

## 1 Description of the use case

### 1.1 Name of use case

<i>Use case identification</i>		
<i>ID</i>	<i>Area Domain(s)/ Zone(s)</i>	<i>Name of use case</i>
BC04		Interoperability and Control of Flexibility during operation

### 1.2 Version management

<i>Version management</i>				
<i>Version No.</i>	<i>Date</i>	<i>Name of author(s)</i>	<i>Changes</i>	<i>Approval status</i>
0.1	2016-09-23	Troels Brødsgaard	Annotation of required fields	draft
0.2	2016-10-17	Troels Brødsgaard	Integrated feedback from use case workshop, changed 1.4 and 2 (Aggregator control loop)	draft
0.3	2016-10-26	Troels Brødsgaard	Integrate comments from Haris and Jasmin, changed 1.5, 2, 3.1. Added two new sequence diagrams and described scenarios in 4.1.	draft
0.4	2016-11-10	Kai Heussen, Charalampos Ziras, Troels Brødsgaard	Complete rewrite to describe interoperability instead of control.	draft
0.5	2016-11-17	Troels Brødsgaard	Incorporate feedback from Team 0 meeting. Main change is replacement of schedule with generic coordination. Changed 1.3, 1.4, 1.5, 2, 3.1, 4 and 5.	Ready for approval
0.6	2016-11-28	Koen Kok	Review	Approved

### 1.3 Scope and objectives of use case

<i>Scope and objectives of use case</i>	
<i>Scope</i>	The interactions between aggregator and DERs during operation, as they pass through the Flexibility Interoperability Platform.
<i>Objective(s)</i>	Allow as diverse a set of DERs as possible to provide flexibility to aggregators. This will maximise the amount of flexibility that can enter the flexibility market, and will protect end-users from vendor lock-in.
<i>Related business case(s)</i>	(x)

### 1.4 Narrative of use case

<i>Narrative of use case</i>
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**Short description**

The aggregator and DER continuously exchange information in order to facilitate control and activate flexibility. The information exchanged depends on the DERs flexibility capabilities. The flexibility capabilities of a DER describes its ability to provide flexibility to an aggregator, which types of information it can use for control, and which kind of local intelligence it has. The DERs control scheme may either be coordinated or real-time, and the aggregator can keep track of the DER state through state information exchanges. In addition, the aggregator can send general information messages to the DER, such as a price or weather forecast, which the DER can use as input to internal algorithms, which do not affect any aggregator-initiated control.

**Complete description**

The messages exchanged between aggregator and Flexibility Interoperability Platform (FIP) during operation will depend upon the contract that has been settled between aggregator and DER owner. The contract specifies which DER flexibility capabilities will be utilized during the contract, and these capabilities define the information exchange between aggregator and the FIP during operation.

If the capabilities in the contract include real-time control by the aggregator, the aggregator can send control messages which are to be effectuated immediately. The control message will be translated to a control signal by the FIP, which is then forwarded to the DER. Depending on the capabilities of the DER, it may send a receipt in acknowledgement of receiving the signal to the FIP. In any case, the FIP should send a receipt to the aggregator.

The DER will evaluate the control action and apply it. Depending on the capabilities of the DER, the DER may respond with a control report, which will be forwarded by the FIP to the aggregator. If the DER does not send control reports, the aggregator will have to confirm that the control has been applied through different means, such as a DER state information exchange (see below).

If the capabilities in the contract include a type of coordinated control, the aggregator and DER can perform control coordination. Control coordination can be initiated at any time and by either party. The aggregator can trigger the coordination by sending a coordination message to the FIP, which is forwarded to the DER. The DER will evaluate the coordination message and return a response, which indicates some form of commitment to the coordination. The DER can trigger coordination by sending a coordination request message.

When prior coordination triggers a control action, the DER will evaluate and apply the control action. As in the case of real-time control, the DER may send a control report. If the DER does not send control reports, the aggregator will have to confirm that the control has been applied through different means, such as a DER state information exchange (see below).

The capabilities in the contract can include two different means of exchanging DER state information. One is initiated by the aggregator, which sends a request for state information to the FIP. The FIP translates and forwards it to the DER, which replies with a signal describing current state, which is again translated and forwarded by the FIP.

The exchange of DER state information can also be triggered by an event internal to the DER. This could be a physical state change, configuration change, or a timer. Once triggered, the DER sends a state signal to the FIP, which is translated and forwarded.

The state exchange messages can either be a full or partial description of the DER state. Some DERs may be capable of connecting to external data sources, such as a separate power meter, and in this case the DER state information might also include information from external to the DER.

Control information exchanges (both coordination and real-time) and DER state information exchanges have contractual relevance, and each party will have certain expectations of information flow for these exchanges. The expectations will be expressed as a configuration of flexibility capabilities as part of the contract, and failing to meet the expectations can result in contract renegotiation.

In addition to the information flow which has contractual relevance, the parties may exchange general information. This general information exchange could be used by the DER to learn information to optimize its control inside the boundaries specified by the aggregator. For example, if the aggregator has only scheduled that the DER must be off from 16:00 to 22:00, the DER could use its own internal algorithms for optimizing control outside that timespan. This internal control algorithm could depend on price or weather forecasts, which could be supplied by the aggregator. Exchange of general information may be triggered by either DER or aggregator.

