Minimum Required Error Codes and OCPP

Improving the EV Charging Experience

CHARGEX consortium

LED BY

Argonne NATIONAL LABORATORY · INL Idaho National Laboratory · NREL Transforming ENERGY

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What are MRECs?

- **M**inimum **R**equired **E**rror **C**odes (MRECs) provide a standard way for a minimum set of recommended errors to be communicated uniformly across industry.

- Consortium published the guide in September.

- Next steps include demonstrating their usage in real-world tests at test events and then identifying how these errors will be communicated across participants.

MRECS – Definition and Responsibility

Number	Error Code	Description
1.	ConnectorLockFailure	Failure to lock or unlock connector on the vehicle side.
2.	GroundFailure	Ground fault circuit interrupter has been activated.
3.	HighTemperature	High temperature inside the EVSE is derating power delivery.
4.	OverCurrentFailure	Over current protection device has tripped.
5.	OverVoltage	Input voltage to the vehicle has risen above an acceptable level.
6.	UnderVoltage	Input voltage to the vehicle has dropped below an acceptable level.

26 MREC's in Total

Number	Error Code	Responsibility Classification			
		EV User	CSO	EVSE	EV
1.	ConnectorLockFailure	✓	-	-	✓
2.	GroundFailure	-	-	✓	✓
3.	HighTemperature	-	-	✓	-
4.	OverCurrentFailure	-	-	✓	✓
5.	OverVoltage	-	-	✓	✓
6.	UnderVoltage	-	-	✓	✓

Number	Error Code	Functional Classification				
		Safety	Security	Mainten-ance	Financial	Authoriza-tion
1.	ConnectorLockFailure	✓	✓	-	-	-
2.	GroundFailure	✓	-	✓	-	-
3.	HighTemperature	✓	-	-	-	-
4.	OverCurrentFailure	✓	-	-	-	-
5.	OverVoltage	✓	-	-	-	-
6.	UnderVoltage	✓	-	-	-	-

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Mapping MRECs – OCPP and ISO 15118

- Data required to trigger MRECs can be found using existing data pipelines and messages.
- Typical sources include OCPP and ISO 15118.

Example

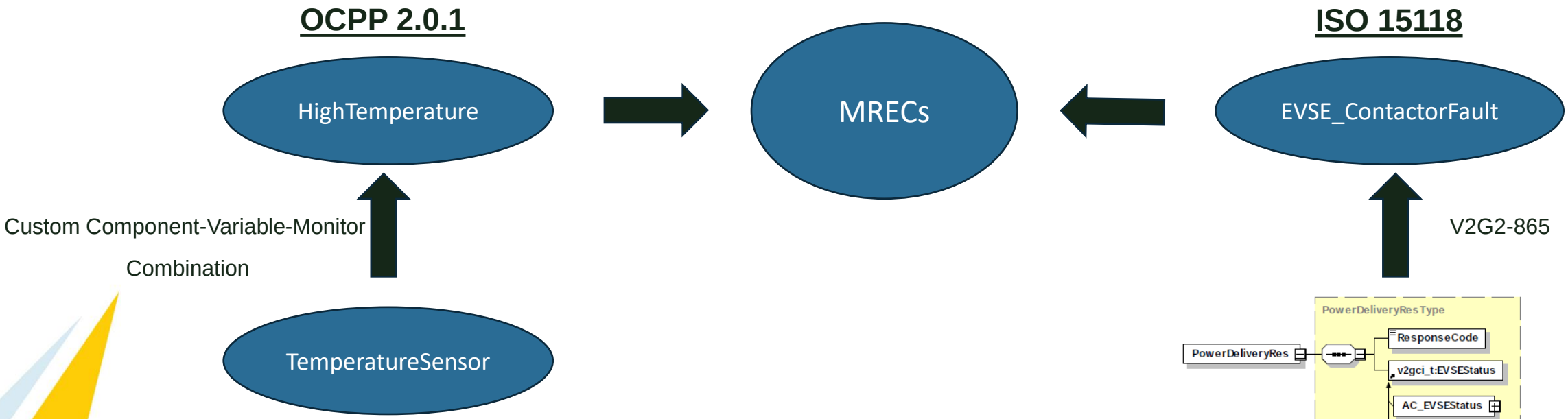

Figure 38 — Schema Diagram – PowerDeliveryRes

How will they be transported via OCPP 1.6J?

