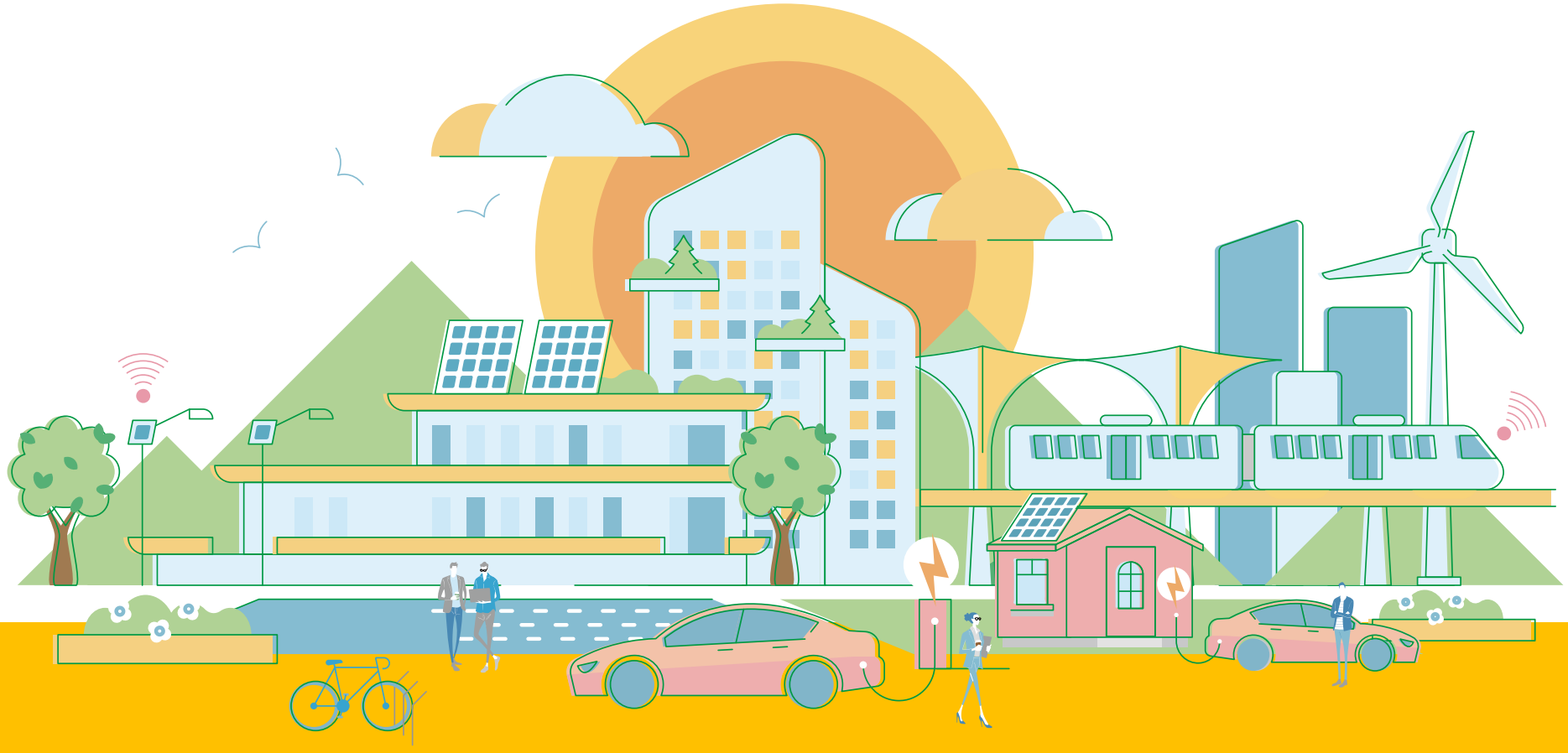
Next-gen protocol

10 Aug. 2022
Kazumasa Arai
SUBARU CORPORATION



Agenda

1. 2-wire Ethernet evaluation

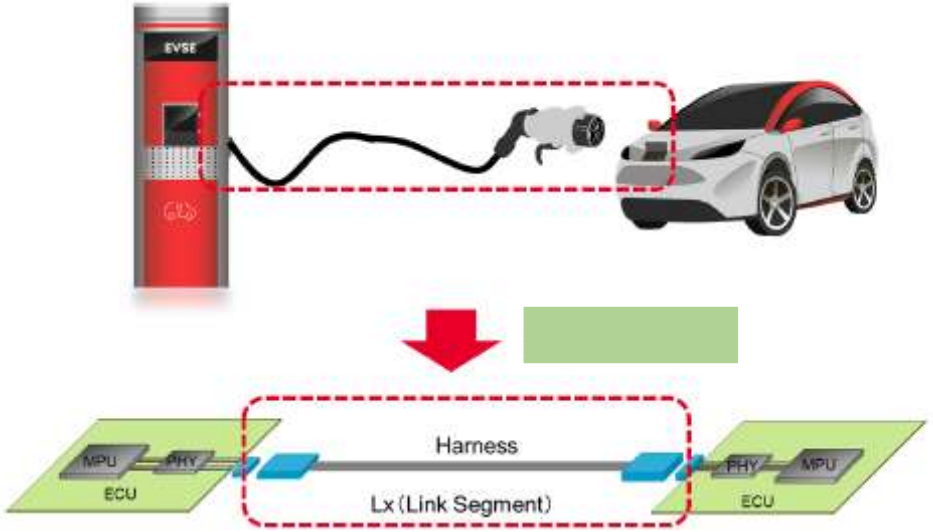
2. Standardization status of communication protocol - ISO 15118

1． 2-wire Ethernet evaluation

ChaoJi 2-wire Ethernet evaluation plan

Where is the target of Evaluation

1. Charger ECU
2. EV ECU
3. **Charging cable, connector & inlet**



Our scope of the early prototype evaluation is the charging cable, connector and inlet

- The parts related to ChaoJi mechanism
- In particular, the degradation of band width at the connection between charging cable and connector, and connector and inlet may be the risk

Note that the charger ECU and vehicle ECU will be evaluated by each manufacture

ChaoJi 2-wire Ethernet evaluation plan

Objective of the evaluation

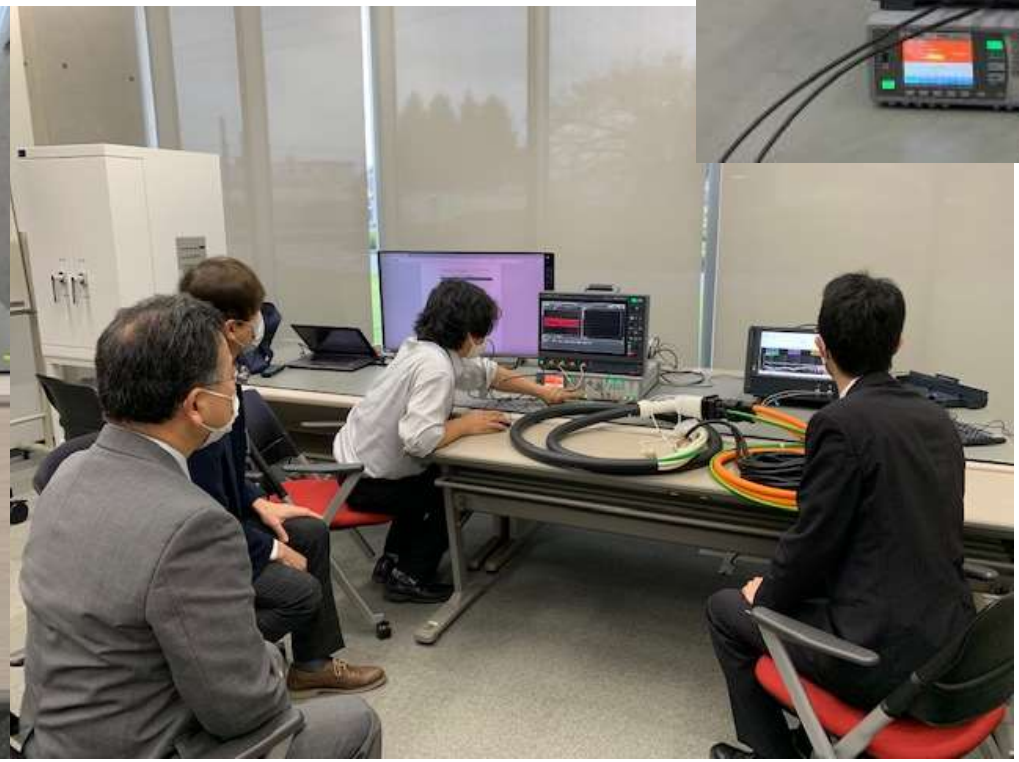
Evaluation of basic characteristics of 2 wire ethernet in ChaoJi cables/connector and inlet.

