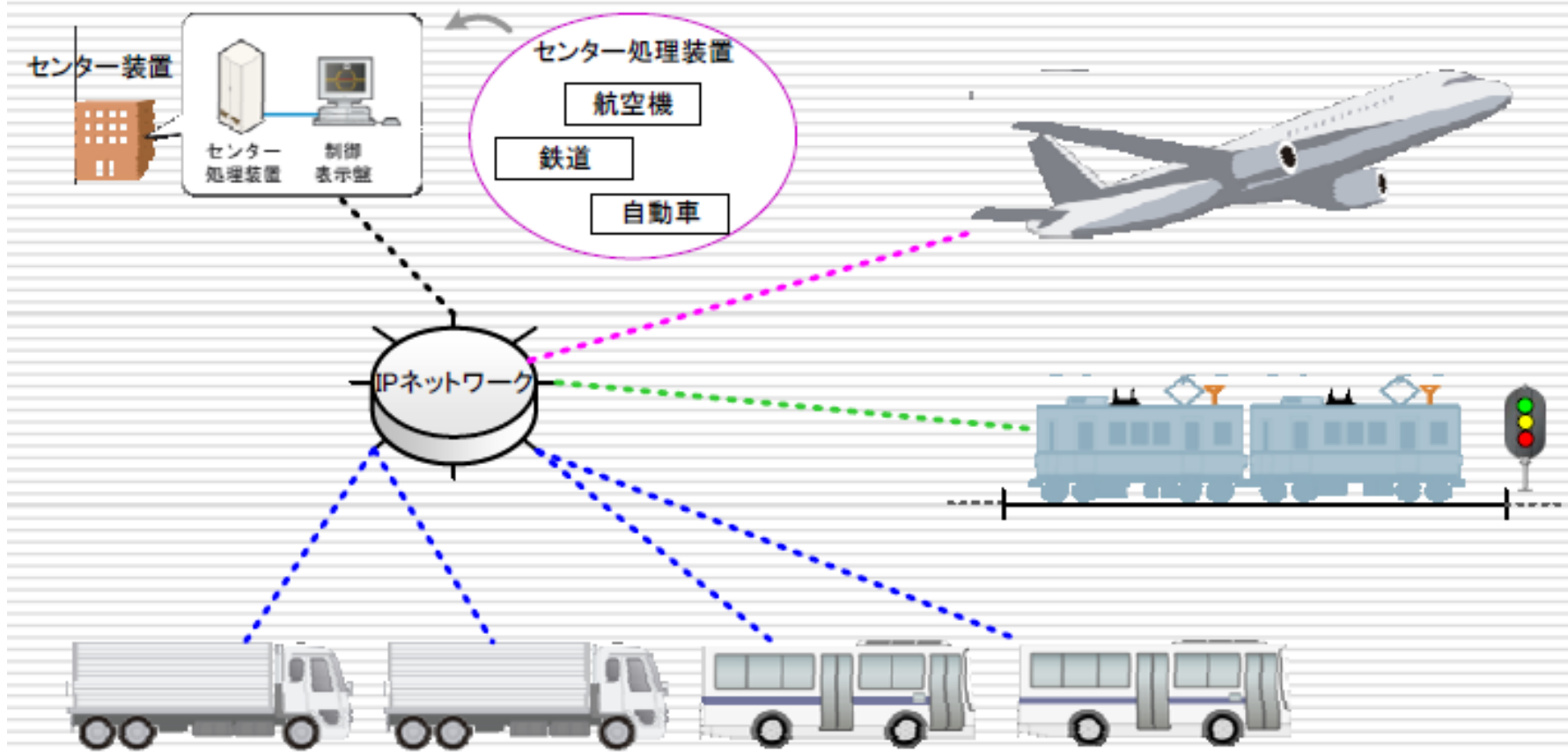
横割りの“階層構成”へ



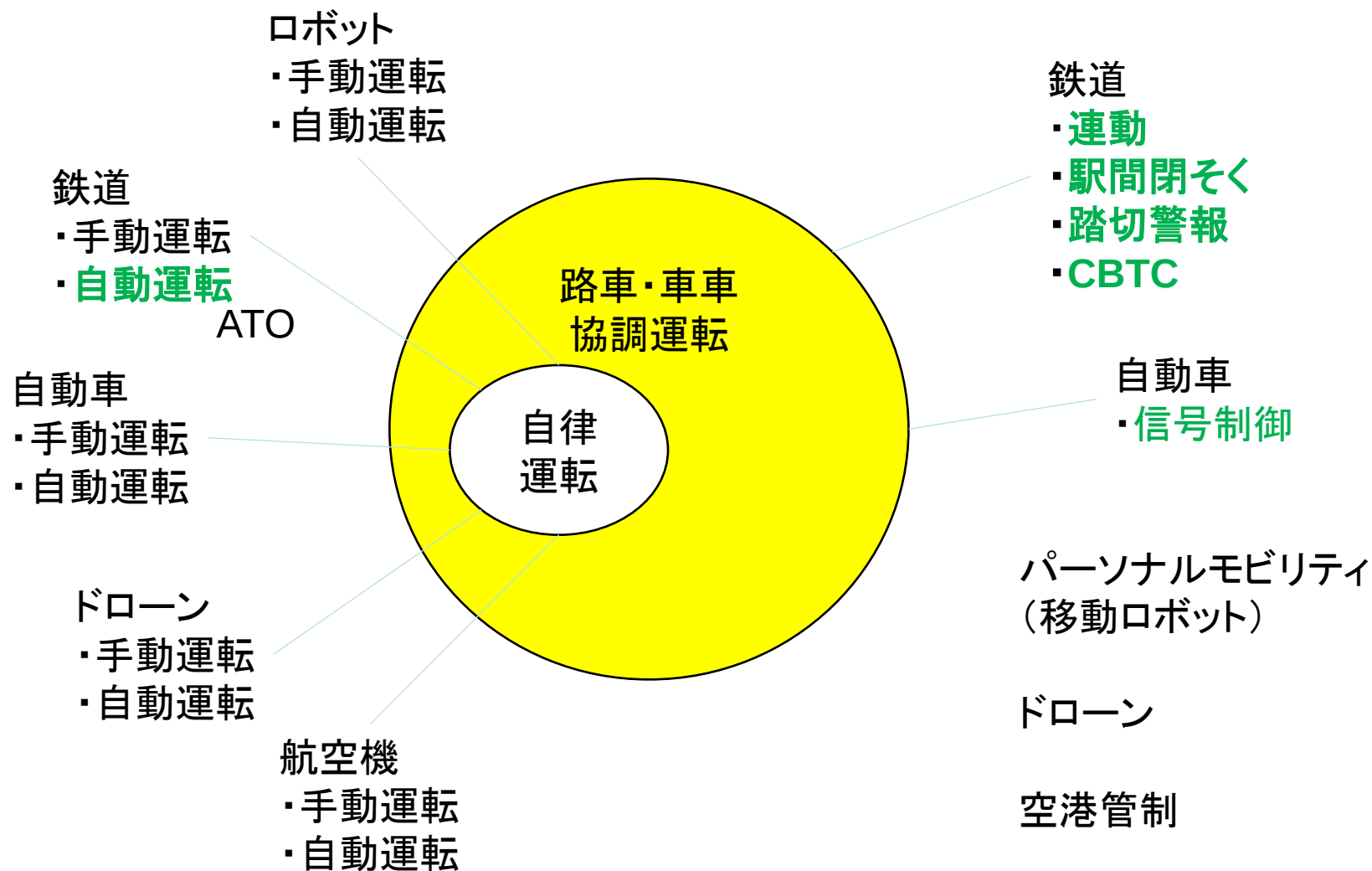
統合型列車制御システム



交通インフラシステムの新たな方向性は？

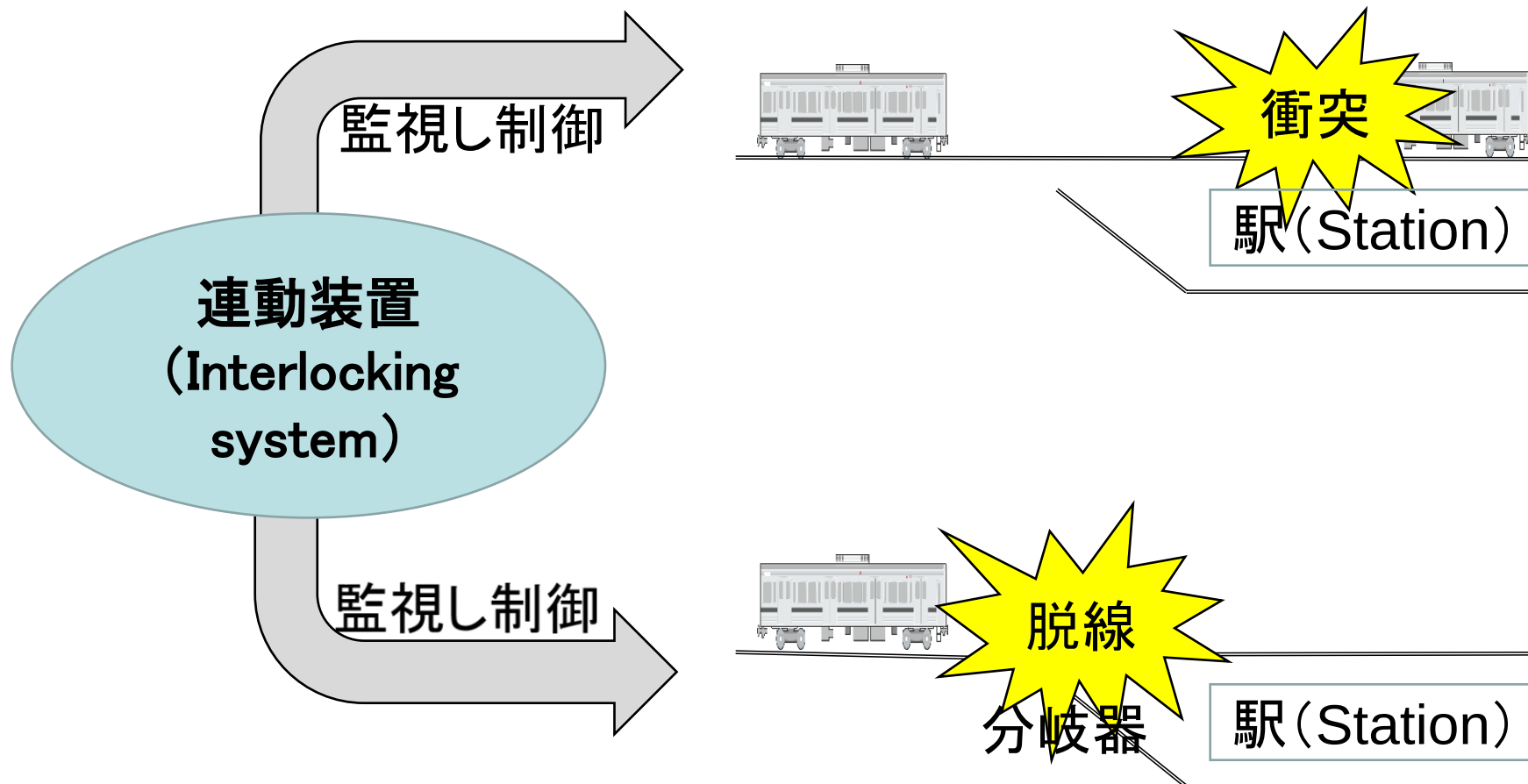