### 1.5 Key performance indicators (KPI)

<i>Key performance indicators</i>			
<i>ID</i>	<i>Name</i>	<i>Description</i>	<i>Reference to mentioned use case objectives</i>
1	Amount of different DERs which are supported		

### 1.6 Use case conditions

<i>Use case conditions</i>
<b>Assumptions</b>
<ul style="list-style-type: none"> <li>- The contract between the aggregator and the DER owner specifies which flexibility capabilities will be utilized by the contract.</li> <li>- Any change to the flexibility capabilities of the DER should result in changes to contract and are out of scope of this BC.</li> </ul>
<b>Prerequisites</b>
<ul style="list-style-type: none"> <li>- Aggregator and DER owner has agreed on a contract which makes the flexibility of the DER available to the aggregator.</li> <li>- The Flexibility Interoperability Platform has established a communication channel between the aggregator and the DER that allows for two-way communication.</li> </ul>

### 1.7 Further information to the use case for classification / mapping

<i>Classification Information</i>
<b>Relation to other use cases</b>
AGG01, AGG02, AGG03, AGG04, DER01, IOP01, MMS02
<b>Level of depth</b>
High-level
<b>Prioritisation</b>

HS2
<i>Generic, regional or national relation</i>
<i>Nature of the use case</i>
Business
<i>Further keywords for classification</i>

