# **Revisiting Inherent Noise Floors for Interconnect Prediction**

Tuck-Boon Chan<sup>1</sup>, Andrew. B. Kahng<sup>2</sup> and Mingyu Woo<sup>2</sup>

<sup>1</sup>Qualcomm, San Diego, CA, USA <sup>2</sup>UC San Diego, La Jolla, CA, USA

# ABSTRACT

Today's synthesis, placement and routing (SP&R) tools routinely handle millions of instances. Accurate prediction of outcomes is needed to avoid long wasted runtimes from, e.g., unroutable floorplans or placements. However, tool outputs have inherent noise that implies a lower bound on prediction error [10] [7]. The goal of interconnect prediction naturally raises a question of "How accurate can interconnect prediction be?" In this work, we revisit the topic of inherent noise and "chaos" in IC implementation flows, to characterize current noise floors on interconnect prediction. We study effects on commercial P&R tool outcomes of such previouslyidentified noise sources as reordering and renaming in instance cells, nets, and master cells. We also perform studies for macro placement, by slightly shifting the location of macro placement blockages in the center of the layout floorplan. We find that recent commercial tool versions still show significant routed wirelength noise of up to 7% when netlist reordering is applied, and 11.5% when macro placement blockages are shifted. Finally, we also raise the question of "How should predictions be used?" by showing example scenarios where advance knowledge of physical design outcomes can potentially worsen noise and predictability.

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#### 1 INTRODUCTION

With the slowdown of classical scaling, it is more important than ever for industry design organizations to achieve improved design quality with reduced design schedule. Toward this goal, a key lever is prediction: what will be the power, performance and area quality of the design outcome, if the implementation flow is allowed to continue? An accurate predictor can enable more design space exploration earlier in the design process - e.g., at SOC architecture, floorplan or RTL design - since designers can prune solution paths that are hopeless, and free up design resources to pursue more promising paths. In this way, prediction leads to both quality and schedule benefits.

The goal of interconnect prediction naturally raises a question of "How accurate can interconnect prediction be?" [8] and [9] point

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out that modern tools that internally chain many heuristic combinatorial optimizations exhibit the chaotic behaviors reported in [7], especially when pushed to achieve the best possible solution quality. Earlier work of [10] observed inherent noise in P&R tools: different solutions with a large range of solution quality are produced for isomorphic inputs that vary only in the names of cell instances, nets, and cell masters.

Furthermore, the goal of interconnect prediction (and prediction of layout and physical design attributes such as area, timing or power in general) raises a second question of "How should predictions be used?" Useful, or actionable, predictions in IC design tend to be of a constructive nature. For example, a prediction of "total routed wirelength will be 3km" or "3.3GHz is the maximum achievable clock period within a 1W power budget" is not useful without an associated implementation tool recipe (e.g., a Tcl runscript) that will make the prediction come true. In another scenario, acting upon a prediction in the obvious way may actually be harmful to the final design quality. Below, we show that this is a very real risk of prediction.

In this paper, we make the following contributions. (1) We experimentally study the noise floor on interconnect prediction accuracy, using recent releases of leading commercial P&R tools and a commercial sub-20nm foundry technology with commercial cell library and IPs. (2) We reproduce earlier studies of noise [10] and "chaos" [7]. We find that new noise sources (e.g., reordering signal nets in the input Verilog netlist) affect solution quality today. Furthermore, previously identified noise sources (e.g., renaming cell masters, nets and/or instances in the netlist) still affect the solution. (3) We also observe a new form of chaotic behavior in the tool, where the input perturbation is a slight movement of a placement blockage in the middle of the layout region, and the solution shows high instability with respect to this blockage's exact location (see Figure 3). (4) We show examples where naive use of information from prediction can harm solution quality, and propose this as a key consideration for future research on prediction of IC design implementation.

The remainder of this paper is organized as follows. Section 2 reviews several related works, including the key works [10] and [7] whose experiments we revisit in this work. Section 3 describes experiments that revisit the tool noise studies of [10]. Section 4 describes experiments that revisit the "chaos" studies of [7]. Section 5 adds studies of the border between chaotic and stable behaviors in macro placements, as a function of relatively small placement blockages placed near the middle of the layout region. Section 6 shows examples of risk in the use of prediction information, i.e., how a partial prediction can harm solution quality. We conclude the paper in Section 7.

#### **RELATED WORKS** 2

Heuristics for difficult optimizations in VLSI CAD often return locally optimum solutions. The distribution of solution qualities seen in local minima for graph bisection and traveling salesperson problems, as well as 'globally-convex' structure of the set of local

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minima, has been studied by, e.g., [1]. For a given problem, the solution quality distribution seen over local minima will change according to the strength of the heuristic [4]. Predictions of solution quality, i.e., the learning of models for optimization outcomes, must therefore deal with the existence of noise [11].

The work of [10] studied noise sources in the context of Cadence QPlace and WRoute tools. The phenomenon of tool noise due to naming and ordering of cells/nets in a netlist was previously noted in works of Hartoog [5], Harlow and Brglez [6], and Bodapati and Najm [2]. [10] gives a taxonomy of tool behavior criteria (monotonicity, smoothness, scaling) as well as a taxonomy of perturbations (randomness, ordering and naming, library richness, constraints, and geometric properties) that do not affect the correctness (i.e., well-formed nature) of solutions. Experiments are performed to assess tool monotonicity, effect of random seeds, netlist ordering, random renaming of cells and nets, and random cell renaming while preserving hierarchy. Further studies of noise *additivity* and the potential for exploiting noise through best-of-*k* multi-start approaches, are also given.

Jeong et al. [7] also studied noise sources across synthesis, placement and routing (SP&R), and across tools from multiple EDA vendors. This work also addressed "chaos", the non-smoothness of output metrics with respect to small input changes such as picosecondscale changes to timing constraints (clock period, clock uncertainty and IO delay). Experiments in [7] showed that a 1ps change in timing constraints could cause up to 16.4% variation in the area of the post-synthesis gate netlist. A method was proposed to find the input parameters to which solution quality is most sensitive, and to empirically determine the optimal number of runs k needed to obtain a robust "best-of-k" solution in practice.

Motivated by noise and chaos in SP&R tools, Kahng et al. [9] study multi-armed bandit (MAB) formulation and propose an adaptive sampling strategy under license, schedule, area and frequency constraints. Adaptive sampling in the MAB context embodies the exploration versus exploitation tradeoff inherent in search and optimization – in this case, automatic (no-human-in-the-loop) optimization of the design process to obtain a high-quality final design solution.

### **3 REVISITING TOOL NOISE**

In this section, we revisit the taxonomy of P&R noise sources from [10]. In [10], the term noise source connotes a perturbation of the input that is not expected to change the underlying optimization instance, and hence should not change the tool solution. We perform experiments using recent releases of two leading commercial P&R tools, that are selected from among three major tools (Cadence Innovus, Synopsys IC Compiler II, and Mentor Olympus-SoC), but report anonymized results to comply with EULA restrictions. (We use the names "P&R\_1" and "P&R\_2" consistently to refer to these tools, but do not disclose the mapping of names to tools.) Experiments are performed with a commercial 14nm foundry technology, with multiple-VT 9-track standard cells and generated memories from a leading third-party IP provider. All timing metrics (worst negative slack (WNS), total negative slack (TNS)) are reported for worst-case analysis in the same (unnamed) corner for this enablement. Table 1 lists testcases used in our study.<sup>1</sup>

Tabl	le 1	: '	Testcases	used	in	our	ex	perim	ents	5

Design	ClkPer	IO Delay	WNS	TNS	Num	Num
Design	(ns)	(ns)	(ns)	(ns)	Macros	Insts
AES	0.300	0.000	-0.235	-56.502	0	14837
JPEG	0.400	0.000	-0.038	-8.939	0	60127
SweRV_wrapper	0.500	0.000	-0.204	-252.882	28	109692
BlackParrot	0.800	0.760	-0.128	-21.676	49	314393



Figure 1: Noise from reordering, renaming, and hierarchical instance swap. Routed wirelength distributions from *AES* (P&R\_1 tool) over 100 runs, where 0% corresponds to mean wirelength over all runs. Results are for (a) instance reordering in P&R\_1 and (b) inst reordering in P&R\_2; (c) net reordering in P&R\_1 and (d) net reordering in P&R\_2; (e) inst renaming in P&R\_2, (f) net renaming in P&R\_2, and (g) hierarchical swapping in P&R\_2. A 7% spread in routed WL is seen from instance reordering and 2.5% spread in routed WL is show any difference from inst renaming, net renaming, or hierarchical swapping.

<sup>&</sup>lt;sup>1</sup>Sources. (1) AES from [12], (2) JPEG from [13], (3) SweRV\_wrapper from [14], and (4) BlackParrot from [15].

### 3.1 Monotonicity and Random Seeds

Sections 3.1 and 5.1 of [10] define and execute a monotonicity test, and demonstrate how a user-determined tool effort level affects solution quality. In recent P&R tools, such fine-grained control over effort level is now unavailable. Similarly, Sections 4.1 and 5.2 of [10] define and execute a test for sensitivity to user-defined random seeds. However, in recent P&R tools, seeding is not available.

