# AUCTION OF PUBLIC CELLULAR MOBILE TELECOMMUNICATION SERVICES SPECTRUM RIGHTS 

## APPENDIX 6 - ILLUSTRATIONS

18 JANUARY 2008
INFO-COMMUNICATIONS DEVELOPMENT AUTHORITY OF SINGAPORE

## ILLUSTRATIONS

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This Appendix provides examples to illustrate the following:
a) The determination as to whether the Auction proceeds, based on Section 2.6 of the Auction Rules; and
b) The Clock Auction process, based on Section 7 of the Auction Rules
c) The Assignment Stage process, based on Section 10 of the Auction Rules

Part I : Determination as to whether Auction is to proceed.
The following three scenarios illustrate how IDA will determine whether the Auction will proceed, based on the Bidders' Initial Offers. In each scenario, assume there are four Bidders, A, B, C and D.

Scenario A1: Auction does not proceed as there is no more than one First Initial Offer for each of the eighteen PCMTS Spectrum Lots. ("X" indicates the PCMTS Spectrum Lot(s) that a Bidder has specified in its First Initial Offer Document). The Bidders are allocated the PCMTS Spectrum Lots which they made First Initial Offers for, at the Reserve Price.

| Number of PCMTS Spectrum Lot | Paired |  | Bidders' Initial Offers |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Lower band (MHz) | Upper Band (MHz) | A | B | C | D |
| EGSM Lot |  |  |  |  |  |  |
| 1 | 885-890 | 930-935 | X |  |  |  |
| 900 MHz Lots |  |  |  |  |  |  |
| 2 | 890-895 | 935-940 |  | X |  |  |
| 3 | 895-900 | 940-945 |  | X |  |  |
| 4 | 900-905 | 945-950 |  |  | X |  |
| 5 | 905-910 | 950-955 |  |  | X |  |
| 6 | 910-915 | 955-960 |  |  | X |  |
| 1800 MHz Lots |  |  |  |  |  |  |
| 7 | 1710-1715 | 1805-1810 | X |  |  |  |
| 8 | 1715-1720 | 1810-1815 | X |  |  |  |
| 9 | 1720-1725 | 1815-1820 | X |  |  |  |
| 10 | 1725-1730 | 1820-1825 |  | X |  |  |
| 11 | 1740-1745 | 1835-1840 |  | X |  |  |
| 12 | 1745-1750 | 1840-1845 |  | X |  |  |
| 13 | 1750-1755 | 1845-1850 |  |  | X |  |
| 14 | 1755-1760 | 1850-1855 |  |  | X |  |
| 15 | 1760-1765 | 1855-1860 |  |  |  | X |
| 16 | 1765-1770 | 1860-1865 |  |  |  | X |
| 17 | 1770-1775 | 1865-1870 |  |  |  | X |
| 18 | 1775-1780 | 1870-1875 |  |  |  | X |

Scenario A2: Auction of all eighteen PCMTS Spectrum Lots proceeds with the Clock Auction, as there is excess demand in at least one category of PCMTS Spectrum Lots. In this example, there are six Initial Offers for the five 900 MHz Lots.

| Number of PCMTS Spectrum Lot | Paired |  | Bidders' Initial Offers |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Lower band (MHz) | Upper Band (MHz) | A | B | c | D |
| EGSM Lot |  |  |  |  |  |  |
| 1 | 885-890 | 930-935 | X |  |  |  |
| 900 MHz Lots |  |  |  |  |  |  |
| 2 | 890-895 | 935-940 |  | X |  |  |
| 3 | 895-900 | 940-945 |  | X |  |  |
| 4 | 900-905 | 945-950 |  | X | X |  |
| 5 | 905-910 | 950-955 |  |  | X |  |
| 6 | 910-915 | 955-960 |  |  | x |  |
| 1800 MHz Lots |  |  |  |  |  |  |
| 7 | 1710-1715 | 1805-1810 | X |  |  |  |
| 8 | 1715-1720 | 1810-1815 | X |  |  |  |
| 9 | 1720-1725 | 1815-1820 | X |  |  |  |
| 10 | 1725-1730 | 1820-1825 |  | X |  |  |
| 11 | 1740-1745 | 1835-1840 |  | X |  |  |
| 12 | 1745-1750 | 1840-1845 |  | X |  |  |
| 13 | 1750-1755 | 1845-1850 |  |  | X |  |
| 14 | 1755-1760 | 1850-1855 |  |  | X |  |
| 15 | 1760-1765 | 1855-1860 |  |  |  | X |
| 16 | 1765-1770 | 1860-1865 |  |  |  | X |
| 17 | 1770-1775 | 1865-1870 |  |  |  | X |
| 18 | 1775-1780 | 1870-1875 |  |  |  | X |