齊藤嘉久,高田哲也,風間洋(2014). 未来交通管理系統の新展望. 2014軌道工程建設之挑戰與創新發展研討會.

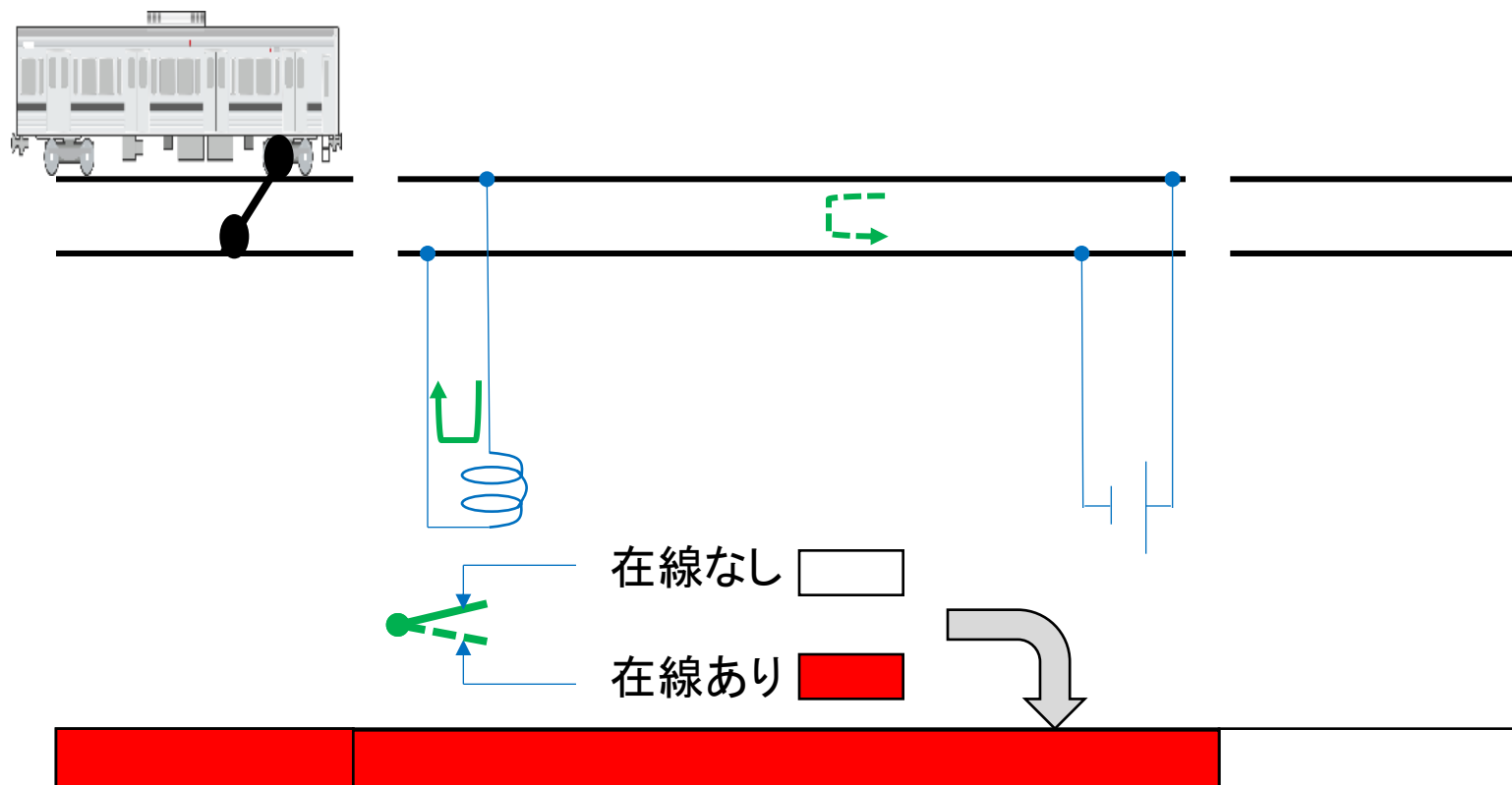


1. はじめに
- 2. 鉄道:CBTC用連動装置**
3. 路面電車:運行制御システム
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連動装置とは



列車の位置検知(軌道回路方式)