## 1.8 General remarks

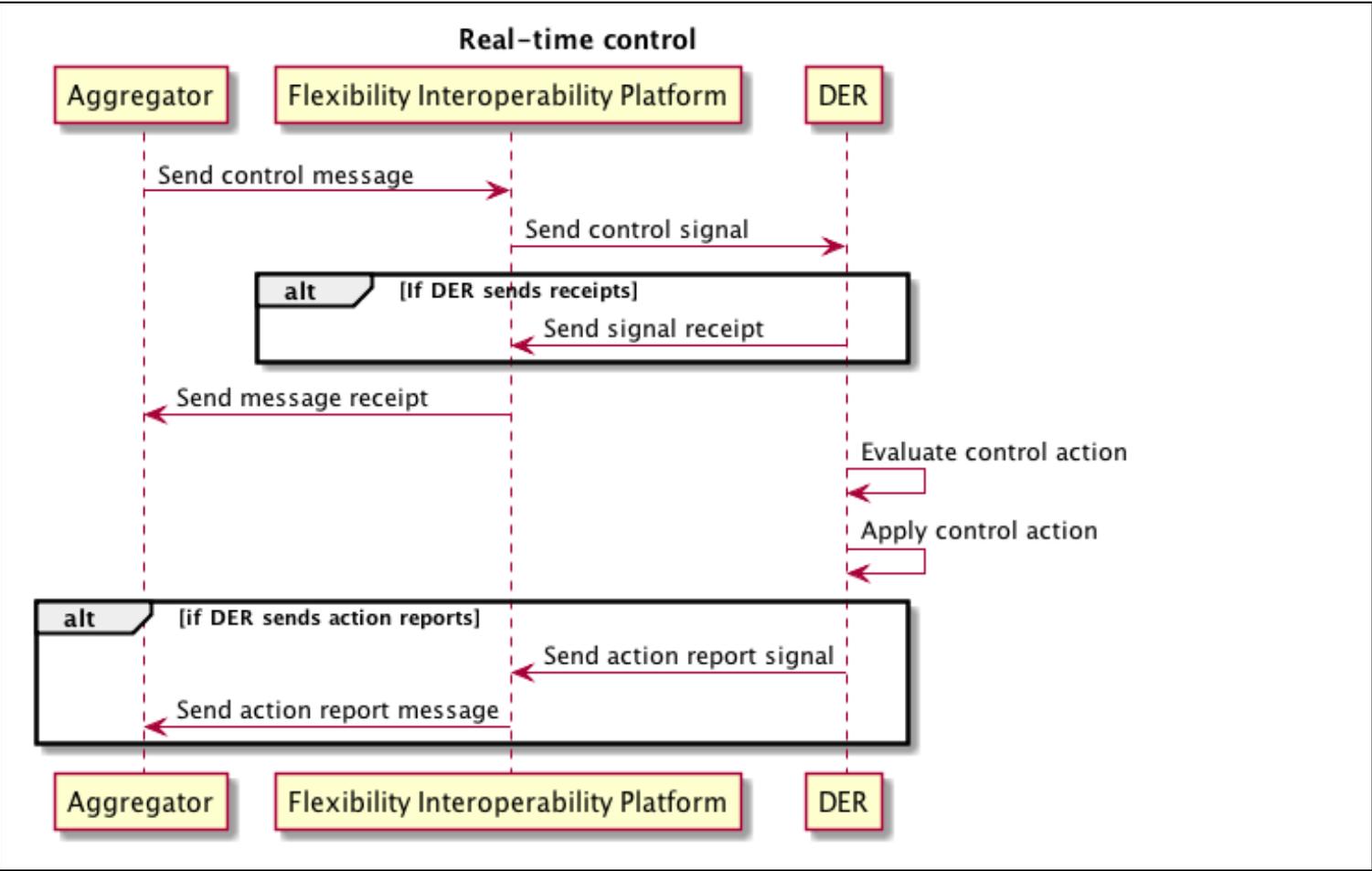
<i>General remarks</i>

## 2 Diagrams of use case

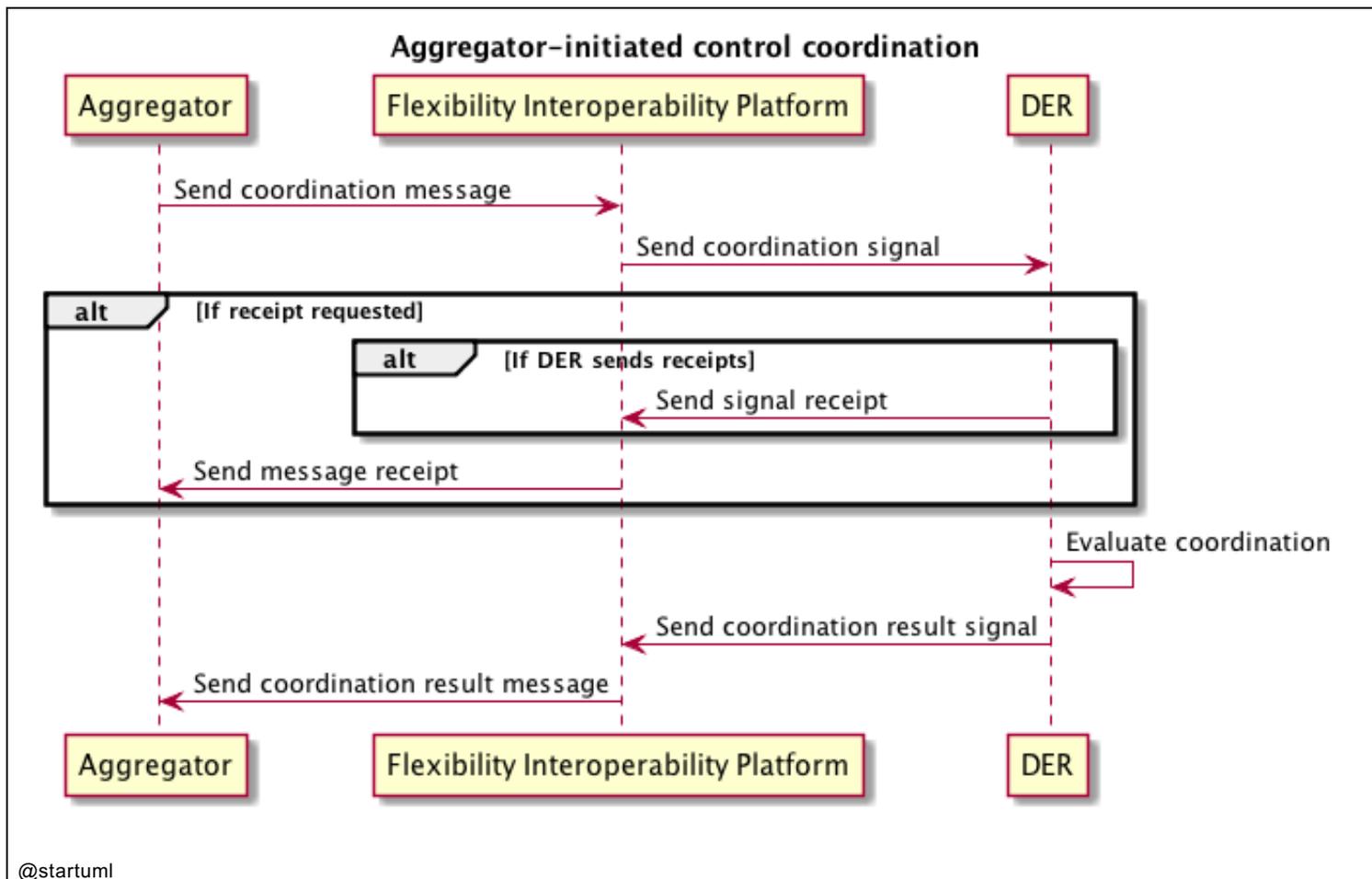
<i>Diagram(s) of use case</i>
(X) - 1) Use Case Diagram
X - 2) (Message) Sequence Diagram @startuml title Real-time control Aggregator -> "Flexibility Interoperability Platform" : Send control message "Flexibility Interoperability Platform" -> DER : Send control signal alt If DER sends receipts "Flexibility Interoperability Platform" <- DER : Send signal receipt end Aggregator <- "Flexibility Interoperability Platform" : Send message receipt DER -> DER : Evaluate control action DER -> DER : Apply control action alt if DER sends action reports "Flexibility Interoperability Platform" <- DER : Send action report signal Aggregator <- "Flexibility Interoperability Platform" : Send action report message end @enduml

**Kommenterede [kh1]:** Illustration of related actors, system boundaries, and other (sub-)use cases

**Kommenterede [kh2]:** Use a drawing tool such as "PlantUML"(script-based) or "MS Visio" to produce the sequence diagram.

