TELSTRA CORPORATION LIMITED

Draft spectrum reallocation recommendation for the 850/900 MHz band

Public submission

8 July 2020

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EXECUTIVE SUMMARY

Access to quality mobile broadband (MBB) services has become an indispensable part of life for most Australians and is an important contributor to economic growth. The adoption of more sophisticated MBB devices and services, as well as the quantity of data exchanged, continues on an exponential growth trajectory, underpinned by the ongoing development of 4G and 5G technologies. Ensuring mobile network operators have access to appropriate amounts of efficiently configured spectrum below 1 GHz is vital for ensuring they continue to deliver the mobile services sought by consumers, especially in regional areas and in dense building environments. We see the reallocation of the 850 MHz expansion band and 900 MHz band as being critical for achieving this outcome.

Telstra supports the ACMA's proposed reallocation recommendation

We strongly support the ACMA's proposal to allocate the spectrum available in the 850 MHz expansion band at the same time as the reconfigured 900 MHz band. Large contiguous spectrum holdings are more efficient than smaller fragmented holdings in different bands. Offering the spectrum in these two bands increases the opportunity for mobile network operators to consider their low-band holdings holistically and acquire larger contiguous spectrum holdings than would be the case if the bands were brought to market separately.

We generally support the ACMA's proposed recommendations, however we believe there would be benefits in aligning the end of the reallocation period and the commencement date for spectrum licences in both the 850 MHz and 900 MHz bands. The end of the reallocation period for both bands should be 30 June 2024 and spectrum licences for both bands should commence on 1 July 2024. Aligning the end of the reallocation period and licence commencement dates will allow an additional six-months for incumbent users of the 900 MHz band to transition to new arrangements within their acquired (or other) spectrum holdings as well as providing unencumbered spectrum from the commencement of the spectrum licence for all successful bidders in the 900 MHz band. We remain of the view service continuity can (and should) be managed by an appropriate reallocation period and a 'reservation' for incumbent users is not required.

A first price combinatorial sealed-bid auction format is not likely to result in an efficient outcome

We have strong reservations about the ACMA's preferred auction format: the first price combinatorial sealed-bid (FPCSB) auction format is not a 'tried and tested' spectrum auction format. It has been used rarely and has resulted in inefficient outcomes.

The ACMA's preference for a FPCSB auction appears to be based on concerns about exposure risk and strategic demand reduction. We believe the ACMA has overestimated the concern these factors raise in the context of allocating the 850 MHz and 900 MHz bands. While package bidding is an effective means of dealing with exposure risk, it is not a necessary one. We believe bidders can manage this risk adequately without the introduction of package bidding and there has been no evidence of strategic demand reduction in Australian auctions. When allowed to compete, Australian mobile operators have competed vigorously in recent options. Reserve price outcomes in some regions in the 3.6 GHz auction were the result of allocation limits being set too low. In the same auction, where the allocation limits allowed competition, bidding was vigorous and resulted in some of the highest prices for 3.6 GHz spectrum in the world, which would not be expected if bidders engaged in strategic demand reduction.

An enhanced simultaneous multi-round ascending auction would better meet the ACMA's objectives

The ACMA's objective of an efficient allocation and the government's policy objectives for the allocation of these spectrum bands will be better achieved by using a proven format such as an enhanced simultaneous multi-round ascending (E-SMRA) auction.

In contrast to the FPCSB, the E-SMRA is a tried and tested auction format. It is also a familiar one in Australia, having been used to award 3.6 GHz spectrum and identified as the ACMA's leading candidate format for future auctions such as the upcoming 26 GHz auction. The E-SMRA gives bidders full control over the spectrum they win, so there is no need for a flexible reservation if this format is used. Nevertheless, if the government decides a flexible reservation is appropriate, this can easily be implemented in the form of a discount in the E-SMRA.

Commitment to the 1 MHz downshift should be a condition of participating in the auction

The full benefits of reconfiguring the 900 MHz band into 2x5 MHz channels will not be realised without implementing the 1 MHz downshift of the existing 850 MHz spectrum licence band. In order to maximise the benefits of reconfiguring the 900 MHz GSM band, we believe the ACMA should make participation in the auction conditional on existing 850 MHz licensees committing to implement the 1 MHz downshift by 30 June 2024.

01 Telstra supports the ACMA's proposal to recommend the Minister make a reallocation declaration

We welcome the opportunity to respond to the Australian Communication and Media Authority's (the ACMA) draft recommendation to the Minister for Communications, Cyber Safety and the Arts (the Minister) to make one or more declarations re-allocating spectrum by spectrum licensing. Spectrum in these bands is a highly valuable resource for the delivery of mobile broadband (MBB) services. Like other spectrum in the other sub-1 GHz bands (low bands), it has excellent propagation characteristics for coverage and in-building penetration. It is vital that the spectrum in this band is allocated in a way that maximises the benefits to the community. Allocating the two bands as spectrum licences in a single auction provides mobile network operators with the best opportunity of acquiring larger contiguous blocks of spectrum.

1.1. Telstra generally agrees with the proposed reallocation recommendation

The terms of the ACMA's proposed draft recommendation and Telstra's views are set out table 1.

Table 1: Proposed terms for the ACMA's draft reallocation recommendation and Telstra's response

Relevant term	The ACMA's proposed recommendation	Telstra's view
Licence type	Spectrum licences	Fully supports.
Parts of the spectrum	809–825 MHz 854–870 MHz 890–915 MHz 935–960 MHz covering all of Australia excluding the mid-west Radio Quiet Zone (RQZ).	Fully supports.
Reallocation period	For the frequency ranges 809–825 MHz and 854–870 MHz, the period ending 30 June 2024. For the frequency ranges 890–915 MHz and 935–960 MHz, the period ending 31 December 2023.	Support with amendment. We believe there would be benefits in aligning the end of the reallocation period for both the 850 MHz and 900 MHz bands to 30 June 2024.
Reallocation deadline	31 December 2022 (12 months before the end of the reallocation period that ends first in time)	Support with amendment. In line with our view about the reallocation period, we believe the reallocation deadline, we believe the reallocation deadline for both bands should be 30 June 2023.

We believe there would be benefits in aligning the end of the reallocation period for both bands to 30 June 2024. The spectrum licences for both bands should commence in 1 July 2024. There are several reasons for aligning the commencement of the licences:

- It is unreasonable to expect successful bidders to pay for spectrum licences which could be significantly encumbered, and therefore have limited utility, for several years after the spectrum licences commence.
- The delay would align commencement (and therefore expiry) of the spectrum licences in the 900 MHz band with those in the 850 MHz expansion band, simplifying any future alignment with the existing 850 MHz band licences.

- An 'early access' apparatus licensing regime (like that adopted after the 700 MHz, 1800 MHz and 3.6 GHz auctions) is the best way to balance early use of a future spectrum right secured at auction against the rights of incumbents during the interim period.

1.2. Telstra supports the proposed frequency and geographic lot configuration

We support the ACMA's 'preferred view' on frequency and geographic lot configuration. That is, we support the 2x5 MHz lots in both the 900 MHz and 850 MHz expansion bands.

1.3. The licence term should be maximum possible period

We support the ACMA's preferred view to issue spectrum licences for the maximum possible term, which is currently 15 years. However, if the maximum licence term is extended to 20 years by successful passage of the Radiocommunications Legislation Amendment (Reform and Modernisation) Bill 2020, we consider these spectrum licences should be issued for 20 years.

1.4. Any allocation to Public Safety Mobile Broadband must be made at the bottom of the 850 MHz expansion band

We believe any allocation for PSMB should be located at the bottom end of the 850 MHz expansion band, with the 2x10 MHz to be allocated by price-based allocation being at the upper end of the band. This allows the additional commercial spectrum to be adjacent to the existing 850 MHz licences so that the possibility of contiguous Band 26 spectrum is created.

In 3GPP, Band 26 is defined as the frequency range 814-849 / 859-894 MHz, whereas the current 850 MHz allocation (Band 5) is 824-849 / 869-894 MHz. Hence Band 26 adds 10 MHz paired to the low end of Band 5, but also fully covers all of Band 5. This is a critical point, because it means that a single Band 26 capable radio can cover any frequency in Band 26 or Band 5.

The ACMA's proposal to reallocate the 850 MHz expansion band, is to reallocate 809−824 / 854−869 MHz. This extends 5 MHz below Band 26 in the 3GPP standard. Equipment capable of operating in the lower 5 MHz part of this proposed allocation is 3GPP Band 27. But 3GPP Band 27 only runs from 807-824/852−869 MHz – so does not cover any of the Band 5 frequencies.

If PSMB were allocated to the top 5 MHz of this proposed reallocation, any MNO securing spectrum in the lower 10 MHz who also holds Band 5 spectrum would not be able to use that spectrum without deploying a separate Band 27 radio, and also would be unable to combine this with any Band 5 channels via carrier aggregation.[1] It would be 'orphaned' spectrum.

02 The proposed auction methodology is not likely to result in an efficient outcome

We have strong reservations about the ACMA's recommendation to use a first-price combinatorial sealed bid (FPCSB) to award 850 and 900 MHz. We believe it is a poor choice of format that puts in jeopardy the ACMA's objectives for this award. We provide a detailed critique of the FPCSB in **Attachment A**.

2.1. The FPCSB format has a poor and limited track record

The FPCSB format is not a 'tried-and-tested' auction format and has rarely been used to sell mobile spectrum. We believe the lack of adoption of the FPCSB can be directly attributed to recognition of the

[1] Carrier aggregation between Bands 26 or 27 and Band 5 is not part of the 3GPP specifications.

strategic complexity faced by participants and the risk that this leads to unpredictable and potentially grossly inefficient auction outcomes. While the track record is limited, what experience there is supports these concerns.