Scenario A3: Auction proceeds with the Assignment Stage without conducting the Clock Auction as there is no excess demand in any category of PCMTS Spectrum Lots, but more than one Initial Offer for a specific Lot (Lot 14, in this example).

| Number of PCMTS Spectrum Lot | Paired |  | Bidders' Initial Offers |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Lower band (MHz) | Upper Band (MHz) | A | B | C | D |
| EGSM Lot |  |  |  |  |  |  |
| 1 | 885-890 | 930-935 | X |  |  |  |
| 900 MHz Lots |  |  |  |  |  |  |
| 2 | 890-895 | 935-940 |  | X |  |  |
| 3 | 895-900 | 940-945 |  | X |  |  |
| 4 | 900-905 | 945-950 |  |  | X |  |
| 5 | 905-910 | 950-955 |  |  | X |  |
| 6 | 910-915 | 955-960 |  |  | X |  |
| 1800 MHz Lots |  |  |  |  |  |  |
| 7 | 1710-1715 | 1805-1810 | X |  |  |  |
| 8 | 1715-1720 | 1810-1815 | X |  |  |  |
| 9 | 1720-1725 | 1815-1820 | X |  |  |  |
| 10 | 1725-1730 | 1820-1825 |  | X |  |  |
| 11 | 1740-1745 | 1835-1840 |  | X |  |  |
| 12 | 1745-1750 | 1840-1845 |  | X |  |  |
| 13 | 1750-1755 | 1845-1850 |  |  | X |  |
| 14 | 1755-1760 | 1850-1855 |  |  | X | X |
| 15 | 1760-1765 | 1855-1860 |  |  |  | X |
| 16 | 1765-1770 | 1860-1865 |  |  |  | X |
| 17 | 1770-1775 | 1865-1870 |  |  |  | X |
| 18 | 1775-1780 | 1870-1875 |  |  |  |  |

## Part II: Conduct of Clock Auction

This illustration of the Clock Auction process proceeds based on Scenario A2 in Part I. At the start of the Clock Auction (ie. the Start-of-Round Prices of Round 1), the Bidder's demand is deemed to be equal to the number of lots that the Bidder made Initial Offers for in each category of PCMTS Spectrum Lots in the Bidder's First Initial Offer Document. This is shown in Table 1 below.

Table 1: Bidder's Demand at the start of the Clock Auction

| Round 1 | EGSM | $\mathbf{9 0 0} \mathbf{~ M H z}$ | $\mathbf{1 8 0 0} \mathbf{~ M H z}$ |
| :--- | :--- | :--- | :--- |
| Bidder A | 1 | 0 | 3 |
| Bidder B | 0 | 3 | 3 |
| Bidder C | 0 | 3 | 2 |
| Bidder D | 0 | 0 | 4 |

## Round 1

Table 2 shows the Start-of-Round and End-of-Round prices for Round 1. For the first round, the Start-of-Round Price is equal to the Reserve Price. For the EGSM and 1800 MHz Rounds, as there is no excess demand for the PCMTS Spectrum Lots in these categories at the start of the Auction, the End of Round Price has been set equal to the Start-of-Round price for this case.