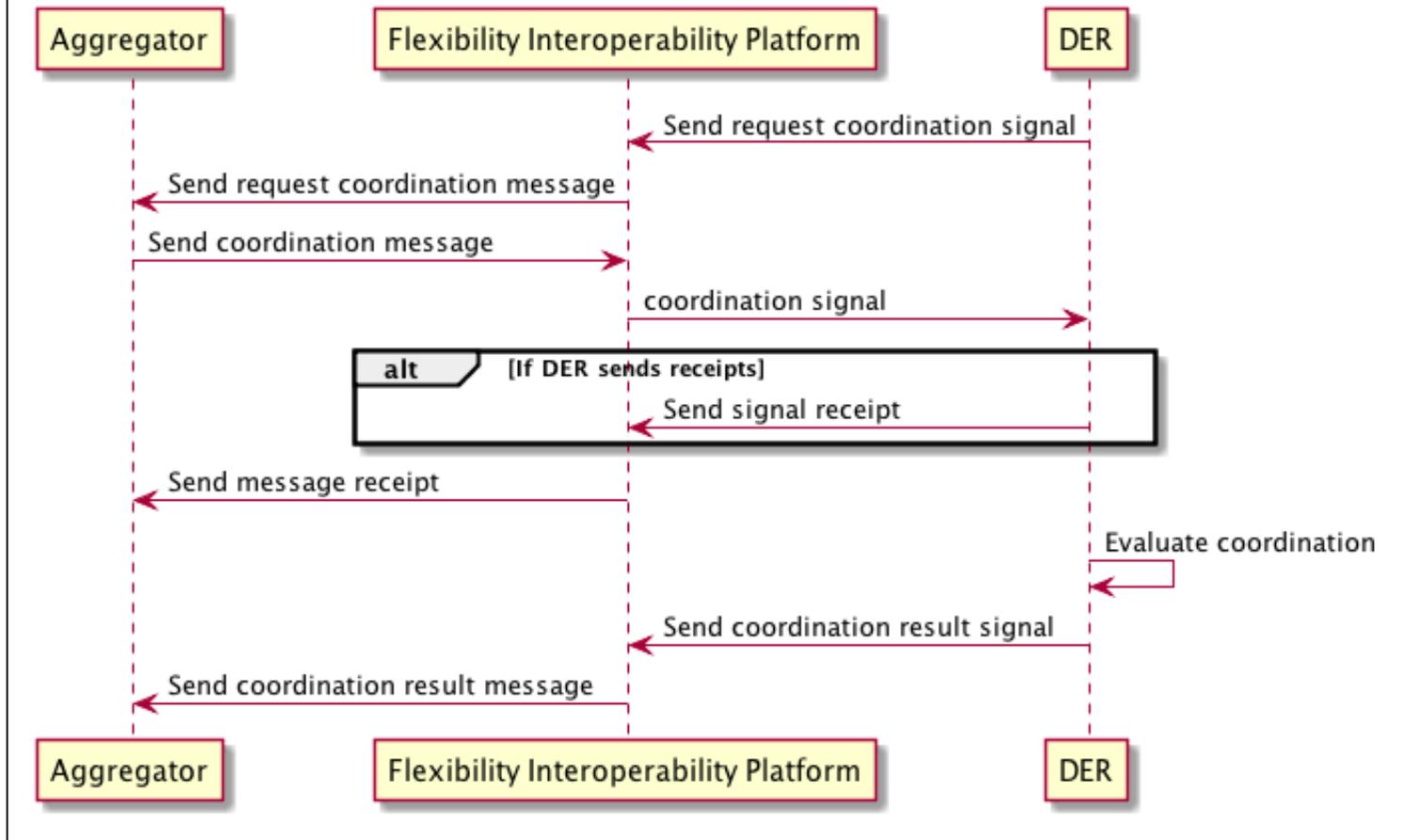


```
@startuml
title Aggregator-initiated control coordination
Aggregator -> "Flexibility Interoperability Platform" : Send coordination message
"Flexibility Interoperability Platform" -> DER : Send coordination signal
alt If receipt requested
  alt If DER sends receipts
    "Flexibility Interoperability Platform" <- DER : Send signal receipt
  end
end
Aggregator <- "Flexibility Interoperability Platform" : Send message receipt
end
DER -> DER : Evaluate coordination
"Flexibility Interoperability Platform" <- DER : Send coordination result signal
Aggregator <- "Flexibility Interoperability Platform" : Send coordination result message
@enduml
```

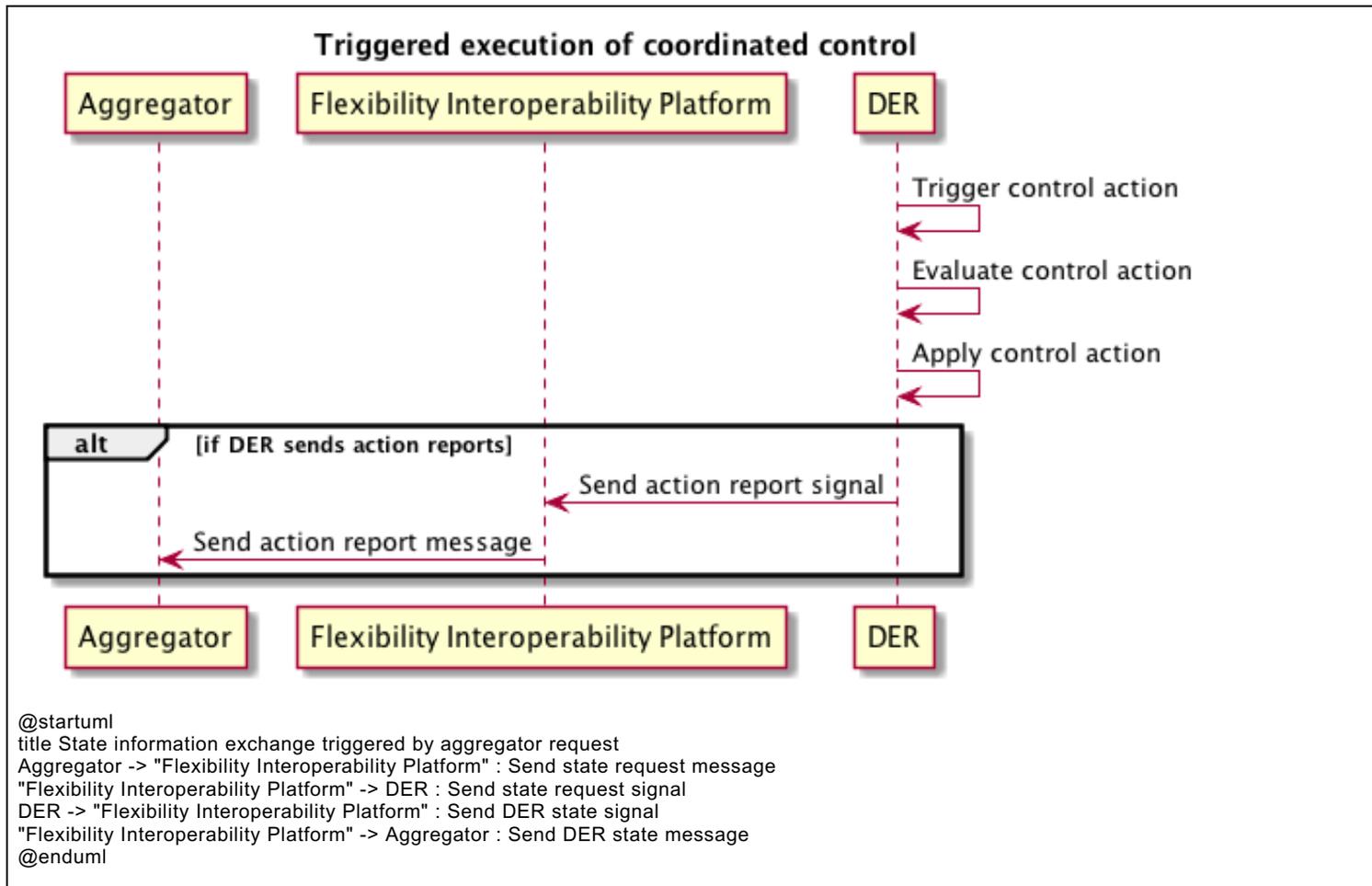


```
title DER-initiated control coordination
participant Aggregator
participant "Flexibility Interoperability Platform"
participant DER
"Flexibility Interoperability Platform" <- DER : Send request coordination signal
Aggregator <- "Flexibility Interoperability Platform" : Send request coordination message
Aggregator -> "Flexibility Interoperability Platform" : Send coordination message
"Flexibility Interoperability Platform" -> DER : coordination signal
alt If DER sends receipts
    "Flexibility Interoperability Platform" <- DER : Send signal receipt
end
Aggregator <- "Flexibility Interoperability Platform" : Send message receipt
DER -> DER : Evaluate coordination
"Flexibility Interoperability Platform" <- DER : Send coordination result signal
Aggregator <- "Flexibility Interoperability Platform" : Send coordination result message
@enduml
```