### 3.2 Ordering and Naming

Sections 4.2 and 5.3, 5.4 and 5.5 of [10] define and execute several tests involving ordering, naming, and hierarchy perturbation in the input design data.

3.2.1 Renaming instances, nets and master cells. [10] reported that Cadence P&R tools showed routed wirelength variation of up to 7% when renaming is applied. We follow the experimental procedure described in [10]. We rename the instance names as "INST\_XXX", net names as "NET\_XXX" and master cell names as "MASTER\_XXX", where XXX is a random number between 1 and #INSTs, #NETs, and #MASTERs, respectively. When cell instances or nets are renamed, we change the gate-level Verilog that is input to P&R accordingly. When master cells are renamed, we change Verilog, cell LEFs, and cell Liberty models accordingly.

We find that one vendor's P&R tool P&R\_1 is unaffected by instance, net and master renaming. However, the other vendor tool, P&R\_2, gives different results when names are changed in the netlist. This noise effect is shown in Figures 1(e) and (f). Up to 2.5% variation in routed wirelength is seen across 100 runs with the *AES* testcase. The authors of [10] also study perturbation of the design hierarchy (Sections 4.2, 5.5 of their paper), that swaps two instance names in the same hierarchical-level modules. We find that P&R\_1 is unaffected by such perturbation, as one would expect from being unaffected by renaming. P&R\_2 results do change with hierarchy perturbation, as presented in Figure 1(g). The magnitude of total wirelength variation reported in [10] for this type of noise source was 12%, which is larger than what we observe for the modern tool.

3.2.2 Reordering instances and nets. To assess the impact of instance and net ordering, we shuffle wire statements for given nets and reorder instance declaration lines inside the input gate-level Verilog. Shuffling of master cell declarations is subsumed by the shuffling of cell instance declarations, since the input gate-level Verilog has an instance declaration on each line. We do not separately study reordering of master cell declarations.

We generate 100 different gate-level Verilogs by shuffling the instance declaration orders using NumPy with different seeds. Similarly, we generate 100 different gate-level Verilogs by shuffling net declarations. We run the P&R tools on each instance- or net-shuffled Verilog. For the P&R\_1 tool, the routed wirelength distributions with shuffling for the AES (aes\_cipher\_top) design are shown in Figure 1. The tool shows up to 7% noise. For P&R\_2, the observed wirelength variation is 2.5%. The magnitude of total wirelength variation reported in [10] for this type of noise source was 7%, which is similar to what we observe for the modern tools.<sup>2</sup>

#### 3.3 Another Noise Source: Floorplan Symmetry

We also consider a noise source that is absent from previous studies, namely, whether an optimization such as macro placement



Figure 2: Test of symmetry noise in macro placement, using the SweRV\_wrapper design. The center light blue square is a fixed macro placement blockage. Fixed macros are shown in darker blue and movable macros are shown in orange. (a) Some macros in lower-left, upper-left, upper-right regions are fixed, while remaining macros are movable in P&R\_1 tool. (b) Same as (a), but mirrored about the Y-axis. (c) Some macros in lower-right, upper-left, upper-right regions are fixed, while remaining macros are movable in P&R\_2 tool. (d) Same as (c), but mirrored about the Y-axis.

Table 2: Routed wirelength distribution on SWeRV\_wrapper design when all macros are fixed in advance.

Flipped Info	Routed Wirelength (µm)				
i nppcu nno	P&R_1	P&R_2			
Original	1720095	1752283			
LR Flipped	1728234	1775584			
UD Flipped	1731809	1731447			
LRUD Flipped	1730830	1794888			

or standard-cell place-and-route is affected by *symmetries*. For example, in modern technologies, it is possible to mirror the entire layout about the Y-axis, obtaining an equally manufacturable layout with identical timing and wirelength metrics. We have examined whether the macro placement step in modern tools shows noise in outcomes due to such symmetry.

We study the behavior of the P&R\_1 and P&R\_2 tools on the SweRV\_wrapper design, when all of the macros are fixed in advance. Table 2 shows routed wirelength after all of the macros are fixed in advance as in original, left-right flipped, up-down flipped, and left-right-up-down flipped. P&R\_1 and P&R\_2 show 0.6% and 3.6% variations in routed wirelength, respectively.

<sup>&</sup>lt;sup>2</sup>We have separately examined the effect of reordering macro definitions inside each LEF file (using a python parser and "shuffle"), and changing the order in which multiple LEF files are read into the P&R tool. For P&R\_1, no change in tool outcome is observed.

We further study the behavior of  $P\&R_1$  using the same design, where three macros at corners of a placed floorplan are selected randomly and fixed (dark blue instances in Figure 2). We then mirror the fixed layout about the Y-axis and determine whether the tool solution will also be mirrored. Figure 2 shows that very different solutions result from the two mirrored pre-placements.<sup>3</sup>

Furthermore, the routed wirelength of (a) is 9.7% greater than that of (b), while the routed wirelength of (c) is 0.1% greater than that of (d). This type of noise (in the P&R\_1 tool) suggests simple heuristics, as noted in [10] [7]: e.g., run place-and-route twice (mirrored and non-mirrored), and return the better solution. Mirroring of site maps (N, FS row orientations) and pre-placements about the X-axis to induce noise in outcomes may also be possible.

#### 4 REVISITING TOOL "CHAOS"

In this section, we revisit the concept of tool "chaos" [7], where very small changes to inputs (clock period, I/O delay, and clock uncertainty) are observed to cause large changes to outputs.

In replicating studies of [7], we use the designs and clock settings as in Table 1. For synthesis tools, Table 3 shows post-synthesis WNS and area outcomes of the Syn\_1 and Syn\_2 tools. Here, the two tools are selected from among three major tools (Synopsys Design Compiler, Cadence Genus, and Mentor Oasys-RTL). To further anonymize, we consistently refer to one of these tools as "Syn\_1" and the other as "Syn\_2". Both Syn\_1 and Syn\_2 show small post-synthesis WNS effects from small perturbations, particularly clock period and clock uncertainty. The Syn\_2 tool shows neardeterministic results with respect to I/O delay perturbation in most cases.

Our studies of chaotic effects in P&R show that small changes in timing constraints, as well as perturbations of aspect ratio and utilization, can cause changes in post-routed results. Table 4 shows the post-routed outcomes for WNS and TNS (self-reported) of the P&R\_1 and P&R\_2 tools. One discovery is that P&R\_1 has very deterministic results when run multiple times with exactly the same settings, i.e., zero perturbations of clock period perturbation by +0 ps, clock uncertainty by +0 ps, I/O delay by +0 ps, aspect ratio by +0.00, and utilization by +0 % show deterministic results on most of the designs. In contrast, P&R\_2 generates quite noisy results when run multiple times with the same settings. Further, we find that the P&R\_2 tool exhibits extremely large "chaos" in its outcomes.<sup>4</sup> Arguably, chaotic effects in place-and-route are *larger* than what was seen a decade ago. This suggests a greater challenge for interconnect prediction today than in the past.

## 5 CHAOTIC TOOL BEHAVIOR IN MACRO PLACEMENT

We further study a type of chaotic behavior involving designs with large numbers of macros (e.g., SRAMs and register files). This type of design is increasingly relevant in modern IC products. Today's commercial place-and-route tools offer automated macro placement capability, typically for use in early design planning steps. Macro placements strongly affect final layout metrics, including



Figure 3: Visualized solutions when a relatively small macro placement blockage (light blue square) is shifted slightly in the *SweRV\_wrapper* implementation. The orange rectangles are movable macros. Four example P&R\_1 macro placements are shown. The macro placement blockage is  $64um \times$ 64um. From its original position, the blockage is (a) located at center (baseline), (b) 6um to the left, (c) 6um to the right, and (d) 12um to the right. These correspond respectively to Rows 4, 10, 12, 13 of Table 5.

timing, wirelength, routability (number of post-route DRC violations), and power. The commercial macro placement follows the conventional strategy of pushing macros to corners and sides of the layout, leaving a relatively unobstructed region for standardcell place-and-route. Such a strategy can be seen in such academic works as Chen et al. [3], whose MP-tree algorithm leaves empty space at the center of the layout to maintain routability. In practice, a physical designer normally defines the macro placement blockage at the center of the layout during auto-macro placement, in order to preserve the region for place-and-route.

In our study, we first run auto-macro placement repeatedly and confirm that the outcomes are identical in each run. This indicates that the auto-macro placer produces a deterministic output for a fixed input. However, we observe chaotic behavior when the small macro placement blockage in the center region of the block is shifted slightly. Figure 3 shows example outcomes for SweRV\_wrapper and the P&R 1 tool, in which macro placements are drastically different when a small fixed macro placement blockage (light blue square) is shifted slightly. Details of 13 macro placement outcomes (post P&R) with slight changes in the location of a fixed  $64um \times 64um$ macro placement blockage (i.e., original location, and shifts of {left, up, right, down} by {6, 12, 18} um) are given in Table 5. Results in Table 5 show that the different implementations with slight changes in the macro placement blockage location have up to -3%/+11.5% difference in wirelength compared to the baseline implementation. This is again a challenge for interconnect prediction.

<sup>&</sup>lt;sup>3</sup>Note that in (a) and (c), the dark-blue fixed macros are in either N, FN, S, FS orientation; in (b) and (d), they are flipped individually (i.e., N <-> FN, S <-> FS). All orange (unfixed) macros are allowed to be placed freely by the tool, with any orientation among (N, FN, S, FS).

