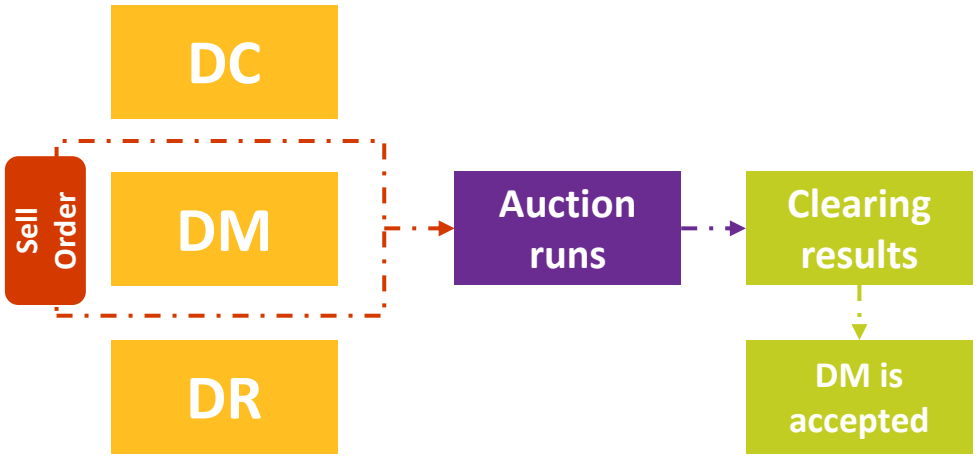
EAC Sell Order Design

18 January 2023

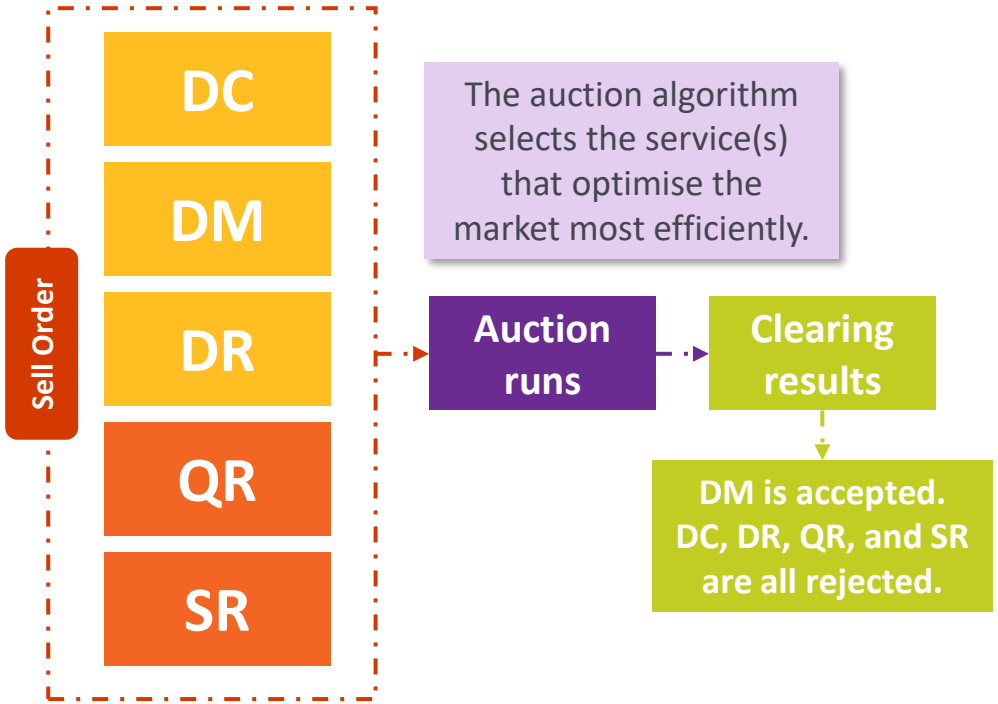
Co-optimisation

Current frequency response auctions



Only one service (i.e., either DC, DM, or DR) can be offered into the auction. Participants need to decide which service to offer ahead of the auction.