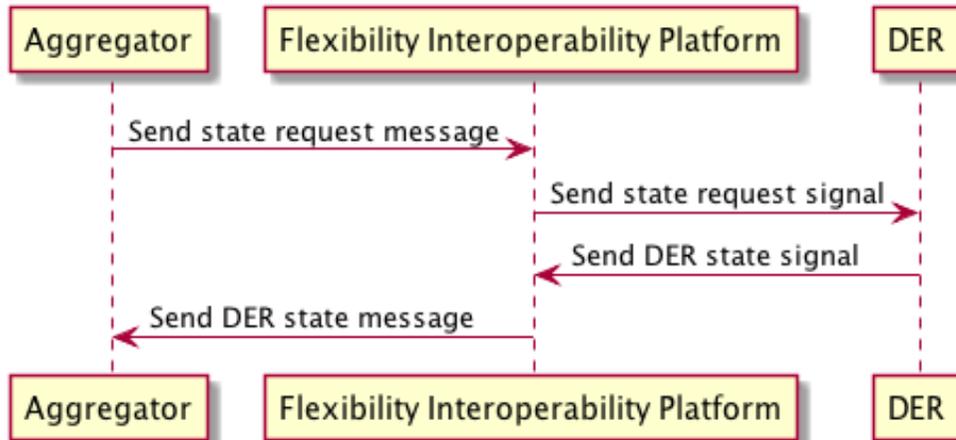
### DER-initiated control coordination



```
@startuml
title Triggered execution of coordinated control
participant Aggregator
participant "Flexibility Interoperability Platform"
participant DER
DER -> DER : Trigger control action
DER -> DER : Evaluate control action
DER -> DER : Apply control action
alt if DER sends action reports
    "Flexibility Interoperability Platform" <- DER : Send action report signal
    Aggregator <- "Flexibility Interoperability Platform" : Send action report message
end
@enduml
```

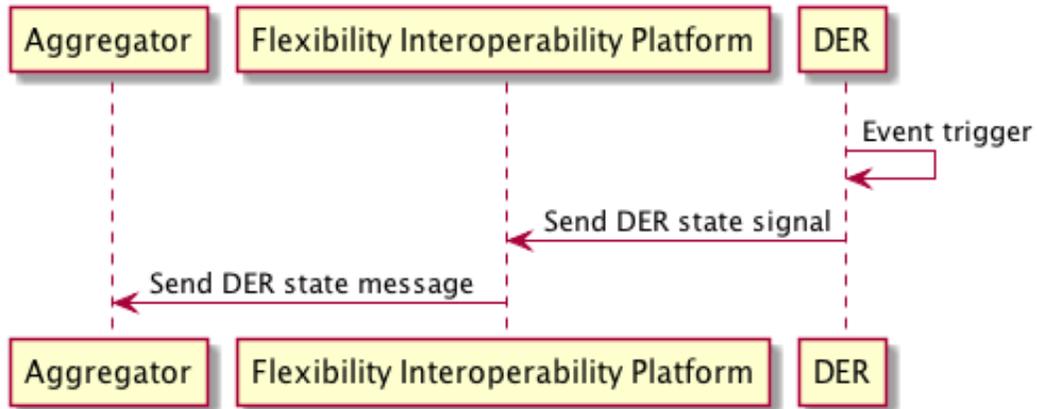


### State information exchange triggered by aggregator request



```
@startuml
title State information exchange triggered by DER event
participant Aggregator
participant "Flexibility Interoperability Platform"
participant DER
DER -> DER : Event trigger
DER -> "Flexibility Interoperability Platform" : Send DER state signal
"Flexibility Interoperability Platform" -> Aggregator : Send DER state message
@enduml
```