<sup>&</sup>lt;sup>4</sup>The worst TNS of -101.280ns for JPEG is not a typo. Indeed, most of the JPEG runs of P&R\_2 return very reasonable results. A possible explanation of the outlier is that today's tools are known to "give up" mid-run if timing or routability looks incurable. This may have happened with the outlier run.

		AES				JPEG			
Parameter	Noise $(\Delta)$	Sy	rn_1	Sy	m_2	Sy	n_1	Sy	m_2
		WNS (ns)	Area $(\mu m^2)$	WNS (ns)	Area $(\mu m^2)$	WNS (ns)	Area ( $\mu m^2$ )	WNS (ns)	Area $(\mu m^2)$
	-3 ps	-0.137	3349.422	-0.065	3873.663	-0.113	15734.759	-0.088	13780.086
Clock Period	-2 ps	-0.133	3492.679	-0.061	3924.829	-0.113	15420.182	-0.084	13921.811
	-1 ps	-0.135	3446.472	-0.061	3962.004	-0.114	15621.580	-0.081	13814.640
	+0 ps	-0.130	3490.099	-0.063	3863.825	-0.117	15433.850	-0.084	13896.732
	+1 ps	-0.131	3454.899	-0.055	4052.402	-0.109	15537.876	-0.078	13660.376
	+2 ps	-0.131	3393.452	-0.055	3985.350	-0.109	15523.643	-0.074	13769.401
	+3 ps	-0.130	3438.852	-0.049	4061.877	-0.105	15684.117	-0.081	13749.080
	-3 ps	-0.130	3438.852	-0.055	4061.877	-0.105	15684.117	-0.081	13747.749
	-2 ps	-0.131	3393.452	-0.055	3985.350	-0.109	15523.643	-0.074	13773.756
	-1 ps	-0.131	3454.899	-0.049	4052.402	-0.109	15537.876	-0.078	13662.795
Clock Uncertainty	+0 ps	-0.130	3490.099	-0.063	3863.825	-0.117	15433.850	-0.084	13896.732
	+1 ps	-0.135	3446.472	-0.059	3995.470	-0.114	15621.580	-0.081	13814.640
	+2 ps	-0.133	3492.679	-0.061	3924.829	-0.113	15420.182	-0.084	13921.206
	+3 ps	-0.137	3349.422	-0.065	3873.663	-0.113	15734.759	-0.087	13784.279
	-3 ps	-0.132	3465.423	-0.063	3863.825	-0.124	15436.834	-0.084	13896.732
	-2 ps	-0.131	3455.746	-0.063	3863.825	-0.107	15854.065	-0.084	13896.732
	-1 ps	-0.130	3489.454	-0.063	3863.825	-0.117	15376.636	-0.084	13896.732
IO Delay	+0 ps	-0.130	3490.099	-0.063	3863.825	-0.117	15433.850	-0.084	13896.732
5	+1 ps	-0.132	3432.965	-0.063	3863.825	-0.114	15583.720	-0.084	13896.732
	+2 ps	-0.132	3453.690	-0.063	3863.825	-0.123	15419.134	-0.084	13896.691
	+3 ps	-0.133	3422.200	-0.063	3867.333	-0.121	15357.484	-0.084	13895.965
Best	-	-0.130	-	-0.049	-	-0.105	-	-0.074	-
Worst	-	-0.137	-	-0.065	-	-0.124	-	-0.088	-
Delta	-	0.007	-	0.016	-	0.019	-	0.014	-
Dena		0.007		0.010		0.017		0.011	
		0.007	SweRV	wrabber		0.017	Black	Parrot	
Parameter	Noise (Δ)	Sy	SweRV_	wrapper Sy	rn 2	Sy	Black	Parrot Sy	rn 2
Parameter	Noise (Δ)	Sy WNS (ns)	SweRV_ m_1 Area (µm <sup>2</sup> )	wrapper Sy WNS (ns)	m_2 Area (μm <sup>2</sup> )	Sy WNS (ns)	Black n_1 Area (μm²)	Parrot Sy WNS (ns)	n_2 Area (μm²)
Parameter	Noise ( $\Delta$ )	Sy WNS (ns)	SweRV_ m_1 Area (μm <sup>2</sup> )	wrapper Sy WNS (ns)	rn_2 Area (μm <sup>2</sup> )	Sy WNS (ns)	Black n_1 Area (μm <sup>2</sup> ) 315843.656	Parrot Sy WNS (ns)	n_2 Area (μm <sup>2</sup> ) 294107 103
Parameter	Noise ( $\Delta$ ) -3 ps -2 ps	Sy WNS (ns) -0.198 -0.210	SweRV_ m_1 Area (μm <sup>2</sup> ) 137864.035 137659.250	wrapper Sy WNS (ns) -0.167 -0.151	m_2 Area (μm <sup>2</sup> ) 135813.803 136047.579	Sy WNS (ns) -0.388 -0.406	Black n_1 Area (μm <sup>2</sup> ) 315843.656 315855.067	Parrot Sy WNS (ns) -0.318 - <b>0.328</b>	n_2 Area (μm <sup>2</sup> ) 294107.103 294984.224
Parameter	Noise ( $\Delta$ ) -3  ps -2  ps -1  ps	Sy WNS (ns) -0.198 -0.210 -0.202	SweRV_ n_1 Area (μm <sup>2</sup> ) 137864.035 137659.250 137777.629	wrapper Sy WNS (ns) -0.167 -0.151 -0.154	n_2 Area (μm <sup>2</sup> ) 135813.803 136047.579 135833.318	Sy WNS (ns) -0.388 -0.406 -0.398	Black n_1 Area (μm <sup>2</sup> ) 315843.656 315855.067 315836.076	Parrot Sy WNS (ns) -0.318 -0.328 -0.323	n_2 Area (μm <sup>2</sup> ) 294107.103 294984.224 295421.898
Parameter Clock Period	Noise (Δ) -3 ps -2 ps -1 ps +0 ps	Sy WNS (ns) -0.198 -0.210 -0.202 -0.206	SweRV_ n_1 Area (μm <sup>2</sup> ) 137864.035 137659.250 137777.629 137688.079	wrapper Sy WNS (ns) -0.167 -0.151 -0.154 -0.174	n_2 Area (μm <sup>2</sup> ) 135813.803 136047.579 135833.318 135649.741	Sy WNS (ns) -0.388 -0.406 -0.398 -0.392	Black n_1 Area (μm <sup>2</sup> ) 315843.656 315855.067 315836.076 315798.498	Parrot Sy WNS (ns) -0.318 -0.328 -0.323 -0.315	n_2 Area (μm <sup>2</sup> ) 294107.103 294984.224 295421.898 295225.983
Parameter Clock Period	Noise (Δ) -3 ps -2 ps -1 ps +0 ps +1 ps	Sy WNS (ns) -0.198 -0.210 -0.202 -0.206 -0.198	SweRV_ n_1 Area (μm <sup>2</sup> ) 137864.035 137659.250 137777.629 137688.079 137806.176	wrapper Sy WNS (ns) -0.167 -0.151 -0.154 -0.174 -0.173	m_2 Area (μm <sup>2</sup> ) 135813.803 136047.579 135833.318 135649.741 135648.088	Sy WNS (ns) -0.388 -0.406 -0.398 -0.392 -0.399	Black n_1 Area (μm <sup>2</sup> ) 315843.656 315855.067 315836.076 315798.498 315886.879	Parrot Sy WNS (ns) -0.318 -0.328 -0.323 -0.315 -0.321	n_2 Area (μm <sup>2</sup> ) 294107.103 294984.224 295421.898 295225.983 295110.063
Parameter Clock Period	Noise (Δ) -3 ps -2 ps -1 ps +0 ps +1 ps +2 ps	Sy WNS (ns) -0.198 -0.202 -0.202 -0.206 -0.198 -0.188	SweRV_ n_1 Area (μm <sup>2</sup> ) 137864.035 137659.250 137777.629 137688.079 137806.176 137973.464	wrapper Sy WNS (ns) -0.167 -0.151 -0.154 -0.174 -0.173 -0.156	m_2 Area (μm <sup>2</sup> ) 135813.803 136047.579 135833.318 135649.741 135648.088 135976.333	Sy WNS (ns) -0.388 -0.398 -0.398 -0.392 -0.399 -0.393	Black n_1 Area (μm <sup>2</sup> ) 315843.656 315855.067 315836.076 315798.498 315886.879 315773.338	Parrot Sy WNS (ns) -0.318 -0.323 -0.323 -0.315 -0.321 -0.317	n_2 Area (μm <sup>2</sup> ) 294107.103 294984.224 295421.898 295225.983 295110.063 295342.467
Parameter Clock Period	Noise (Δ) -3 ps -2 ps -1 ps +0 ps +1 ps +2 ps +3 ps	-0.198 -0.210 -0.202 -0.202 -0.206 -0.198 -0.188 -0.183	SweRV_ n_1 Area (μm <sup>2</sup> ) 137864.035 137659.250 137777.629 137806.176 137973.464 137905.283	wrapper Sy WNS (ns) -0.167 -0.151 -0.154 -0.174 -0.173 -0.156 -0.167	n_2 Area (μm <sup>2</sup> ) 135813.803 136047.579 135833.318 135649.741 135648.088 135976.333 135238.598	Sy WNS (ns) -0.388 -0.406 -0.398 -0.392 -0.399 -0.393 -0.386	Black n_1 Area (μm <sup>2</sup> ) 315843.650 315855.067 315836.076 315798.498 315886.879 315773.338 316127.912	Parrot Sy WNS (ns) -0.318 -0.328 -0.323 -0.315 -0.321 -0.317 -0.297	n_2 Area (μm <sup>2</sup> ) 294107.103 294984.224 295421.898 295225.983 295342.467 294933.905
Parameter Clock Period	Noise (Δ) -3 ps -2 ps -1 ps +0 ps +1 ps +2 ps +3 ps -3 ps	Sy           WNS (ns)           -0.198           -0.210           -0.202           -0.206           -0.188           -0.183           -0.183	SweRV_ n_1 Area (μm <sup>2</sup> ) 137864.035 137659.250 137777.629 137688.079 137806.176 137973.464 137905.283 137866.495	wrapper Sy WNS (ns) -0.167 -0.151 -0.154 -0.173 -0.156 -0.167 -0.167 -0.154	n_2 Area (μm <sup>2</sup> ) 135813.803 136047.579 135833.318 135649.741 135648.088 135976.333 135238.598 135619.945	537 50 50 50 50 50 50 50 50 50 50 50 50 50	Black n_1 Area (μm <sup>2</sup> ) 315843.656 315855.067 315836.076 315798.498 315886.879 315773.338 316127.912 315751.041	Parrot Sy WNS (ns) -0.318 -0.328 -0.323 -0.315 -0.321 -0.317 -0.297 -0.297	n_2 Area (μm <sup>2</sup> ) 294107.103 294984.224 295421.898 295225.983 295110.063 295342.467 294933.905 294933.905