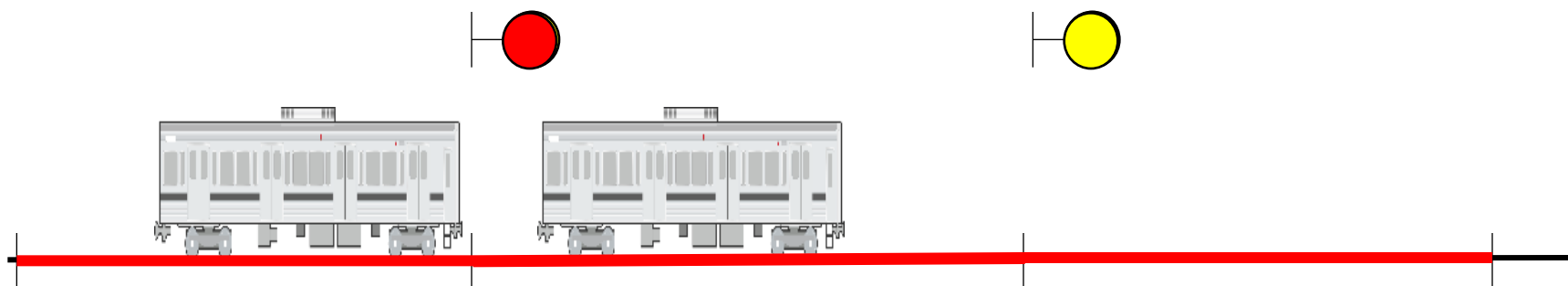


無線式列車制御システム(CBTC)とは

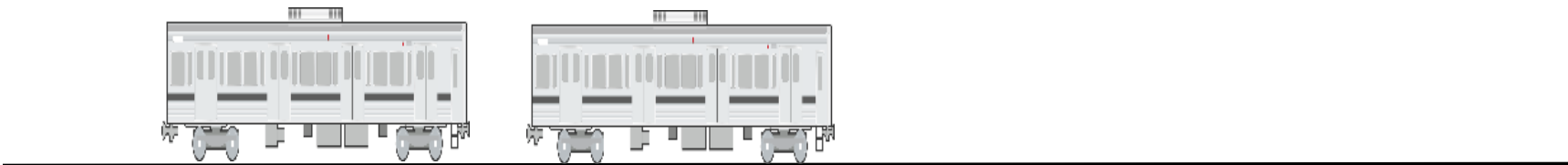
CBTCにおけるATPの定義

- ① 軌道回路を使わない高精度な列車位置検知
- ② 連続双方向の高速通信
- ③ 車上主体型列車制御

軌道回路方式の列車制御



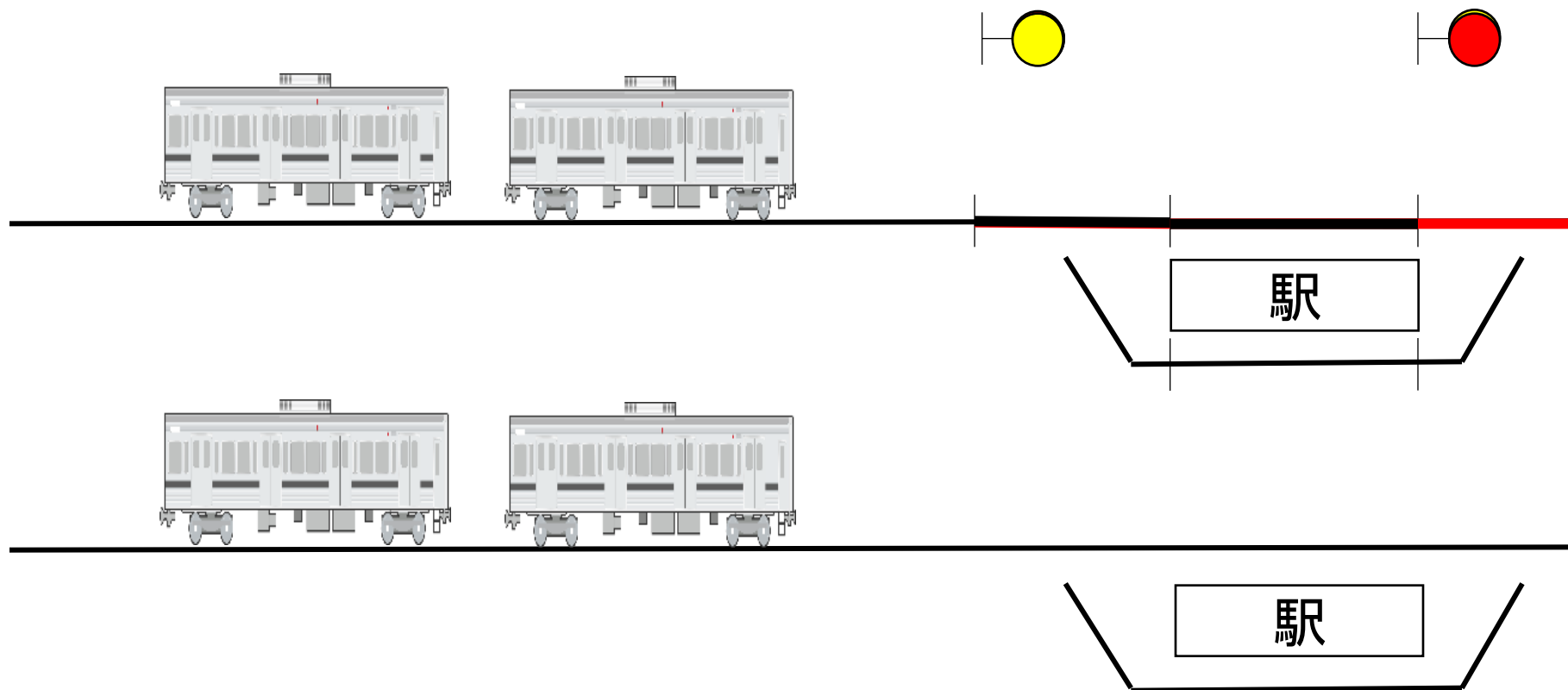
CBTC方式(移動閉そく式)の列車制御



2. 鉄道:CBTC用連動装置

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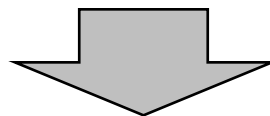
課題