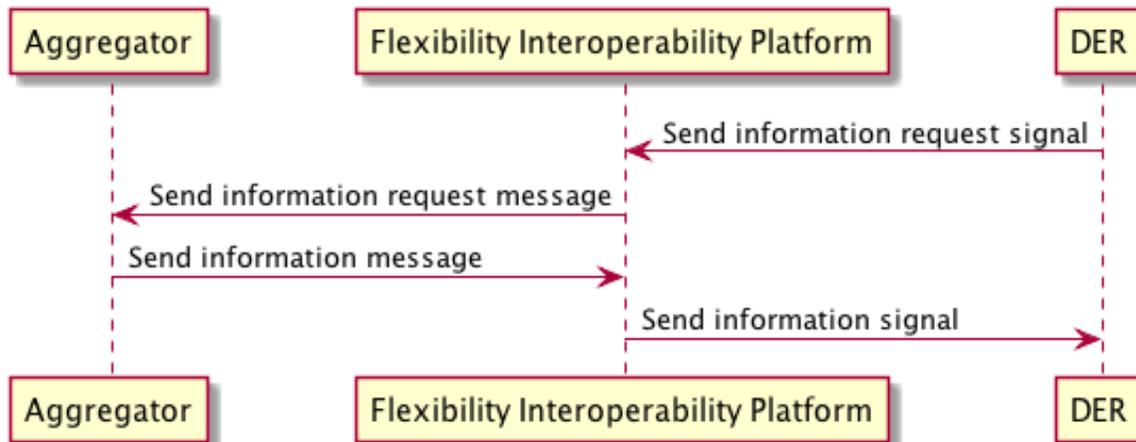
### State information exchange triggered by DER event



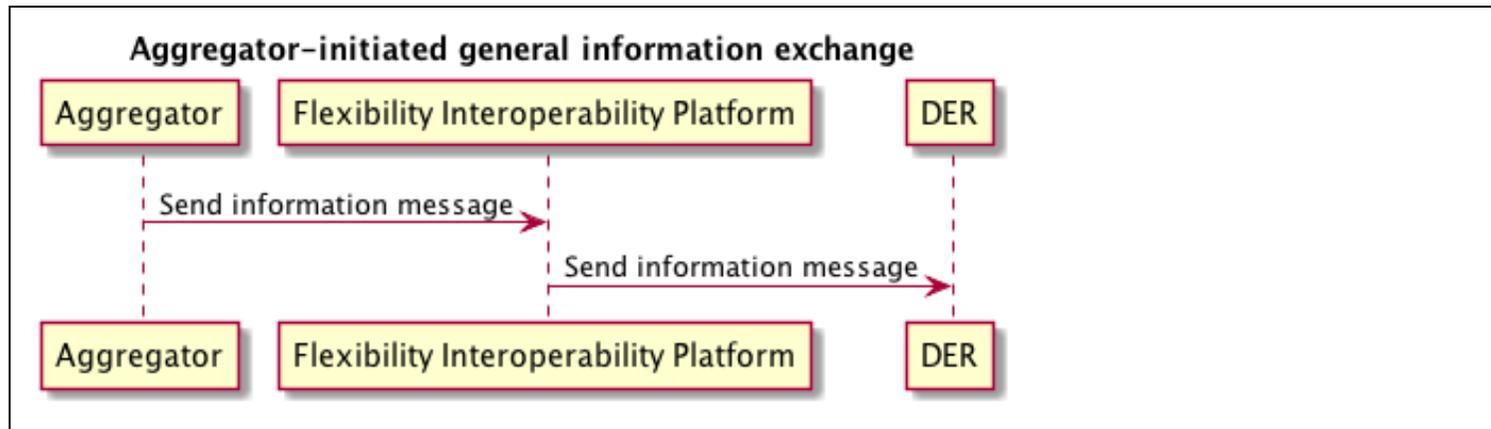
```

@startuml
title DER-initiated general information exchange
participant Aggregator
participant "Flexibility Interoperability Platform"
participant DER
"Flexibility Interoperability Platform" <- DER : Send information request signal
Aggregator <- "Flexibility Interoperability Platform" : Send information request message
Aggregator -> "Flexibility Interoperability Platform" : Send information message
"Flexibility Interoperability Platform" -> DER : Send information signal
@enduml
    
```

### DER-initiated general information exchange



```
@startuml
title Aggregator-initiated general information exchange
Aggregator -> "Flexibility Interoperability Platform" : Send information message
"Flexibility Interoperability Platform" -> DER : Send information message
@enduml
```



### 3 Technical details

#### 3.1 Actors

<i>Actors</i>			
<i>Grouping</i>		<i>Group description</i>	
System		ICT System; exchanges between systems are "Messages"	
Role		Legal role or business actor	
<i>Actor name</i>	<i>Actor type</i>	<i>Actor description</i>	<i>Further information specific to this use case</i>
Aggregator	Role	Has a contract with end-customers owning a DER. Aggregates DERs into a portfolio and makes the flexibility of the portfolio available on the markets. Uses the Flexibility Interoperability Platform to control its portfolio of DERs according to the trading results.	
Customer	Role	Owns a DER and has a contract with an aggregator. The aggregator controls the DER, but the customer may specify product settings which	

		impose additional constraints on the aggregators ability to exploit flexibility.	
BRP	Role	Forwards activation signals from the rea-time flexibility market to the aggregator.	
TSO	Role		
DSO	Role	Performs activations of conditional services bought on the DSO locational market.	
Verification Service Provider	Role		
Flexibility Interoperability Platform	System	Translates between interoperability flexibility messages and equipment-specific control signals.	
Flexibility Trading Platform	System		
DER	System	A distributed energy resource which can modify its energy consumption/production to deviate from its baseline. Each DER has some set of flexibility capabilities and local intelligence. The DER can be partly autonomous and partly under control by an aggregator.	
DSO SCADA system	System		
...			