Parameter Clock Period	Noise (Δ) -3 ps -2 ps -1 ps +0 ps +1 ps +2 ps +3 ps -2 ps	-0.198 -0.210 -0.202 -0.206 -0.198 -0.183 -0.183 -0.183 -0.184	SweRV_ n_1 Area (μm <sup>2</sup> ) 137864.035 137659.250 137777.629 137806.176 137905.283 137866.495 137942.216	wrapper           Sy           WNS (ns)           -0.167           -0.151           -0.154           -0.173           -0.167           -0.167           -0.167	n_2 Area (μm <sup>2</sup> ) 135813.803 136047.579 135833.318 135649.741 135648.088 135976.333 135238.598 135619.945 135530.918	5379 58 59 50 50 50 50 50 50 50 50 50 50 50 50 50	Black n_1 Area (μm <sup>2</sup> ) 315843.656 315855.067 315836.076 315798.498 315886.879 315773.338 316127.912 315751.041 315918.490	original	n_2 Area (μm <sup>2</sup> ) 294107.103 294984.224 295421.898 295225.983 295110.063 295342.467 294933.905 294933.905
Parameter       Clock Period	Noise (Δ) -3 ps -2 ps -1 ps +0 ps +1 ps +2 ps +3 ps -3 ps -2 ps -1 ps	590 500 500 500 500 500 500 500	SweRV_ n_1 Area (μm <sup>2</sup> ) 137864.035 137659.250 137777.629 137880.776 137880.176 137973.464 137905.283 137866.495 137942.216 137797.144	wrapper           Sy           WNS (ns)           -0.167           -0.151           -0.174           -0.175           -0.167           -0.156           -0.167           -0.156           -0.167           -0.156           -0.156           -0.157	$\begin{array}{c} n\_2\\ \hline Area \ (\mu m^2)\\ 135813.803\\ 136047.579\\ 135833.318\\ 135649.741\\ 135648.088\\ 135976.333\\ 135238.598\\ 135530.918\\ 135530.918\\ 135502.628\\ \end{array}$	59 50 50 50 50 50 50 50 50 50 50	Black n_1 Area (μm <sup>2</sup> ) 315843.656 315855.067 31578.498 315886.879 315773.338 316127.912 315751.041 315718.490	Original	n_2 Area (μm <sup>2</sup> ) 294107.103 295421.898 295421.898 295225.983 295342.467 294933.905 294933.905 294933.905 294933.905 295343.153
Parameter Clock Period Clock Uncertainty	Noise (Δ) -3 ps -2 ps -1 ps +0 ps +1 ps +2 ps +3 ps -3 ps -2 ps -1 ps +0 ps +0 ps +1 ps +2 ps +2 ps +1 ps +2 ps +1 ps +2 ps +2 ps +1 ps +2 ps +2 ps +1 ps +2 ps +2 ps +1 ps +2 ps +2 ps +2 ps +1 ps +2 p	530 54 55 55 55 55 55 55 55 55 55	SweRV_ n_1 Area (μm <sup>2</sup> ) 137864.035 137659.250 13777.629 137688.079 137688.079 137806.176 137973.464 137905.283 137866.495 137942.216 137797.144 137797.144	wrapper           Sy           WNS (ns)           -0.167           -0.151           -0.154           -0.167           -0.167           -0.154           -0.165           -0.155	n_2 Area (μm <sup>2</sup> ) 135813.803 136047.579 135833.318 135649.741 135648.088 135976.333 135238.598 135519.945 135530.918 135902.628 135649.741	59 50 50 50 50 50 50 50 50 50 50	Black n_1 Area (μm <sup>2</sup> ) 315843.656 315855.067 315836.076 315798.498 31578.498 316127.912 315751.041 3157918.490 315788.902 315788.902	Parrot Sy WNS (ns) -0.318 -0.328 -0.323 -0.315 -0.321 -0.317 -0.297 -0.327 -0.315 -0.321 -0.315	n_2 Area (μm <sup>2</sup> ) 294107.103 294984.224 295421.898 295225.983 295110.063 295342.467 294933.905 294933.905 294933.905 295343.153 295110.063
Parameter Clock Period Clock Uncertainty	Noise (Δ) -3 ps -2 ps -1 ps +0 ps +1 ps +2 ps +3 ps -3 ps -2 ps -1 ps +0 ps +1 ps +1 ps +2 ps +3 ps +1 ps +2 ps +1 ps +1 ps +2 ps +1 ps +1 ps +2 ps +1 ps +1 ps +1 ps +2 ps +1	-0.198 -0.210 -0.202 -0.206 -0.198 -0.188 -0.183 -0.183 -0.184 -0.188 -0.196 -0.206 -0.206 -0.198	SweRV_ n_1 Area (μm <sup>2</sup> ) 137864.035 137659.250 137777.629 137868.079 137806.176 137973.464 137905.283 137866.495 137797.144 137688.079 137796.459	wrapper           Sy           WNS (ns)           -0.167           -0.151           -0.154           -0.167           -0.166           -0.167           -0.167           -0.155           -0.167	n_2 Area (μm <sup>2</sup> ) 135813.803 136047.579 135833.318 135649.741 135648.088 135976.333 135238.598 135619.945 135502.628 135502.628 135649.741 135877.186	537 54 55 55 55 55 55 55 55 55 55	Black n_1 Area (μm <sup>2</sup> ) 315843.656 315855.067 315836.076 315788.498 315886.879 315773.338 316127.912 315751.041 315918.490 315788.902 315798.498	original           Parrot           Sy           WNS (ns)           -0.318           -0.323           -0.315           -0.317           -0.327           -0.317           -0.323	n_2 Area (μm <sup>2</sup> ) 294107.103 294984.224 295225.983 295225.983 295210.063 295342.467 294933.905 295343.153 295110.063 295225.983 295417.825
Parameter Clock Period Clock Uncertainty	Noise (Δ) -3 ps -2 ps -1 ps +0 ps +1 ps +2 ps +3 ps -3 ps -3 ps -1 ps +0 ps +1 ps +2 ps +3 ps -3 ps -2 ps -3 ps -2 ps -3 ps -2 ps -3 ps -3 ps -2 ps -3 ps -2 ps -3 ps -3 ps -2 ps -2 ps -3 ps -2 ps -3 ps -2 ps -1 ps -2 ps -2 ps -2 ps -2 ps -2 ps -2 ps -1 ps -2 ps -2 ps -1 ps +0 ps -2 ps -1 ps -2 ps -2 ps -1 ps -2 ps -2 ps -2 ps -1 ps -2 p	50007 5y WNS (ns) -0.198 -0.210 -0.202 -0.206 -0.198 -0.188 -0.188 -0.188 -0.188 -0.188 -0.196 -0.206 -0.206 -0.198 -0.214	SweRV_ n_1 Area (μm <sup>2</sup> ) 137864.035 137659.250 137777.629 137886.79 137806.176 137973.464 137905.283 137866.495 137942.216 137797.144 137688.079 137796.459 137796.459	wrapper Sy WNS (ns) -0.167 -0.151 -0.154 -0.173 -0.174 -0.173 -0.167 -0.167 -0.160 -0.155 -0.174 -0.155 -0.167 -0.154 -0.154 -0.154 -0.154 -0.154 -0.154 -0.154 -0.155 -0.167 -0.154 -0.154 -0.155 -0.155 -0.167 -0.154 -0.154 -0.155 -0.158	$\begin{array}{c} n\_2\\ \hline Area \ (\mu m^2)\\ 135813.803\\ 136047.579\\ 135833.318\\ 135649.741\\ 135648.088\\ 135976.333\\ 135238.598\\ 135619.945\\ 135530.918\\ 135530.918\\ 135502.628\\ 135649.741\\ 135877.186\\ 135612.123\\ \end{array}$	59 59 59 50 50 50 50 50 50 50 50 50 50	Black n_1 Area (μm <sup>2</sup> ) 315843.656 315855.067 315836.076 315798.498 315788.498 315773.338 316127.912 3157751.041 315751.041 315798.490 315798.498 315876.880 315798.498	Parrot Parrot Sy WNS (ns) -0.318 -0.328 -0.323 -0.315 -0.321 -0.317 -0.297 -0.297 -0.317 -0.317 -0.321 -0.312 -0.323 -0.323 -0.328	n_2 Area (μm <sup>2</sup> ) 294107.103 294984.224 295421.898 295225.983 295342.467 294933.905 294933.905 294933.905 294933.905 295343.153 295110.063 295225.983 295117.825 294983.901
Parameter Clock Period Clock Uncertainty	Noise (Δ) -3 ps -2 ps -1 ps +0 ps +1 ps +2 ps +3 ps -3 ps -2 ps -1 ps +0 ps +1 ps +2 ps +2 ps +3 ps -3 ps -2 ps -3 p	599 599 599 599 599 599 599 599	SweRV_ n_1 Area (μm <sup>2</sup> ) 137864.035 137659.250 137777.629 137688.079 137686.176 137973.464 137905.283 137866.495 137942.216 137797.144 137688.079 137764.559 137618.890	wrapper Sy WNS (ns) -0.167 -0.154 -0.174 -0.173 -0.156 -0.167 -0.154 -0.167 -0.155 -0.155 -0.155 -0.155 -0.158 -0.158 -0.159	$\begin{array}{c} n\_2\\ \hline Area \ (\mu m^2)\\ 135813.803\\ 136047.579\\ 135833.318\\ 135649.741\\ 135648.088\\ 135976.333\\ 135238.598\\ 135530.918\\ 135530.918\\ 135502.628\\ 135649.741\\ 135877.186\\ 135612.123\\ 13589.653\\ \end{array}$	5y WNS (ns) -0.388 -0.406 -0.398 -0.392 -0.399 -0.393 -0.386 -0.388 -0.383 -0.385 -0.392 -0.395 -0.402 -0.394	Black n_1 Area (μm <sup>2</sup> ) 315843.656 315855.067 315836.076 315788.498 315773.338 316127.912 315751.041 315788.902 315788.498 315876.880 315839.745 315804.788	Partot Partot Sy WNS (ns) -0.318 -0.323 -0.323 -0.315 -0.321 -0.317 -0.297 -0.317 -0.321 -0.321 -0.323 -0.328 -0.328 -0.328 -0.328 -0.328 -0.328 -0.328 -0.328 -0.328 -0.328 -0.328 -0.328 -0.328 -0.321 -0.329 -0.321 -0.321 -0.329 -0.321 -0.323 -0.321 -0.323 -0.323 -0.321 -0.323 -0.323 -0.328	n_2 <u>Area (μm<sup>2</sup>)</u> 294107.103 294984.224 295421.898 295225.983 295110.063 294933.905 294933.905 294933.905 295433.153 295110.063 295225.983 295417.825 294983.901 294106.780