Table 2 : Round 1 Prices

| Round 1 | EGSM | $\mathbf{9 0 0} \mathbf{~ M H z}$ | $\mathbf{1 8 0 0} \mathbf{~ M H z}$ |
| :--- | :--- | :--- | :--- |
| Start-of-Round | $\$ 300,000$ | $\$ 300,000$ | $\$ 300,000$ |
| End-of-Round | $\$ 300,000$ | $\$ 350,000$ | $\$ 300,000$ |

Table 3 shows the bids made by each Bidder for Round 1. For simplicity, in this Round, every Bidder's Entire Bid comprises of just one Bid:

Table 3: Round 1 Bids

| Round 1 | Price Point | Bid |  |  |
| :--- | :--- | :--- | :--- | :--- |
|  |  | EGSM | $\mathbf{9 0 0} \mathbf{~ M H z}$ | $\mathbf{1 8 0 0} \mathbf{~ M H z}$ |
| Bidder A | $100.00 \%$ | 1 | 0 | 3 |
| Bidder B | $50.00 \%$ | 1 | 2 | 3 |
| Bidder C | $100.00 \%$ | 0 | 3 | 2 |
| Bidder D | $100.00 \%$ | 0 | 0 | 4 |

Based on the bids submitted, Bidders $A, C$ and $D$ hold their demand constant for the whole Round. Bidder B maintains its demand, as expressed in its Initial Offer, until the 49.99\% Price Point. At the 50.00\% Price Point, which corresponds to prices $(\$ 300000, \$ 325000, \$ 300000)^{1}$ for (EGSM, $900 \mathrm{MHz}, 1800 \mathrm{MHz}$ )

[^0]respectively, Bidder B switches, by one Lot, its demand for 900 MHz to EGSM. ${ }^{2}$ Diagram 1 shows the aggregate demand for Round 1:


At the End of Round Price, the aggregate demand for EGSM Lots is 2 Lots. This exceeds the supply. Hence the Clock Auction proceeds to the next Round.

## Round 2

Table 4 shows the Start-of-Round and End-of-Round prices for Round 2. The Start-of-Round Prices equal the End-of-Round Prices in Round 1.

Table 4 : Round 2 Prices

| Round 2 | EGSM | $\mathbf{9 0 0} \mathbf{~ M H z}$ | $\mathbf{1 8 0 0} \mathbf{~ M H z}$ |
| :--- | :--- | :--- | :--- |
| Start-of-Round | $\$ 300,000$ | $\$ 350,000$ | $\$ 300,000$ |
| End-of-Round | $\$ 360,000$ | $\$ 350,000$ | $\$ 300,000$ |

Table 5 shows the bids made by each bidder for Round 2:
Table 5: Round 2 Bids

| Round 1 | Price Point | Bid |  |  |  |
| :--- | :--- | :--- | :--- | :--- | :---: |
|  |  | EGSM | $\mathbf{9 0 0} \mathbf{~ M H z}$ | $\mathbf{1 8 0 0} \mathbf{~ M H z}$ |  |
| Bidder A | $80.00 \%$ | 0 | 0 | 4 |  |
| Bidder B | $95.00 \%$ | 0 | 3 | 3 |  |
| Bidder C | $100.00 \%$ | 0 | 3 | 2 |  |
| Bidder D | $100.00 \%$ | 0 | 0 | 4 |  |

[^1]Bidder A maintains its demand, as at the end of Round 1, until the 79.99\% Price Point. At the 80.00\% Price Point, Bidder A stops demanding the EGSM Lot, and instead switches to demanding one more 1800 MHz Lot.

Bidder B maintains its demand, as at the end of Round 1, until the 94.99\% Price Point. At the 95.00\% Price Point, Bidder B stops demanding the EGSM Lot, and instead switches to demanding one more 900 MHz Lot.

Bidders $C$ and $D$ hold their demand constant for the whole Round.
Diagram 2 shows the aggregate demand in Round 2.


There is now excess demand for both the 900 MHz and 1800 MHz Lots at the End-of-Round Prices. Hence the Clock Auction proceeds to the next Round.

## Round 3

Table 6 shows the Start-of-Round and End-of-Round prices for Round 3. The Start-of-Round Prices equal the End-of-Round Prices in Round 2.