EAC auction (with co-optimisation)



More than one service can be offered into the auction. Participants can offer all services they wish to provide ahead of the auction.

Mutually exclusivity - the implementation of co-optimisation

Unit X	Response		
	DC	DM	DR
EFA 1	A	B	C
EFA 2	A	B	C
EFA 3	A	B	C
EFA 4	A	B	C
EFA 5	A	B	C
EFA 6	A	B	C

Mutually exclusive orders

Examples:

For a single unit X and a single EFA, I want to offer either one of the three options:

Order A: 20 MW DCL, £2
Order B: 15 MW DML, £5
Order C: 10 MW DRL, £20

Order A, B, C are mutually exclusive to each other.

→ However, participants may want to offer mixed services as a bundle. These bundles are mutually exclusive to each other.

→ **To facilitate this, we introduce a new sell order design called "(mutually exclusive) baskets".**

Mutually exclusivity - the implementation of co-optimisation

In EAC, co-optimisation is implemented by using mutually exclusive *baskets*.
Baskets can contain a mix of Response products.

Unit X	Response		
	DC	DM	DR
EFA 1	A	B	C
EFA 2	A	B	C
EFA 3	A	B	C
EFA 4	A	B	C
EFA 5	A	B	C
EFA 6	A	B	C

Mutually exclusive baskets

Examples:

For a single unit X and a single EFA, I want to offer:

Basket A:

Order A1: 20 MW DCL, £2
Order A2: 20 MW DCH, £1

Basket B:

Order B1: 15 MW DML, £5
Order B2: 15 MW DMH, £3

Basket C:

Order C1: 10 MW DCL, £2
Order C2: 10 MW DCH, £1
Order C3: 5 MW DRL, £20
Order C4: 5 MW DRH, £0

Baskets A, B, C are mutually exclusive to each other.

Specification of a Basket

Response (DC, DM, DR)			QR	SR
EFA 1	EFA 1	EFA 1	EFA 1a	EFA 12
			EFA 1b	
EFA 2	EFA 2	EFA 2	EFA 2a	
			EFA 2b	
EFA 3	EFA 3	EFA 3	EFA 3a	EFA 3a
			EFA 3b	EFA 3b
EFA 4	EFA 4	EFA 4	EFA 4a	EFA 4a
			EFA 4b	EFA 4b
EFA 5	EFA 5	EFA 5	EFA 5a	EFA 5a
			EFA 5b	EFA 5b
EFA 6	EFA 6	EFA 6	EFA 6a	EFA 6a
			EFA 6b	EFA 6b