The FPCSB format was first used for an award of FWA spectrum in Nigeria in 2002, but that award was marred by wide variation in prices paid and high levels of default. We have only identified one instance in which it has been used for a major spectrum auction in an OECD country[2] – Norway in 2013 – an event that led directly to the shock exit of the country's third operator. In addition to these auctions, the Dutch government received advice to implement a FPCSB auction for its 5G award, but this advice was subsequently rejected in favour of a SMRA clock hybrid format, a format similar to the E-SMRA.

Nigeria (2002)

A FPCSB was first used to sell spectrum in Nigeria in 2002, with the award of regional FWA licences. The format was selected owing to its simplicity, transparency and ability to address aggregation risk across adjacent regions, all of which were important in the local context. Although the award was broadly successful in allocating the spectrum, the designers highlighted two less attractive aspects of the outcome – some identical licences sold for very different prices and there was a high incidence of default, primarily by bidders who had submitted relatively high winning bids.[3]

Norway (2013)

In 2013, Norway ran a multi-band 4G spectrum award featuring the 800, 900 and 1800 MHz bands using the FPCSB format. The outcome was, to put it mildly, not a success. As illustrated in Table 2, the auction resulted in the exit of one of the country's three MNOs, modest revenues but a wide range of prices, and unsold spectrum in a leading mobile band. The biggest shock was that the smaller of the three incumbents, Tele2, failed to win any spectrum, and was eclipsed by a new entrant, Ice. Seven months after the auction, Tele2 announced that it was selling its Norwegian operation to TeliaSonera, citing its lack of spectrum as the main reason. As of 2020, Ice's market share still lags that of Tele2 at its point of exit, meaning the market has become more concentrated.

Table 2: Results of the Norwegian multi-band spectrum auction in 2013

	800 MHz	900 MHz	1800 MHz	Price paid (NOK)
Telenor (#1 MNO)	2×10 MHz	2×5 MHz	2×10 MHz	453 million
TeliaSonera (#2 MNO)	2×10 MHz	2×5 MHz	2×10 MHz	627 million
Tele2 (#3 MNO)	-	-	-	-
Ice (new entrant)	2×10 MHz	2×5 MHz	2×20 MHz	705 million
Unsold			2×15 MHz	

In the Information Memorandum for the award the Norwegian telecoms regulator (Nkom) stated that its two main objectives for the auction were:

- an efficient allocation of spectrum which should "promote sustainable infrastructure-based competition"; and
- to maximise auction revenues.

[2] The two beauty contests conducted in France for 800 MHz and 2. 6 GHz in 2011 had some of the features of a FPCSB, but we do not think them comparable, as the selection mechanism included points for hosting MVNOs and coverage commitments.

[3] Richard Marsden, Christian Koboldt and Dan Maldoom, DotEcon Discussion Paper, *The First Combinatorial Spectrum Auction: lessons from the Nigerian auction of fixed wireless licences*, available at www.dotecon.com.

It is clear that neither objective was achieved. Almost certainly, an efficient outcome would have involved all the spectrum being sold, and most likely Tele2 securing enough spectrum to stay in business, whether or not Ice secured entry. It would be hard to argue that the result promoted "sustainable infrastructure-based competition" given the exit of Tele2 and consolidation of its infrastructure with that of a larger rival.

When re-auctioning the unsold 1800 MHz spectrum Nkom decided against using the FPCSB format again and instead opted for a simple clock auction. Nkom also used a multi-round format for more recent 5G awards.

The Norwegian auction has subsequently been cited by Goeree and Bichler (2017) as an example of what can go wrong when a FPCSB is used to sell spectrum:

> *"In contrast, in sealed-bid auctions, value uncertainty can lead to surprising, and possibly problematic, outcomes. For example, in a first-price sealed-bid combinatorial auction conducted in Norway in 2013, one of the incumbents bid too low and did not win any spectrum. This incumbent, was later forced to leave the market, and many argued this would not have happened if an iterative auction had been used."*[4]

Netherlands 5G (on-going)

The Dutch authorities are currently in the process of conducting an auction of spectrum in the 700 MHz, 1400 MHz and 2100 MHz bands. Bidders were required to submit their applications in April, and bidding commenced in late June.

During the early stages of planning for the auction, the Ministry of Economic Affairs commissioned a report to advise on an appropriate format for the auction. This was conducted by the Center for Research in Experimental Economics and Political Decision Making (CREED) of the University of Amsterdam in conjunction with Professor Jacob Goeree of UNSW.[5] CREED/Goeree recommended a first price combinatorial sealed bid format (FPCSB) for the auction. A key rationale for this was that the FPCSB was the only format that provided realistic opportunities for small players to win.

CREED/Goeree's proposal met with strong opposition. Bidders felt that is was a relatively untried format that placed unacceptable risks on bidders. Subsequently, the Ministry of Economic Affairs decided to engage another auction advisor – DotEcon – to provide further advice regarding which auction format should be chosen for the award. This advice was provided in a report published in July 2019,[6] in which DotEcon recommended an SMRA clock hybrid format (which is similar to the E-SMRA).

In a final step, the Ministry engaged a third set of auction advisors – Peter Cramton and Pacharasut Sujarittanonta – to review DotEcon's work.[7] Cramton and Sujarittanonta agreed with DotEcon's overall recommendations. The only material point of disagreement was regarding DotEcon's specific choice of the SMRA clock hybrid format, where they favoured a clock auction that avoids standing high bids (again similar to the E-SMRA).

2.2. The ACMA has over-estimated the benefits and under-estimated the complexity of the FPCSB

The ACMA's preference for the FPCSB format appears to be driven by concerns about aggregation risk and strategic demand reduction. We believe this view is based on flawed analysis in four respects:

- **The ACMA overestimates** the importance of:

[4] Outlook chapter by Bichler and Goeree, in 'Handbook of Spectrum Auction Design', J. Goeree and M. Bichler (Eds), Cambridge University Press, 2017.

[5] "Auction Design 700/1400/2100 MHz Licenses", Center for Research in Experimental Economics and Political Decision Making (CREED) of the University of Amsterdam in conjunction with Professor Jacob Goeree of UNSW, October 2018.

[6] "Recommended auction model for the award of 700, 1400 and 2100 MHz spectrum", July 2019, DotEcon.

[7] "Review of DotEcon's Recommendations", 15 July 2019, Peter Cramton and Pacharasut Sujarittanonta.

- **Aggregation risk.** The ACMA appears to be concerned that bidders may have strong synergies for two or three 2x5 MHz blocks. This leads it to propose a package bid format, owing to concerns that a non-combinatorial format would unduly expose bidders to aggregation risk. Although we agree that package bidding is effective in addressing aggregation risk, we disagree that this is a necessary step. The experience of bidders participating in non-combinatorial auctions in similar situations in Europe (detailed in Table A1 of **Attachment A**) is evidence that bidders can manage this risk adequately without package bidding.

- **Strategic demand reduction incentives in uniform price auctions.** The ACMA appears to be concerned that there is a risk in open ascending auctions with uniform pricing (such as the E-SMRA or clock auction) that bidders do not compete fiercely for marginal blocks that they are unlikely to win in an attempt to keep prices low. While theoretically this is a risk, it only leads to an inefficient allocation if bidders' expectations are wrong. There are many examples of operators competing fiercely for marginal spectrum in uniform price auctions, including in the recent 3.6 GHz auction in Australia. The reserve price outcome for some regions in that auction was not the result of strategic demand reduction but instead the allocation limits being set too low, preventing competition between the three mobile operators. In regions where the allocation limits allowed competition between mobile operators, competition was fierce and competition for marginal lots was strong, resulting in some of the highest prices for similar spectrum in the world. This would not be expected if bidders engaged in strategic demand reduction.

- **The ACMA underestimates** the impact of:

  - **Strategic complexity owing to use of a first price instead of a second price rule.** For most auction formats, including sealed bids using variations of a second price rule, or standard open formats such as the E-SMRA, clock or CCA, the auction literature provides guidance on how to develop an optimal bid strategy. Bidders begin with straightforward (value-based) bidding as it is considered "roughly optimal", but have latitude to vary specific bids depending on what happens in the auction. There is no such "roughly optimal" strategy in a FPCSB, and this lack of guidance may lead to bidders adopting very different approaches to determining their bid amounts relative to valuations. This introduces a significant risk that spectrum is not awarded to the bidders with highest value. If a bidder misjudges competition in the FPCSB and bids $1 (or whatever the minimum bid quantity is) too little for a particular package, the result could be 'fatal', resulting in auction exit.

  - **Common-value uncertainty.** The FPCSB does not allow bidders to revise their valuations based on what they observe in the auction. If a bidder's valuations are too conservative, the result could again be 'fatal' with no opportunity to reconsider valuation. An open format would allow operators to observe demand from others, which would give them more confidence in their own valuations and, if necessary, revise their assumptions.

We address each of these points in more detail in **Attachment A**.

2.3. E-SMRA would better meet ACMA's objectives

The E-SMRA is based on the SMRA format which is the most commonly used format for awarding spectrum, having been used on dozens of occasions over the past decade (including in Australia, Belgium, Canada, Czech Republic, Finland, Germany, Greece, Hong Kong, Iceland, India, Italy, Latvia, Lithuania, Poland, Portugal, Singapore, South Korea, Spain, Sweden, Thailand, Taiwan, the UK and the USA). The E-SMRA, which also borrows from the popular clock auction format, has several variants. It has recently been used in Australia, UK and USA, and will be used in forthcoming auctions in Austria, Canada, Luxembourg, Slovakia, the Netherlands, UK and USA.