**Kommenterede [kh3]:** Please add / refine systems as needed

### 3.2 References

<i>References</i>						
<i>No.</i>	<i>References type</i>	<i>Reference</i>	<i>Status</i>	<i>Impact on use case</i>	<i>Originator / organisation</i>	<i>Link</i>
x						

**Kommenterede [kh4]:** Any literature or reports referred in the text.

## 4 Step by step analysis of use case

### 4.1 Overview of scenarios

<i>Scenario conditions</i>						
<i>No.</i>	<i>Scenario name</i>	<i>Scenario description</i>	<i>Primary actor</i>	<i>Triggering event</i>	<i>Pre-condition</i>	<i>Post-condition</i>
1	Real-time control	The aggregator sends control	Aggregator	A control event internal to the		

		messages to the DER to be effectuated immediately.		aggregator.		
2	Aggregator-initiated control coordination	The aggregator sends a coordination message to the DER, The DER evaluates the coordination message and returns a response which indicates some form of commitment.	Aggregator	A control event internal to the aggregator.		
3	DER-initiated control coordination	The DER sends a coordination request to the aggregator. The aggregator then begins the coordination flow in scenario 2.	DER	A control event internal to the DER.		
4	Triggered execution of coordinated control	The DER evaluates and applies a control action according to prior coordination, and optionally sends an action report to the aggregator.	DER	A control event internal to the DER, caused by prior control coordination.		
5	State information exchange triggered by aggregator request	The aggregator sends a request for DER state information. The	DER	An event internal to the aggregator.		.

		DER responds with information on its current state.				
6	State information exchange triggered by DER event	An event internal to the DER triggers the DER to send information on its current state to the aggregator.	DER	An event internal to the DER. E.g. a physical state change (DER switching to "off" state), configuration change (DER owner changing temperature settings), a timer (send measurements every 5 seconds), or a signal from an external system connected to the DER.		
7	DER-initiated general information exchange	The DER requests a piece of general information from the aggregator. The aggregator responds with the information.	DER	An event internal to the DER.		
8	Aggregator-initiated general information exchange	The aggregator sends a piece of general information to the DER.	Aggregator	E.g. an update of price or weather forecast.		

#### 4.1 Steps – Scenarios

Scenario								
Scenario name :		Real-time control						
Step No.	Event	Name of process/	Description of process/	Service	Information producer	Information receiver (actor)	Information exchanged (IDs)	Requirements R-ID

		<i>activity</i>	<i>activity</i>		<i>(actor)</i>			
10		Send control message	The aggregator sends a control message to be effectuated immediately.		Aggregator	FIP	IA10	-
20		Send control signal	The FIP has translated the control message into a control signal and forwards it to the DER.		FIP	DER	IA20	
30		Send signal receipt	The DER may optionally send a signal receipt to the FIP.		DER	FIP	IA30	
40		Send message receipt	The FIP sends a message receipt to the aggregator.		FIP	Aggregator	IA40	
50		Evaluate control action	The DER evaluates how the control action should be applied to avoid violating any constraints.		DER	DER		
60		Apply control action	The DER applies the control action.		DER	DER		
70		Send action report signal	The DER may optionally send an action report signal to the FIP.		DER	FIP	IA50	
80		Send action report message	If the FIP receives an action report		FIP	Aggregator	IA60	

			signal from the DER, it must translate and forward the message to the aggregator.					
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<b>Scenario</b>								
<b>Scenario name :</b>		Aggregator-initiated control coordination						
<b>Step No.</b>	<b>Event</b>	<b>Name of process/activity</b>	<b>Description of process/activity</b>	<b>Service</b>	<b>Information producer (actor)</b>	<b>Information receiver (actor)</b>	<b>Information exchanged (IDs)</b>	<b>Requirements R-ID</b>
10		Send coordination message	The aggregator sends a coordination message.		Aggregator	FIP	IB10	-
20		Send coordination signal	The FIP translates the coordination message into a coordination signal and forwards it to the DER.		FIP	DER	IB20	
30		Evaluate coordination	The DER evaluates the information in the coordination message.		DER	DER		
40		Send coordination result signal	The DER sends a coordination result signal to the FIP.		DER	FIP	IB30	
50		Send action report message	The FIP translates the coordination		FIP	Aggregator	IB40	

			signal into a coordination message and forwards it to the aggregator.					
--	--	--	---	--	--	--	--	--

<b>Scenario</b>								
<b>Scenario name :</b>		DER-initiated control coordination						
<b>Step No.</b>	<b>Event</b>	<b>Name of process/activity</b>	<b>Description of process/activity</b>	<b>Service</b>	<b>Information producer (actor)</b>	<b>Information receiver (actor)</b>	<b>Information exchanged (IDs)</b>	<b>Requirements R-ID</b>
10		Send coordination request signal	The DER sends a request for control coordination.		DER	FIP	IC10	
20		Send coordination request message	The signal is translated into a message by the FIP.		FIP	Aggregator	IC20	
30		Send coordination message	The aggregator sends a coordination message.		Aggregator	FIP	IB10	-
40		Send coordination signal	The FIP translates the coordination message into a coordination signal and forwards it to the DER.		FIP	DER	IB20	
50		Evaluate coordination	The DER evaluates the information in the coordination message.		DER	DER		

60		Send coordination result signal	The DER sends a coordination result signal to the FIP.		DER	FIP	IB30	
70		Send action report message	The FIP translates the coordination signal into a coordination message and forwards it to the aggregator.		FIP	Aggregator	IB40	

<b>Scenario</b>								
<b>Scenario name :</b> Triggered execution of coordinated control								
<b>Step No.</b>	<b>Event</b>	<b>Name of process/activity</b>	<b>Description of process/activity</b>	<b>Service</b>	<b>Information producer (actor)</b>	<b>Information receiver (actor)</b>	<b>Information exchanged (IDs)</b>	<b>Requirements R-ID</b>
10		Trigger control action	The DER triggers a control event in accordance with prior coordination.		DER	DER		-
20		Evaluate control action	The DER evaluates how the control action should be applied to avoid violating any constraints.		DER	DER		
30		Apply control action	The DER applies the control action.		DER	DER		
40		Send action report signal	The DER may optionally send		DER	FIP	IA50	

			an action report signal to the FIP.					
50		Send action report message	If the FIP receives an action report signal from the DER, it must translate and forward the message to the aggregator.		FIP	Aggregator	IA60	