1. Baskets are defined on **a single unit**

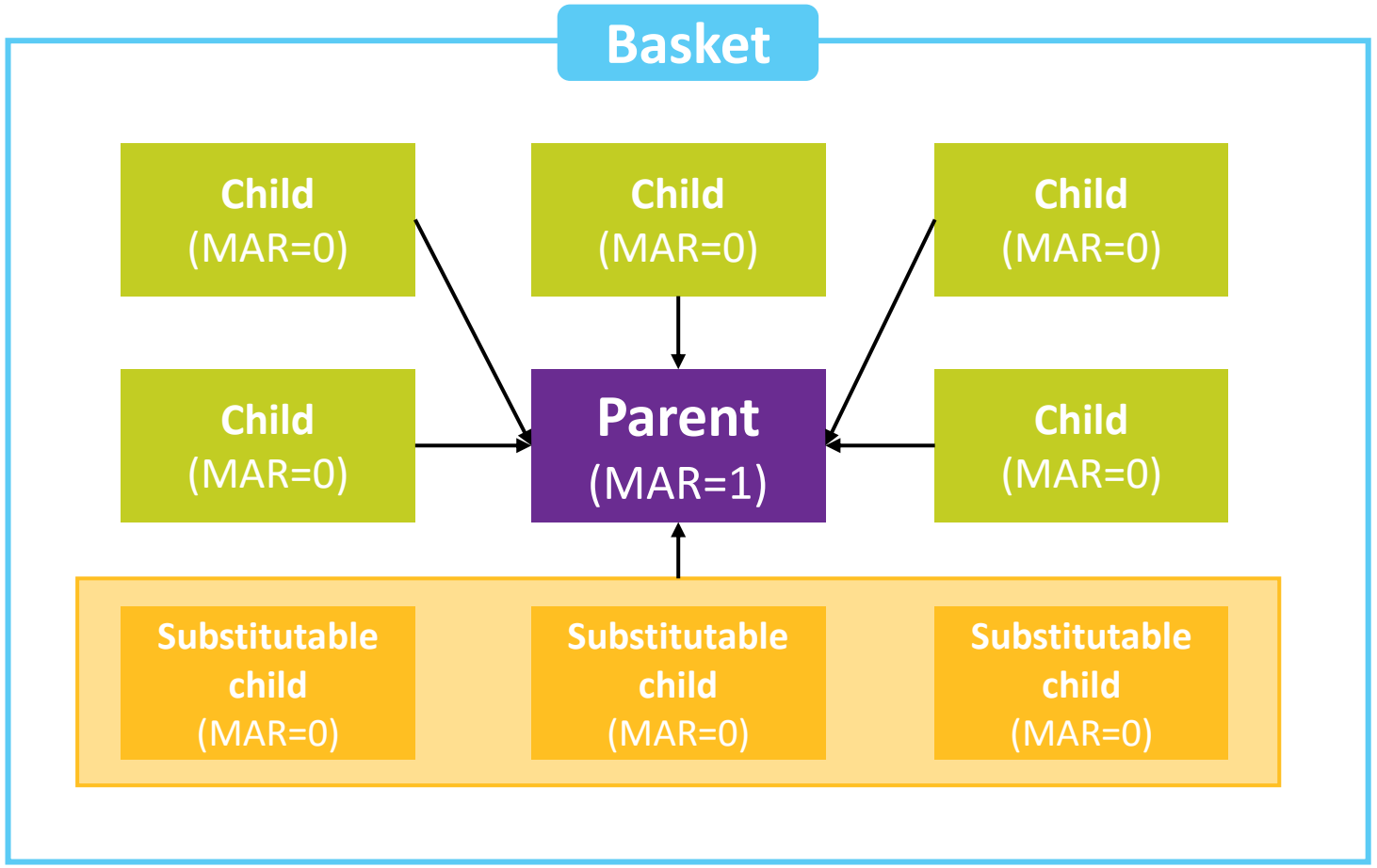
2. Baskets are defined on **a single service type**: Response, Quick Reserve, Slow Reserve.

3. Baskets are defined on **a single delivery period**

4. Each basket must contain exactly one parent order.

5. (Optional) A basket can be looped to a basket immediately preceding it.

Specification of a Basket



- **There are three types of orders:**
  1) Parent orders
  2) Child orders
  3) Substitutable child orders.
- **Each basket must have exactly one parent order.**
  - Parent orders are non-curtailable (MAR=1).
  - The parent order can be a 0MW order.
  - The parent order can have no child, 1 child, or more than 1 children.
- **In each basket, apart from the parent order, all other orders are children of this single parent**
  - Children are fully curtailable (MAR = 0).
- **These orders could be either child orders or substitutable child orders.**
  - **Child orders:** the acceptance ratio of each child order must be less than or equal to 1. Child orders are not substitutable, and each can be accepted up to 100%
  - **Substitutable child orders:** the sum the of acceptance ratios of all substitutable child orders must be less than or equal to 1.