Table 6: Round 3 Prices

| Round 2 | EGSM | $\mathbf{9 0 0} \mathbf{~ M H z}$ | $\mathbf{1 8 0 0} \mathbf{~ M H z}$ |
| :--- | :--- | :--- | :--- |
| Start-of-Round | $\$ 360,000$ | $\$ 350,000$ | $\$ 300,000$ |
| End-of-Round | $\$ 360,000$ | $\$ 370,000$ | $\$ 350,000$ |

Table 7 shows the bids made by each bidder for Round 3:
Table 7

| Round 1 | Price Point | Bid |  |  |
| :--- | :--- | :--- | :--- | :--- |
|  |  | EGSM | $\mathbf{9 0 0} \mathbf{~ M H z}$ | $\mathbf{1 8 0 0} \mathbf{~ M H z}$ |
| Bidder A | $20.00 \%^{*}$ | 0 | 1 | 3 |


|  | $50.00 \% *$ <br> *Bidder A has <br> submitted 2 Bids <br> for its Entire Bid <br> in this Round | 1 | 0 | 3 |
| :--- | :--- | :--- | :--- | :--- |
| Bidder B | $60.00 \%$ | 0 | 2 | 3 |
| Bidder C | $90.00 \%$ | 0 | 2 | 2 |
| Bidder D | $100.00 \%$ | 0 | 0 | 4 |

Bidder A's Entire Bid consists of 2 bids. It maintains its demand, as at the end of Round 2, until the 19.99\% Price Point. At the $20.00 \%$ Price Point, Bidder A reduces its demand for 1800 MHz Lots by one lot, and switches to demanding one more 900 MHz lot. This demand holds until the 49.99\% Price point. At the $50.00 \%$ Price point, Bidder A switches its demand for one 900 MHz Lot to one EGSM Lot.

Bidder B maintains its demand, as at the end of Round 2, until the 59.99\% Price Point. At the 60.00\% Price Point, Bidder B reduces its demand for 900 MHz Lots by one Lot. It should be noted that at this point, Bidder B's total demand for PCMTS Spectrum Lots has reduced from six to five. The maximum number of PCMTS Spectrum Lots that Bidder B may subsequently bid for in subsequent Rounds should the Clock Auction proceed further (or at higher Price Points in the current Round) would be capped at five.

Bidder C maintains its demand, as at the end of Round 2, until the 89.99\% Price Point. At the $90.00 \%$ Price Point, Bidder C reduces its demand for 900 MHz Lots by one Lot. This implies a decrease in its overall demand from five to four PCMTS Spectrum Lots.

Bidder D keeps its demand unchanged.


The Clock Auction closes at the 60\% Price Point, as this is the first point where there is no excess demand in any category. The results of the Clock Auction are as follows:

Table 8:

|  | EGSM | $\mathbf{9 0 0} \mathbf{~ M H z}$ | $\mathbf{1 8 0 0} \mathbf{~ M H z}$ |
| :--- | :--- | :--- | :--- |
| Closing | $60 \% \times \$ 360,000+$ | $60 \% \times \$ 370,000+$ | $60 \% \times \$ 350,000+$ |
| Clock | $(1-60 \%) \times \$ 360,000$   <br> Prices   <br> $=$   <br> $(1-60 \%) \times \$ 350,000$   <br> $=\$ 362,000$   | $(1-60 \%) \times \$ 300,000$ <br> $=\$ 330,000$ |  |
| Eligibility Points |  |  |  |
| Bidder A | 1 | 0 | 3 |
| Bidder B | 0 | 2 | 3 |
| Bidder C | 0 | 3 | 2 |
| Bidder D | 0 | 0 | 4 |

## Part III: Assignment Stage

This illustration of the Assignment stage process proceeds based on Scenario A2 in Part I and the Clock Auction example in Part II.