課題解決手法

駅構内でも行きたいところ(走行路)に対して、
行かれるところ(確保した走行路)まで行く

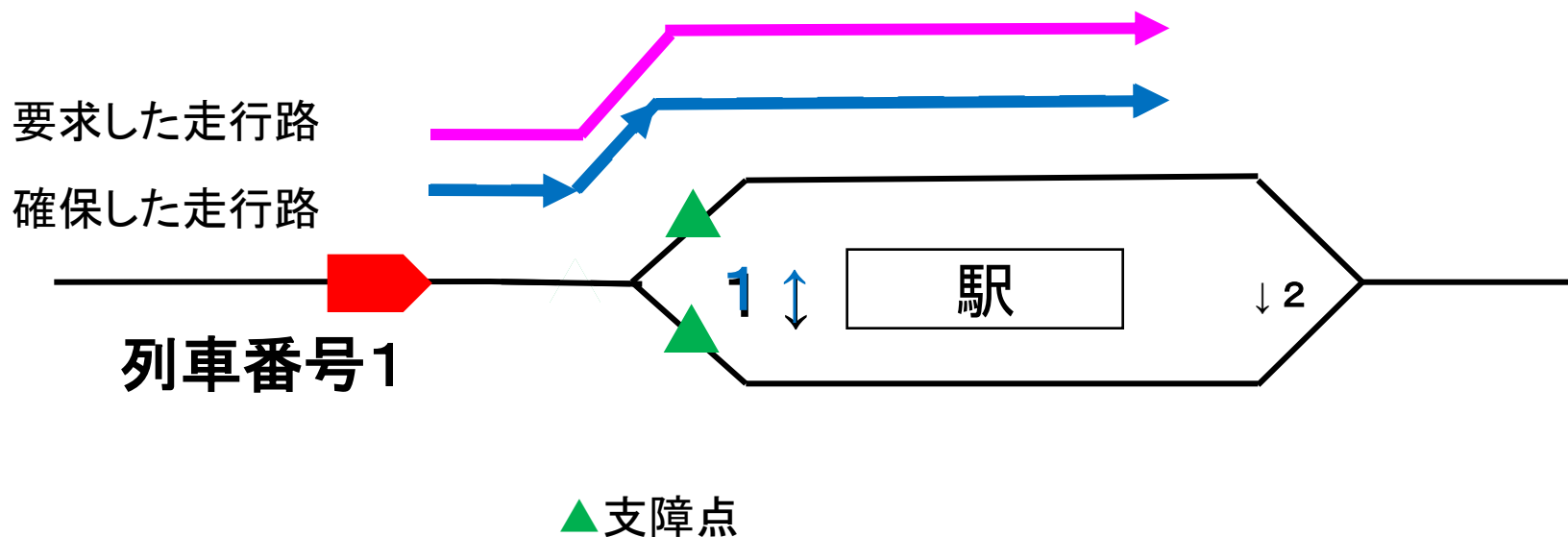
- ①前方列車の後端位置
- ②分岐器の方向を確認



走行路確保の考え方に基づく論理

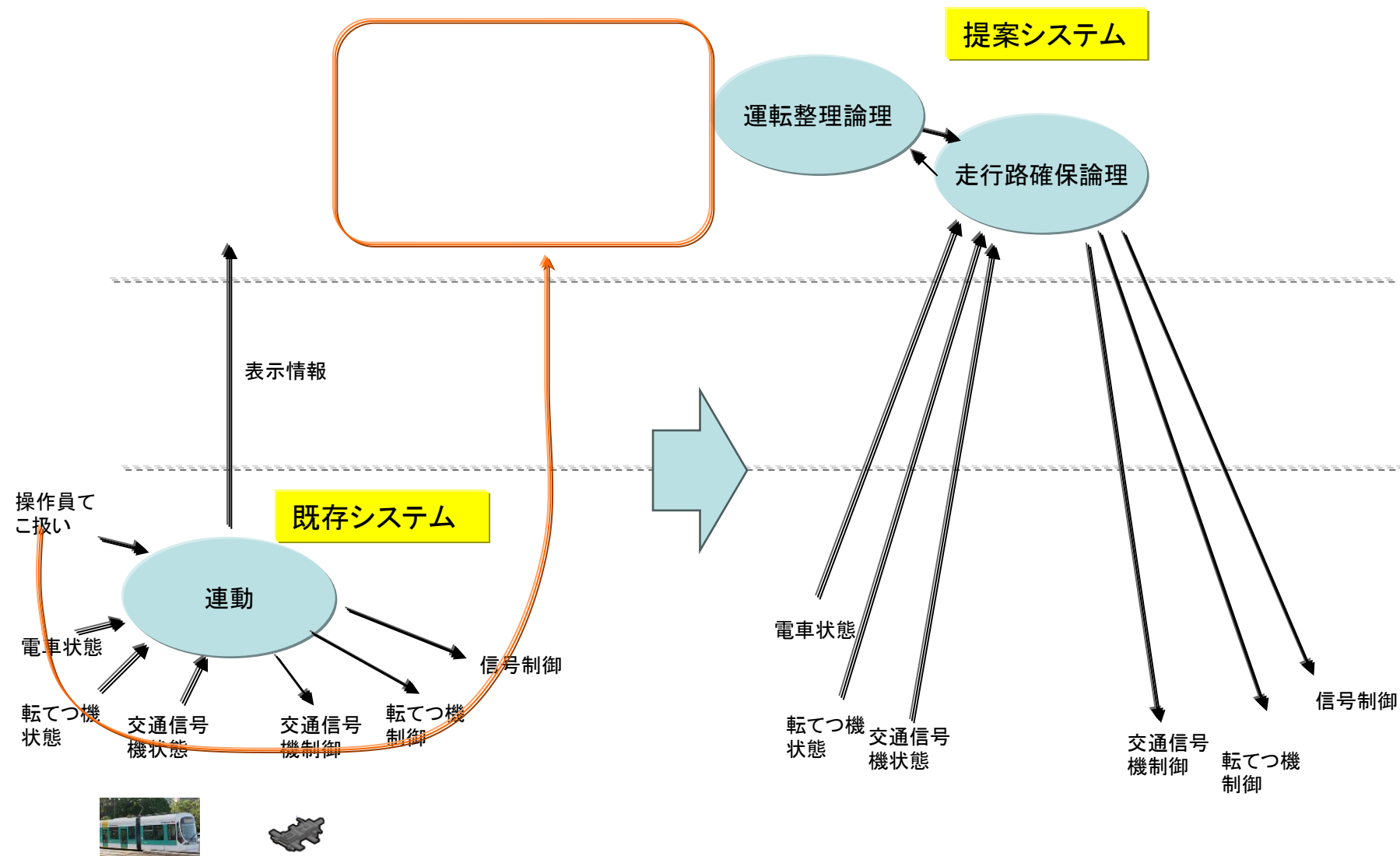
駅構内でも行きたいところ(走行路)に対して、
行かれるところ(確保した走行路)まで行く

②分岐器の方向を確認



1. はじめに
2. 鉄道:CBTC用連動装置
- 3. 路面電車:運行制御システム**
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6. おわりに