Specification of a Basket

Data Field	Comment
Basket ID	
Unit ID	Baskets are defined on a single unit.
Service Type	Response/ Quick Reserve/ Slow Reserve
Delivery Period	Baskets are defined on a single delivery period, appropriate to the Service Type.
Parent Order	A basket must have a parent order, which is non-curtailable (i.e., MAR=1). The volume of the parent order can be 0MW for all products.
Loop Basket ID	ID of a basket immediately preceding this basket. May be left blank.

Notes:

A. Service Type: the service type of a basket determines what products can be put in the basket and the possible delivery periods (e.g., 4-hour, 2-hour, 8-hour).

B. Looped baskets: baskets of which respective parent orders are looped linked

C. Multi-period blocks are enabled by looping adjacent baskets together.

D. Response and reserve services can be looped into multi-period blocks (i.e. delivered sequentially – not stacked). Response cannot follow reserve.

Specification of a Parent Order

Data Field	Comment
Order ID	
Order Type	**Parent**
Basket ID	Orders belong to only one basket
Volume	A volume for each product. May be 0 for some or all products.
Price	A single price in £/MW/h

Notes:

A. Parent orders have a MAR of 1. They must be completely accepted or rejected.

B. The unit, delivery period, and service type of the order depends on the basket to which it belongs.

C. The products included in each parent order depend on the service on which its basket is defined.

D. A parent order can be defined on multiple products.

E. A basket must have exactly 1 parent order (which may have 0 volume for all products).

Parent Order for Frequency Response

Order ID	Order Type	Basket ID	DCL	DCH	DML	DMH	DRL	DRH	Price
P1	Parent	B1	18	16	0	0	4	4	12.25

Parent Order for Quick Reserve

Order ID	Order Type	Basket ID	PQR	NQR	Price
P2	Parent	B2	0	30	8.30

Parent Order for Slow Reserve

Order ID	Order Type	Basket ID	PSR	NSR	Price
P3	Parent	B3	80	150	19.35

Specification of a Child Order

Data Field	Comment
Order ID	
Order Type	**Child**
Basket ID	Orders belong to only one basket
Volume	A volume for a single product. Exactly one product must have a non-zero volume. Other products must have 0 volumes.
Price	A single price in £/MW/h

Notes:

A. Child orders have a MAR of 0. They are fully curtailable.
   a) A child order is linked to a parent, which is the parent order in the same basket (and which may have 0 volume).
   b) All child orders in a basket must be defined on the same parent order

B. The unit, delivery period, and service type of the order depends on the basket to which it belongs

C. The products included in each child order depend on the service on which the basket of its parent is defined.

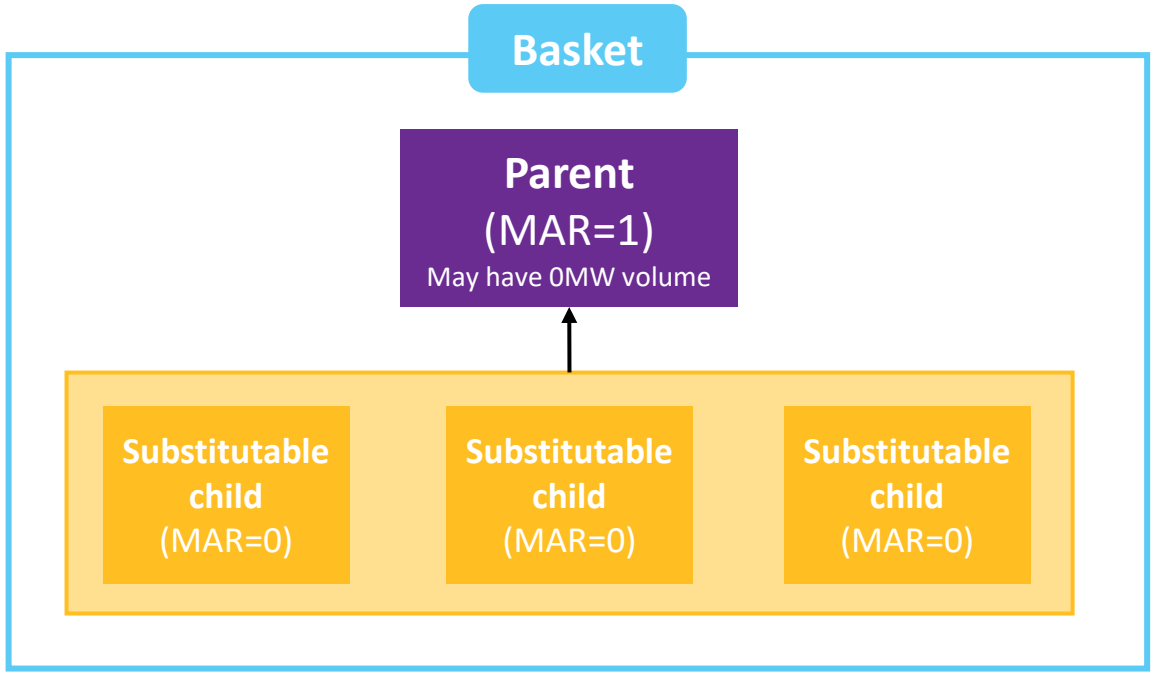
D. A child can only be defined on 1 product.