## Exercise of First Rights of Refusal

Assume that $A$ is a new entrant, while Bidders $B, C$ and $D$ may possibly exercise First Rights of Refusal ("FROR") in respect of the following PCMTS Spectrum Lots:

Table 1

| Bidder | $\mathbf{9 0 0} \mathbf{~ M H z}$ | $\mathbf{1 8 0 0} \mathbf{~ M H z}$ |
| :--- | :--- | :--- |
| B | Lots 2 \& 3 | Lots 10,11 \& 12 |
| C | Lots 5 \& 6 | Lots 13 \& 14 |
| D | Nil | Lots $15,16,17,18$ |

In this case, the number of Eligibility Points that Bidders $B, C$ and $D$ have respectively is equal to or more than the number of FROR that they may possibly in each category.

## Scenario B1:

Bidders B, C and D each exercise all their FROR, and their Eligibility Points are reduced accordingly. Table 2 shows the number of PCMTS Spectrum Lots remaining, as well as the Bidders remaining Eligibility Points after the FRORs are exercised.

Table 2:

|  | EGSM | $\mathbf{9 0 0} \mathbf{~ M H z}$ | $\mathbf{1 8 0 0} \mathbf{~ M H z}$ |
| :--- | :--- | :--- | :--- |
| Lots remaining | Lot 1 | Lot 4 | Lots 7,8,9 |
|  | Eligibility Points |  |  |
| Bidder A | 1 | 0 | 3 |
| Bidder B | 0 | 0 | 0 |
| Bidder C | 0 | 1 | 0 |
| Bidder D | 0 | 0 | 0 |

In this scenario, in each category, there is only one Bidder with Eligibility Points remaining, and the Bidder's Eligibility Points equals the number of Lots remaining in that category. The remaining PCMTS Spectrum Lots are thus allocated to the Bidder with the Eligibility Point(s) in that category.

The Auction closes since all PCMTS Spectrum Lots have been allocated. Table 3 summarises the result

Table 3:

| Number of PCMTS Spectrum Lot | Base Year <br> Charge (\$) | Allocation |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | A | B | C | D |
| 1 | 360,000 | X |  |  |  |
| 2 | 362,000 |  | X |  |  |
| 3 | 362,000 |  | X |  |  |
| 4 | 362,000 |  |  | X |  |
| 5 | 362,000 |  |  | X |  |
| 6 | 362,000 |  |  | X |  |
| 7 | 330,000 | X |  |  |  |
| 8 | 330,000 | X |  |  |  |
| 9 | 330,000 | X |  |  |  |
| 10 | 330,000 |  | X |  |  |
| 11 | 330,000 |  | X |  |  |
| 12 | 330,000 |  | X |  |  |
| 13 | 330,000 |  |  | X |  |
| 14 | 330,000 |  |  | X |  |
| 15 | 330,000 |  |  |  | X |
| 16 | 330,000 |  |  |  | X |
| 17 | 330,000 |  |  |  | X |
| 18 | 330,000 |  |  |  | X |

## Scenario B2:

Bidder B exercises its FROR for PCMTS Spectrum Lots 2, 310 and 11, leaving it with one remaining Eligibility Point in the 1800 MHz category

Bidders C and D exercise all their FROR, and their Eligibility Points are reduced accordingly.

Table 4 shows the number of PCMTS Spectrum Lots remaining, as well as the Bidders remaining Eligibility Points after the FRORs are exercised.

Table 4

|  | EGSM | $\mathbf{9 0 0} \mathbf{~ M H z}$ | $\mathbf{1 8 0 0} \mathbf{~ M H z}$ |
| :--- | :--- | :--- | :--- |
| Lots remaining | Lot 1 | Lot 4 | Lots 7,8,9,12 |
|  | Eligibility Points |  |  |
| Bidder A | 1 | 0 | 3 |
| Bidder B | 0 | 0 | 1 |
| Bidder C | 0 | 1 | 0 |
| Bidder D | 0 | 0 | 0 |

In this scenario, for the EGSM and 900 MHz Lots, there is only one Bidder with Eligibility Points remaining, and the Bidders' Eligibility Points equal the number of Lots remaining. The EGSM and 900 MHz Lots are thus allocated to the Bidders with the Eligibility Point(s) in that category.