In contrast to the FPCSB, the E-SMRA may therefore be considered a tried and tested auction format. It is also a familiar one in Australia, having been used to award 3.6 GHz spectrum and identified as the ACMA's leading candidate format for future auctions such as the upcoming 26 GHz auction.

Table 3 summarises our assessment of the three auction formats considered by the ACMA for this award: the FPCSB, the sealed bid with a second price rule, and the E-SMRA. We conclude that the FPCSB is clearly the weakest candidate, whereas the E-SMRA is the leading candidate. Accordingly, we urge the ACMA to change to the E-SMRA for this award.

Table 3: Summary comparison of candidate formats

Objective	FPCSB	Sealed bid with second price	E-SMRA
(1) **Efficiency**			
Addresses common value uncertainty	*No*	*No*	*Yes*
Strategic complexity	*Extremely complex*	*Simple*	*Reasonably simple*
Aggregation risk	*No*	*No*	*Yes, but manageable*
Incentives for strategic demand reduction	*No*	*No*	*Yes, but academic experiments and experience in Australia suggest this rarely affects efficiency*
(2) **Managing strategic complexity**	 Extremely complex for bid strategy	 Complex, as no feedback. Sign-off on a large number of bids required	 Straightforward
(3) **Competition**	 May encourage participation by entrants but not an objective	 Less attractive to entrants but better for strong ones	 Less attractive to entrants but better for strong ones
(4) **Business continuity**	 Only with reservation	 Only with reservation	 With or without reservation
(5) **Fairness**	 Risk of severe overpayment and asymmetric prices	 Asymmetric pricing possible	 No risk of overpayment, symmetric prices
Can be implemented with a flexible reservation	Yes	Yes	Yes

We believe that because the E-SMRA gives bidders full control over the spectrum they win, there is no need for a flexible reservation if this format is used. Nevertheless, if the government decides a flexible reservation is necessary, this can easily be implemented in the form of a discount in the E-SMRA.

In the case of the 850/900 MHz auction, it appears that the ACMA wants to allow for the possibility of a reservation (in some shape or form) of one or more blocks for existing users, but that the location of these blocks (either in the 850 MHz or 900 MHz band) would be determined in the auction. This goal can be achieved in an E-SMRA in the form of a discount. Incumbent bidders would be guaranteed to receive a discount on the cheapest block(s) irrespective of the bands where they win spectrum. The discount could be up to 100% of the auction price. In essence, this approach is similar to that adopted for the recent awards of 39 GHz in the United States, where incumbent spectrum was included in the award, but incumbents could win the same amount back at zero cost regardless of the final price (in that auction, incumbents also had the option to let other parties buy the spectrum and be rebated the selling price, but this feature is not needed here).

Table 4 provides a strawman design for an E-SMRA which we believe could deliver all of the ACMA's objectives for this award.

Table 4: E-SMRA strawman design

Application	Deed	▪ Any applicant for this auction, if they also hold an 850 MHz spectrum licence, must sign a Deed that they agree to downshift their holdings by 1 MHz by 30 June 2024. Any existing 850 MHz licensee which does not wish to make this commitment would be ineligible to bid in this auction.
Main stage	Lot structure	Three categories: ▪ 850 MHz A: 1 frequency-specific nationwide block of 2x5 MHz at the bottom of the 850 MHz band[8] ▪ 850 MHz: 2 frequency-generic nationwide blocks of 2x5 MHz each ▪ 900 MHz A: 1 frequency-specific nationwide block of 2x5 MHz at the bottom of the 900 MHz band ▪ 900 MHz: 4 frequency-generic nationwide blocks of 2x5 MHz
	Activity rules for clock rounds	▪ Same as for 3.6 GHz auction, but with an activity requirement of 100% from round 1 ▪ Each 2x5 MHz block is associated with 1 eligibility point
	Flexible reservation (optional)	▪ If an incumbent acquires at least 1 frequency-generic block in any band, a discount is applied to the cheapest frequency-generic block ▪ If an incumbent only acquires the 900 MHz A block, the discount is applied to that block instead
Assignment stage	General	▪ Separate bidding rounds for each band ▪ Assignment stage rounds follow same rules as for 3.6 GHz auction (sealed bid, second price format, guarantee of contiguity for all winners)
	850 MHz	▪ The winner of the A block is assigned a contiguous block at the bottom of the 850 MHz band including any frequency-generic 850 MHz blocks it may win in the main stage ▪ Assignment stage bidding (if needed) to determine frequency assignments for the remaining winners of frequency-generic blocks in the 850 MHz band
	900 MHz	▪ The winner of the A block is assigned a contiguous block at the bottom of the 900 MHz band including any frequency-generic 900 MHz blocks it may win in the main stage ▪ Assignment stage bidding (if needed) to determine frequency assignments for the remaining winners of frequency-generic blocks in the 900 MHz band

[8] The bottom 2x5 MHz in the 850 MHz band is not part of Band 26. It may therefore be advisable to include it as a frequency-specific block in the auction.

03 Commitment to the 1 MHz downshift should be a condition of participating in the auction

We have long supported a 1 MHz downwards shift of the existing 850 MHz band to maximise the utility of the lower frequencies in the 900 MHz GSM band.[9] The ACMA has previously stated this downshift should occur when the 850 MHz licences expire in 2028 and, if possible, would consider ways to bring the shift forward so the benefits can be realised sooner.[10]

The 1 MHz downshift is required to fully realise full benefits of reconfiguring the 900 MHz band into 2x5 MHz channels and minimising the risk that the lowest block is viewed as 'poisoned', so we support efforts being made to achieve the downshift earlier than 2028. While the proposed allocation of the 2x1 MHz segment is a necessary condition for achieving the downshift prior to 2028, it is not enough: a commercial arrangement with both licensees in the 850 MHz band would also be required.

Attaching the 2x1 MHz segment to the lowest block in the 900 MHz band provides the party who will be the beneficiary of the reduced interference with the means and motivation to seek a commercial agreement with the existing 850 MHz licensees. However, there is no guarantee a commercial agreement will be reached. Since any early downshift would still be subject to a (potentially tripartite) commercial agreement being reached with the existing spectrum licensees in this band, we believe the appropriate allocation of the 2x1 MHz segment needs to satisfy two criteria:

- It needs to provide appropriate incentives for a commercially negotiated outcome.
- It should not stand in the way of an ACMA initiated downshift at the expiry of existing licences in the 850 MHz band if a commercially negotiated downshift does not occur earlier than 2028.

However, we think the ACMA could do more to achieve implementation of the downshift earlier.

The ACMA should impose a condition on participation in the proposed auction of auction requiring existing 850 MHz spectrum licensees to agree to shift their 850 MHz spectrum licence down by 1 MHz. This condition should stipulate the downshift must be completed before commencement of the 900 MHz spectrum licences, regardless of whether that applicant is successful in acquiring 900 MHz spectrum or not. If an 850 MHz spectrum licensee at the time of application does not wish to accept this condition, they would not be able to be a bidder in the auction, just as they would not if they did not agree with any other auction terms or conditions.

Such an approach is not uncommon in other jurisdictions. Examples of auctions in which incumbents were required to move their existing holdings if they decide to participate:

- Canada (forthcoming). ISED has announced a replan of at least 200 MHz of spectrum in the 3.5 GHz band, consisting of a mix of previously unallocated frequencies and spectrum held by incumbent FWA operators. ISED has announced a plan to convert all existing holdings into generic spectrum rights, subject to a cap of 60 MHz per operator. These generic holdings will be included in the assignment round of the auction, alongside any new spectrum allocated in the auction. The plan ensures that each operator will be guaranteed contiguous allocations suitable for deployment of 5G mobile. [11]
- Mexico (2016) – Going into Mexico's award of additional AWS-1 and AWS-3 spectrum, existing AWS-1 holdings were fragmented between the three MNOs, raising concerns about the ability of operators

[9] Telstra, *The 803-960 MHz band – exploring options for change*, 22 February 2013.
[10] Australian Communications and Media Authority, *Reconfiguring the 890–915/935–960 MHz band: Way forward*, p. 23-24.
[11] ISED, June 2019, Section 6, Decision on Revisions to the 3500 MHz Band to Accommodate Flexible Use and Preliminary Decisions on Changes to the 3800 MHz Band, https://www.ic.gc.ca/eic/site/smt-gst.nsf/eng/sf11437.html.

to deploy 4G services with existing and new spectrum. To address this, the regulator required that all participants commit to including their existing holdings into the assignment round, with a guarantee that both existing and winning bidders would receive contiguous nationwide holdings in the AWS-1 band. After the rules were announced, one of the three MNOs (Movistar) sold its AWS-1 holdings to a rival (AT&T), and the remaining two MNOs (Telcel and AT&T) both accepted the terms. This approach led to the replanning and defragmentation of the band, with AT&T and Telcel each positioned to deploy LTE.[12]

- UK (2018). For the UK award of 2.3 GHz and 3.5 GHz, the incumbent operator H3G was given the option to convert a 20 MHz existing holding, which sat in the middle of the 150 MHz of available spectrum, into a frequency generic 20 MHz block and a guarantee of contiguity with any new spectrum it acquired. This would have removed the risk for all bidders of being assigned fragmented spectrum. However, for tactical reasons, H3G declined the option. Ofcom's decision not to make participation in the auction conditional on accepting the option was likely a key factor in its failure to address the fragmentation issue.[13]

- USA (2020)– Ahead of the auction for 39 GHz, existing holders were asked to choose between the following three options:

  - have their licences modified based on the FCC's proposed reconfiguration of its licence holdings;

  - have their licences modified based on an acceptable alternative reconfiguration that the existing holder proposes

  - commit to relinquish their licences in exchange for incentive payment (determined in the auction) and the ability to bid for new licences.