E. More than 1 child order is allowed in a single basket.

Example of a basket with child orders for response

Order ID	Order Type	Basket ID	DCL	DCH	DML	DMH	DRL	DRH	Price
P1	Parent	B1	10						0.01
C1	Child	B1	5						5
C2	Child	B1				4			7

Substitution family – the implementation of (continuous) splitting/stacking



A basket must be fully deliverable (full acceptance of the parent and all child orders plus 100% acceptance of the substitution family must be feasible for the unit). This is the responsibility of the participant.

Substitution family

Examples:

My technology is capable of delivering DCL, DML, and DRL simultaneously. I wish to split (in a very flexible way). Here are my capacity for each service:

At most 20MW of DCL
At most 16MW of DML
At most 10MW of DRL

In a single basket B, I can offer three substitutable child orders. These three orders form a single substitution family:

Order A: 20 MW DCL, £2
Order B: 16 MW DML, £5
Order C: 10 MW DRL, £20

→ The sum of the acceptance ratios of a substitution family must be less than or equal to 1. I.e.,

$$x_A + x_B + x_C \leq 1$$

where $x_{order\ i}$ is the acceptance ratio of order i.

→ Potential clearing results:

1) 20MW DCL, $(x_A, x_B, x_C) = (1,0,0)$
2) 10MW DCL, $(x_A, x_B, x_C) = (0.5,0,0)$
3) 10MW DCL + 5MW DRL, $(x_A, x_B, x_C) = (0.5,0,0.5)$
4) 5MW DCL + 4MW DML + 5MW DRL , $(x_A, x_B, x_C) = (0.25,0.25,0.5)$

Specification of a Substitutable Child Order

Data Field	Comment
Order ID	
Order Type	**Substitutable child**
Basket ID	Orders belong to only one basket
Volume	A volume for each product. May be 0 for some (but not all) products.
Price	A single price in £/MW/h

Notes:

A. Substitutable orders have a MAR of 0. They are fully-curtailable.
   a. A substitutable order is linked to a parent, which is the parent order in the same basket (and which may have 0 volume).
   b. All substitutable orders in a basket must be defined on the same parent order
   c. All substitutable orders in a basket form a single substitution family
   d. The sum of the acceptance ratios of a substitution family must be less than or equal to 1.