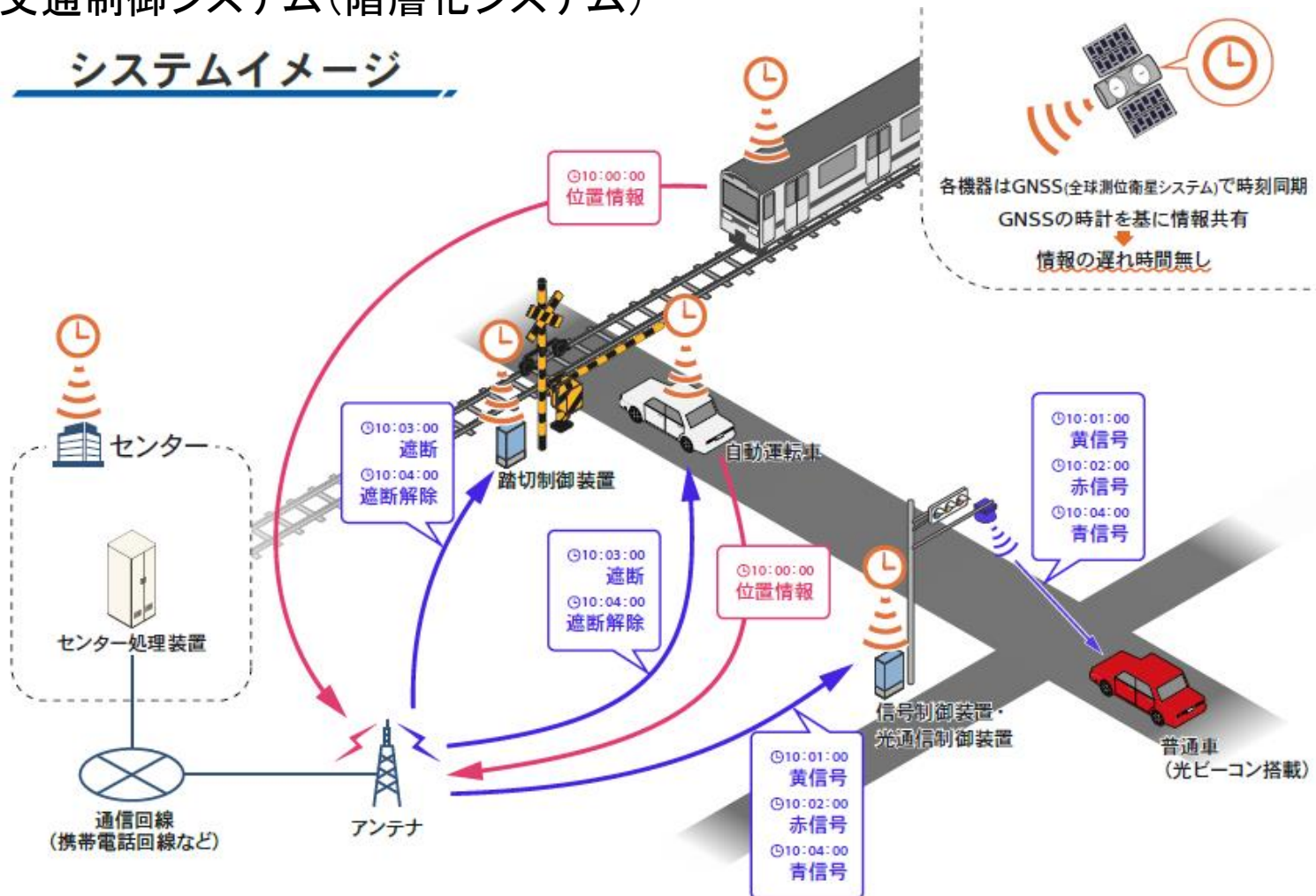
3. 路面電車: 運行制御システム



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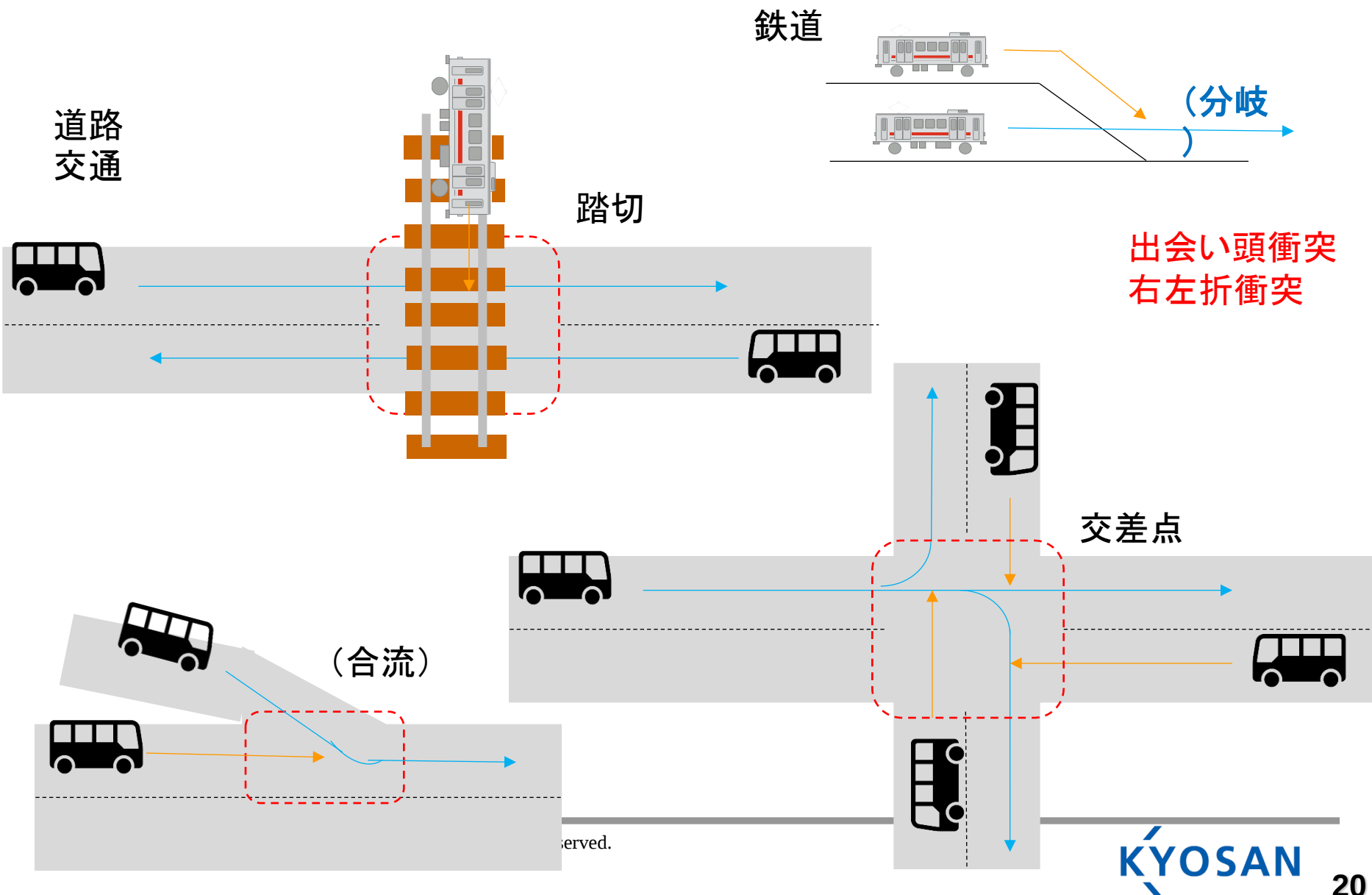
4. 道路:交差点信号制御

統合型交通制御システム(階層化システム)



4. 道路: 交差点信号制御

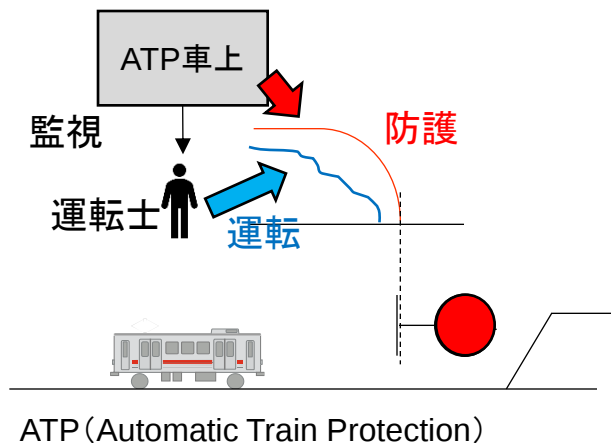
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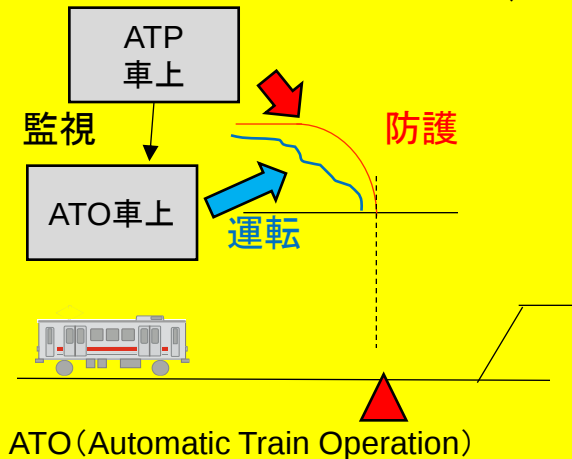
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5. 自律運転と路車協調制御

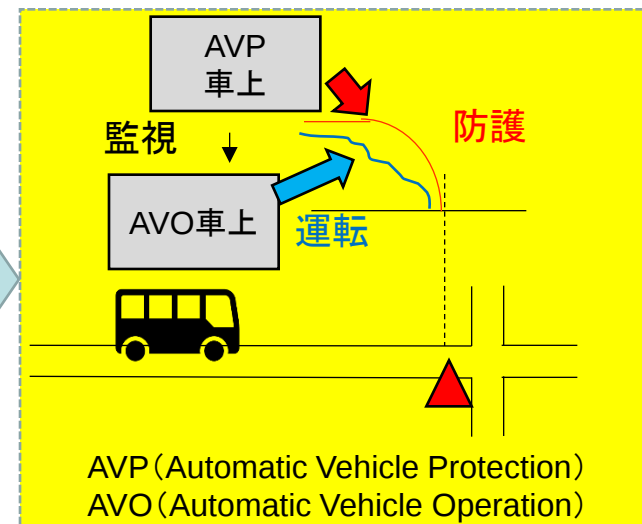
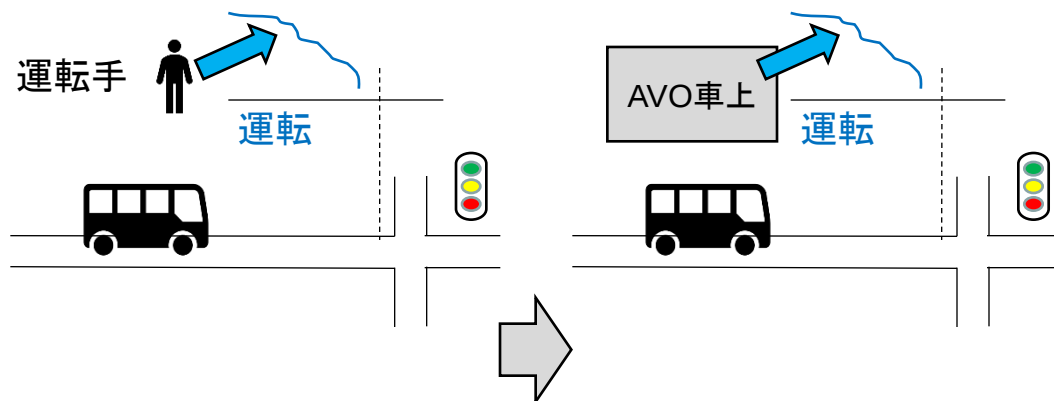
鉄道