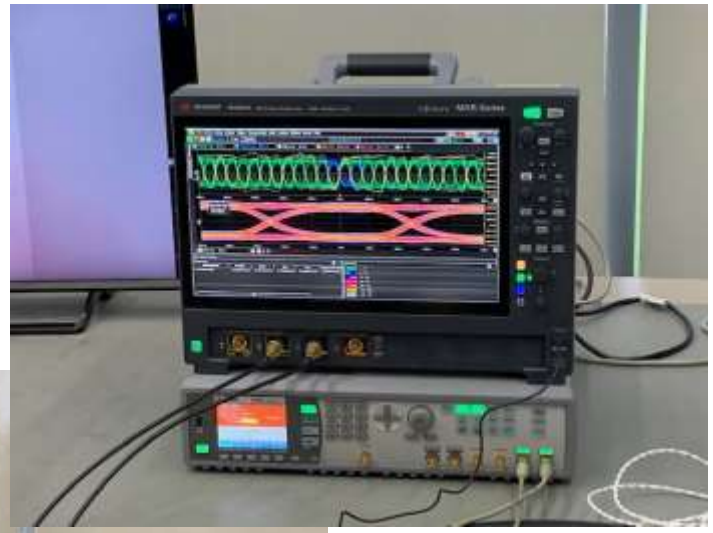
Scope of evaluation

Phase	Schedule	Target	Scope
1	22 Oct. 2021	Evaluation of existing charging cable, connector and inlet	Bandwidth, Bit Error Rate
2	8 Mar. 2022	Evaluation by ChaoJi EV charging	Bit Error Rate
3	1-2 Sep. 2022	EMC tests under actual ChaoJi EV charging	ECE R10.06 Annex 14
4	tbd	Noise superimposition test on communication line	Tbd (ISO 11452-4 and so on)

Evaluation of existing charging cable, connector and inlet

Phase 1





ChaoJi basic characteristics evaluation overview

Phase 1

What to test

- Charging connector, inlet and cable

Basic evaluation test cases

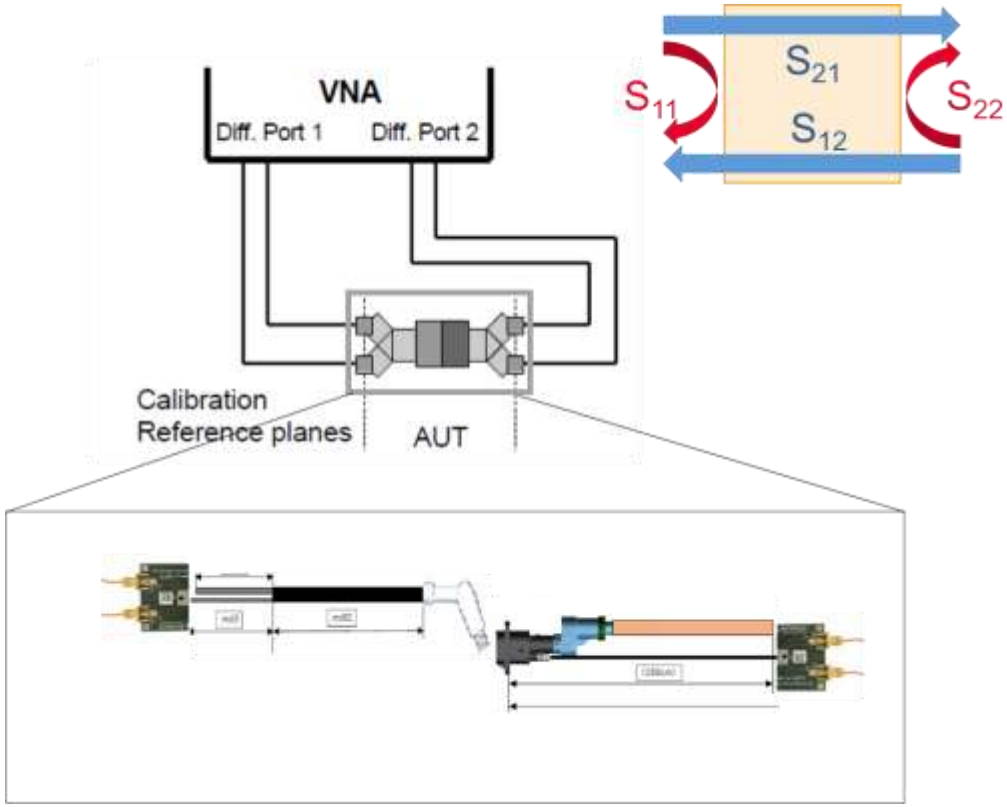
- For charging cable, adapter assembly :
  - frequency response
  - insertion loss, return loss and timing skew (between two cables)

Test instrument requirements

- VNA (4-port E5080B or higher) with an eCAL module for cable assembly test

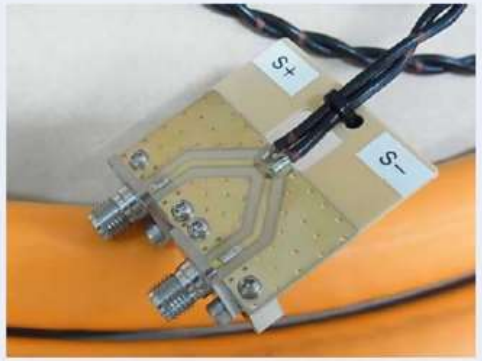
Test fixture requirements

- ChaoJi to SMA adapter (main development)



ChaoJi Evaluation Cable (made by Fujikura)

Phase 1

Test target	Appearance 1	Appearance 2
ChaoJi connector		
ChaoJi inlet Twisted pair or Non-twisted pair		

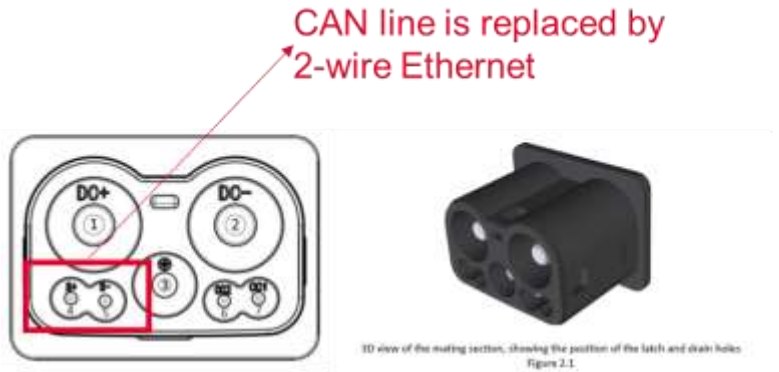
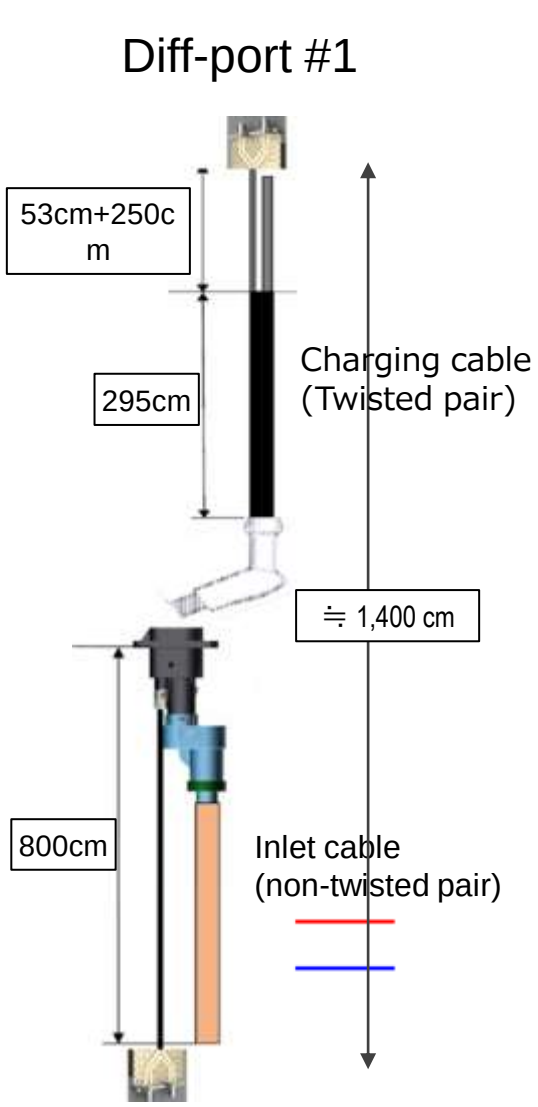


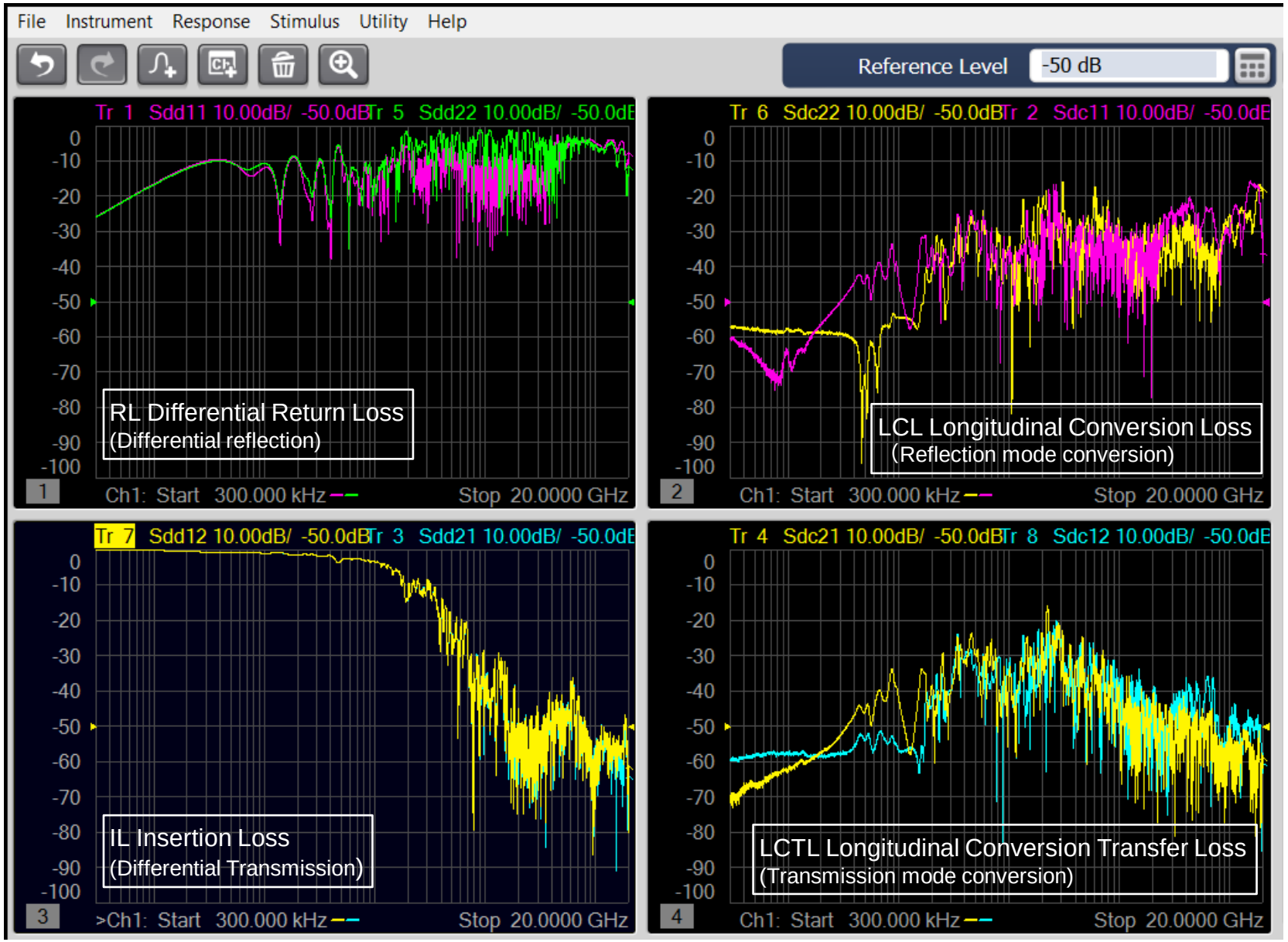
Table 2.1 Terminal name and pin assignment of charging connector