<b>Scenario</b>								
<b>Scenario name :</b>		State information exchange triggered by aggregator request						
<b>Step No.</b>	<b>Event</b>	<b>Name of process/activity</b>	<b>Description of process/activity</b>	<b>Service</b>	<b>Information producer (actor)</b>	<b>Information receiver (actor)</b>	<b>Information exchanged (IDs)</b>	<b>Requirements R-ID</b>
10		State request message	The aggregator sends a request for DER state information.		Aggregator	FIP	ID10	-
20		State request signal	The message is translated into a signal by the FIP.		FIP	DER	ID20	
30		DER state signal	The DER responds with the requested state information.		DER	FIP	ID30	
40		DER state message	The signal is translated into a message by the FIP.		FIP	Aggregator	ID40	

<b>Scenario</b>								
<b>Scenario name :</b>		State information exchange triggered by DER event						
<b>Step No.</b>	<b>Event</b>	<b>Name of process/activity</b>	<b>Description of process/activity</b>	<b>Service</b>	<b>Information producer (actor)</b>	<b>Information receiver (actor)</b>	<b>Information exchanged (IDs)</b>	<b>Requirements R-ID</b>
10		Event trigger	An event internal to the DER triggers sending of state information to DER.		DER	DER		-
20		DER state signal	The DER responds with the requested state information.		DER	FIP	ID30	
30		DER state message	The signal ins translated into a message by the FIP.		FIP	Aggregator	ID40	

<b>Scenario</b>								
<b>Scenario name :</b>		DER-initiated information exchange						
<b>Step No.</b>	<b>Event</b>	<b>Name of process/activity</b>	<b>Description of process/activity</b>	<b>Service</b>	<b>Information producer (actor)</b>	<b>Information receiver (actor)</b>	<b>Information exchanged (IDs)</b>	<b>Requirements R-ID</b>
10		Information request signal	The DER sends a signal requesting general information.		DER	FIP	IE10	-
20		Information request message	The signal is translated into a message by the FIP.		FIP	Aggregator	IE20	

30		Information message	The aggregator sends the requested information.		Aggregator	FIP	IE30	
40		Information signal	The message is translated into a signal by the FIP.		FIP	DER	IE40	

<b>Scenario</b>								
<b>Scenario name :</b> Aggregator-initiated information exchange								
<b>Step No.</b>	<b>Event</b>	<b>Name of process/activity</b>	<b>Description of process/activity</b>	<b>Service</b>	<b>Information producer (actor)</b>	<b>Information receiver (actor)</b>	<b>Information exchanged (IDs)</b>	<b>Requirements R-ID</b>
10		Information message	The aggregator sends an information message.		Aggregator	FIP	IE30	
20		Information signal	The message is translated into a signal by the FIP.		FIP	DER	IE40	

## 5 Information exchanged

<b>Information Exchanged</b>			
<b>Information exchanged ID</b>	<b>Name of information exchanged</b>	<b>Description of information exchanged</b>	<b>Requirements IDs</b>
IA10	Control action	The message contains control information to be evaluated and effectuated immediately by the DER. The control information could be e.g. an on/off signal, a temperature setpoint or a price signal, depending on the capabilities of the DER.	-
IA20	Control signal	The signal contains the control information from the aggregators control message, but it has been translated to an equipment-specific signal.	

IA30	Signal receipt	A receipt that the DER has received the signal.	
IA40	Message receipt	A receipt that the message was received by the FIP. May optionally contain information on whether the signal was also received by the DER.	
IA50	Action report signal	A signal describing the result of evaluating the control information and applying the corresponding control action.	
IA60	Action report message	A translation of the DER-specific action report signal to a matching message in the interoperability protocol.	
IB10	Coordination message	The message contains information that can be used to coordinate control between aggregator and DER ahead of time. The content of the message depends on the control algorithm of the DER. Examples are a schedule of when the DER must turn on or off, or a voltage reference.	
IB20	Coordination signal	The coordination message translated to an equipment-specific signal.	
IB30	Coordination result signal	The coordination result contains information similar to that submitted by the aggregator. It indicates whether the DER has accepted, rejected and/or altered the control being coordinated.	
IB40	Coordination result message	The coordination result signal translated to a matching message in the interoperability protocol.	
IC10	Coordination request signal	A signal with a request to initiate control coordination. The request may specify the of type of coordination information that the DER wants to receive.	
IC20	Coordination request message	The coordination request signal translated to a matching message in the interoperability protocol.	
ID10	State request message	A message containing a request for state information. The request should indicate what state information the DER is to return, and may also indicate a time frame for returning the result.	
ID20	State request signal	The state request message translated to an equipment-specific signal.	
ID30	DER state signal	A response to the state request signal containing the requested information on DER state.	

ID40	DER state message	The DER state signal translated to a matching message in the interoperability protocol.	
IE10	Information request signal	A request for general information such as weather and price forecasts.	
IE20	Information request message	The information request signal translated to a matching message in the interoperability protocol.	
IE30	Information message	A message containing as much of the requested information as the aggregator is able to deliver.	
IE40	Information signal	The information message translated to an equipment-specific signal.	

## 6 Requirements (optional)

<i>Requirements (optional)</i>		
<i>Categories ID</i>	<i>Category name for requirements</i>	<i>Category description</i>
<i>Requirement ID</i>	<i>Requirement name</i>	<i>Requirement description</i>

**Kommenterede [kh5]:** Just FYI - formalized requirements not relevant here.

## 7 Common Terms and Definitions

<i>Common terms and definitions</i>	
<i>Term</i>	<i>Definition</i>

## 8 Custom information (optional)

<i>Custom information (optional)</i>		
<i>Key</i>	<i>Value</i>	<i>Refers to section</i>