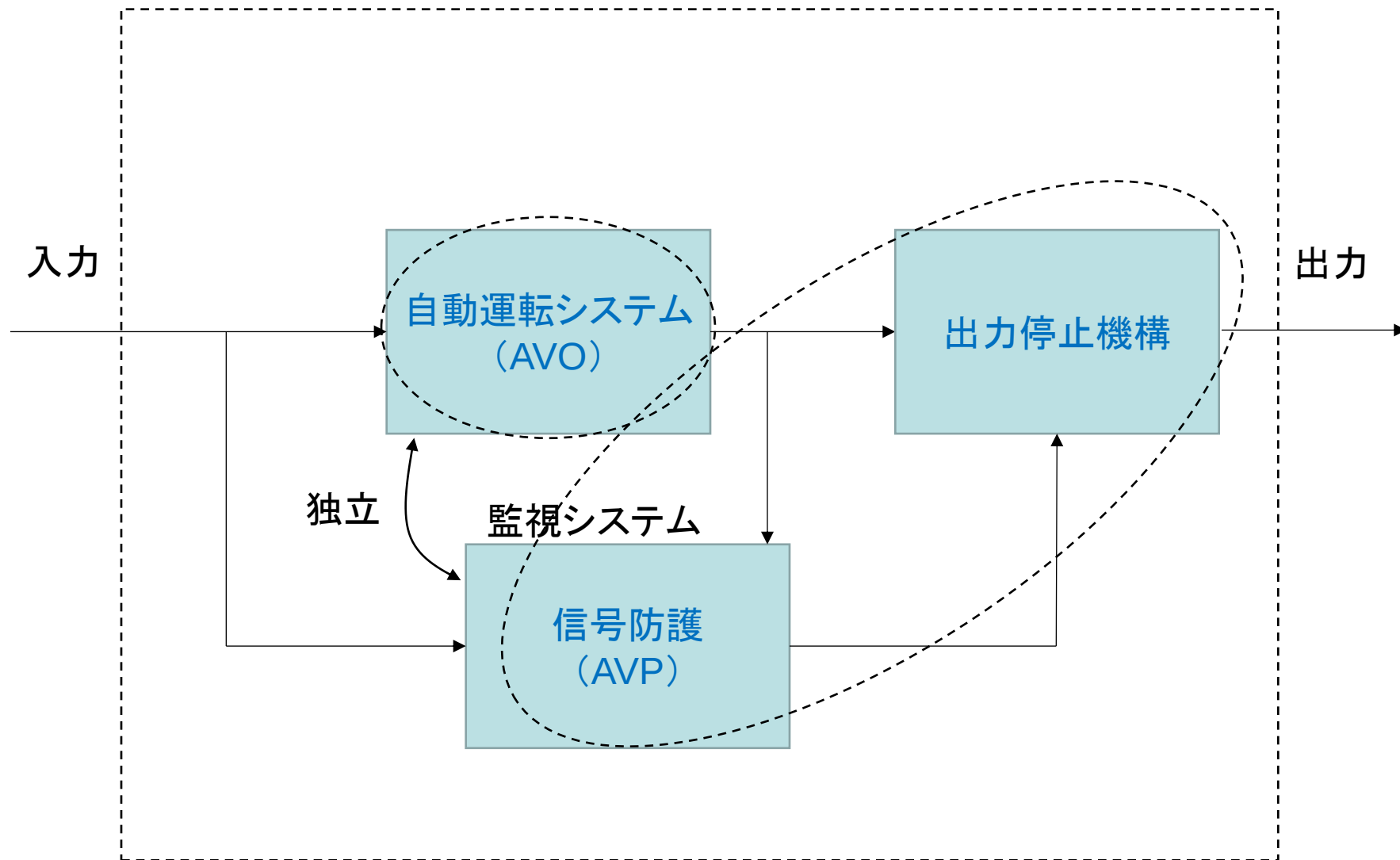


CBTC (Communications-Based Train Control)