  Existing holders who wanted to bid in the auction therefore had to relinquish their holdings before the auction. All existing holders took this option as it meant that they could effectively exchange their old licences for reconfigured licences in the auction at no additional cost. The incentive payment covered the cost of the new licence.[14]

[12] IFT, March 2015, Section 2.2.1 ,Bases de Licitación Pública Para Concesionar el Uso, Aprovechamiento y Explotación commercial de 80 MHz de Espectro Radioeléctrico Disponibles en la Banda de Frecuencias 17-10-1780 MHz/2110-2180 MHz (Licitación No. IFT-3), http://www.ift.org.mx/industria/espectro-radioelectrico/espectro/2015/licitacion-ift-3-banda-aws. Telegeography, 23 December 2015, AT&T, Movistar agree spectrum swap; AT&T, Telcel register for AWS spectrum auction, https://www.commsupdate.com/articles/2015/12/23/att-movistar-agree-spectrum-swap-att-telcel-register-for-aws-spectrum-auction/.

[13] Ofcom, 24 January 2018, Paragraph 28-30, Statement on the making of the regulations for the award of the 2.3 GHz and 3.4 GHz spectrum, https://www.ofcom.org.uk/__data/assets/pdf_file/0033/109788/statement-auction-regulations.pdf.

[14] FCC, 14 May 2019, Appendix A: Updated Reconfiguration Technical guide, https://www.fcc.gov/file/15915/download.

ATTACHMENT A: Identifying the right auction format

A1. Introduction

We have strong reservations about the ACMA's proposal to use a first-price combinatorial sealed bid (FPCSB) to award 850 and 900 MHz bands. Use of this format would put the ACMA's objectives for this award in jeopardy. There are alternative formats that pose less risk for bidders and for society more generally.

Our position is set out in five further sections:

- Section A2 outlines our understanding of the ACMA's objectives for this award and how they should be prioritised.
- Section A3 explains why a FPCSB is a poor fit with the ACMA's objectives, in particular its primary goal of promoting efficient use of spectrum and concludes that if a sealed-bid auction format is used, it should be a second-price auction, rather than a first-price auction.
- Section A4 argues that auction theory generally favours the SMRA over the sealed-bid format.

A2. Auction objectives guide design choices

In this section, we identify five objectives – promoting efficiency, avoiding undue complexity, safeguarding competition, continuity of service, and fairness – that we believe describe ACMA's statutory objectives for this award. We use these criteria in subsequent sections to explain why the FPCSB is a poor choice of format for this award and why the E-SMRA is a better choice.

The ACMA's primary objective when auctioning spectrum is to achieve **(1) an efficient allocation**, as described in the AMCA's principles for spectrum management:

- principle 1—allocate spectrum to the highest value use or uses
- principle 2—enable and encourage spectrum to move to its highest value use or uses
- principle 3—use the least cost and least restrictive approach to achieving policy objectives
- principle 4—to the extent possible, promote both certainty and flexibility
- principle 5—balance the cost of interference and the benefits of greater spectrum utilisation.

A related objective (which is closely linked to principles 3 and 4) is **(2) to reduce complexity**. The auction design should be as simple as possible subject to meeting other objectives. In this respect, strategic simplicity for bidders is key and not the simplicity of the rules per se. If an auction is unduly strategically complex for bidders, it may prevent them from adequately managing risks or submitting bids that fairly represent their valuations, which could lead to an inefficient outcome.

In addition to the primary objectives related to allocative efficiency, the ACMA must also support the communications policy objectives of the Australian Government. For the 850/900 MHz auction, the Government has set the following objectives:

- supporting the deployment of 5G technologies;
- promoting competitive market outcomes for the long-term benefit of consumers;
- encouraging investment in infrastructure, including in regional Australia;
- supporting continuity of services; and

- supporting a national PSMB capability.[15]

From these, we can derive two additional objectives relevant to the choice of auction format. The first is **(3) to promote competitive market outcomes** for the long-term benefit of consumers. The spectrum available in this auction is unlikely to be sufficient to support new entry. However, as noted in the recent VHA/TPG merger case, *"it is not necessarily the number of competitors that are in the relevant market, but the quality of competition that must be assessed"*.[16]

The other is to **(4) to support continuity of services**. Although Telstra does not believe it is necessary to reserve spectrum for incumbents in the 850/900 MHz bands, it is essential that incumbents be afforded a fair opportunity to win back equivalent amounts of spectrum in bands where they are already deployed, provided they have the highest value. For reasons we will explain, a FPCSB does not provide such a fair opportunity.

Our final objective is **(5) fairness**. Only a fair allocation process that does not put at risk existing investment in network infrastructure can encourage efficient investment in the future. To achieve this objective, the ACMA needs to avoid formats that pose unfair risk to bidders of either not winning spectrum for which they have the highest value or significantly overpaying.

A3. Why a FPCSB is a poor fit with the ACMA's objectives for this award

In the following, we assess the ability of a FPCSB design to deliver each of the five objectives that we identified in Section A2 as being relevant to the choice of auction design. We find that the use of a FPCSB creates a real likelihood that ACMA could fail to meet the objectives of (1) efficiency, (2) avoiding unnecessary complexity, and (5) fairness. Further, it offers no substantive advantages in relation to the other two objectives of (3) promoting competition, and (4) business continuity that could justify the risks of not fulling the other objectives.

Efficiency

This objective is typically supported by adopting auction rules that minimise risk and strategic complexity for bidders. In our view the FPCSB is not the format that best supports these objectives because:

- Aggregation risk is manageable.
- Strategic demand reduction should not be a priority concern.
- Using a first price instead of a second price rule exposes bidders to strategic complexity.
- Use of an open auction format reduces the risk of common value uncertainty.

Aggregation risk is manageable

The ACMA has **overestimated the importance of aggregation risk** in the context of this award. We agree that bidders may face some aggregation risk, primarily related to securing minimum packages of 2x10 MHz, but we think that they can manage this risk in an open format.

The deployment costs and transmission overheads of deploying a spectrum band are largely fixed regardless of the size of the carrier. Consequently, there are economies of scale associated with deploying larger carriers (up to the maximum carrier size, which is 2x20 MHz for LTE, but larger for 5G NR). At the same time, the incremental benefits of adding spectrum typically fall with larger carriers, as

[15] Department of Infrastructure, Transport, Regional Development and Communications, *Communications policy objectives for the allocation of the 850 and 900 MHz bands*.

[16] - Middleton J in Vodafone Hutchison Australia Pty Limited v Australian Competition and Consumer Commission [2020] FCA 117, at para 11.

the extra capacity is likely to be less utilised. The result is that, depending of the spectrum band and the specific circumstances, a bidder's valuations for incremental lots may increase before then falling. Indeed, this may lead to situations where small quantities of spectrum are economically unviable, leading to a bidder having a requirement for a minimum quantity of spectrum.

The point at which valuations for incremental lots of spectrum start to fall, and indeed the size of minimum spectrum requirements, is likely to vary by bidder and spectrum band. Notably, bidders with larger market shares are likely to have larger spectrum requirements. Also, minimum requirements are likely to be smaller in lower frequency bands than higher frequency bands, as lower frequencies are primarily used to provide coverage and so are less relied upon to provide capacity. Therefore, it is plausible that a bidder may, for example, require a minimum of say 2x20 MHz in a high-frequency band but only 2x10 MHz (or even 2x5 MHz) in a low-frequency band.

In the context of the 850/900MHz band, we recognise that some bidders may have a minimum requirement for 2x10 MHz, as they may judge that the fixed costs and transmission overheads of deploying only 2x5 MHz at 850/900MHz are too great relative to the benefits. That said, this clearly is not true for all, as there are many examples of mobile operators opting to acquire 2x5 MHz of spectrum in low-frequency bands in recent years, as illustrated in Table A1. These examples are all package-bid auction formats, so we know that bidders actively elected to win 2x5 MHz in the absence of aggregation risk. Indeed, VHA acquired just 2x5 MHz of 700MHz spectrum in Australia in the 2017 auction.

Table A1: Sub 1-GHz auctions in Europe with no aggregation risk where an MNO won 2x5 MHz

Country	Award Year	Award format	Band and spectrum available	Bidder who won 2x5 MHz
Austria	2013	Combinatorial (CCA)	900 MHz (2x35 MHz)	Hutchison Drei
Denmark	2019	Combinatorial (CMRA)	700 MHz (2x30 MHz)	Telenor/Telia (bid as one entity)
Ireland	2012	Combinatorial (CCA)	900 MHz (2x35 MHz)	Three Ireland^
Romania	2012	Clock Auction+	900 MHz (2x35 MHz)	Cosmote
Switzerland	2012	Combinatorial (CCA)	900 MHz (2x35 MHz)	Orange (SWI)
Switzerland	2020	Clock Auction+	700 MHz (2x30 MHz)	Sunrise
United Kingdom	2012	Combinatorial (CCA)	800 MHz (2x30 MHz)	Three UK and Everything Everywhere

Notes: + The auction formats in Switzerland and Romania were unique in that there was no demand retention if demand fell below supply. For example, if excess demand was 1 lot of 2x5 MHz, then a bidder could drop demand in 2 lots for a total of 2x10 MHz. In this example, the bidder would not be a winning bidder for 2x5 MHz. ^ The 2012 auction was prior to the merger between Telefonica Ireland and Three Ireland.

We find no evidence from past auctions of bidders having ascending value synergies for a third or fourth lot. Evidence from both European and Australian 700MHz auctions suggest that even when offered the option of acquiring 2x15 or 2x20 MHz, many mobile operators have been happy to settle for 2x10MHz.