Pin number	Terminal name	CHAdeMO 2.x equivalent
1	DC output P	DC output P
2	DC output N	DC output N
3	Protective conductor	Protective conductor
4	S+	CAN – High Ethernet (Tx/Rx+)
5	S-	CAN – Low Ethernet (Tx/Rx-)
6	CC2	Connector proximity detection
7	CC1	Charge sequence signal 1 / Vehicle charge permission

Test#1 Transfer characteristics (Full path)

Phase 1





KEYSIGHT TECHNOLOGIES

CHAdeMO

Test#1 Open Alliance specification

Phase 1

IEEE 100BASE-T1
Definitions for
Communication Channel
Version 1.0

OPEN ALLIANCE

5.1.1 Requirements for Cables (SCC)

r evaluation of twisted pair cable, intended to use for standalone communication Channel (SCC), test rameter and limits are required according to Table 5 -1. Depending on the maximum length of the SCC ferent limits are required for IL. All other limits are independent of SCC length.

Test parameter		Test standard	Limit (max. value for parameter)
CIDM	Z_{df}	IEC 62153-1-1	100 Ω +/- 10 %, valid for 700 ps rise time evaluation)3 Evaluation window: t = 0.5m to 1.5m, see)5
IL)1	S_{sdd21})2	ISO/IEC 11801 DIN EN 50289-1-1	Maximum length of SCC = 15m: 1 MHz: 0.06 dB/m 10 MHz: 0.16 dB/m 33 MHz: 0.31 dB/m 66 MHz: 0.45 dB/m Maximum length of SCC = 10m: 1 MHz: 0.09 dB/m 10 MHz: 0.24 dB/m 33 MHz: 0.46 dB/m 66 MHz: 0.68 dB/m
RL	S_{sdd11} , S_{sdd22})1		1 MHz: 20.0 dB 20 MHz: 20.0 dB 66 MHz: 14.8 dB
LCL LCTL	S_{sdc11} , S_{sdc22})1 S_{scd11} , S_{scd22})1		1 MHz: 46.0 dB 50 MHz: 46.0 dB 200 MHz: 34.0 dB

)1 linear axis for dB, linear interpolation for limit value at logarithmic frequency axis
)2 logarithmic axis for dB, linear interpolation for limit value at logarithmic frequency axis
)3 two measurements are required: systems rise time ≤ 25 ps for information purpose only, systems rise time 700 ps for limit comparison
)4 refer to Figure 5-1 for evaluation window definition
)5 for IL limits for cables, two classes of cable are specified, depending on maximum length of implemented SCC

Table 5 -1: Required parameter and limits for cables (SCC)

5.1.2 Requirements for Connectors (SCC)

For evaluation of two pin connectors, intended to use for standalone communication Channel (SCC), test parameter and limits are required according to Table 5 -2.

Test parameter		Test standard	Limit (max. value for parameter)
Intra Pair Skew	$T_{intra\_pair\_r}$	IEC 60512-25-4	Only for information)1
CIDM	Z_{df}	IEC 60512-25-7	100 Ω +/- 10 %, valid for 700 ps rise time evaluation)4
IL	S_{sdd21})2	IEC 60512-25-2	1 MHz: 0.025 dB 10 MHz: 0.038 dB 33 MHz: 0.050 dB 66 MHz: 0.075 dB
RL	S_{sdd11} , S_{sdd22})1	IEC 60512-25-5	1 MHz: 38.0 dB 33 MHz: 38.0 dB 66 MHz: 30.5 dB
LCL LCTL	S_{sdc11} , S_{sdc22})1 S_{scd11} , S_{scd22})1	IEC 60603-7-7 Annex I	1 MHz: 46.0 dB 50 MHz: 46.0 dB 200 MHz: 34.0 dB

)1 linear axis for dB, linear interpolation for limit value at logarithmic frequency axis
)2 logarithmic axis for dB, linear interpolation for limit value at logarithmic frequency axis
)3 no limit applied, measurement result can be used for compensation of connector propagation delay skew at the layout of the ECU, if needed
)4 two measurements are required: systems rise time ≤ 25 ps for information purpose only, systems rise time 700 ps for limit comparison

Table 5 -2: Required parameter and limits for connectors (SCC)

5.1.3 Requirements for Whole Communication Channel Configuration (SCC part including Assembly)

For evaluation of complete WCC implementation, intended to use for Standalone Communication Channel (SCC), parameter and limits are required according to Table 5 -3.

Test parameter		Test standard	Limit (max. value for parameter)
CIDM	Z_{df}	IEC 62153-1-1	100 Ω +/- 10 %, valid for 700 ps rise time evaluation)3)4
IL)1	S_{sdd21})1	ISO/IEC 11801 DIN EN 50289-1-1	1 MHz: 1.0 dB 10 MHz: 2.6 dB 33 MHz: 4.0 dB 66 MHz: 7.2 dB
RL	S_{sdd11} , S_{sdd22})2		1 MHz: 18.0 dB 20 MHz: 18.0 dB 66 MHz: 12.8 dB
LCL LCTL	S_{sdc11} , S_{sdc22})2 S_{scd11} , S_{scd22})2		1 MHz: 43.0 dB 33 MHz: 43.0 dB 50 MHz: 39.4 dB 200 MHz: 27.3 dB

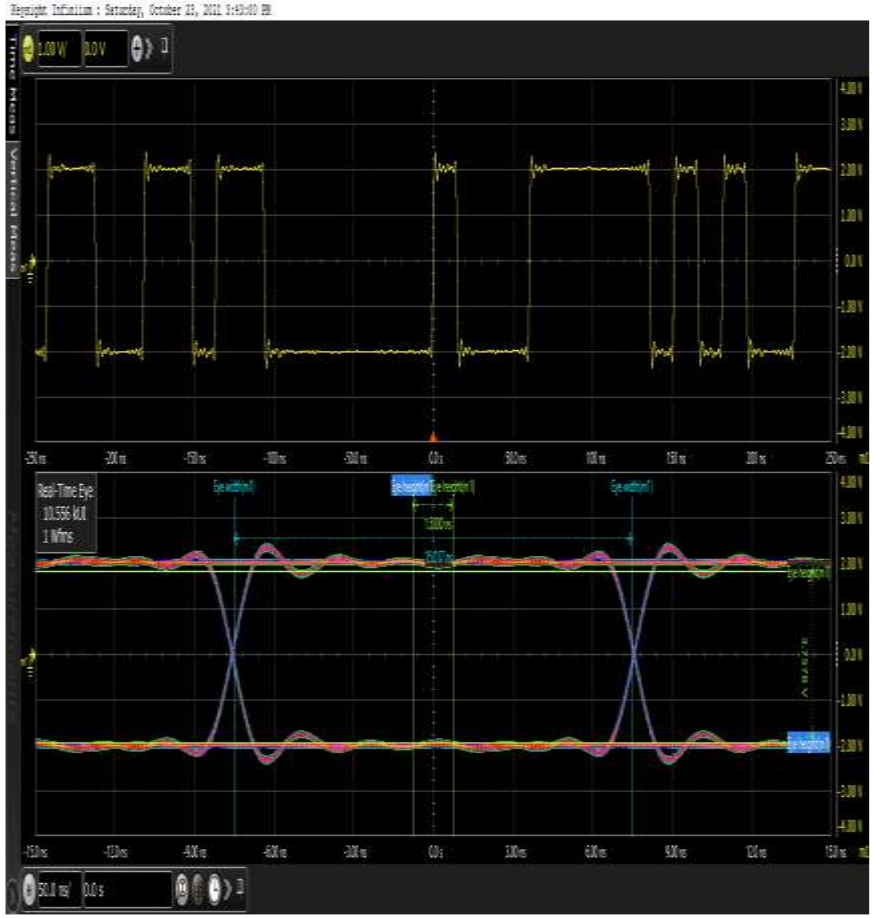
)1 logarithmic axis for dB, linear interpolation for limit value at logarithmic frequency axis
)2 linear axis for dB, linear interpolation for limit value at logarithmic frequency axis
)4 Two measurements are required: systems rise time ≤ 25 ps for information purpose only, systems rise time 700 ps for limit comparison.
)5 For long channels the TDR measurement technique may lead to incorrect measuring results. To prevent getting faulty results either software based solutions of the TDR measurement device or the correction procedure given in Annex B – Correction Method for TDR Measurements should be used.
The limit is valid for $CIDM_{corrected}$ (t). Both results for $CIDM_{measured}$ (t) and $CIMD_{corrected}$ (t) must be given in the resulting diagram.
)6 Because of measurement at RT and possible temperature dependent IL value for used cable the limit is valid for the corrected measurement result according to section 4.6 of this document.