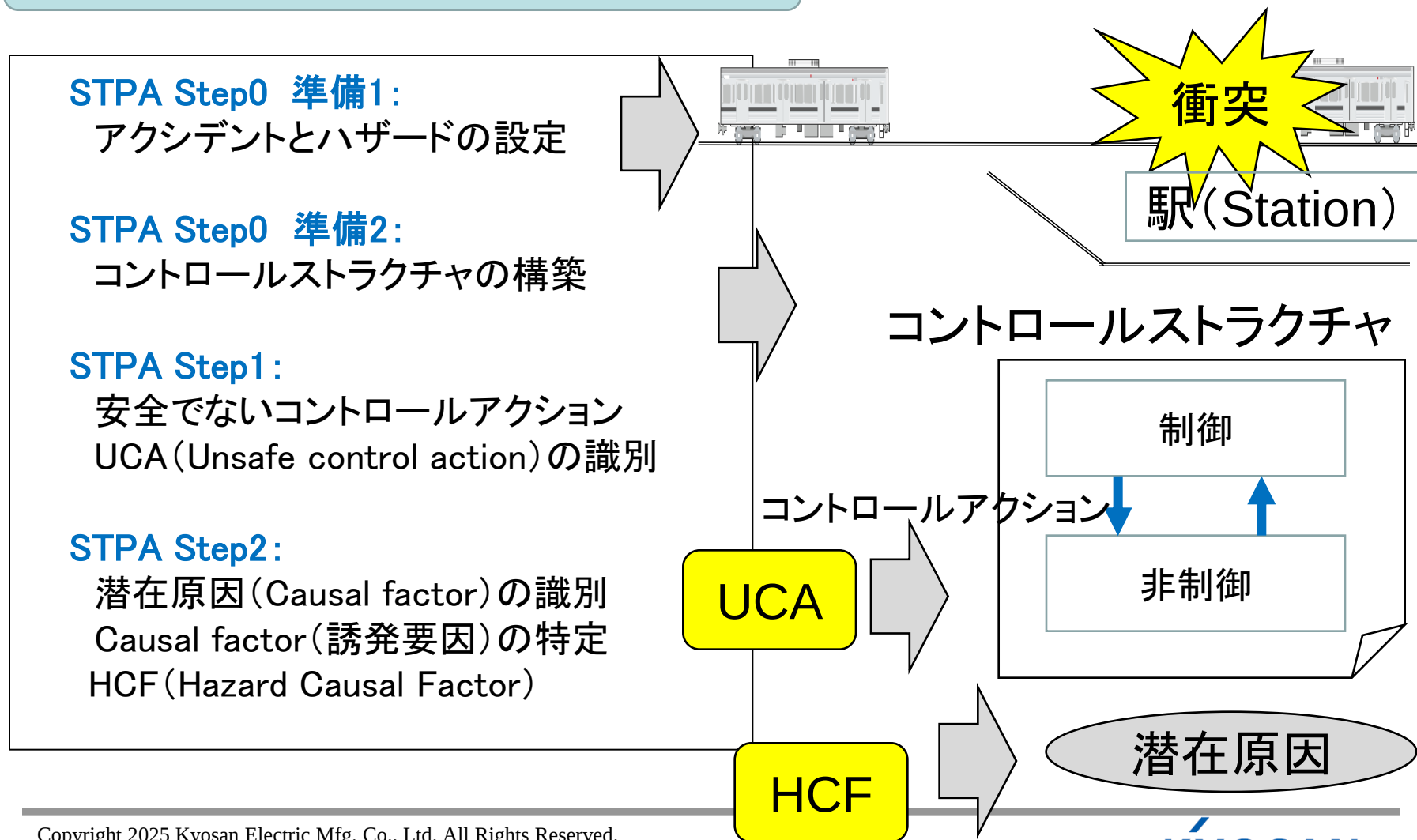


道路交通

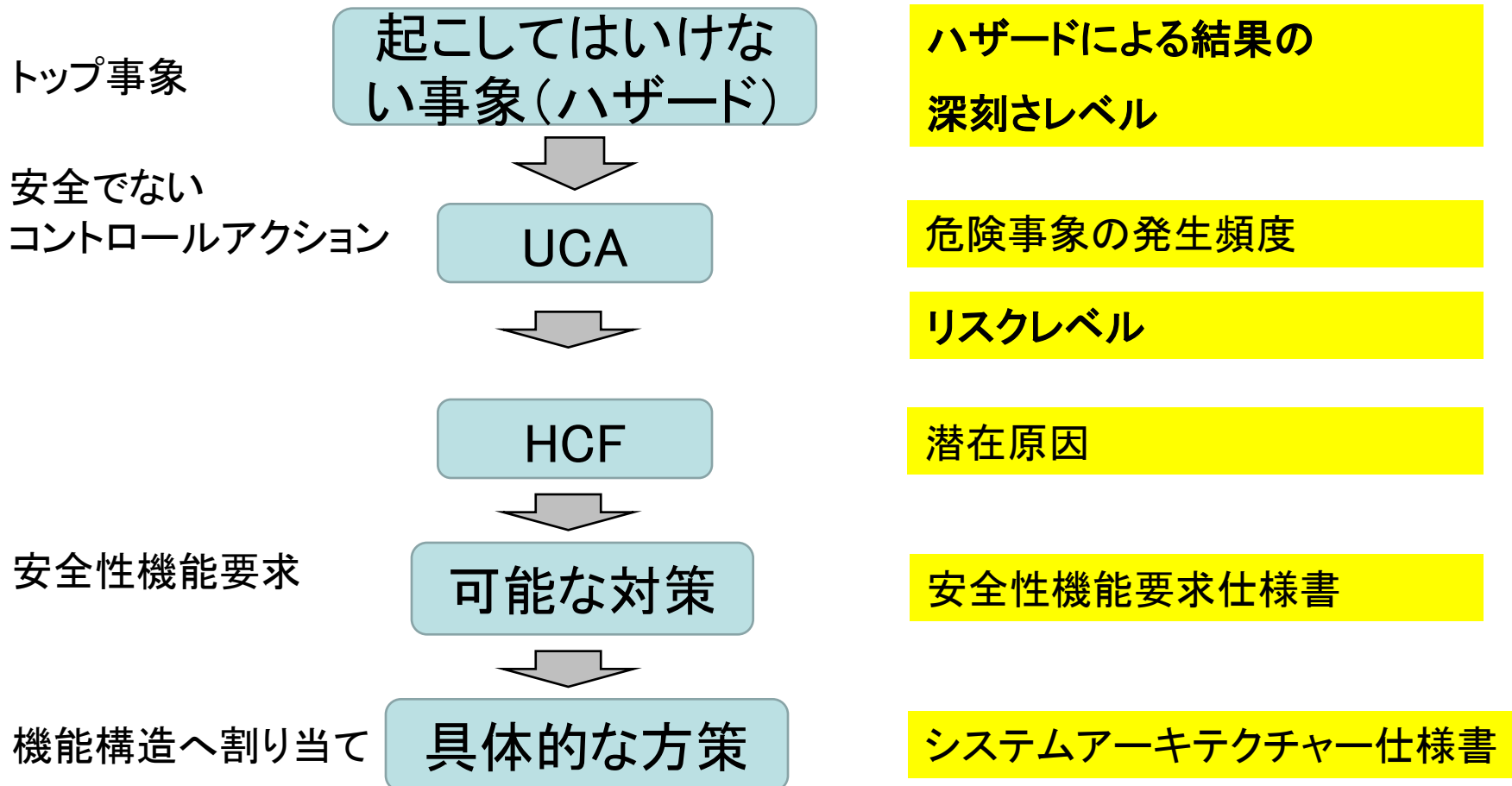




STAMP手法



新たな安全性解析手法を開発



5. 自律運転と路車協調制御

STAMP/STPA と FTA を融合した、新たな安全解析手法の開発

No.	ITEM (Name)	Hazard	Unsafe Control Action	Hazard Severity (Select)	Frequency Occurrence of hazardous event (Select)	Qualitative Risk categorie	Hazard Causal Factor	Determine possible actions	Method	Risk (RPN)	Comment
1	Guideway control equipment	(H1) A train runs through a turnout to a wrong point, a front-end or rear-end collision between them will occur.	(UCA3) If the train in question is move forward through the wrong point, a front-end or rear-end collision between them will occur.	Catastrophic	Remote	Undesirable	The position of the train cannot be distinguished correctly (error).	Check constantly the soundness of input circuits that transmit the position of points and make relevant track sections as occupied once an abnormality is found.	The integrity of the input circuit - PS CPU Block Processing in case of abnormality - Interlocking processing (Interlocking processing shall support the top level functions to meet the requirement of SIL4 in conformance with IEC62279.)	Negligible	For running trains, 1. Devices to ensure a block shall be capable of providing the aspects that complies with the condition of the
2				Catastrophic	Remote	Undesirable	A movement authority is provided according to an correct control algorithm.	Verify thoroughly process modes to be used.	The verification shall support the top level functions to meet the requirement of SIL4 in conformance with IEC62279.		
3				Catastrophic	Remote	Undesirable	The train cannot be located correctly (inaccurate).	Verify thoroughly process modes to be used.	The verification shall support the top level functions to meet the requirement of SIL4 in conformance with IEC62279.		
4				Remote	Remote	Undesirable	Interlocking equipment misrecognizes the train.	Check constantly the soundness of input circuits that transmit the current location of trains and deal with relevant track sections as occupied once an abnormality is found.	Interlocking processing (Interlocking processing shall support the top level functions to meet the requirement of SIL4 in conformance with IEC62279.)		
5				Remote	Remote	Undesirable	A train detection sensor (e.g., track circuits) misses the train.	(Precondition) Apparatus to detect trains shall be able to detect trains without failure.	Train detector equivalent to SIL 4 (Not a function of interlocking devices.)		
6				Remote	Remote	Undesirable	A proceed aspect is shown although an authorization to proceed has not been provided.	Monitor the status of control related to the authorization to proceed and initiate safety control in the event of an abnormality.	Monitoring - Interlocking processing (Interlocking processing shall support the top level functions to meet the requirement of SIL4 in conformance with IEC62279.) PS-CPU side is defined based on interlocking processing.		
7				Catastrophic	Improbable	Tolerable	A movement authority is provided according to an correct control algorithm, although allow the train to enter an unauthorized section, (if another train is present in the section, a collision or derailment may occur.)	In the approach section, even if the traffic is stopped, the switch is locked until a certain indication from the indication of progressed until constant time passes. (Interlocking processing shall support the top level functions to meet the requirement of SIL4 in conformance with IEC62279.)	Interlocking processing (Interlocking processing shall support the top level functions to meet the requirement of SIL4 in conformance with IEC62279.)	Negligible	Interlocking processing shall be appropriately installed to let the train/cor decelerate or stop according to the speed instructed by its aspect, before it comes to the front end of the section to be protected by the signal. 3. To secure safe train/cor operation, signal indication devices shall be installed at intersections or junctions or other vulnerable locations that could cause collision or derailment. → (Article 55 of Technical Regulatory Standards on Japanese Railways, "Railway signal devices, etc.") 1. In the case when trains are operated by the block system, apparatus to automatically decelerate or stop trains depending upon signal aspects and line conditions shall be installed. This does not apply, however, to those cases where safe train operation will not be jeopardized from the standpoint of operational and route conditions. → (Article 57 of Technical Regulatory Standards on Japanese Railways, "Apparatus to Automatically Decelerate or Stop Trains")
8				Catastrophic	Improbable	Tolerable	The train cannot be located correctly (inaccurate).	Verify thoroughly process modes to be used.	The verification shall support the top level functions to meet the requirement of SIL4 in conformance with IEC62279.	Negligible	
9				Catastrophic	Improbable	Tolerable	Check constantly the soundness of input circuits that transmit the current location of trains and deal with relevant track sections as occupied once an abnormality is found.	Check constantly the soundness of input circuits that transmit the current location of trains and deal with relevant track sections as occupied once an abnormality is found.	The integrity of the input circuit - PS CPU Block Processing in case of abnormality - Interlocking processing (Interlocking processing shall support the top level functions to meet the requirement of SIL4 in conformance with IEC62279.)	Negligible	
10				Catastrophic	Improbable	Tolerable	A train detection sensor (e.g., track circuits) misses the train.	(Precondition) Apparatus to detect trains shall be able to detect trains without failure.	Train detector equivalent to SIL 4 (Not a function of interlocking devices.)	Negligible	
11				Catastrophic	Remote	Undesirable	A command to prohibit train movement has been issued but the proceed aspect remains unchanged.	Monitor the status of control related to the authorization to proceed and initiate safety control in the event of an abnormality.	Monitoring - Interlocking processing (Interlocking processing shall support the top level functions to meet the requirement of SIL4 in conformance with IEC62279.) (Definition on the safety side is defined based on interlocking processing.)	Negligible	
12				Critical	Remote	Undesirable	The train running on the turnout cannot be detected. (the train is undetected.)	Check constantly the soundness of input circuits that transmit the current location of trains and deal with relevant track sections as occupied once an abnormality is found.	The integrity of the input circuit - PS CPU Block Processing in case of abnormality - Interlocking processing (Interlocking processing shall support the top level functions to meet the requirement of SIL4 in conformance with IEC62279.)	Negligible	