We note the following examples:

- Australia – Having already secured 2x10 MHz of 700 MHz, TPG chose not to bid for an incremental 2x5 MHz, despite the reserve price being less than half the price per MHz that it spent on the first 2x10 MHz.

- Germany – a cap of 2x15MHz applied, but all three operators acquired 2x10 MHz.

- Sweden – a cap of 2x20 MHz applied, but Telia and Net4Mobility acquired 2x10 MHz each.

Having said that, we do not preclude the possibility that a bidder in this or some other future low-band spectrum auction might have ascending value synergies for a third or fourth 5 MHz lot.

In any case, even if there are bidders with a minimum requirement for 2x10 MHz, we believe that this exposure risk is manageable within a non-combinatorial format. This view is supported by both theory and practical observation:

- There is also a growing academic literature based on lab experiments that highlights how effectively bidders are able to manage aggregation (exposure) risk in non-combinatorial formats. Lab experiments have shown that bidders in SMRAs typically manage aggregation risk well.[17]

- In Europe, bidders in non-combinatorial auctions for spectrum in the 900 MHz band have generally won at least 2x10 MHz (e. g. Greece in 2011, Germany in 2015 and Norway in 2017). This implies that aggregation risk should also be manageable in other instances with the same or similar number of bidders and bandwidth, as is the case with this award.

We also note that if a flexible reservation is implemented in a non-combinatorial format, there is no aggregation risk for existing users in moving from 2x5 to 2x10, as they would be effectively guaranteed a first block at the reserve price.

Strategic demand reduction should not be a priority concern

We understand that, in certain circumstances, uniform price auctions may theoretically provide bidders with incentives for demand reduction. Strategic demand reduction, however, only has an impact on allocation efficiency if bidders deviate from their expected outcome and/or have inaccurate expectations. If this is not the case, strategic demand reduction only affects the prices paid. Revenue generation is explicitly not an objective for the ACMA, so even if bidders dropped their demand for spectrum that they believe is unattainable earlier in the auction rather than later, this should not be of relevance to the ACMA's decision on the auction format.

The extent of demand reduction as well as its potential impact on efficiency has been overstated by the ACMA. Evidence from past Australian auctions and from academic lab experiments suggests that strategic demand reduction should not be a priority concern for the ACMA:

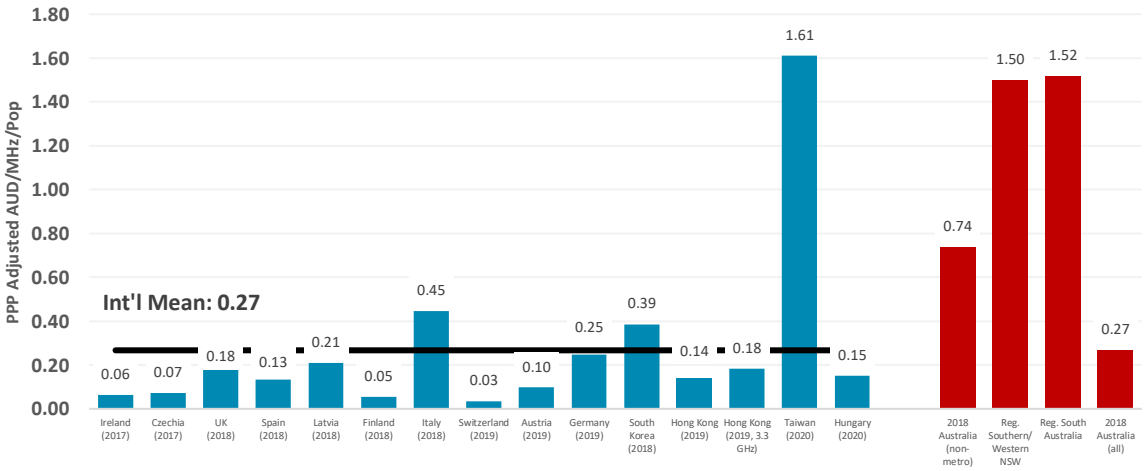
- In Australia, uniform price auctions have been competitive and demand reduction has not been an issue. For example, the 3.6 GHz auction in 2018, which used an E-SMRA format, featured intense competition between Telstra, Optus and the VHA-TPG JV in non-metro areas, where collectively they

[17] Bichler, Shabalin, Wolf, 2012, Do Core-Selecting Combinatorial Clock Auctions always lead to high Efficiency? An Experimental Analysis of Spectrum Auction Designs, http://dss. in. tum. de/files/bichler-research/2012_bichler_shabalin_wolf_cca. pdf ; Bichler, Goeree, Mayer, Shabalin, 2014, Spectrum Auction Design: Simple Auctions For Complex Sales, https://www. aeaweb. org/conference/2014/retrieve. php?pdfid=7

were less constrained by spectrum caps. We note that the prices paid on a $/MHz/pop basis in Regional NSW and Regional South Australia were the highest in the world at the time (and have only been surpassed on a PP basis by the exceptionally competitive Taiwan auction), as illustrated in Figure A1. Prices in metro areas were lower as competition was impeded by very tight spectrum caps, a factor that is unrelated to the choice of auction format.

- This experience from the field is supported by recent academic research into the importance of strategic demand reduction on the efficiency in the SMRA. Bichler, Shabalin and Wolf (2012)[18] ran extensive lab experiments to compare the efficiency in the SMRA against the Combinatorial Clock Auction (CCA). They find that the SMRA achieves very high efficiency (95%+) in all settings, including multiband auctions with large synergies. They did not find any signs of tacit collusion and "none of the auctions resulted in agreements at low revenue"[19].

Figure A1: International 3.6 GHz benchmarks



Source: From regulator documents.

Notes: Inclusive of the net present value of annual fees, adjusted for inflation using ABS data and a standard licence duration (11 years). Converted to AUD using IMF PPP rates. A standard 8% discount rate is used.

If there are concerns over demand reduction due to perceived revenue risks, these may be substantially addressed by setting higher reserve prices[20] and/or restricting transparency in the auction. The latter has precedence in the 3.6 GHz auction in Australia where bidders were only provided with information about excess demand as long as it exceeded four lots.

Using a first price instead of a second price rule exposes bidders to strategic complexity

In its consultation, the ACMA argues that the FPCSB is simpler than a second-price rule and therefore superior:

> *"First price provides for a simple pricing rule, but creates incentives for bidders to shade their bids, where a bidder places a bid that is below their true valuation. Alternatively, second pricing runs into the same issues identified above in the discussion on the CCA (creating incentives for strategic bidding and disadvantage weaker bidders). A first price rule is likely to be optimal where simplicity is an objective, or where complexity is a serious issue, making second pricing unsuitable"*

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18 Bichler, Shabalin Wolf, 2013, Do Core-Selecting Combinatorial Clock Auctions always lead to high Efficiency? An Experimental Analysis of Spectrum Auction Designs, available online: http://dss. in. tum. de/files/bichler-research/2012_bichler_shabalin_wolf_cca. pdf

19 Ibid. p. 25.

20 Setting higher reserve prices reduces the incentives to engage in strategic demand reduction. See Bresky, 2013, Revenue and efficiency in multi-unit uniform-price auctions, https://www. sciencedirect. com/science/article/pii/S0899825613000808#br0040

> *"Using a pay-your-bid pricing (first-price) rule within the SBCA format also provides for a simple and transparent allocation that would enhance the efficiency of allocation, rather than the inherent complexity of second pricing in a combinatorial format."*

Both of these statements confuse the complexity of the mechanics of the pricing rule with strategic complexity for bidders. While the rules for a first price sealed bid are simple, deciding how much to bid is complex.

For example, consider an auction for a single lot: each bidder submits just one bid, the highest bidder wins and pays the amount of its winning bid. The process is simple but bidders face strategic complexity over how much to bid. A bidder that bids its full value will make no profit if they win and may be at risk of paying an amount significantly above the market price (which should be the value of the second strongest bidder). Logically, they should shade their bid, but if they shade too much they could lose to another bid even if that bid is below their value. A bidder must therefore trade off the profit it makes if it wins against the probability of winning. The latter is intrinsically linked to the valuations of other bidders, so each bidder will need to estimate every other bidder's valuations and the extent to which its rivals will shade their bids. If these expectations are wrong and/or if bidders apply different heuristics to determine bid amounts, the highest-value bidder may lose.

The strategic complexity in a first price sealed bid with package bidding (FPCSB) increases with the number of categories and lots. Now bidders will need to form expectations over the entire bid space for their competitors and factor in that their own package bids are in competition with each other, i. e. increasing the bid for one package may increase the bidder's overall chance of winning but may simultaneously reduce the likelihood of winning another package, which may be preferred. The auction literature offers some heuristics that bidders could adopt but no optimal bid strategy. [21] Critically, an equilibrium would only be achieved if all other bidders employ similar heuristics, but this is not particularly likely in a one-off event and there is also no guarantee that such an equilibrium would be efficient.

In his seminal book on auction design, Paul Milgrom had the following to say about the FPCSB:

> *"A disadvantage of the first-price auction compared to the Vickrey auction is that bidders in the first-price package auction need to know a lot for the first-price auction to perform well. To choose their optimal bids, bidders need to set their profit targets accurately and they need to be able to coordinate on one of the multiple equilibria. These observations suggest that the full information equilibrium outcomes are unlikely ever to hold exactly, although it remains possible that they may describe a central tendency for some kinds of environments."*[22]

Our concern is that for this award, bidders may employ very heterogenous approaches to determining bid amounts if an FPCSB is used, which would turn the auction into a lottery – both for bidders as well as the ACMA. Bidders face the risk of either overpaying or not winning what they should have won in an efficient allocation, whereas the ACMA faces the risk of an inefficient allocation. Turning such an important allocation for scarce low-band spectrum into a lottery is untenable.