We recommend:

1. Using the ***StatusNotification.req*** message in OCPP 1.6J as a transport mechanism of MRECs.

2. Setting the 'vendorId' to 'https://chargex.inl.gov' and,

3. Populating the 'vendorErrorCode' field by respective MREC fault code(s) denoted as 'CX0nn'.

Conventions for OCPP 1.6J

It is recommended to transmit MRECs using the `vendorErrorCode` field in the `StatusNotification.req` message housed within **OCPP 1.6J**. The table below outlines all the data fields housed within the `StatusNotification.req` message that need to be modified to transmit MRECs using **OCPP 1.6J**.

Data Field	Suggested Data	Description
errorCode	ChargePointErrorCode	If available, suitable *ChargePointErrorCode* in OCPP 1.6 should be reported here. If not available, 'OtherError' should be used.
info	Actual Value	This includes additional information related to the error. The actual or observed value is recommended to be reported here and can be left blank if no information is available. More details of the error can be included in this field separated by the ";" delimiter.
vendorId	{vendor specific information}; **https://chargex.inl.gov**	This identifies the vendor-specific implementation. It is highly recommended to use **https://chargex.inl.gov** to help provide the end-user easier access to the details of the reported MREC, including its description and responsibility and functional classifications using the ";" delimiter.
vendorErrorCode	Fault code	*Fault code* for a specified MREC as given in table above.

```
{
"connectorId": 1,
"errorCode": "HighTemperature",
"info": "50",
"status": "Finishing",
"timestamp": "2023-09-06T00-08-09Z",
"vendorId": "https://chargex.inl.gov",
"vendorErrorCode": "CX003"
}
```

Example

StatusNotification.req in OCPP 1.6J

ChargeX MREC Webpage

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How will they be transported via OCPP 2.0.1?

We recommend:

1. Using the ***NotifyEventRequest*** message in OCPP 2.0.1 as a transport mechanism of MRECs.
2. Populating the 'techCode' field by a respective MREC fault code denoted as 'CX0nn'.

Conventions for OCPP 2.0.1

It is recommended to transmit MRECs using the `techCode` data field in the `NotifyEventRequest` message of OCPP 2.0.1 for transmitting the MRECs. The table below highlights the data fields within the `NotifyEventRequest` message that need to be modified for transmitting MRECs using **OCPP 2.0.1**.

Data Field	Suggested Data	Description
techCode	Fault code	*Fault code* for a specified MREC as given in table above.

We do not recommend any specific component-variable-monitor combinations.

ChargeX MREC Webpage

Example

NotifyEventRequest in OCPP 2.0.1

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What Next?

1. Integrating MRECs into OCPP will harmonize their adaption and implementation across the industry.

2. MRECs provide a common language for error but, sharing detailed diagnostic information still occurs through traditional channels like emails etc.

3. Diagnostics could be further improved by adopting a common set of information that would be shared with each MREC. Additionally, providing a similar interface to access that information could facilitate exchange of information between organizations.

Diagnostic Information Exchange

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CSPR – Charging System Performance Reporting

- Developed by SAE International
- Data structure **designed to facilitate the reporting of charging system performance** data by CPOs, EV OEMs, etc.
- Data structure broken into function sections around **Top Five Criterias** i.e. Uptime, Pricing, etc.
- **Monolithic data structure** that doesn't change between use cases.