Table 5 -3: Required parameter and limits for whole channel (SCC)

66.67Mbps (100BASE-T1) Eye Pattern

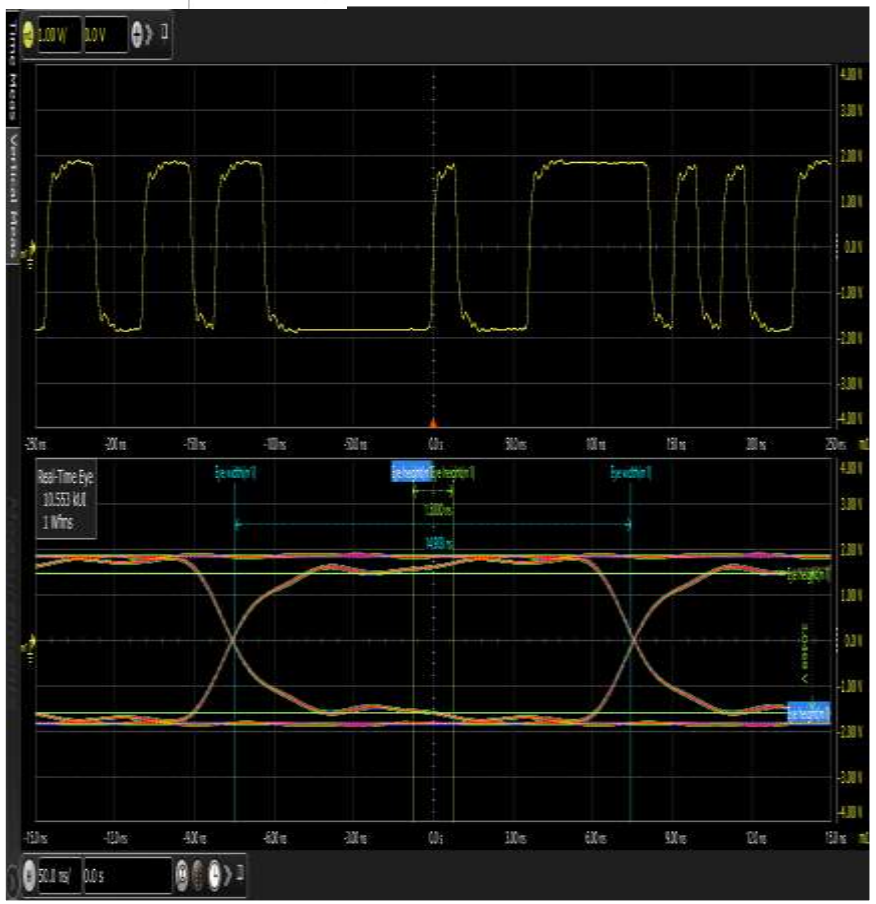
Phase 1

Reference Signal (Pulse Generator)



Eye Height=3.758V
Eye Width=15.017ns

Full path



Eye Height=3.047V
Eye Width=14.908ns

At 100BASE-T1 speed (66.7Mbps), the Eye pattern is open enough.

Evaluation Summary

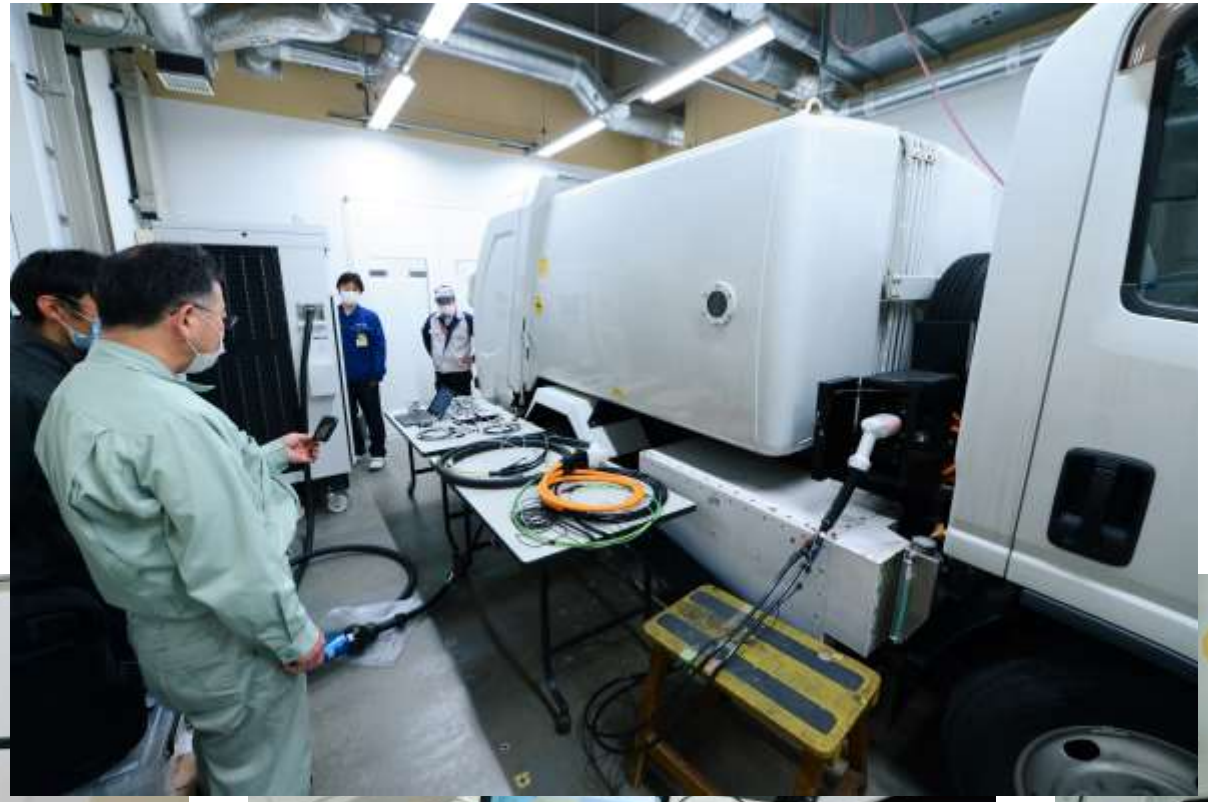
Phase 1

By this evaluation, we found that the transfer & reflection characteristics of ChaoJi cable is enough for 100Base-T1 level 2-wire ethernet communication through CAN line.

Note that one of our concern was the degradation by non-twisted pair inlet cable, however, its degradation was not critical for 100Base-T1 level communication.

Evaluation by ChaoJi EV charging

Phase 2



2-wire Ethernet test configuration under actual EV charging

Phase 2

Evaluate 2-wire Ethernet communication during charging using ChaoJi EV, CHAdeMO EVSE and ChaoJi cable adaptor.