For this and other reasons, we believe that a multiple round, ascending bid format, namely the E-SMRA, is a much better choice for this award than the FPCSB. However, were the ACMA to persist in using a sealed bid, and we strenuously object to this position, it should at the least switch to a second price rule, as this approach is more likely to deliver an efficient allocation compared to a first price rule.[23] If the

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21 Wilenius, 2009, Bidding in Combinatorial Auctions, http://uu. diva-portal. org/smash/get/diva2:218682/FULLTEXT01. pdf

22 Milgrom, 2003, Putting Auction Theory to Work, p. 258, http://www. econ. ucla. edu/riley/271/Milgrom-Putting%20Auction%20Theory%20to%20Work. pdf

23 The pricing rule in an E-SMRA, though very different in implementation, is strategically equivalent to a second price rule, as the general principle that winning prices are set by marginal losing bids applies.

ACMA insists on a sealed-bid format, then we propose two better options for a sealed bid combinatorial auction - Vickrey-Clarkes-Grove (VCG) pricing or Minimum-revenue core (MRC) pricing.

In a sealed bid with VCG pricing, winners only pay what other bidders were prepared to pay for the packages that they won. While the pricing rule is more complex, bid strategy is straightforward. It is optimal for all bidders to bid their value for each and every package. [24] The VCG pricing rule then works out the maximum amount by which their bid can be reduced to ensure that it is just high enough to still win. In this case, the pricing algorithm does the work for bidders as it determines by how much winning bids can be shaded to still win. The VCG auction is incentive compatible as it is a dominant strategy to bid value and is thus fully efficient.

The main concern with a VCG auction is that it may produce low revenues. [25] This, however, is only an issue when synergies are strong. For example, if two individual bidders win one item each and beat a combinatorial bidder who only wanted both, the second prices determined for the two individual bidders may be less than the combinatorial bid. In this case, the "combinatorial" bidder is referred to as an "envious bidder" because its value is greater than the sum of the prices determined for the other two bidders.

Given the limited nature of synergies in the auction, in particular once the reservation is taken into account, we do not believe this to be a major concern. However, if the ACMA wants to ensure that prices for any coalition of winners are jointly high enough to beat any other offer, it can adopt a core pricing rule. This rule – while no longer incentive compatible – ensures that prices are individually and jointly high enough to beat other offers. The best option would be to adopt a Minimum-revenue core (MRC) pricing rule as implemented in combinatorial clock auctions (CCAs) in Australia and elsewhere. This pricing rule again does the work for bidders in that it determines by how much bids can be shaded down maximally both individually and jointly across winners to ensure that each winner individually as well as each coalition of winners jointly pay just enough to still win. What creates the incentive incompatibility under this pricing rule is that the joint cost of beating other offers needs to be allocated across a coalition. If a bidder in a coalition shades his own bid amount by a small amount, it can potentially reduce the amount of the coalitional cost he has to share. Shading bid amounts 'at the margin' may therefore lead to a lower price.

Day and Raghavan (2007) [26] and Day and Milgrom (2008)[27] have shown that MRC pricing rules minimise the maximal gains from deviations from value-based bidding. Given the limited nature of the synergies, there is a very high chance that an MRC rule reduces to VCG prices. There would then be no incentive to deviate from value-based bidding in practice. [28]

An advantage of an MRC rule compared to a first price rule is therefore that it provides a starting point for bidders to determine their bid amounts. Given its closeness to the VCG pricing rule, bidders can generally start off with value-based bidding and then determine whether marginal deviations would likely

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[24] Vickrey, "Counterspeculation, Auctions, and Competitive Sealed Tenders", The Journal of Finance 16, no. 1 (1961): 8–37; Clarke, (1971). "Multipart Pricing of Public Goods". Public Choice. 11 (1): 17–33; Groves, T. (1973). "Incentives in Teams". Econometrica. 41 (4): 617–631.

[25] Other arguments against the use of a VCG pricing rule are not relevant in the context of spectrum auctions. The first is that it may provide bidders with incentives to bid as multiple entities (shill bidding) to reduce the amount they pay if they win. This is not a concern as the ACMA vets all applicants prior to the auction to ensure they are not related. The second is that it provides losing bidders with an incentive to collude. Collusion is a general issue regardless of auction format. The ACMA has very stringent anti-collusion rules in place which prevent such behaviour. Having said this, the minimum-revenue core pricing rule addresses both of these concerns. See Ausubel, Baranov, 2019, Core-Selecting Auctions with Incomplete Information, http://www. obaranov. com/docs/Ausubel-Baranov-Core-Selecting-Auctions-with-Incomplete-Information. pdf

[26] Day and Raghavan, 2007, Fair Payments for Efficient Allocations in Public Sector Combinatorial Auctions, Management Science 53(9), 1389-1406

[27] Day and Milgrom, 2008, Core-selecting Package Auctions, International Journal of Game Theory, 36(3-4), 393-407

[28] If VCG prices are 'in the core', they are high enough to beat any other offers both individually and jointly. In this case, the Vickrey-nearest minimum core pricing rule will pick VCG prices. If bidders expect this to happen, their best strategy is to bid value. See Goeree, Lien, 2016, On the impossibility of core-selecting auctions, https://onlinelibrary. wiley. com/doi/abs/10. 3982/TE1198

lead to an increase in expected surplus. Such marginal deviations would be based on an expectation of the valuations and bid strategies of other bidders. Given the sealed bid nature, there will be very little information to guide such marginal deviations and we would not expect them to be material (or even relevant) in this context.

The relative advantages and disadvantages of each the VCG and MRC second price rules vs the first price rule are summarised in Table A2.

Table A2: Advantages and disadvantages of sealed bid pricing rules compared

	VCG pricing	MRC pricing	First price (pay your bid)
Complexity for bidders	Very simple Dominant strategy is to bid value	Relatively simple; minor deviations form value-based bidding may be profitable	Extremely complex – no optimal strategy and very little guidance in auction literature on how to determine bid amounts
Efficiency	Fully efficient	Highly efficient	Ambiguous – could be efficient or inefficient depending on heterogeneity of bid-shading heuristics employed by bidders
Revenues	May be lower if valuations dominated by synergies	Potentially higher than under VCG	Ambiguous – could be high or low depending on heterogeneity of bid-shading heuristics employed by bidders

The ACMA's primary objective is to allocate spectrum efficiently. A VCG pricing rule is more likely to deliver an efficient allocation under a sealed-bid format, as value-based bidding is a dominant strategy and deviations would lead to either the same or lower profits for bidders. If the ACMA is concerned about revenues (or "fairness" of pricing in case of losing package bids), its next best choice from an efficiency perspective is the MRC pricing rule. This pricing rule may lead to higher revenues than the VCG rule, and promotes the principle of "happy winners, happy losers", but this comes at the expense of introducing incentives to deviate from value-based bidding at the margin which in turn may lead to small inefficiencies. In contrast, a first price rule cannot be relied on to deliver efficiency or revenues as it effectively turns the 850/900 MHz auction into a lottery.

We again stress that our canvassing of these alternative pricing mechanisms for a sealed bid auction is in no way to be interpreted as endorsement for ACMA's sealed bid proposal. We do not support a sealed bid auction format. The alternatives discussed above are simply less-bad ways of determining price in a sealed bid auction.

Use of an open auction format reduces the risk of common value uncertainty

The ACMA states that:

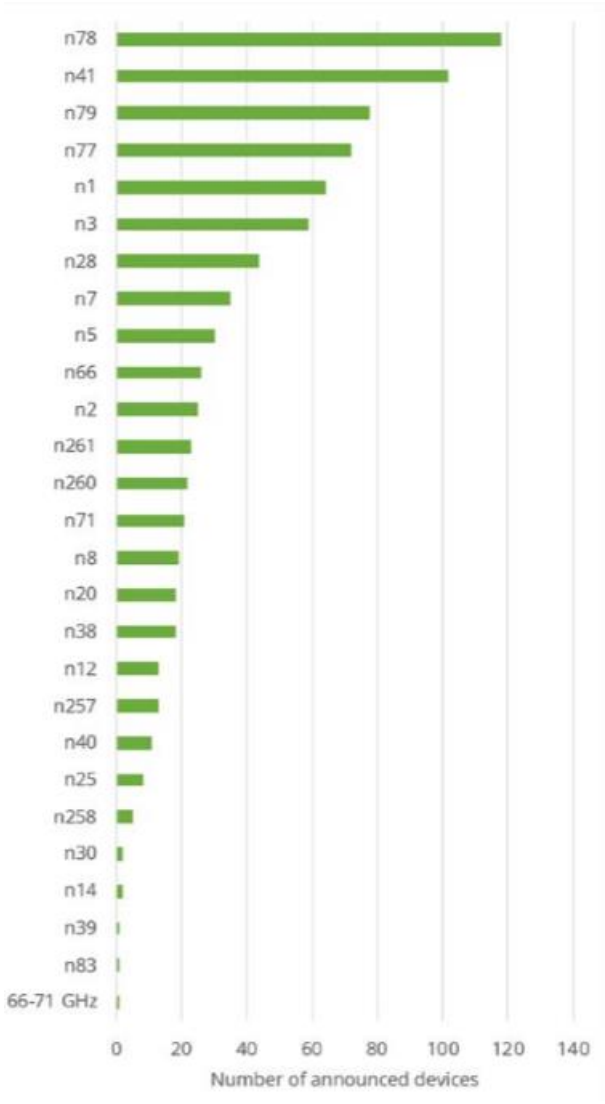
> *"We acknowledge that there is no price discovery in a SBCA. However, we consider that it is possible that price discovery is of reduced importance in the 850/900 MHz band because of the complementarities between lots and the relatively small quantum of spectrum on offer. As it is possible that likely participants in the allocation include current users of the spectrum, or equivalent spectrum, there is less need for price discovery as potential bidders are already aware of the capabilities and therefore likely market value of the spectrum."*

We do not agree that the uncertainty regarding the value of 850/900MHz spectrum is materially different to other spectrum bands, including newly awarded spectrum bands. Although Telstra has used the 900MHz band to provide GSM services in the past, and uses it today to provide 4G services in selected locations, and Optus and TPG Telecom (formerly VHA) continue to use it for their 3G services, this

spectrum is likely to be used to provide 5G services in the future. While it could be argued there is some uncertainty regarding the value of 850/900MHz spectrum for 5G services, the extent to which any such uncertainty exists is common across bidders. In this respect, we do not believe that valuation uncertainty in the 850/900MHz bands are materially different to, for example, the 3.4/3.6GHz band, which are being used to provide 5G services.