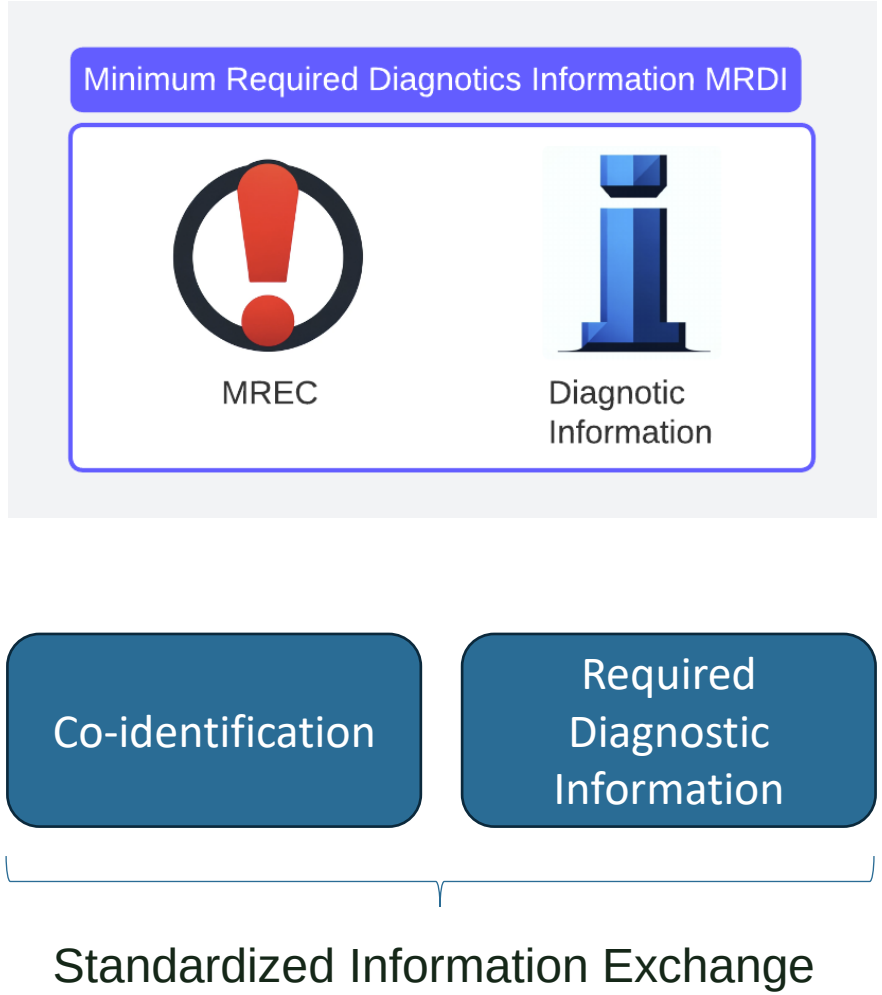
DC CHARGING PROTOCOLS: DIN 70121

"Top Five" Issues Reporting Data	Sub-Issue	Data	Significance
Availability (uptime)	No issue	***CurrentDemandReq*/*DC_EVStatus*/*EVReady=True*** from EV and ***CurrentDemandRes*/*ResponseCode=OK*** from EVSE	Charging started
	Poor network connectivity	>50% occurrence: EVSE sends ***ContractAuthenticationRes*/*EVSEProcessing=Ongoing*** for 150 seconds	Intermittent payment authentication timeout
	Non-responsive SECC	EV sends ***CM_SLAC_PARAM.REQ*** but EVSE does not send ***CM_SLAC_PARAM.RES***	EVSE not responding to vehicle cues
	Power module failure	EVSE sends ***CableCheckRes*/*EVSEProcessing=Ongoing*** for 20 seconds	Cable check timeout; EVSE unable to output insufficient voltage
Charging session data	No issue	Final SOC: Last ***CurrentDemandReq*/*EVRESSOC*** Delta SOC: Subtract first from last ***CurrentDemandReq*/*EVRESSOC*** Max current requested: Find maximum value of ***CurrentDemandReq*/*EVTargetCurrent*** Max power requested: Find maximum value of ***CurrentDemandReq*/*EVTargetCurrent**** ***CurrentDemandReq*/*EVTargetVoltage*** Max power delivered: Find maximum value of ***CurrentDemandRes*/*EVSEPresentCurrent**** ***CurrentDemandRes*/*EVSEPresentVoltage*** Rate-limiting: EVSE if (max power requested > max power delivered or max power requested = ***CurrentDemandRes*/*EVSEMaximumPowerLimit*** or max current requested = ***CurrentDemandRes*/*EVSEMaximumCurrentLimit***, else EV	Statistics to aggregate power-limiting and customer behavior based on SOC
Pricing data	n/a	Duration of ***ContractAuthenticationRes*/*EVSEProcessing=Ongoing***	Time for user to pay and for EVSE to recognize payment