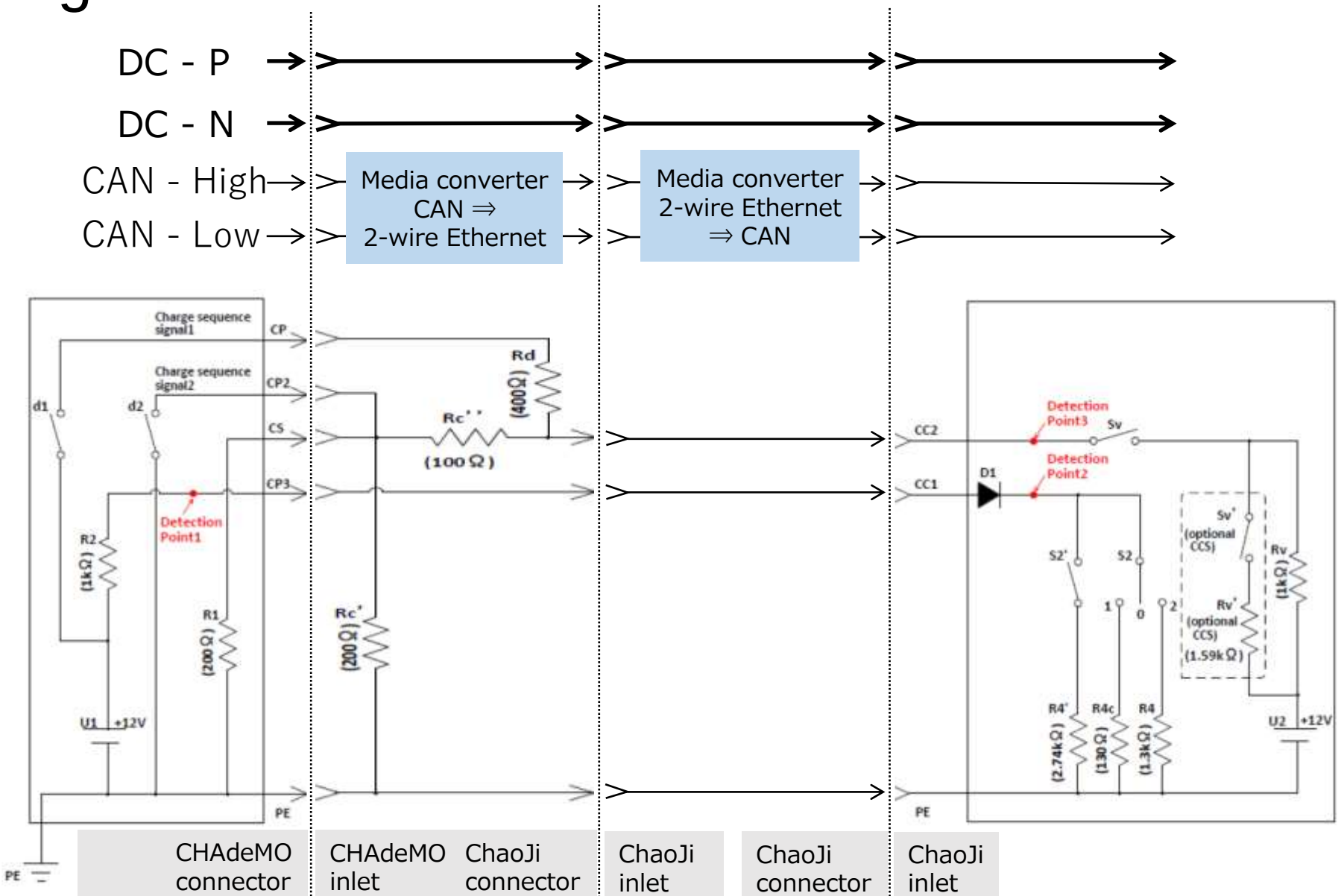
CHAdeMO EVSE

ChaoJi EV

Test system configuration

Cable configuration

Phase 2



Evaluation results

Phase 2

Charging conditions

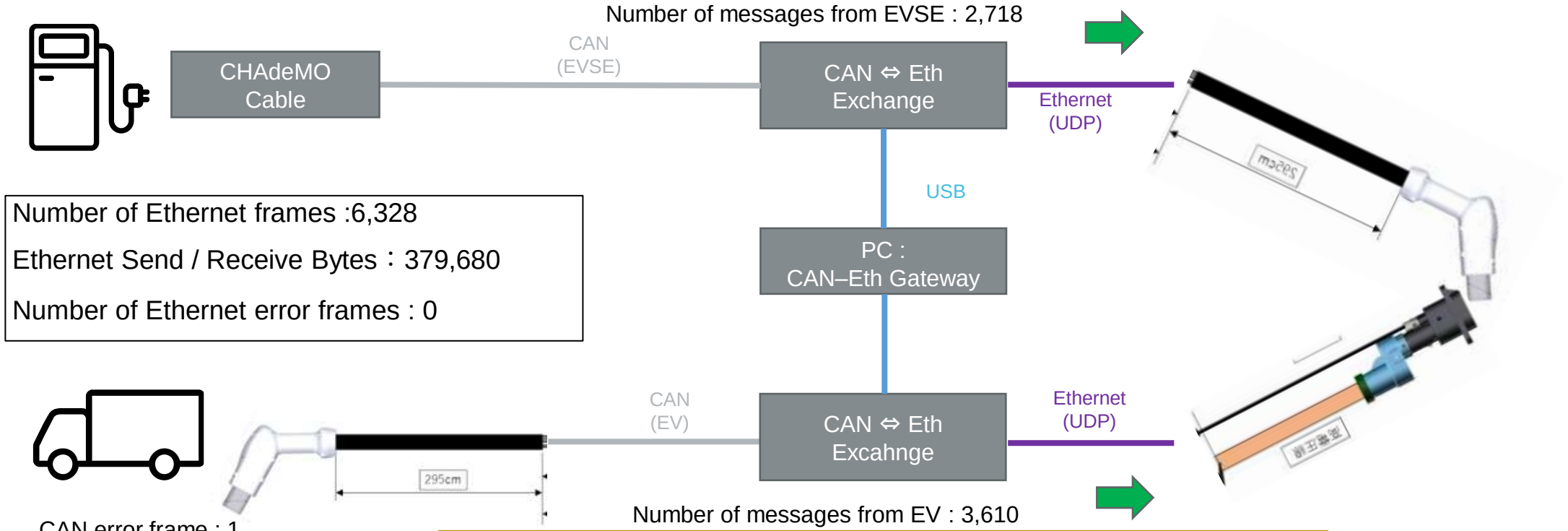
Charge at 100A → OK

Charge at 250A → OK

Error confirmation of CAN-Ethernet conversion data

Measurement time from the start to the end of charging: 90.532 s

(Time when CAN message was sent and received)



Number of Ethernet frames :6,328

Ethernet Send / Receive Bytes：379,680

Number of Ethernet error frames : 0

CAN error frame : 1

(stuff bit error, transmission from EV)

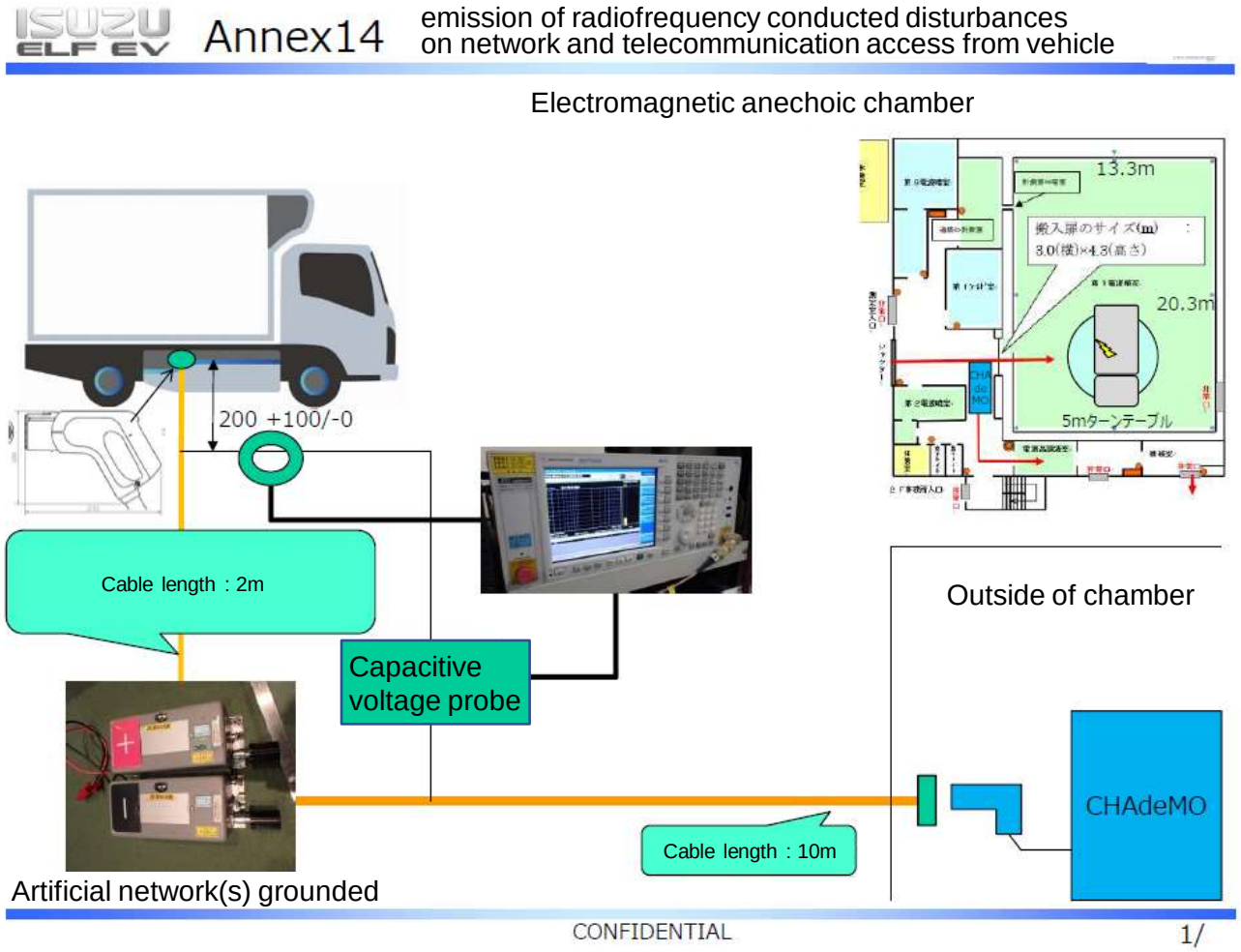
Charging via ethernet is sufficiently stable

EMC Test

Phase 3

ECE R10.06 Annex14：Testing for emission of radiofrequency conducted disturbances on wired network port from vehicles （CISPR22）

- Objective
  - We evaluated the conductive emission difference between CAN and automotive ethernet (100Base-T1).
    - Note that we used Vector's CAN-Ethernet converter for the communication
- Date : 2022.09.01 to 09.02
- Place : KEC Ikoma site



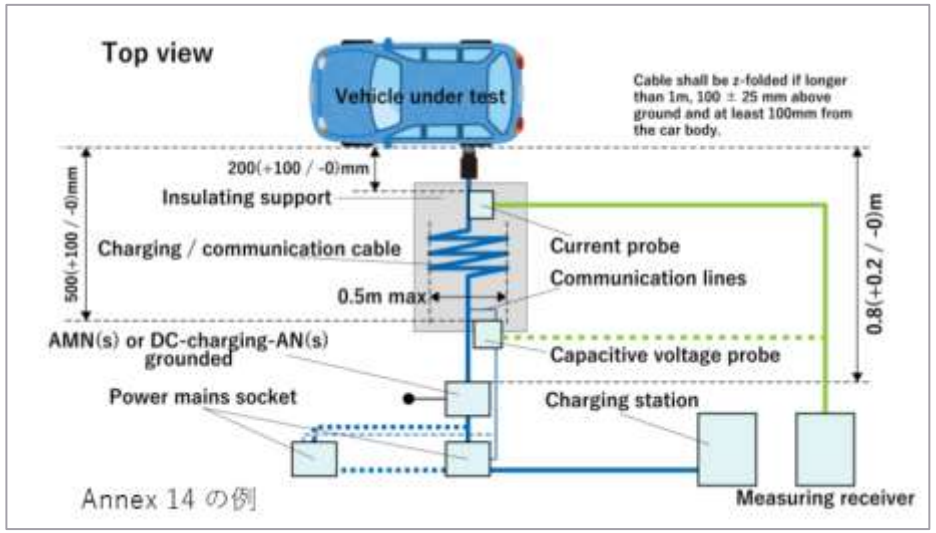
EMC Test

Phase 3

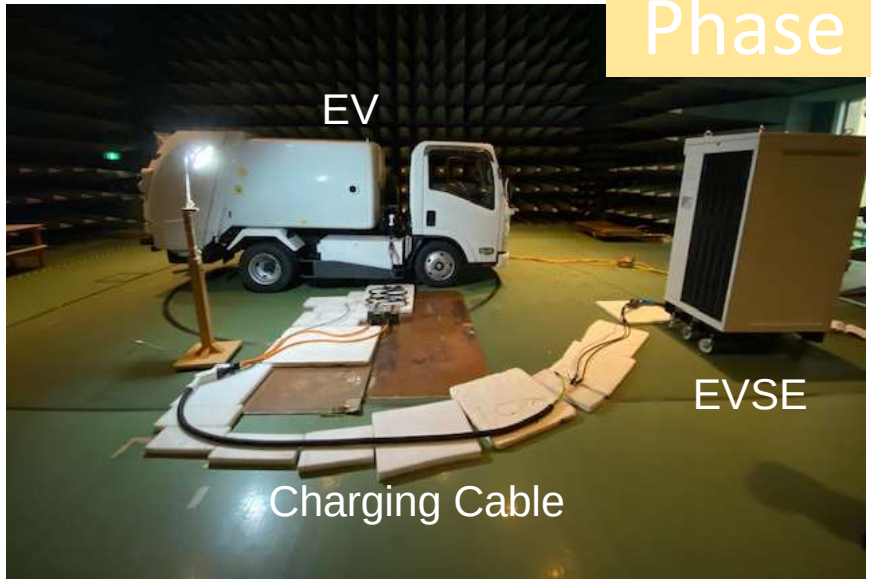
ECE R10 Annex 14 (CSPR 22)