B. The unit, delivery period, and service type of a substitutable order depend on the basket to which its parent belongs

C. The products included in each substitutable order depend on the service on which the basket of its parent is defined.

D. A substitutable order can be defined on multiple products.

E. More than 1 substitutable order is allowed in a single basket.

Example of a basket with a substitution family

Order ID	Order Type	Basket ID	DCL	DCH	DML	DMH	DRL	DRH	Price
P1	Parent	B1	0	0	0	0	0	0	0
S1	Substitutable Child	B1	0	0	0	0	5	5	12.25
S2	Substitutable Child	B1	0	0	0	0	0	10	4.65
S3	Substitutable Child	B1	16	0	0	0	0	0	9.75

Sell Order Design

Current Frequency Response Sell Order Design	EAC Sell Order Design
Parent order • Non-curtailable (i.e., MAR=1) • 1 parent order per service window, per product, per unit	***Parent order*** • Non-curtailable (i.e., MAR=1) • 1 parent order per basket (a basket is defined on a service window and a unit) • A parent order can be defined on multiple products. All products in the parent order must be either accepted or rejected
Child order • Fully-curtailable (i.e., MAR=0) • A child must be defined on a single product • A parent order can only have at most one child per service window • A child and its linked parent can be defined on the same or different service windows	***Child order*** • Fully-curtailable (i.e., MAR=0) • A child must be defined on a single product • A parent order can have multiple children • A child and its linked parent must be defined on the same service window
No splitting	***Substitutable child order*** • Fully-curtailable (i.e., MAR=0) • This order type can be used for (continuous) splitting • A substitutable child and its linked parent must be defined on the same service window
No co-optimisation	***Baskets*** • Each basket must be defined on a single unit, a single service window, a service type and a parent order • This feature is designed to allow mutually exclusivity (e.g., co-optimisation)
Looped order • Looped orders have same actual acceptance ratio (AAR)	***Parent order (for the same service window)*** • The parent orders of looped baskets must be either accepted or rejected ***Looped baskets (for consecutive service windows)*** • All products in a parent order must be either accepted or rejected
Multi-period order • Multi-period order has same actual acceptance ratio (AAR)	***Looped baskets*** • The parent orders of looped baskets must be either accepted or rejected

Appendix – Sell Order Design

18 January 2023

Basket Overview

Basic Principles	• A basket contains orders belonging to a single unit, service type, and delivery period. • A basket must be fully deliverable (full acceptance of the parent and all child orders plus 100% acceptance of the substitution family must be feasible for the unit). This is the responsibility of the participant.
Key Validations	• A basket contains exactly one parent order (which may have 0 volume) and may contain 1 or more child orders and 1 or more substitutable child orders. • A basket may be looped only to a basket immediately preceding it ("start delivery time" of basket must equal "end delivery time" of looped basket). • A basket with service type = "Response" cannot be looped to a basket with service type = "Quick Reserve" or "Slow Reserve" (but the other way around is possible).
Mutual Exclusivity (see note below)	• A basket is mutually exclusive with all other concurrent baskets (i.e., defined on the same delivery period or a portion of the delivery period) • A Basket with service type = "Response" is mutually exclusive with a basket with service type = "Quick Reserve" or "Slow Reserve" that immediately precedes it (i.e., where start time of the Response basket = end time of the QR/SR basket)
Limitations (TBD)	• Maximum of M baskets per unit in a single auction. • Maximum of N child orders in a single basket. • Maximum of L substitutable child orders in a single basket. • Maximum of K baskets per unit per EFA day.

Note: The participant does not indicate which baskets are mutually exclusive. The EAC platform determines this from the service type and delivery periods of each basket.

Mutually exclusive baskets

A basket is mutually exclusive with all other concurrent baskets (i.e., defined on the same delivery period or a portion of the delivery period). The participant does not indicate which baskets are mutually exclusive. The EAC platform determines this from the service type and delivery periods of each basket.

Scenario 1

EFA 1 B1	EFA 1 B2	EFA 1 B3

- B1, B2, and B3 are mutually exclusive to each other.