Further, as with historic generations of mobile technologies, there is uncertainty regarding the extent that specific bands will be supported by device manufacturers for 5G New Radio (NR). According to the GSA, current support varies by band (see Figure A2). The NR bands being included in the upcoming auction are Band n8 (900MHz) and n26 (850MHz extended band). We note that the bottom 2x5MHz being awarded is not included in any of the harmonised NR bands but is included in LTE Band 27. Band n8 is significantly behind other NR bands, such as Band n78 (3.4-3.8 GHz band); and, according the GSM, no planned devices will support Band n26. This contrasts to the large number of devices supporting Band n5 – the original 850MHz band. While this situation will likely change quite quickly in coming years, it does mean there is uncertainty regarding the level of 5G (NR) device support for all of the available spectrum which is common to all mobile operators.

Figure A1: Announced devices with known spectrum support, by specific band



Source: 5G Device Ecosystem Report, June 2020, GSA

In addition to the uncertainty regarding the use of 850/900MHz spectrum for 5G, recent technological developments mean that the premium in value traditionally associated with low-frequency spectrum is not necessarily as large as it was. The advent of massive MIMO antennas and beam forming techniques will mean that transmissions at higher frequencies will provide better coverage than in the past. While coverage using e.g. 2.3 GHz or 3.4/3.6 GHz will not match that of sub-1GHz spectrum, the improvements in coverage using such higher frequencies may partially erode the value premium historically associated with sub-1GHz spectrum. The extent of this erosion, while common to all operators, is uncertain.

It is a well-established fact that "*when there is a common value component to valuation and when bidders' signals are affiliated, an open ascending bid format may induce participants to bid more aggressively (on average) than in a sealed bid format, since participants can infer greater information about their opponents' signals at the time they place their final bids*. "[29]

This has been shown, for example, by Goeree and Offerman who analysed a model with private and common values – an analogy to the 850/900 MHz auction where bidders' valuations will include common uncertainties as well as private components related to their own network costs. They find that additional high-quality information about the common value increases efficiency.[30]

Most regulators who have allocated the 900 MHz band in Europe in auctions have done so in open ascending formats for exactly this reason. Only Norway has used the FPCSB to allocate spectrum in the 900 MHz band – with highly peculiar results. Adopting a sealed bid format for this award is therefore inconsistent with best practice in other jurisdictions.

Managing complexity

The priority for mobile operators is that, in spectrum auctions, bid strategy complexity is minimised rather than bid implementation complexity. While participation in open multiple-round auction formats can require more time and resources, this is preferable compared to the higher risk of unintended outcomes associated with auction formats that require complex bid strategies (either due to bidders making mistakes in the auction or due to the format creating strategic bidding incentives that risk inefficient outcomes).

It is significantly more challenging for a Board to sign off a single set of bids in a FPCSB than multiple sets of bids in each round of an open auction because:

a) bids (both for the bidder and its competitors) will not be verified through price discovery;

b) bids may be derived from complex game theory analysis to determine the optimal amount of shading; and

c) there is no opportunity to correct any errors in later rounds.

Prior to the auction, bidders typically undertake detailed valuation modelling. A large range of input assumptions and forecasts are required for a spectrum valuation – from traffic forecasts to spectral efficiency assumptions to forecasts of customer migrations to newer technologies. There are uncertainties in all these assumptions, and consequently there are uncertainties in the results of any spectrum valuation. As discussed above, we do not believe the uncertainties in the value of 850/900MHz spectrum are any less than other spectrum bands.

[29] Ausubel, 2004, "An Efficient Ascending Bid Auction for Multiple Objects", American Economic Review, 94(5), pp. 1452–1475.

[30] Cramton, 1998, Ascending Auctions, European Economic Review 42:3-5,pp 745-756, http://www. cramton. umd. edu/papers1995-1999/98eer-ascending-auctions. pdf; Goeree, Offerman, 2000, Efficiency in Auctions with Private and Common Values: An Experimental study, ftp://ftp. repec. org/opt/ReDIF/RePEc/vir/virpap/papers/virpap347. pdf

In a FPCSB, bidders then have to shade the bid amount for each package that they may plausibly win. To do this, they will need to apply a set of heuristics which are based on assumptions about competitor valuations. The error bounds in competitor valuation modelling is significantly higher than for a bidder's own valuations.

The process to value the spectrum and develop a bid strategy is extensive and time-consuming. It results in a set of bids which need to be explained to the company's Board of Directors to gain approval. In a FPCSB, the risks are incredibly high for a board. Given the large sums of money associated with spectrum auctions and given that all incumbents in Australia are either publicly listed or owned by publicly listed companies, it is important that auction formats permit boards to make well-informed decisions and to put governance procedures in place that minimise the risk of either gross overpayment or not winning the efficient amount of spectrum, both of which could have substantial financial and operational implications.

In contrast, multi-round formats typically allow bidders to start bidding below their valuations and gradually increase bid amounts over the rounds. This allows for price discovery – i. e. bidders gaining information about the value of the spectrum from the bids that competitors place. This can provide confidence that a bidder's valuations are valid, reduces the uncertainty in the valuations, and provides a gated bid governance mechanism that can be appropriately managed. In short – the information gained through price discovery reduces the potential for 'bidder remorse' – i. e. for a bidder to win spectrum, only to later learn that it overvalued the spectrum; or indeed for a bidder to fail to win spectrum, only to later realise that it should have bid more.

In multi-round auction formats, there is the possibility of setting interim thresholds for budget – where due to price discovery and based on the progression of the auction, additional budget can be released or budgets can be shifted between lots, regions or bands. This is not possible in the FPCSB format – meaning that senior management must choose a final budget and bid amounts at the start of the auction, without the benefit of price discovery – i. e. confidence in valuations and better expectation regarding the quantity of the spectrum they are likely to win and the price they are likely to pay.

Ensuring business continuity

One of the policy objectives for this award is to ensure business continuity. We understand this to mean that existing holders can win sufficient spectrum to continue providing existing services in the short to medium term. The ACMA has indicated a reservation may be required to support incumbents but we do not agree this is necessary. We think that the best way to ensure business continuity is (a) to adopt an open format, so bidders can manage their exposure to winning different amounts of spectrum over multiple rounds; and (b) allocating frequency generic lots so that bidders buying multiple lots in the same band will be guaranteed contiguous spectrum suitable for 5G use.

The 850/900 MHz auction should be seen in the context of a possible wider reorganisation of sub-1 GHz spectrum. A reservation or direct allocation might ensure continuity of any existing services in these bands today, but at the same time, it could also cement the existing fragmentation across bands well into the future which would reduce the quality of 5G networks for consumers.

Ensuring business continuity therefore does not necessarily require handing out long-term licences at reserve price to existing users. It can also be achieved by choosing a format in which bidders have full control over what they win and where they can always bid back if they are outbid (such as the E-SMRA). The only reason for an existing user not to win spectrum is if it is no longer justified given its business cases – which factors in the cost of migrating legacy customers to newer technologies. In other words, a bidder would exit the auction if the business case for acquiring the spectrum reached the point where it was worse than the business case to exit the spectrum, in which case, it is an economically rational decision by the bidder. Consequently, we do not believe that a reservation is necessary if an E-SMRA is adopted.

In contrast, in a FPCSB, MNOs must shade their bids which exposes them to the risk of losing important spectrum without an option to bid back. In this 'one-shot' situation, there is a stronger rationale for a reservation, in order to mitigate the risk of a grossly inefficient outcomes. To our mind, the fact that the ACMA believes a reservation is necessary implies a lack of confidence in the FPCSB and its ability to produce an outcome in which the value of business continuity is appropriately factored in.

The ACMA has suggested that an advantage of the FPCSB for this particular award is that it can support a flexible reservation. Obviously, we disagree, as we are not convinced a reservation is required. Regardless, it appears that the ACMA believes that such a flexible reservation can only be implemented in a combinatorial format. If necessary, a flexible reservation can in fact be incorporated into a non-combinatorial auction format such as the E-SMRA.

Fairness

A further problem with the FPCSB is that the outcomes it may produce may be widely regarded as unfair. Most obviously, the prices that bidders pay for identical spectrum may vary considerably, which may create perceptions that some parties did much better than others. More generally, outcomes may not conform to the notion of "happy winners, happy losers" in that there may be losing parties who would have been willing to pay more than the prices paid by winners, and there may be winning bidders who believe they have paid prices significantly above the fair market level. There is a non-trivial risk that this leads to a loss of trust in ACMA's approach to allocating spectrum.

Rightly or wrongly, the investment community judges auction results on a relative basis and considers bidders that gained good relative price outcomes as 'winners'. It can be very difficult for a bidder to explain why it paid more than a competitor, even if the premium paid was based on a sound decision process. This issue is particularly stark for publicly listed companies, as it will influence their share price.