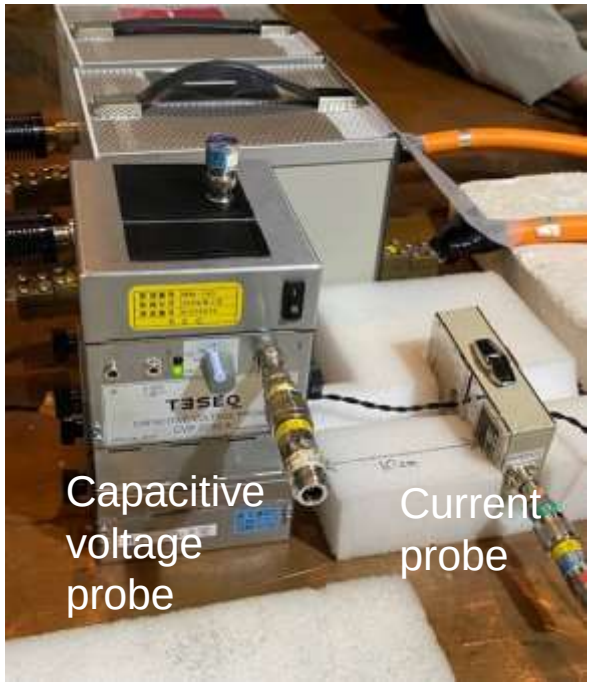
Conducted emissions in vehicle networks and communication lines

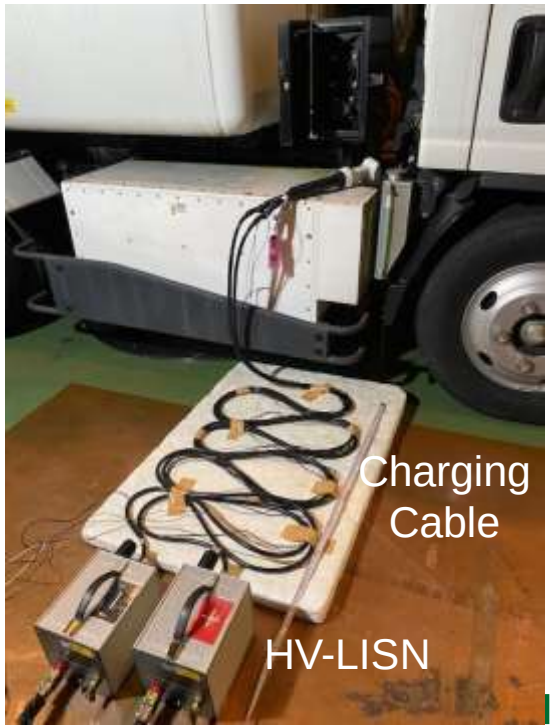
- Charger noise is usually cut to a sufficient level with a noise filter and then passed through the EV through the LISN (AMN).
- This time, the charging cable is connected directly from the Shindengen charger to the LISN without filtering. Emulate the condition that charger noise is on the communication line in the charging cable.
  → It would be harder than R10 regulation test
- Measure noise on communication line with an EMI receiver through capacitive voltage probe and current probe (0.15 kHz ～ 30 MHz)



Kikusui様セミナー資料より

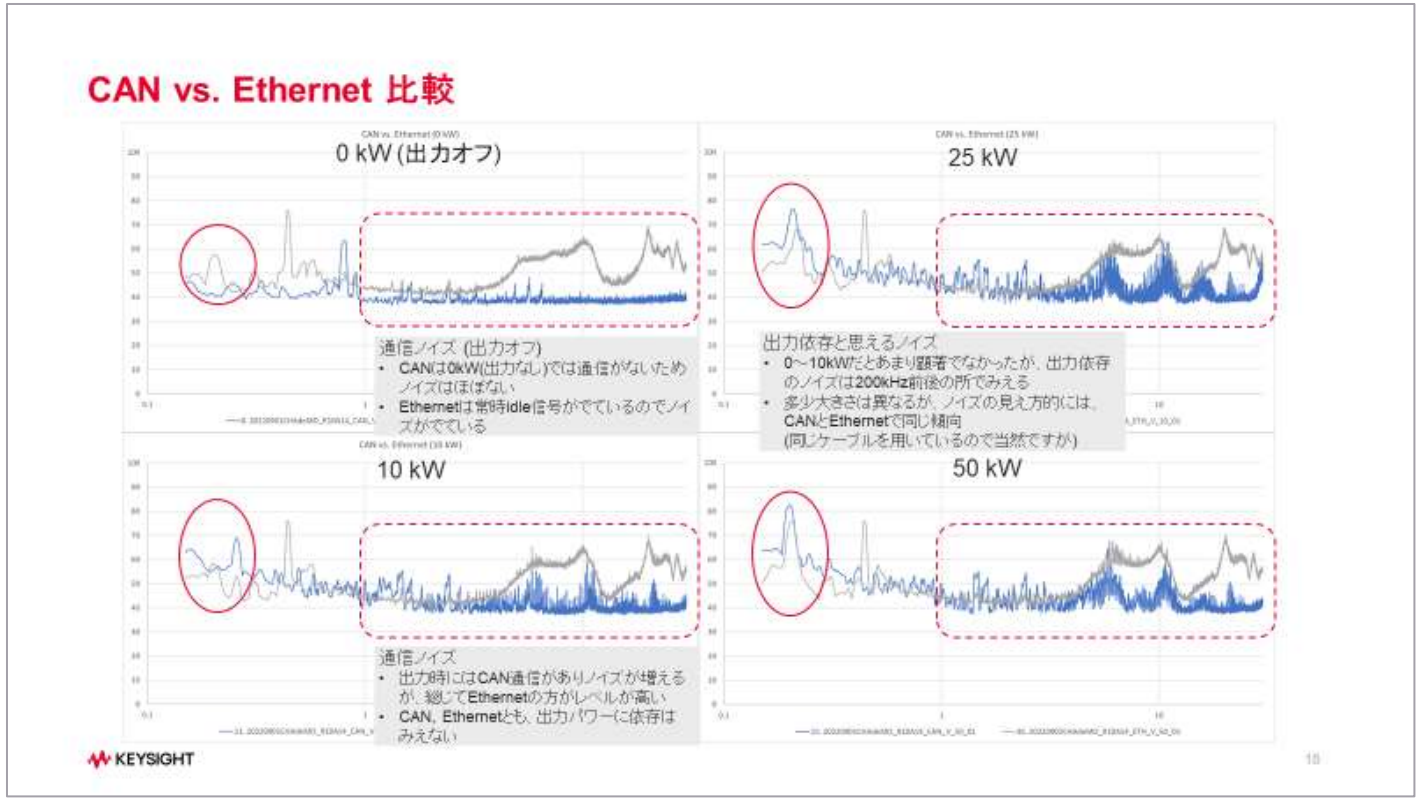






Measurement Result

- In this experiment, communication noise of automotive ethernet was higher than CAN, especially in the high frequency area. This probably came from the media converter (PHY) of automotive ethernet (*)
- The trend of noise characteristics depends on DC power was similar between CAN and automotive ethernet. We could confirm it although it was expected result because of using same charging cable.