Scenario 2

EFA 5 B4	EFA 5a B5	EFA 5a B6
EFA 6 B7	EFA 6a B8	EFA 6a B9

- B4, B5, and B6 are mutually exclusive to each other.
- B7, B8, and B9 are mutually exclusive to each other.

→ You can have B4+B8, etc.

Scenario 3

EFA 5 B10	EFA 5a B11	EFA 5a B12
	EFA 5b B13	EFA 5b B14
	EFA 6a B15	EFA 6a B16
	EFA 6b B17	EFA 6b B18

- B10, B11, and B12 are mutually exclusive to each other.
- B10, B13, and B14 are mutually exclusive to each other.
- B15 and B16 are mutually exclusive to each other.
- B17 and B18 are mutually exclusive to each other.

→ You can have B11+B14, B12+B13, B10+B15+B16, etc.

Scenario 4

EFA 1 B19	EFA 1 B20	EFA 1a B21	EFA 12 B23
		EFA 1b B22	
		EFA 2a B24	
		EFA 2b B25	

- B19, B20, B21, and B23 are mutually exclusive to each other.
- B19, B20, B22, and B23 are mutually exclusive to each other.
- B24 and B23 are mutually exclusive to each other.
- B25 and B23 are mutually exclusive to each other.

→ You can have B21+B22, B24+B25, B19+B24, etc.

Mutually exclusive baskets

A Basket with service type = "Response" is mutually exclusive with a basket with service type = "Quick Reserve" or "Slow Reserve" that immediately precedes it (i.e., where start time of the Response basket = end time of the QR/SR basket). The participant does not indicate which baskets are mutually exclusive. The EAC platform determines this from the service type and delivery periods of each basket.

Scenario 5

EFA 5 B4	EFA 5a B5	EFA 5a B6
	EFA 5b B7	EFA 5b B8
EFA 6 B9	EFA 6a B10	EFA 6a B11
	EFA 6b B12	EFA 6b B13

Non-concurrent baskets may be mutually exclusive if they are impacted by the crossover reserve service design:

- $\{B7, B9\}$
- $\{B8, B9\}$

Concurrent baskets must be mutually exclusive:

- $\{B4, B5, B6\}$
- $\{B4, B7, B8\}$
- $\{B9, B10, B11\}$
- $\{B9, B12, B13\}$

Scenario 6

EFA 1 R1	EFA 1a Q1	EFA 12 S1
	EFA 1b Q2	
EFA 2 R2	EFA 2a Q3	
	EFA 2b Q4	
EFA 3 R3	EFA 3a Q5	EFA 3a S2
	EFA 3b Q6	EFA 3b S3
EFA 4 R4	EFA 4a Q7	EFA 4a S4
	EFA 4b Q8	EFA 4b S5
EFA 5 R5	EFA 5a Q9	EFA 5a S6
	EFA 5b Q10	EFA 5b S7
EFA 6 R6	EFA 6a Q11	EFA 6a S8
	EFA 6b Q12	EFA 6b S9

Non-concurrent baskets may be mutually exclusive if they are impacted by the crossover reserve service design:

- $\{R2, Q2\}$
- $\{R3, Q4, S1\}$
- $\{R4, Q6, S3\}$
- $\{R5, Q8, S5\}$
- $\{R6, Q10, S7\}$

Concurrent baskets must be mutually exclusive:

- $\{R1, Q1, S1\}$
- $\{R1, Q2, S1\}$
- $\{R2, Q3, S1\}$
- $\{R2, Q4, S1\}$
- $\{R3, Q5, S2\}$
- $\{R3, Q6, S3\}$
- $\{R4, Q7, S4\}$
- $\{R4, Q8, S5\}$
- $\{R5, Q9, S6\}$
- $\{R5, Q10, S7\}$
- $\{R6, Q11, S8\}$
- $\{R6, Q12, S9\}$

Notation: All baskets in { } are mutually to each other. For example, $\{B9, B10, B11\}$ implies that baskets B9, B10 and B11 are mutually exclusive to each other.