Parameter Clock Period Clock Uncertainty	Noise (Δ) -3 ps -2 ps -1 ps +0 ps +1 ps +2 ps +3 ps -3 ps -2 ps -1 ps +0 ps +1 ps +2 ps +3 ps -3 ps +2 ps -3 ps -2 ps -3 ps -3 ps -3 ps -2 ps -3 ps -2 ps -3 ps -2 ps -3 ps	Sign           -0.198           -0.210           -0.202           -0.206           -0.198           -0.183           -0.184           -0.184           -0.198           -0.206           -0.198           -0.183           -0.184           -0.198           -0.206           -0.206           -0.198           -0.206           -0.198           -0.219           -0.219	SweRV_ n_1 Area (μm <sup>2</sup> ) 137864.035 137659.250 13777.629 137688.079 137886.079 137806.176 137973.464 137905.283 137866.495 137942.216 137797.144 137688.079 137764.459 137764.599 1377618.890 137535.951 13792.362	wrapper           Sy           WNS (ns)           -0.167           -0.151           -0.153           -0.167           -0.154           -0.167           -0.153           -0.155           -0.153           -0.153           -0.159           -0.159	$\begin{array}{c} n\_2\\ \hline Area (\mu m^2)\\ 135813.803\\ 136047.579\\ 13583.318\\ 135649.741\\ 135648.088\\ 135976.333\\ 135238.598\\ 135509.628\\ 135509.2628\\ 135509.2628\\ 135649.741\\ 135612.123\\ 135877.186\\ 135612.123\\ 135895.653\\ 135649.741\\ \end{array}$	Sy           0.388           -0.388           -0.393           -0.393           -0.393           -0.393           -0.393           -0.386           -0.388           -0.388           -0.386           -0.385           -0.392           -0.395           -0.402           -0.394	Black n_1 Area (μm <sup>2</sup> ) 315843.656 315855.067 315836.076 315798.498 315773.338 316127.912 315751.041 315751.041 315788.902 315788.902 315839.745 315804.788 315804.788	Original	n_2 <u>Area (μm<sup>2</sup>)</u> 294107.103 294984.224 295225.983 2952125.983 295110.063 295342.467 294933.905 294933.905 294933.905 295343.153 295225.983 295215.983 295417.825 294983.901 294106.780 295225.983
Parameter Clock Period Clock Uncertainty	Noise (Δ) -3 ps -2 ps -1 ps +0 ps +1 ps +2 ps +3 ps -3 ps -2 ps -1 ps +0 ps +1 ps +0 ps +1 ps +2 ps -3 ps -3 ps -2 ps -3 ps -2 ps -3 ps -2 ps -2 ps	590 500 500 500 500 500 500 500	SweRV_ m_1 Area (μm <sup>2</sup> ) 137864.035 137659.250 137077.629 137886.079 137806.176 137973.464 137905.283 137964.599 137796.459 137796.459 137796.459 13768.890 137535.951 137925.362 13787.194	wrapper Sy WNS (ns) -0.167 -0.151 -0.154 -0.174 -0.173 -0.156 -0.167 -0.167 -0.160 -0.155 -0.174 -0.158 -0.158 -0.158 -0.174	$\begin{array}{c} n\_2 \\ \hline Area \ (\mu m^2) \\ 135813.803 \\ 136047.579 \\ 135833.318 \\ 135649.741 \\ 135648.088 \\ 135976.333 \\ 135238.598 \\ 135530.918 \\ 135530.918 \\ 135502.628 \\ 135649.741 \\ 135877.186 \\ 135612.123 \\ 135895.653 \\ 135649.741 \\ 135895.653 \\ 135649.741 \\ 135897.186 \\ 135649.741 \\ 135897.186 \\ 135649.741 \\$	Sy           Sy           WNS (ns)           -0.388           -0.406           -0.392           -0.393           -0.388           -0.388           -0.388           -0.388           -0.388           -0.388           -0.385           -0.392           -0.395           -0.394           -0.395           -0.394           -0.390	Black n_1 Area (μm <sup>2</sup> ) 315843.656 315855.067 315836.076 315798.498 31578.8498 315773.038 316127.912 3157751.041 315778.490 315798.498 315876.880 315798.498 315804.788 315804.788 315790.877	Parrot Sy WNS (ns) -0.318 -0.328 -0.323 -0.315 -0.317 -0.317 -0.317 -0.317 -0.317 -0.317 -0.315 -0.328 -0.318 -0.318 -0.321 -0.315 -0.328 -0.315 -0.321 -0.315 -0.321 -0.315 -0.321 -0.317 -0.321 -0.317 -0.321 -0.317 -0.321 -0.317 -0.317 -0.321 -0.317 -0.323 -0.323 -0.317 -0.321 -0.317 -0.323 -0.323 -0.323 -0.321 -0.317 -0.323 -0.323 -0.323 -0.323 -0.323 -0.335 -0.355 -0.555	n_2 Area (μm <sup>2</sup> ) 294107.103 294984.224 295421.898 295225.983 295342.467 294933.905 294933.905 295343.153 295343.153 295110.063 295225.983 29483.901 294106.780 295225.983
Parameter Clock Period Clock Uncertainty	Noise (Δ) -3 ps -2 ps -1 ps +0 ps +1 ps +2 ps +3 ps -3 ps -2 ps -1 ps +0 ps +1 ps +0 ps +1 ps -3 ps -2 ps -3 ps -2 ps -3 ps -2 ps -3 ps -3 ps -2 ps -3 ps -2 ps -3 ps -3 ps -2 ps -3 ps -3 ps -2 ps -3 ps -1 ps -1 ps -1 ps -1 ps	Sign           Sy           WNS (ns)           -0.198           -0.210           -0.202           -0.206           -0.198           -0.183           -0.183           -0.184           -0.206           -0.198           -0.206           -0.198           -0.184           -0.206           -0.198           -0.214           -0.214           -0.191           -0.191	SweRV_ n_1 Area (μm <sup>2</sup> ) 137864.035 137659.250 137777.629 137880.776 137806.176 137973.464 137905.283 137866.495 137942.216 137797.144 137688.079 137796.459 137796.459 137795.362 137825.362 137825.362	wrapper           wrapper           Sy           WNS (ns)           -0.167           -0.151           -0.154           -0.173           -0.156           -0.167           -0.155           -0.167           -0.154           -0.155           -0.167           -0.154           -0.155           -0.160           -0.155           -0.158           -0.159           -0.174           -0.174           -0.174	$\begin{array}{c} n\_2\\ \hline Area \ (\mu m^2)\\ 135813.803\\ 136047.579\\ 135833.318\\ 135649.741\\ 135648.088\\ 135976.33\\ 135238.598\\ 135530.918\\ 135503.0945\\ 135530.918\\ 135902.628\\ 135649.741\\ 135897.186\\ 135649.741\\ $	59 59 59 59 50 50 50 50 50 50 50 50 50 50	Black n_1 Area (μm <sup>2</sup> ) 315843.656 315855.067 315836.076 31578.498 31577.338 316127.912 315751.041 31578.902 31578.902 31578.498 315876.880 315839.745 315804.788 315790.877 315790.877	Parrot Parrot Sy WNS (ns) -0.318 -0.328 -0.323 -0.315 -0.321 -0.317 -0.297 -0.297 -0.317 -0.323 -0.315 -0.323 -0.315 -0.328 -0.318 -0.318 -0.315 -0.323 -0.315 -0.323 -0.315 -0.321 -0.315 -0.321 -0.315 -0.321 -0.315 -0.321 -0.315 -0.321 -0.315 -0.321 -0.315 -0.321 -0.315 -0.321 -0.327 -0.321 -0.325 -0.323 -0.325 -0.327 -0.327 -0.327 -0.327 -0.327 -0.328 -0.318 -0.318 -0.328 -0.318 -0.318 -0.318 -0.328 -0.315 -0.328 -0.318 -0.315 -0.328 -0.315 -0.325 -0.328 -0.315 -0.325 -0.328 -0.315 -0.315 -0.325 -0.328 -0.315	n_2 Area (μm <sup>2</sup> ) 294107.103 294984.224 295421.898 29525.983 295342.467 294933.905 294933.905 294933.905 294933.905 295417.825 295110.663 295225.983 295417.825 294983.901 294106.780 295225.983 295225.983