*) Note that the CAN-Ethernet converter by Vector is designed for general purpose, and not optimized for the noise test)

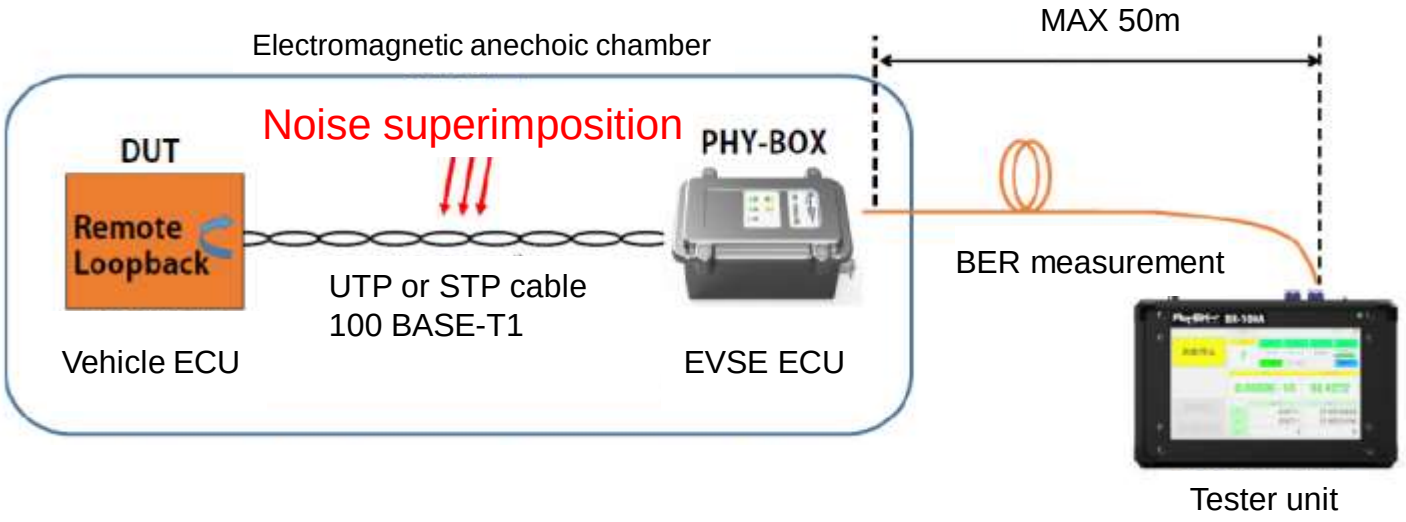
Noise superimposition test on communication line (Tentative)

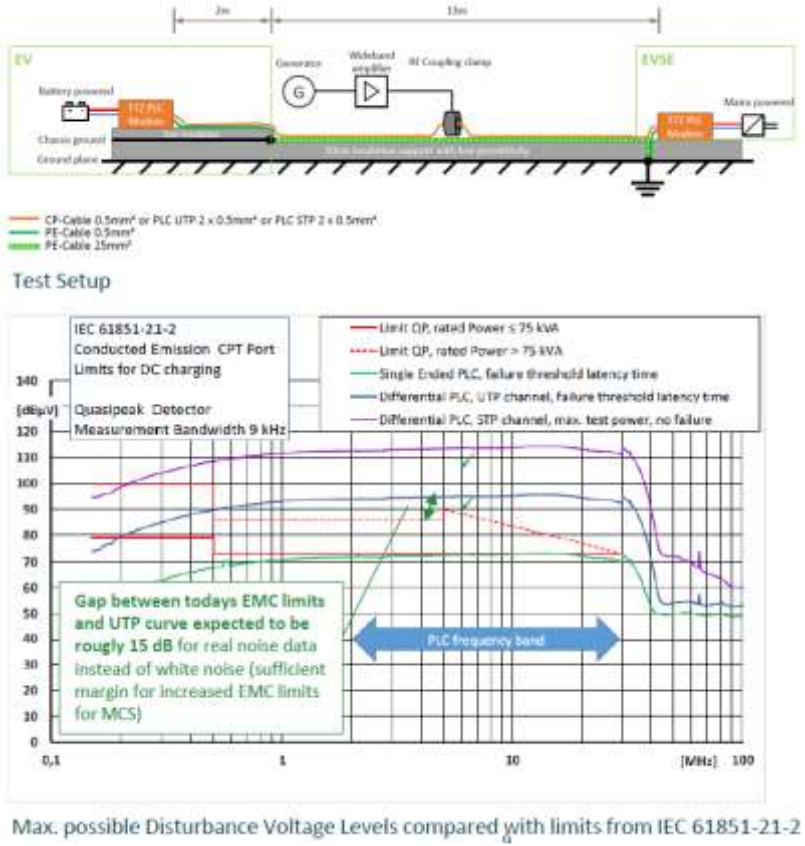
Phase 4

Examining test methods and criteria

- Superimposing noise level and method
- Measurement method
- Criteria, and so on

Also considering testing according to ISO 11452-4





Differential PLC test case of MCS

結論
Conclusion

・帯域試験、充電試験、EMC試験の結果、Ethernet通信による充電が問題ないことが確認できた。
• As a result of band-width test, charging test, and EMC test, it was confirmed that there were no major problems with charging by Ethernet communication.

・伝導ノイズについては現在、試験法が定められてないので、IEC 61851-21-2改定で織り込まれるであろう内容での評価が期待される。
• Currently, no test method has been established for conduction noise, so it is expected that the evaluation will be based on the test method that will be included in the revision of IEC 61851-21-2.

2. Standardization status of communication protocol - ISO 15118

Study status of ChaoJi communication protocol

通信プロトコルは国際標準であるISO 15118に基本的には準拠すべき。ただし充電シーケンス等の違いにより、ISO 15118の機能を織り込む部分、ChaoJi独自の部分が生じる見込み。ChaoJi独自の部分については日中合意の上、各規格に改定に合せ織り込む。

The communication protocol should basically conform to the international standard ISO 15118. However, due to differences in the charging sequence, etc., it is expected that there will be a part that incorporates the functions of ISO 15118 and a part that is unique to ChaoJi. ChaoJi's original part will be incorporated into each standard according to the revision after agreement between Japan and China.

Study status of ChaoJi communication protocol

- Use case
  ChaoJi独自のユースケースをISO 15118-1に追加が必要。
  Need to add ChaoJi's own use case to ISO 15118-1.

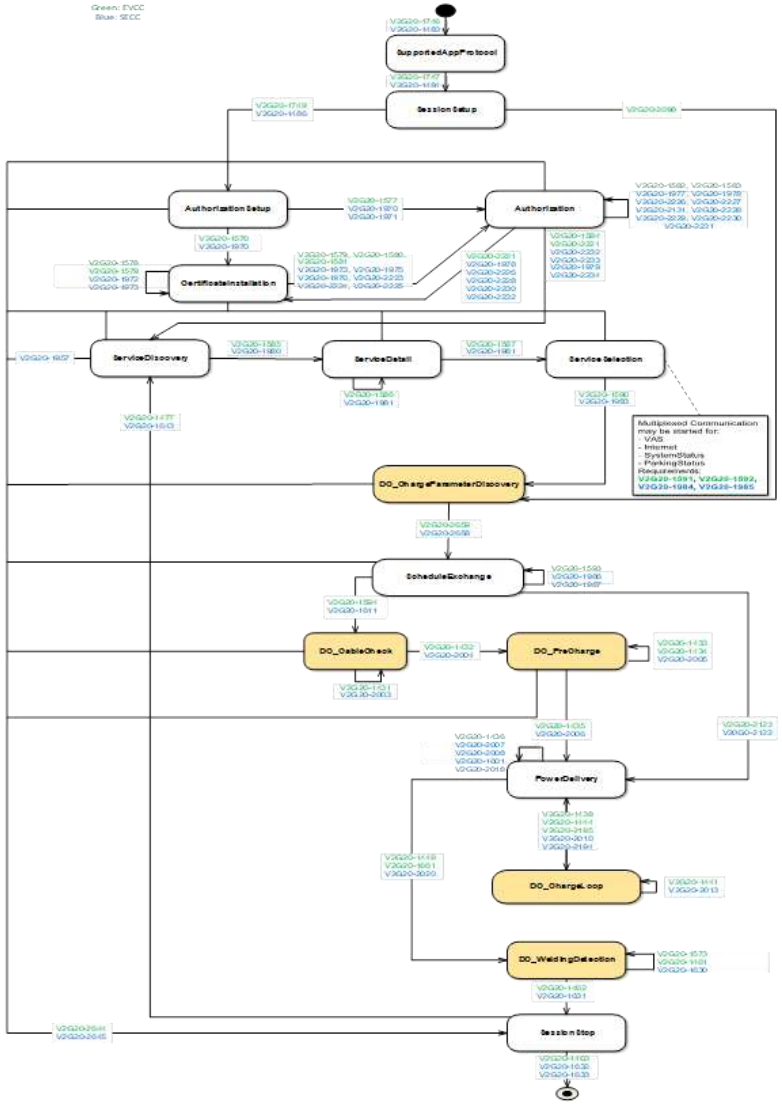
- Physical layer
  2-wire Ethernetについては ISO 15118-10としてNWIPが提案されており、ChaoJiの通信に適合できるよう調整する。通信速度は100BASE-T1（IEEE 802.3bw）、10BASE-T1S(IEEE802.3cg)で互換性がないため、どちらかに統一、若しくは切り替えの機能の織込みが必要。
  For 2-wire Ethernet, NWIP has been proposed as ISO 15118-10, and it will be adjusted to suit ChaoJi's communication. Communication speeds are incompatible with 100BASE-T1 (IEEE 802.3bw) and 10BASE-T1S (IEEE802.3cg), so it is necessary to either unify or incorporate a switching function.

- Communication protocol:
  ISO 15118-20改定（ED2）に、ChaoJiのシーケンスを織り込む
  Incorporating the ChaoJi sequence into the ISO 15118-20 revision (ED2)

Study status of ChaoJi communication protocol

ChaoJi-2 と ISO 15118-20のシーケンスの違い

Sequence differences between ChaoJi-2 and ISO 15118-20

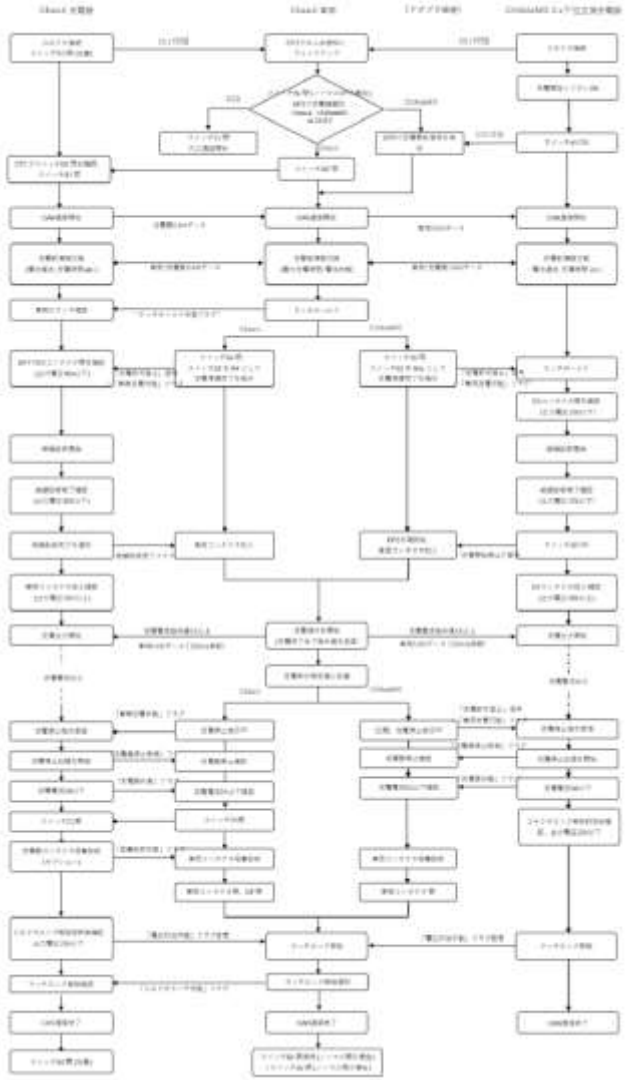


・充電機・車両双方のシーケンス、通信内容に差異がある。

• There is a difference in the sequence of both the charger and the vehicle and communication contents.