Example from CSPR

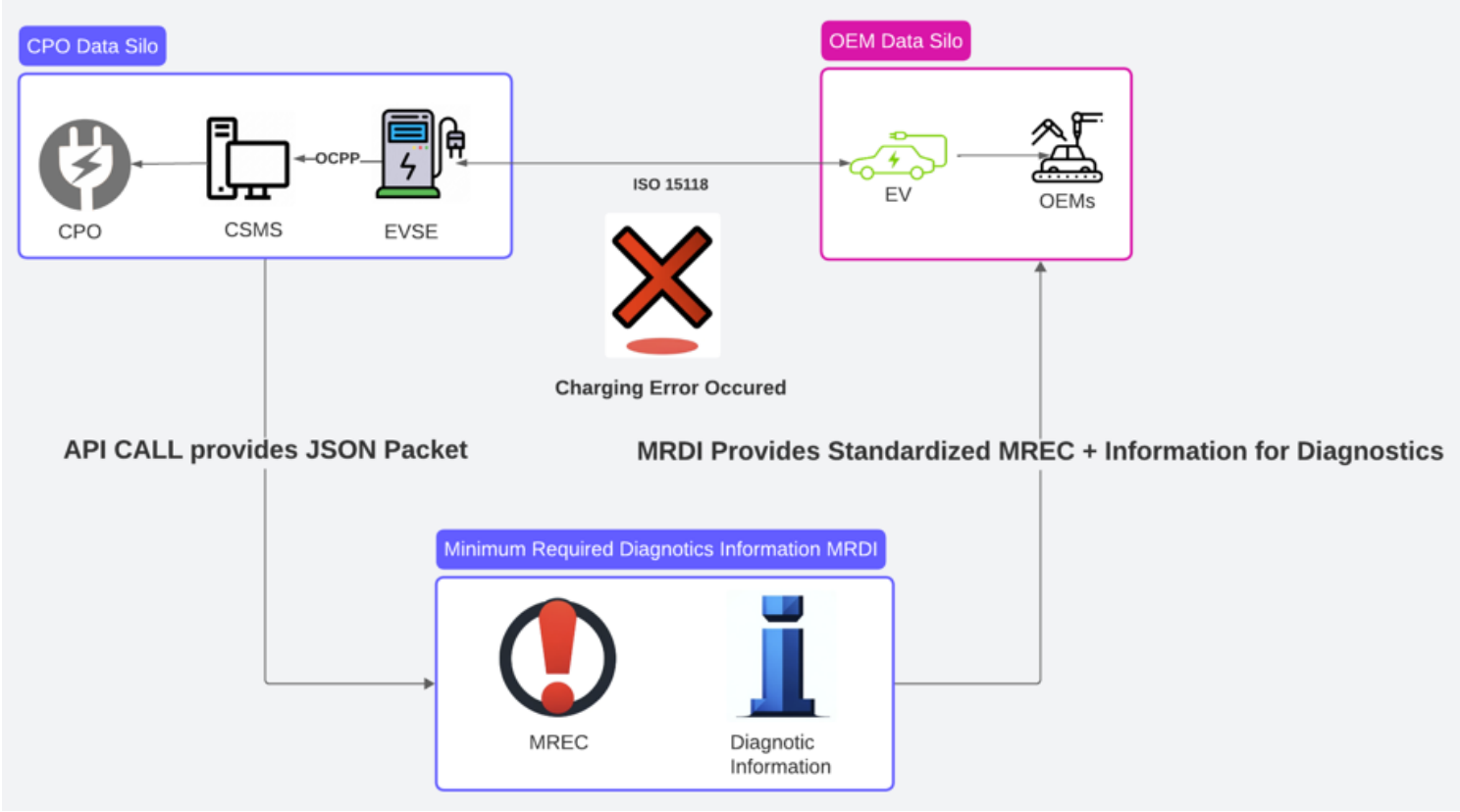
MRDI – Minimum Required Diagnostic Information

- Some data points in CSPR would be essential for diagnostics but sharing the full set of data between charging entities could be problematic due to "ownership" concerns.
- To overcome this, we propose alternative data structure(s), called '**MRDI**,' for sharing diagnostic data.
- Each MRDI will provide means to exchange *only necessary co-identification and session data*.
- Each MRDI will focus only on the minimum data required to diagnose the root cause of the MREC being reported.



Why MRDI?

- Many times, one of the charging entities doesn't have full insight into why a session ended with an error.
- This is primarily due to "data siloes" that exist at CPOs or EV OEMs.
- As a result, non-standardized information request-response is required, usually via traditional methods such as emails.



1. MRDI provides an improvement over this and allows for a seamless information exchange between agreed upon parameters required to diagnose the root cause of certain erroneous session(s).
2. Note that such a method:
   - Allows for wider information sharing in standardized format.
   - Efficient request-response between data siloes.

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How will diagnostic data be shared?