Parameter Clock Period Clock Uncertainty IO Delay	Noise (Δ) -3 ps -2 ps -1 ps +0 ps +1 ps +2 ps +3 ps -3 ps -2 ps -1 ps +0 ps +1 ps +2 ps +3 ps -3 ps -2 ps -1 ps +0 ps +1 ps +1 ps +2 ps -3 ps -2 ps -1 ps +0 ps +1 ps +1 ps +2 ps -1 ps +0 ps +1 ps +1 ps +2 ps -1 ps +0 ps +1 ps +1 ps +2 ps -1 ps +0 ps +1 ps +2 ps +2 ps +1 ps +2 ps +0	Sign           -0.198           -0.210           -0.202           -0.203           -0.188           -0.188           -0.188           -0.188           -0.188           -0.188           -0.188           -0.188           -0.188           -0.196           -0.206           -0.191           -0.214           -0.205           -0.205           -0.206	SweRV_ n_1 Area (μm <sup>2</sup> ) 137864.035 137659.250 13777.629 137688.079 137688.079 137688.079 137688.079 137942.216 137797.144 137797.144 137688.079 13764.859 137618.890 137535.951 137925.362 137879.196 137652.799	wrapper           Sy           WNS (ns)           -0.167           -0.154           -0.173           -0.167           -0.154           -0.167           -0.153           -0.167           -0.154           -0.167           -0.153           -0.155           -0.158           -0.158           -0.159           -0.174           -0.174           -0.174           -0.174	$\begin{array}{c} n\_2 \\ \hline Area \ (\mu m^2) \\ 135813.803 \\ 136047.579 \\ 13583.318 \\ 135649.741 \\ 135648.088 \\ 135976.333 \\ 135238.598 \\ 135619.945 \\ 135530.918 \\ 135902.628 \\ 135649.741 \\ 135877.186 \\ 135612.123 \\ 13589.653 \\ 135649.741 \\ 1$	Sy           0.388           -0.388           -0.392           -0.393           -0.393           -0.386           -0.388           -0.388           -0.385           -0.385           -0.385           -0.392           -0.395           -0.394           -0.390           -0.390	Black n_1 Area (μm <sup>2</sup> ) 315843.656 315855.067 315836.076 315788.498 315773.338 316127.912 315751.041 31571.041 31571.041 315788.902 315788.902 315788.498 315876.880 315839.745 315804.788 315870.877 315790.877 315790.877	O.311           Parrot           Sy           WNS (ns)           -0.318           -0.323           -0.321           -0.315           -0.321           -0.315           -0.327           -0.3297           -0.321           -0.315           -0.323           -0.323           -0.315           -0.328           -0.315           -0.315           -0.315           -0.315	n_2 Area (μm <sup>2</sup> ) 294107.103 294984.224 295421.898 295225.983 295110.063 294933.905 294933.905 294933.905 294933.905 29525.983 295215.983 295225.983 295225.983 295225.983 295225.983
Parameter Clock Period Clock Uncertainty IO Delay	Noise (Δ) -3 ps -2 ps -1 ps +0 ps +1 ps +2 ps +3 ps -3 ps -2 ps -1 ps +0 ps +1 ps +0 ps +1 ps +2 ps -3 ps -2 ps -1 ps +0 ps +1 ps +0 ps +1 ps +0 ps +1 ps +2 ps +3 ps -2 ps -1 ps +0 ps +1 ps +1 ps +0 ps +1 ps +2 ps +3 ps -2 ps -1 ps +0 ps +1 ps +2 ps +1 ps +2 ps +1 ps +1 ps +2 ps +1	Sy           Sy           WNS (ns)           -0.198           -0.210           -0.202           -0.203           -0.198           -0.183           -0.184           -0.188           -0.198           -0.206           -0.198           -0.204           -0.205           -0.206           -0.198           -0.214           -0.205           -0.206           -0.205	SweRV_ m_1 Area (μm <sup>2</sup> ) 137864.035 137659.250 137077.629 137806.176 137973.464 137973.464 137905.283 137964.599 137796.459 137796.459 137796.459 137688.079 137652.799 13785.209 137652.799 137652.799 137652.888.079 137745.888	wrapper           Sy           WNS (ns)           -0.167           -0.151           -0.154           -0.173           -0.156           -0.167           -0.155           -0.154           -0.155           -0.155           -0.153           -0.158           -0.158           -0.174           -0.174           -0.174           -0.174           -0.174	$\begin{array}{c} n\_2 \\ \hline Area \ (\mu m^2) \\ 135813.803 \\ 136047.579 \\ 135833.318 \\ 135649.741 \\ 135648.088 \\ 135976.333 \\ 135238.598 \\ 135619.945 \\ 135530.918 \\ 135530.918 \\ 135649.741 \\ 135895.653 \\ 135649.741 \\ 135649.741 \\ 135649.741 \\ 135649.741 \\ 135649.741 \\ 135649.741 \\ 135649.741 \\ 1356449.741 \\ 1356449.741 \\ 135644.741 \\ 135644.741 \\ 135644.741 \\ 135644.741 \\ 135644.741 \\ 135714.0111 \\ 135714.011 \\ 135714.011 \\ 135714.011 \\ 135714.011 \\ 135714.01$	Sy           0.383           -0.388           -0.398           -0.392           -0.393           -0.393           -0.388           -0.388           -0.388           -0.388           -0.388           -0.388           -0.385           -0.392           -0.394           -0.395           -0.394           -0.390           -0.390           -0.392           -0.393	Black n_1 Area (μm <sup>2</sup> ) 315843.656 315855.067 315836.076 315798.498 315886.879 315773.338 316127.912 315775.1041 315781.490 315784.998 315876.880 315798.498 315804.788 315790.877 315790.877 315790.877 315790.872	Parrot Sy WNS (ns) -0.318 -0.328 -0.323 -0.315 -0.321 -0.317 -0.297 -0.297 -0.321 -0.315 -0.328 -0.328 -0.329 -0.329 -0.321 -0.325 -0.321 -0.321 -0.321 -0.321 -0.325 -0.325 -0.325 -0.321 -0.325 -0.325 -0.325 -0.325 -0.325 -0.325 -0.325 -0.325 -0.325 -0.325 -0.325 -0.325 -0.325 -0.315	n_2 Area (μm <sup>2</sup> ) 294107.103 294984.224 295421.898 295225.983 295342.467 294933.905 294933.905 295343.153 295110.063 295225.983 295417.825 294983.901 294106.780 295225.983 295225.983 295225.983 295225.983
Parameter Clock Period Clock Uncertainty IO Delay	Noise (Δ) -3 ps -2 ps -1 ps +0 ps +1 ps +2 ps +3 ps -3 ps -2 ps -3 ps -2 ps -1 ps +0 ps +1 ps +2 ps +3 ps -3 ps -3 ps -3 ps -2 ps -1 ps +0 ps +1 ps +1 ps +2 ps +3 ps -3 ps -2 ps -3 ps -2 ps -3 ps -2 ps -3 ps -2 ps -3 ps -3 ps -2 ps -3 ps -1 ps +0 ps +1	Sign           Sy           WNS (ns)           -0.198           -0.210           -0.202           -0.206           -0.198           -0.183           -0.183           -0.184           -0.196           -0.214           -0.214           -0.191           -0.205           -0.205           -0.209	SweRV_ n_1 Area (μm <sup>2</sup> ) 137864.035 137659.250 137777.629 137880.776 137880.776 137973.464 137905.283 137866.495 137942.216 137797.144 137688.079 137796.459 137796.459 1377925.362 137825.361 137925.362 137825.799 137688.079 137688.079 137688.079 137688.079 137688.079	wrapper           Sy           WNS (ns)           -0.167           -0.154           -0.173           -0.156           -0.167           -0.155           -0.167           -0.154           -0.173           -0.155           -0.167           -0.159           -0.174           -0.174           -0.174           -0.174           -0.174           -0.174           -0.174           -0.174           -0.174           -0.164           -0.164	$\begin{array}{c} n\_2\\ \hline Area \ (\mu m^2)\\ 135813.803\\ 136047.579\\ 