Further, given that bidders will compete with each other in the downstream market, asymmetric price outcomes may distort competition. As pointed out by the GSMA in its report regarding spectrum pricing, *"Although upfront fees paid for spectrum are sunk, they continue to weigh on the business decisions made by operators and their owners throughout the licence term"*.[31] Therefore, an asymmetric price outcome may mean that bidders' future behaviour is different despite possibly winning identical spectrum packages.

Given that relative price differences matter, bidders are therefore incentivised to achieve a positive relative price outcome in an auction. In the context of an FPCSB, it very difficult to ensure the objective of not overpaying relative to other operators is met; this accentuates the strategy complexity of bidding in this type of auction. Because operators do not want to overpay relative to competitors, they may be incentivised to bid shade more than they otherwise would. This increases the risk of an inefficient outcome.

A.4 Mainstream auction theory generally favours the SMRA over the FPCSB format

We are of the view that mainstream auction theory favours the use of the SMRA over the FPCSB auction format. While we have identified an academic paper that analyses the purported benefits of the FPSCB auction format[32] and is presented as being based on the sale of 900 MHz spectrum in Australia, we consider it deviates from the proposed award in some very fundamental respects and so its conclusions cannot be relied upon when deciding on the format for the upcoming auction:

a) The paper makes no attempt to consider the impact of common value uncertainty. As we have discussed above, given the change in use of the 850 and 900 MHz bands, there is some common value uncertainty which can best be addressed in an open, ascending format such as the E-SMRA.

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31 GSMA, 'Effective Spectrum Pricing: Supporting better quality and more affordable mobile services', February 2017.

32 Bedard, Goeree, Louis and Zhang, 2019, The favoured but flawed Simultaneous Multiple-Round Auction, available online: https://f5e78aae-6b7c-46d7-8fe1-07c9473920a2.filesusr.com/ugd/a4ac94_56f1e94625c74402a4c15ac941a39306.pdf

b) The valuation setup with extremely high synergies for either two blocks or three blocks favours a combinatorial auction, but the authors make no attempt to compare the performance of the first-price rule against other pricing rules (VCG or MRC) or to open, ascending combinatorial formats such as the CCA which would be more suitable if valuations were indeed so extreme.

c) The assumed valuation setup puts too much weight on either a two-block or three-block synergy and assigns almost no weight to other packages. This setup is detached from reality as bidders will have substantial valuations for all packages, including single blocks. Here, however, bidders only come in two types: a 2-block bidder who effectively only values two contiguous blocks and a 3-block bidder who effectively only values 3 contiguous blocks. The marginal valuations for any other blocks are so small that they are immaterial.[33] This setting is extremely unrealistic.

d) The simplified valuation setup in which bidders effectively either only have a valuation for two blocks or three blocks greatly simplifies bidding in the FPCSB. Bidders effectively only need to consider how much to bid for a single package. If they are a 2-block bidder, they only really need to consider their 2-block bid. If they are a 3-block bidder, they only really need to consider their 3-block bid. This simplification is not representative of the real bid decision problem facing a bidder in the 850 /900 MHz auction. Depending on the lot structure, bidders here will have to determine bid amounts for a much larger number of packages across the two bands.

e) The authors' introduction of fragmentation risk into the SMRA setup does not align with the practical reality of the proposed auction in this case. While bidders in the FPSB effectively bid on a frequency-generic basis, they are forced to bid for frequency-specific blocks in the SMRA. This means they can end up with a fragmented assignment which would have little/no value to them. This is a well-understood concern with an SMRA with frequency-specific blocks and exactly the reason why the ACMA adopted two-stage setups for both the E-SMRA as well as prior CCAs in which bidders compete first for frequency-generic blocks and then winning bidders compete for contiguous frequency positions. The paper looks at the efficiency of such a two-stage format which, unsurprisingly, performs much better and even beats the FPCSB in some settings.

f) The authors' introduction of an exposure problem in the 2-stage SMRA does not align with the practical reality of the proposed auction in this case. In the 2-stage SMRA, bidders first bid for frequency-generic blocks and in a second step for the location of the blocks they won in the band. The lowest block in the 900 MHz band has lower value and so in the first stage bidders are exposed to winning this block in stage 2. First of all, the valuation impact of being assigned this block is very large. It more than halves the value of the most valuable marginal.[34] We do not think that the value difference is, if at all, anywhere near that large. However, if it was, it would pose an additional exposure risk if the frequency allocation was decided in the second stage. To remove this risk, the A block should have its own category in stage 1. There would therefore be one category for block A (with supply of 1) and one category for the other blocks (with supply of 4).

We note that this paper does not find strategic demand reduction to be an issue in the SMRA – in fact it is not even mentioned once. This is in line with experience from spectrum auctions in Australia as well as other lab experiments by Bichler et al (2012) who also find that demand reduction is not a concern.

The findings of this paper are in contrast with experimental research published in the Journal of Experimental Economics, one of the key journals in this area which shows very high efficiency results for the SMRA even in setups with very strong synergies. Bichler, Shabalin and Wolf (2012) find that the SMRA achieves very high efficiency and revenues in both single and multiband settings. The

[33] Ibid. , p. 12. The 2-block bidder has a valuation of 10 for the first block at 10 and of between 75 and 105. A 3-block bidder has a valuation of 10 for the first block, of between 25 and 35 for the second block and between 100 and 140 for the third block.

[34] Ibid. , p. 12. For example, for a two-block bidder, the marginal for the second block decreases from between 75 and 105 to between 37. 5 and 52. 5.

SMRA outperforms the CCA, a combinatorial format, which addresses aggregation risk.[35] The main difference between the two papers is that Bichler, Shabalin and Wolf (2012) do not introduce fragmentation risk as they run an SMRA with frequency-generic lots (similar to ACMA's two-stage E-SMRA as used for 3.6 GHz).

This is not the only experimental study which finds that the SMRA performs well against combinatorial formats. Bichler, Goeree, Mayer and Shabalin (2014)[36] find that in experiments for a range of different synergy models, the SMRA even outperforms the FPCSB and leads to higher efficiency, as illustrated in Table A3.

Table A3: Comparison of the efficiency in the SMRA and the FPCSB

Auction	Efficiency	Unsold licences
SMRA	98. 51%	0
FPCSB with simple bidding language (SB_{SS})	94. 33%	0
FPCSB with complex bidding language (SBcs)	88. 56%	0. 82 (3.4%)

Source: Bichler, Goeree, Mayer and Shabalin (2014), p. 6.

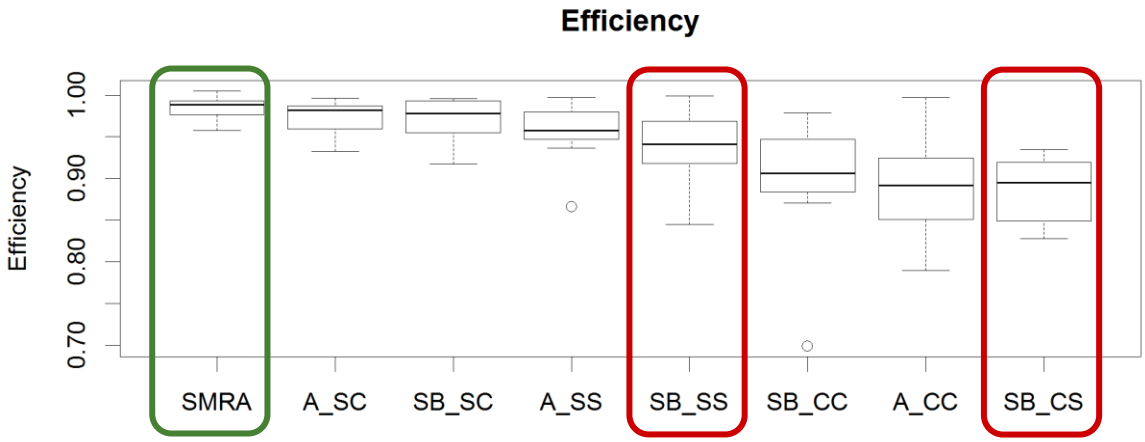
The results in Bichler, Goeree, Mayer and Shabalin (2014) also provide evidence that the FPCSB leads to a much wider range of possible outcomes and thus makes an extremely inefficient outcome in any one particular auction far more likely. Figure A2 shows the range of outcomes in the experiments. The SMRA achieves the highest efficiency and the range of outcomes is fairly small – between 95% and 100% efficiency. On the other hand, the FPCSB (SB_SS and SB_CS) achieved much lower average efficiency and the range of outcomes was also much wider ranging from below 85% to less than 99% efficiency. Bichler, Goeree, Mayer and Shabalin conclude that the *"SMRA comes out ahead despite the substantial complementarities within bands. Bidders did a good job in dealing with the resulting exposure risk, with high-value bidders taking more exposure risk and low-value bidders less. "*[37]

Figure A2: Comparison of the efficiency in the SMRA and the FPCSB

[35] Bichler, Shabalin, Wolf, 2012, Do Core-Selecting Combinatorial Clock Auctions always lead to high Efficiency? An Experimental Analysis of Spectrum Auction Designs, http://dss. in. tum. de/files/bichler-research/2012_bichler_shabalin_wolf_cca. pdf

[36] Bichler, Goeree, Mayer, Shabalin, 2014, Spectrum Auction Design: Simple Auctions For Complex Sales, https://www. aeaweb. org/conference/2014/retrieve. php?pdfid=7

[37] Ibid., p. 7.



Source: Figure 3 in Bichler, Goeree, Mayer, Shabalin (2014). Highlights added by Telstra.