- Propose to use JSON due to flexibility and common usage in industry.
- JSON packet should include basic session information, co-identification data, and finally relevant MRECs.
- This JSON would be served up with a common API by participants providing diagnostic data.


```
{
  "creation_date_time": "2023-12-10T08:22:49 +07:00",
  "start_charge_date_time": "2023-10-26T07:01:10 +06:00",
  "end_charge_date_time": "2016-09-15T11:53:54 +06:00",
  "source": "EVSE",
  "sourceId": "65c2525d9fd38c685b5e6d9a",
  "firmware": "1.1.1 Build 150522 Release 51226",
  "hardwareModel": "Mk 2.",
  "siteId": "Abc123",
  "connectorType": "Quick Plug",
  "connectorId": 1,
  "temperature": 163.301394,
  "MRECS": [
    "High Tempeature"
  ]
}
```


What data is needed?

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Questions?

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MREC 1/3

Number	Error Code	Description
1.	ConnectorLockFailure	Failure to lock or unlock connector on the vehicle side.
2.	GroundFailure	Ground fault circuit interrupter has been activated.
3.	HighTemperature	High temperature inside the EVSE is derating power delivery.
4.	OverCurrentFailure	Over current protection device has tripped.
5.	OverVoltage	Input voltage to the vehicle has risen above an acceptable level.
6.	UnderVoltage	Input voltage to the vehicle has dropped below an acceptable level.
7.	WeakSignal	Wireless communication device reported a weak signal.
8.	EmergencyStop	Emergency stop is pressed by the user (required if equipped).
9.	AuthorizationTimeout	The user plugs in but fails to authorize a charging session prior to the connection timeout between the vehicle and EVSE.
10.	InvalidVehicleMode	The vehicle is in an invalid mode for charging.

MREC 2/3

Number	Error Code	Description
11.	CableCheckFailure	Failure during the cable check phase. Includes isolation failure
12.	PreChargeFailure	The EVSE did not reach the correct pre-charge voltage.
13.	NoInternet	The EVSE has no internet connectivity.
14.	PilotFault	The control pilot voltage is out of range.
15.	PowerLoss	The EVSE is unable to supply any power due to mains failure.
16.	EVContactorFault	Contactors fail to open or close on the vehicle side. May also include welding related errors.
17.	EVSEContactorFault	Contactors fail to open or close on EVSE's side. May also include welding related errors.
18.	CableOverTempDerate	Temperature of charging cable or connector assembly is too high, resulting in reduced power operation.
19.	CableOverTempStop	Temperature of charging cable or connector assembly is too high, resulting in a stopped charging session.
20.	PartialInsertion	Cable latch is raised due to incomplete insertion into the vehicle charging port.

MREC 3/3

Number	Error Code	Description
21.	CapacitanceFault	An Isolation Monitoring Device tripped due to high capacitance during active charging.
22.	ResistanceFault	An Isolation Monitoring Device tripped due to low resistance to the chassis during active charging.
23.	ProximityFault	The proximity voltage is out of range.
24.	ConnectorVoltageHigh	The output voltage of EVSE is high before charging starts or after charging ends.
25.	BrokenLatch	The latch on the connector is broken.
26.	CutCable	The output cable has been severed from the EVSE.

Responsibility 1/2

Number	Error Code	Responsibility Classification			
		EV User	CSO	EVSE	EV
1.	ConnectorLockFailure	✓	-	-	✓
2.	GroundFailure	-	-	✓	✓
3.	HighTemperature	-	-	✓	-
4.	OverCurrentFailure	-	-	✓	✓
5.	OverVoltage	-	-	✓	✓
6.	UnderVoltage	-	-	✓	✓
7.	WeakSignal	-	✓	✓	-
8.	EmergencyStop	✓	-	✓	-
9.	AuthorizationTimeout	✓	✓	✓	✓
10.	InvalidVehicleMode	✓	-	-	✓
11.	CableCheckFailure	-	-	✓	✓
12.	PreChargeFailure	-	-	✓	✓
13.	NoInternet	-	✓	✓	-

Responsibility 2/2

Number	Error Code	Responsibility Classification			
		EV User	CSO	EVSE	EV
14.	PilotFault	-	-	✓	✓
15.	PowerLoss	-	-	✓	-
16.	EVContactorFault	-	-	-	✓
17.	EVSEContactorFault	-	-	✓	-
18.	CableOverTempDerate	-	-	✓	-
19.	CableOverTempStop	-	-	✓	✓
20.	PartialInsertion	✓	-	✓	✓
21.	CapacitanceFault	-	-	✓	✓
22.	ResistanceFault	-	-	✓	✓
23.	ProximityFault	-	-	✓	✓
24.	ConnectorVoltageHigh	-	-	✓	-
25.	BrokenLatch	-	✓	✓	-
26.	CutCable	-	✓	✓	-