・ISO 15118-20に日中統合のChaoJiシーケンスを織り込む、あるいはCCSと整合を図る必要がある

• It is necessary to incorporate the ChaoJi sequence integrated between Japan and China into ISO 15118-20, or to make it consistent with CCS.



Study status of ChaoJi communication protocol

シーケンスの違い・考慮すべきポイント　Sequence differences and points to consider

ISO15118特有
Specific to ISO15118

暗号化した通信が必要な部分
Parts that require encrypted communication

⇒ISO15118を適用
Apply ISO15118

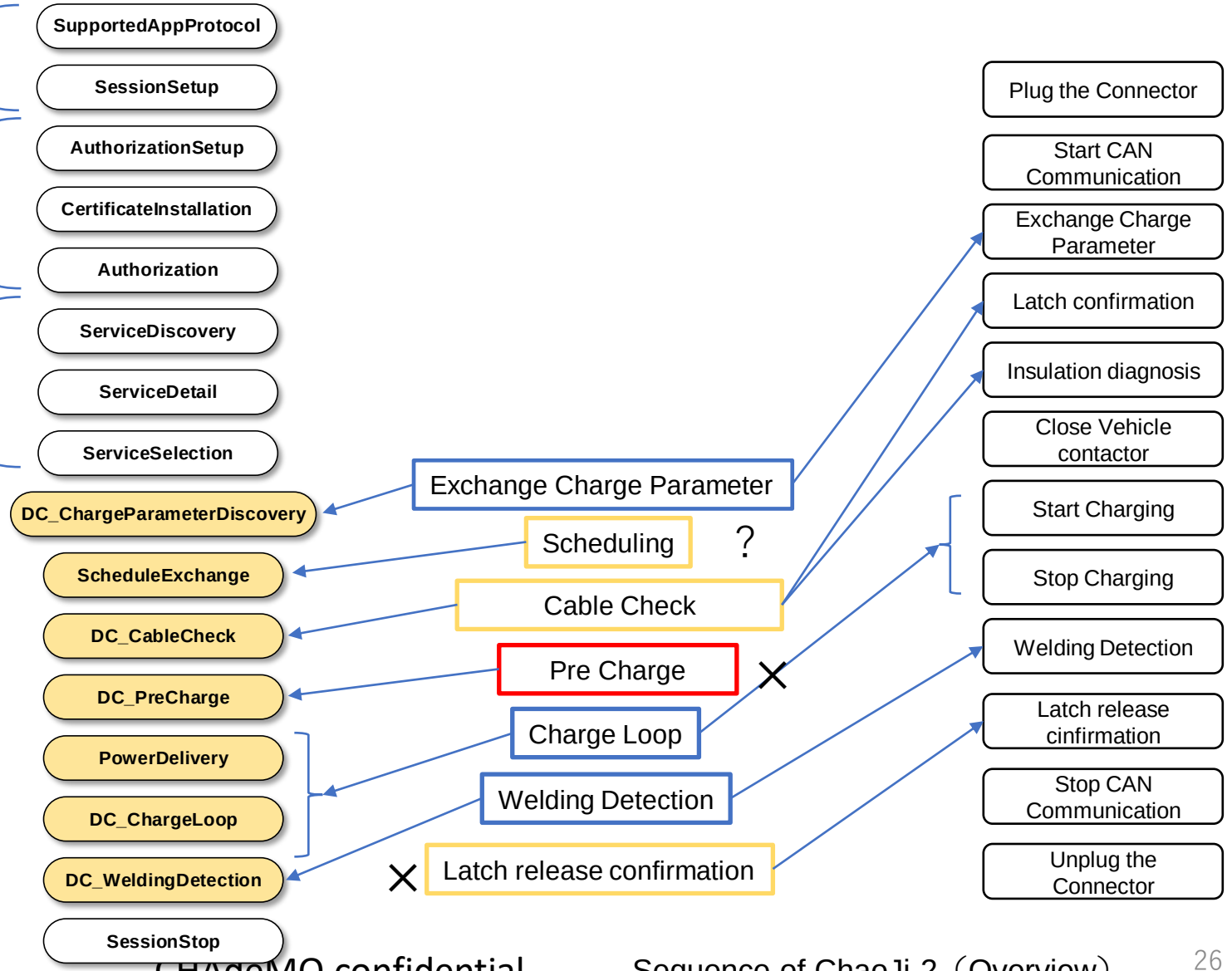
充電制御にかかわる部分
Control related to charging control

ChaoJiのプロトコルを織り込む
Apply ChaoJi Protocol

通信開始
Start Communication

課金・認証
Billing/authentication

サービス選択
Service selection



Sequence of ISO 15118-20（Overview）

Sequence of ChaoJi-2（Overview）

Study status of ChaoJi communication protocol

検討・調整が必要な項目
Items that need to be considered or coordinated

- ChaoJi-1、ChaoJi-2の違い
  Differences between ChaoJi-1 and ChaoJi-2
  - 日中で調整、統合したシーケンスを構築する
  - Construct a sequence that is coordinated and integrated between Japan and China

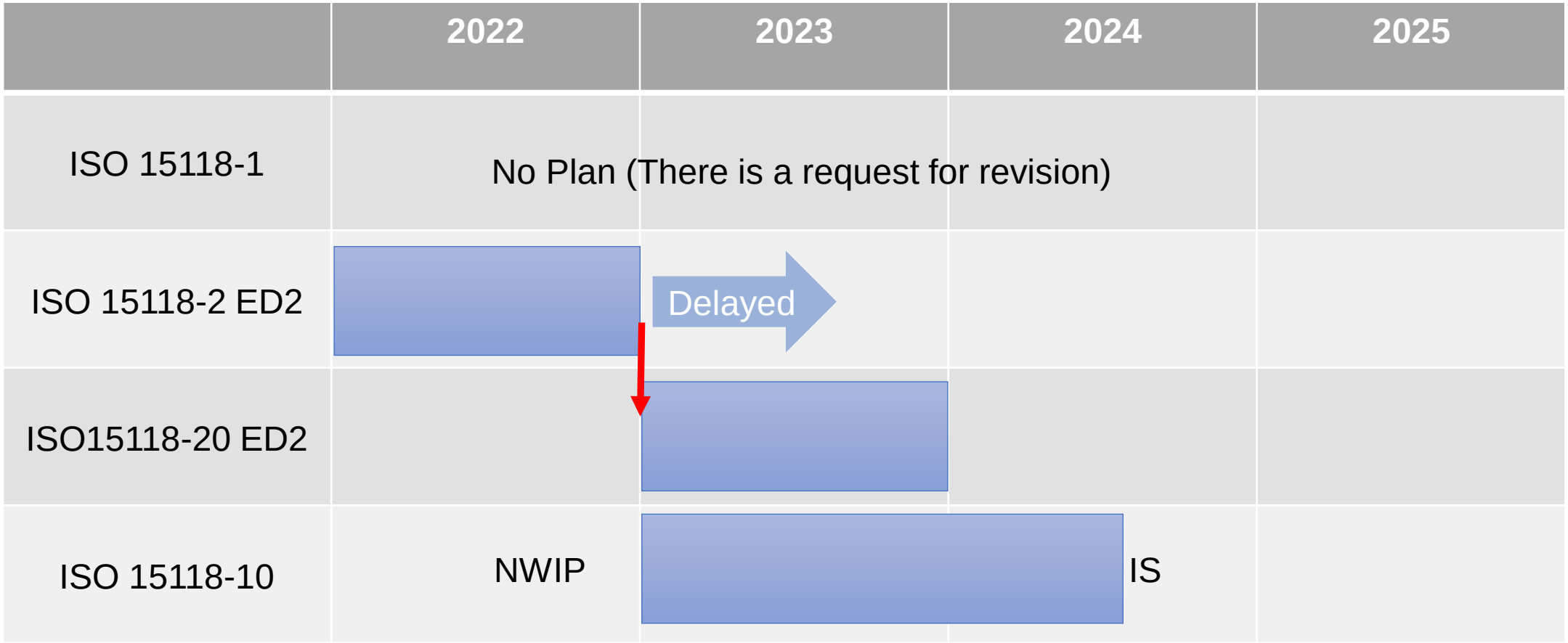
- 機能の追加・選択
  Addition/selection of functions
  - スケジューリング機能、V2H/G、ロードマネジメント機能などを確定する
  - Determine the scheduling function, V2H/G, load management function, etc.

- ChaoJi、ISO 15118のシーケンス差異
  Sequence differences between ChaoJi and ISO 15118
  - ChaoJi独自とする部分、現在のISO 15118に準拠する部分を切り分ける
  - Separate ChaoJi's unique parts and parts that comply with the current ISO 15118

日中で統合シーケンスを決めたうえで、**ISO 15118**の改定に織り込む必要がある
It is important to decide the integration sequence between Japan and China and incorporate it into the revision of ISO 15118

Study status of ChaoJi communication protocol

ISO 15118 revision schedule (Plan of JWG1)



Thank you