(1)ハザード(H)

(3)想定事象
(UCA)

(2) ハザードによる
結果の深刻さレベル

(4) 危険事象(想定
事象)の発生頻度

(9) 対策後のリ
スクレベル
(RPN)

(5) リスクレベル
((2) × (4))

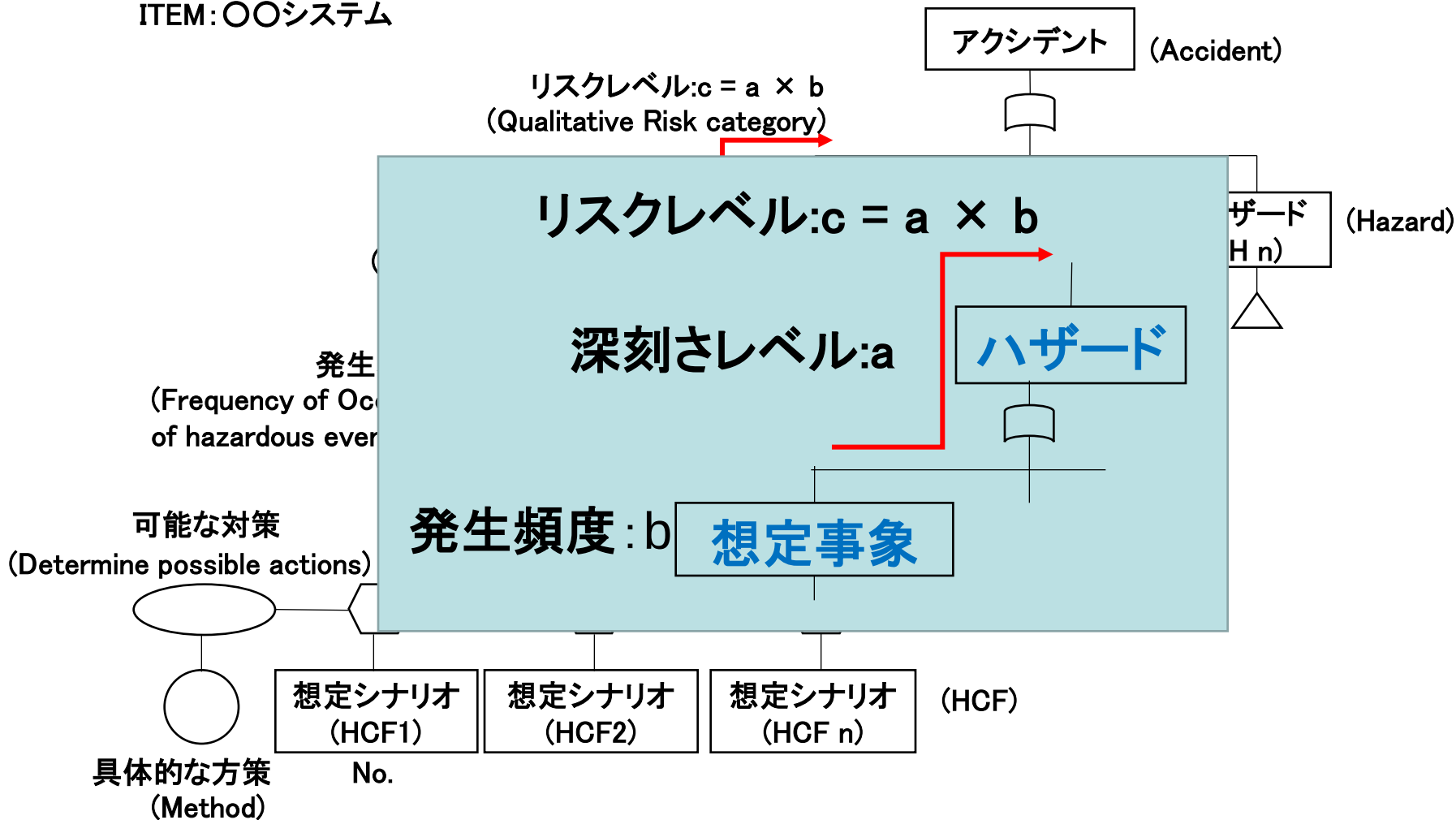
(7) 可能な対策

(8) 可能な対策に
対する具体的な方策

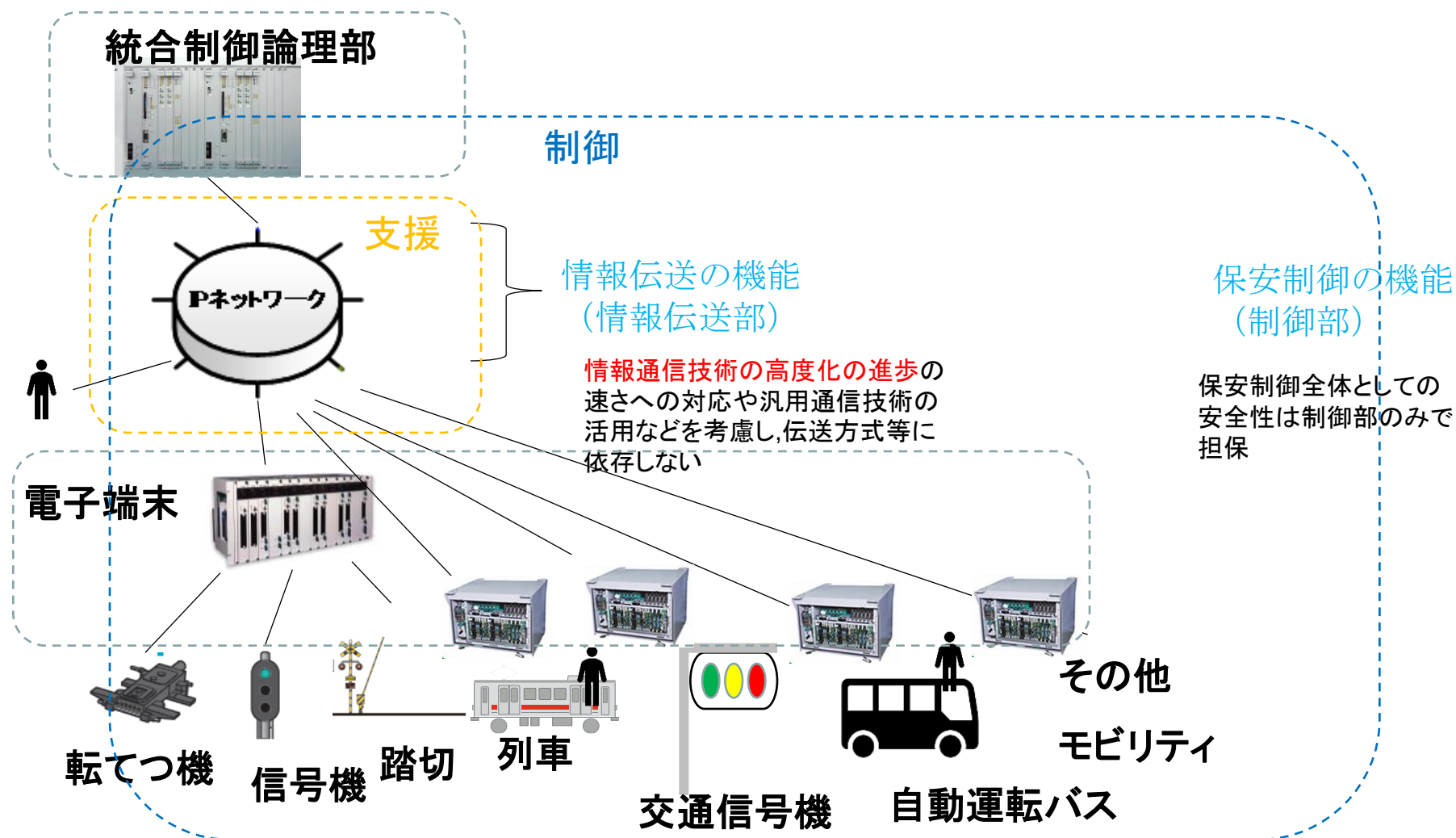
(6) 想定シナリオ(HCF)

STAMP/STPA と FTA を融合した、新たな安全解析手法の開発

ITEM: OOシステム



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Thank you for your kind attention.