However, for the four 1800 MHz Lots remaining, both Bidder A and B have Eligibility Points in that category. Hence the Auction proceeds to the Second Initial Offer for the 1800 MHz Lots

## Second Initial Offer

This illustration of the Second Initial Offer Phase is based on Scenario B2 of the Exercise of FROR.

Scenario C1: Sealed-Bid Combinatorial Auction does not proceed as there is no more than one Second Initial Offer for each of the four available 1800 MHz Lots. ("X" indicates the PCMTS Spectrum Lot(s) that a Bidder has specified in its Second Initial Offer Document). The four 1800 MHz Lots are allocated to Bidders A and B according to the Second Initial Offers, at the Closing Clock Prices.

Table 5

| Number of PCMTS Spectrum Lot | Second Initial Offer |  |
| :---: | :---: | :---: |
|  | A | B |
| 7 | X |  |
| 8 | X |  |
| 9 |  | X |


| 12 | $X$ |  |
| :--- | :--- | :--- |

Scenario C2: Sealed-Bid Combinatorial Auction proceeds as there is more than one Second Initial Offer for at least one of the four available 1800MHz Lots (Lot 9 in this example).

Table 6

| Number of |
| :---: | :---: | :---: |
| PCMTS |
| Spectrum |
| Lot |$\quad$| Second Initial Offer |  |
| :---: | :---: |
|  | X |
| 7 | X |
| 8 | X |
| 9 | X |
| 12 |  |

## Sealed Bid Combinatorial Auction

This illustration of the Sealed bid Combinatorial Auction is based on Scenario C2 of the Second Initial Offer Phase.

Based on the Closing Clock Prices of $\$ 330,000$ (see Table 8 of Part II) for each 1800 MHz Lot, Bidder A's Base Price is $\$ 990,000$ while Bidder B’s Base Price is \$330,000.

The Bidders' Combinatorial Bids are shown below:
Table 7: Bidder A's Bids

| Allowable Combination | Lots | Bid |
| :--- | :--- | :--- |
| A1 | $7,8,9$ | $\$ 30,000$ |
| A2 | $7,8,12$ | $\$ 10,000$ |
| A3 | $7,9,12$ | 0 |
| A4 | $8,9,12$ | $\$ 10,000$ |

Table 8: Bidder B's Bids

| Allowable Combination | Lots | Bid |
| :--- | :--- | :--- |
| B1 | 7 | $\$ 0$ |
| B2 | 8 | $\$ 0$ |
| B3 | 9 | $\$ 10,000$ |
| B4 | 12 | $\$ 0$ |

Based on the above Combinatorial Bids, the winning combination Combinatorial Bids is A1+B4, as this combination gives rise to the highest total value, as shown in Table 9

Table 9

| Feasible selection of Combinatorial Bids | Total value |
| :--- | :--- |
| A1 + B4 | $\$ 30,000$ |
| A2 + B3 | $\$ 20,000$ |
| A3 + B2 | $\$ 0$ |
| A4 + B1 | $\$ 10,000$ |

Table 10 shows the result of the Sealed Bid Combinatorial Auction and the Base Year Charge for each lot that was allocated through the Sealed Bid Combinatorial Auction.

Table 10: Result of Sealed Bid Combinatorial Auction

| Bidder | Lots | Base Year Charge of each lot |
| :--- | :--- | :--- |
| A | $7,8,9$ | $\$ 330,000+(\$ 30,000 / 3)=\$ 340,000$ |
| B | 12 | $\$ 330,000+\$ 0=\$ 330,000$ |


[^0]:    ${ }^{1}$ For the 900 MHz Lots, the price at the $50 \%$ Price Point $=50 \% \times \$ 350,000+(1-50 \%) \times \$ 300,000$. For the 1800 MHz Lots and EGSM Lots, the price at the $50 \%$ Price Point $=50 \% \times \$ 300,000+(1-50 \%) \times \$ 300,000$.

[^1]:    ${ }^{2}$ Note that the total number of PCMTS Spectrum Lots demanded by Bidder B remains at 6 .