135833.318\\ 135647.573\\ 135648.088\\ 135976.333\\ 135238.598\\ 1355619.945\\ 135530.918\\ 135502.628\\ 135649.741\\ 135649.592\\ 135569.592\\$	Sy           0.388           -0.388           -0.398           -0.399           -0.399           -0.393           -0.386           -0.388           -0.388           -0.388           -0.388           -0.389           -0.390           -0.390           -0.390           -0.393           -0.390           -0.393           -0.393	Black n_1 Area (μm <sup>2</sup> ) 315843.656 315855.067 315836.076 31578.498 31578.498 315773.338 316127.912 315751.041 315751.041 31578.490 315788.902 315798.498 315876.880 315839.745 31580.779 315790.877 315790.877 315790.877 315790.877 315790.877 315790.877 315790.877 315790.877 315790.877 315790.877 315790.877 315790.877 315790.877	Parrot Parrot Sy WNS (ns) -0.318 -0.328 -0.323 -0.321 -0.317 -0.327 -0.327 -0.317 -0.327 -0.317 -0.323 -0.315 -0.318 -0.315 -0.315 -0.315 -0.315 -0.315 -0.315 -0.315 -0.315 -0.315 -0.315 -0.315 -0.315 -0.315 -0.315 -0.315 -0.315 -0.315 -0.318 -0.328 -0.329 -0.321 -0.321 -0.329 -0.325 -0.321 -0.321 -0.321 -0.321 -0.321 -0.325 -0.325 -0.321 -0.321 -0.325 -0.317 -0.325 -0.325 -0.315 -0.325 -0.315 -0.325 -0.315	n_2 Area (µm <sup>2</sup> ) 294107.103 294984.224 295421.898 295225.983 295110.063 295342.467 294933.905 294933.905 294933.905 294933.905 295417.825 294983.901 294106.780 295225.983 295225.983 295225.983 295225.983 295225.983 295225.983
Parameter Clock Period Clock Uncertainty IO Delay	Noise (Δ) -3 ps -2 ps -1 ps +0 ps +1 ps +2 ps +3 ps -3 ps -2 ps -1 ps +0 ps +1 ps +2 ps +3 ps -3 ps -2 ps -1 ps +0 ps +1 ps +2 ps +1 ps +1 ps +2 ps +1 ps +2 ps +1 ps +2 ps +1	Sign           -0.198           -0.210           -0.202           -0.206           -0.198           -0.183           -0.188           -0.188           -0.188           -0.188           -0.188           -0.196           -0.206           -0.198           -0.214           -0.214           -0.205           -0.206           -0.199           -0.205           -0.206           -0.199	SweRV_ n_1 Area (μm <sup>2</sup> ) 137864.035 137659.250 137777.629 137688.079 137686.176 137973.464 137905.283 137866.495 137942.216 137797.144 137688.079 137764.459 137618.890 137735.951 137925.362 137879.196 137652.799 137688.079 137745.898 137862.422 137680.136	wrapper           Sy           WNS (ns)           -0.167           -0.154           -0.173           -0.167           -0.154           -0.155           -0.167           -0.154           -0.155           -0.157           -0.153           -0.155           -0.158           -0.159           -0.174           -0.174           -0.174           -0.169           -0.169	$\begin{array}{c} n\_2 \\ \hline Area \ (\mu m^2) \\ 135813.803 \\ 136047.579 \\ 13583.318 \\ 135649.741 \\ 135648.088 \\ 135976.333 \\ 135238.598 \\ 135530.918 \\ 135530.918 \\ 135502.628 \\ 135649.741 \\ 135649.741 \\ 135649.741 \\ 135649.741 \\ 135649.741 \\ 135714.011 \\ 135590.592 \\ 135590.592 \\ 135590.592 \\ 135587.48 \\ 135714.011 \\ 135590.592 \\ 13587.48 \\ 135587.48 \\ 135587.48 \\ 135714.011 \\ 135590.592 \\ 135584.463 \\ 135584.463 \\ 135587.48 \\ 135587.48 \\ 135587.48 \\ 135587.48 \\ 135649.741 \\ 135714.011 \\ 135590.592 \\ 135584.463 \\ 13588.48 \\ 135$	Sy           0.388           -0.388           -0.392           -0.392           -0.393           -0.388           -0.388           -0.388           -0.388           -0.383           -0.384           -0.392           -0.395           -0.392           -0.394           -0.390           -0.393           -0.393           -0.393           -0.393           -0.393           -0.393	$\begin{array}{c} Black\\ n\_1\\ \hline Area (\mu m^2)\\ 315843.656\\ 315855.067\\ 315836.076\\ 315788.498\\ 31578.498\\ 315773.338\\ 316127.912\\ 315751.041\\ 315918.490\\ 315788.902\\ 31578.498\\ 315876.880\\ 315839.745\\ 31579.877\\ 315790.877\\ 315790.877\\ 315790.877\\ 315790.877\\ 315790.877\\ 315790.877\\ 315790.873\\ 31585.553\\ 315855.793\\ 315855.793\\ 315841.600\\ \end{array}$	Parrot Sy WNS (ns) -0.318 -0.323 -0.323 -0.315 -0.321 -0.317 -0.297 -0.317 -0.321 -0.315 -0.323 -0.315 -0.321 -0.327 -0.321 -0.325 -0.315 -0.325 -0.315	n_2 Area (μm <sup>2</sup> ) 294107.103 294984.224 295421.898 295225.983 295110.063 295342.467 294933.905 294933.905 295433.905 295433.905 295433.905 295433.905 295433.905 295433.905 295433.905 295433.905 295225.983 29525.983 2
Parameter Clock Period Clock Uncertainty IO Delay Best	Noise (Δ) -3 ps -2 ps -1 ps +0 ps +1 ps +2 ps +3 ps -3 ps -2 ps -1 ps +0 ps +1 ps +2 ps +3 ps -3 ps -2 ps -1 ps +0 ps +1 ps +2 ps +3 ps -3 ps -2 ps -1 ps +0 ps +1 ps +2 ps +3 ps -2 ps -1 ps +0 ps +1 ps +2 ps +3 ps -2 p	Sy           Sy           WNS (ns)           -0.198           -0.210           -0.202           -0.203           -0.198           -0.184           -0.184           -0.184           -0.196           -0.196           -0.204           -0.205           -0.214           -0.214           -0.205           -0.206           -0.199           -0.196           -0.206           -0.206           -0.206           -0.206           -0.206           -0.206           -0.206           -0.206           -0.206           -0.211	SweRV_           n_1           Area (μm²)           137864.035           137659.250           137077.629           137864.035           137777.629           137806.176           137973.464           137905.283           137866.495           13777.144           137688.079           137688.079           137618.890           137652.799           137682.079           137682.079           137862.422           137862.422           13788.079           13788.0136	wrapper Sy WNS (ns) -0.167 -0.151 -0.154 -0.174 -0.174 -0.173 -0.156 -0.167 -0.167 -0.155 -0.167 -0.155 -0.174 -0.158 -0.158 -0.174 -0.174 -0.174 -0.174 -0.174 -0.174 -0.174 -0.174 -0.174 -0.174 -0.174 -0.151 -0.174 -0.151 -0.155 -0.167 -0.151 -0.155 -0.167 -0.151 -0.155 -0.167 -0.151 -0.155 -0.167 -0.151 -0.155 -0.167 -0.151 -0.155 -0.167 -0.151 -0.155 -0.167 -0.154 -0.156 -0.167 -0.154 -0.154 -0.173 -0.155 -0.167 -0.167 -0.154 -0.173 -0.155 -0.174 -0.173 -0.155 -0.174 -0.173 -0.155 -0.174 -0.155 -0.174 -0.155 -0.174 -0.155 -0.174 -0.155 -0.174 -0.155 -0.174 -0.155 -0.174 -0.155 -0.174 -0.158 -0.174 -0.155 -0.174 -0.174 -0.174 -0.155 -0.174 -0.155 -0.174 -0.155 -0.174 -0.155	$\begin{array}{c} n\_2 \\ \hline Area \ (\mu m^2) \\ 135813.803 \\ 136047.579 \\ 135833.318 \\ 135649.741 \\ 135648.088 \\ 135976.333 \\ 135238.598 \\ 135619.945 \\ 135530.918 \\ 1356249.741 \\ 135649.741 \\ 135649.741 \\ 135649.741 \\ 135649.741 \\ 135590.592 \\ 135590.592 \\ 135590.592 \\ 135590.592 \\ 135590.592 \\ 135584.463 \\ 135714.011 \\ 135590.592 \\ 135584.463 \\ 135544.611 \\ 135590.592 \\ 135584.463 \\ 135544.611 \\ 135590.592 \\ 135584.463 \\ 135584.563 $	Sy           0.387           -0.388           -0.406           -0.392           -0.393           -0.393           -0.388           -0.388           -0.388           -0.388           -0.388           -0.388           -0.388           -0.385           -0.392           -0.394           -0.395           -0.390           -0.390           -0.390           -0.390           -0.393           -0.393           -0.393           -0.393           -0.393           -0.393           -0.393	$\begin{array}{r} Black\\ n\_1\\ \hline Area (\mu m^2)\\ 315843.656\\ 315835.067\\ 315836.076\\ 315798.498\\ 315886.879\\ 315773.338\\ 316127.912\\ 315775.1041\\ 315788.902\\ 315778.498\\ 315788.902\\ 315798.498\\ 315798.498\\ 315798.498\\ 31589.745\\ 315804.788\\ 315790.877\\ 315790.877\\ 315790.877\\ 315790.877\\ 315790.877\\ 315790.877\\ 315790.877\\ 315790.877\\ 315790.877\\ 315790.877\\ 315790.522\\ 315855.553\\ 315855.793\\ 315841.600\\ \hline \end{array}$	Parrot Sy WNS (ns) -0.318 -0.328 -0.323 -0.315 -0.321 -0.317 -0.297 -0.297 -0.321 -0.315 -0.325 -0.327 -0.327 -0.327 -0.327 -0.325 -0.325 -0.327 -0.327 -0.327 -0.327 -0.327 -0.325 -0.325 -0.325 -0.327 -0.325 -0.327 -0.325 -0.325 -0.327 -0.325 -0.355 -0.355 -0.355 -0.355 -0.355 -0.355 -0.355 -0.355 -0.355 -0.355 -0.355 -0.355 -0.355 -0.355 -0.355	n_2 Area (μm <sup>2</sup> ) 294107.103 294984.224 295421.898 295225.983 295342.467 294933.905 295343.153 295110.063 295225.983 295417.825 294983.901 294406.780 295225.983 29525.983 29
Parameter Parameter Clock Period Clock Uncertainty IO Delay Best Worst	Noise (Δ) -3 ps -2 ps -1 ps +0 ps +1 ps +2 ps +3 ps -3 ps -3 ps -1 ps +0 ps +1 ps +2 ps +3 ps -3 ps -3 ps -2 ps -1 ps +0 ps +1 ps +0 ps +1 ps +2 ps +3 ps -3 ps -3 ps -2 ps -1 ps +0 ps +1 ps +2 ps +3 ps -3 ps -3 ps -2 ps -1 ps +0 ps +1 ps +0 ps +1 ps +2 ps +3 ps -3 ps -2 ps -1 ps +0 ps +1 ps +1 ps +0 ps +1 ps +2 ps +3 ps -3 ps -2 ps -1 ps +0 ps +1 ps +3 ps -3 ps -2 ps -1 ps +0 ps +1 ps +3 ps -3 ps -2 ps -1 ps +0 ps +1 ps +3 ps -3 ps -1 ps +0 ps +1 ps +0 ps +1 ps +2 ps +3 ps -1 ps +0 ps +1 ps +2 ps +3 ps -1 ps +0 ps +1 ps +2 ps +3 ps -1 ps +3 ps -1 ps +3 ps -2 ps -3 ps -2 ps -1 ps +3 ps -3 ps -2 ps -3 ps -3 ps -2 ps -3 p	Sy           Sy           WNS (ns)           -0.198           -0.210           -0.202           -0.206           -0.198           -0.183           -0.183           -0.184           -0.188           -0.198           -0.206           -0.183           -0.184           -0.195           -0.206           -0.198           -0.214           -0.214           -0.205           -0.206           -0.199           -0.196           -0.219	SweRV_           m_1           Area (μm²)           137864.035           137659.250           137777.629           137688.079           137886.495           137973.464           137973.464           137973.464           137973.464           137973.464           137973.464           137971.444           137688.079           137796.459           137535.951           137925.362           137879.196           137652.799           137688.079           137645.898           137652.422           137680.136           -	wrapper           Sy           WNS (ns)           -0.167           -0.151           -0.153           -0.173           -0.156           -0.167           -0.155           -0.167           -0.155           -0.153           -0.158           -0.158           -0.174           -0.174           -0.174           -0.174           -0.174           -0.174           -0.174           -0.151	$\begin{array}{c} n\_2 \\ \hline Area \ (\mu m^2) \\ 135813.803 \\ 136047.579 \\ 135833.318 \\ 135649.741 \\ 135648.088 \\ 135976.333 \\ 135238.598 \\ 135619.945 \\ 135530.918 \\ 135530.918 \\ 135649.741 \\ 135649.741 \\ 135649.741 \\ 135649.741 \\ 135649.741 \\ 135649.741 \\ 135649.741 \\ 135649.741 \\ 135590.592 \\ 135584.463 \\ \hline \end{array}$	Sy           0.382           -0.388           -0.406           -0.392           -0.393           -0.393           -0.388           -0.393           -0.386           -0.385           -0.392           -0.395           -0.394           -0.390           -0.393           -0.394           -0.393           -0.393           -0.393           -0.393           -0.393           -0.394           -0.393           -0.383           -0.383           -0.393	Black n_1 Area (μm <sup>2</sup> ) 315843.656 315855.067 315836.076 315798.498 315788.498 315773.041 3157751.041 3157751.041 3157781.491 315778.498 315876.880 315798.498 315876.880 315798.4788 315790.877 315790.877 315790.877 315790.877 315790.712 315798.498 315825.553 315841.600	Parrot Sy WNS (ns) -0.318 -0.328 -0.323 -0.315 -0.321 -0.317 -0.317 -0.317 -0.317 -0.317 -0.315 -0.315 -0.315 -0.315 -0.315 -0.315 -0.315 -0.315 -0.315 -0.315 -0.315 -0.315 -0.315 -0.315 -0.315 -0.315 -0.315 -0.328 -0.328 -0.328 -0.328 -0.328 -0.3297 -0.297 -0.297 -0.297 -0.297 -0.297 -0.297 -0.297 -0.297 -0.297 -0.297 -0.297 -0.297 -0.297 -0.315 -0.315 -0.315 -0.315 -0.315 -0.328 -0.328 -0.328 -0.328 -0.328 -0.328 -0.328 -0.328 -0.328 -0.328 -0.328 -0.328 -0.328 -0.328 -0.329 -0.329 -0.329 -0.329 -0.329 -0.329 -0.329 -0.329 -0.328 -0.328 -0.325 -0.327 -0.329 -0.329 -0.328 -0.328 -0.325 -0.325 -0.325 -0.325 -0.325 -0.325 -0.325 -0.325 -0.325 -0.325 -0.325 -0.325 -0.325 -0.327 -0.327 -0.327 -0.328 -0.328 -0.328 -0.328 -0.328 -0.327 -0.327 -0.327 -0.329 -0.329 -0.329 -0.328 -0.325 -0.325 -0.325 -0.325 -0.327 -0.328 -0.328 -0.328 -0.328 -0.327 -0.327 -0.327 -0.327 -0.328 -0.327 -0.328 -0.388 -0.388 -0.388 -0.388 -0.388 -0.388 -0.388 -0.388	n_2 Area (μm <sup>2</sup> ) 294107.103 294984.224 295421.898 295225.983 295324.467 294933.905 294933.905 294933.905 295343.153 295110.063 295225.983 29525.983

Table 3: Revisiting experiments of [7]. Chaotic behavior is studied in synthesis tools.

# 6 BEYOND NOISE AND CHAOS: CAN PREDICTIONS BE HARMFUL?

We have also studied a second key question, namely, "How should predictions be used?" Recent years have seen tremendous energy devoted to machine learning for modeling and prediction of physical design. Yet, there may be contexts where use of predictions can cause, e.g., additional noise or chaos in tool outcomes. The message here, perhaps, is "Be careful what you ask for."

In this section, we show an example scenario where advance knowledge of the physical design outcome worsens noise and predictability. We select a subset of macros, pre-place them to locations in original macro placement output and let the P&R tool place remaining macros. This experiment mimics the use case where a partial solution (i.e., locations of some macros) is determined through prediction. Figure 4 shows example outcomes for *SweRV\_wrapper* using P&R\_1 and P&R\_2 tools. Results show that macro placement outcomes vary when different subsets of macros are pre-placed. For example, post-P&R implementation wirelength of macro placement in Figure 4(b) is 1,772,586  $\mu$ m or 3.5% longer compared to baseline macro placement in Figure 4(a). This experiment highlights that even though some locations of macros are known and pre-placed, there is still some uncertainty in final P&R wirelength. This chaotic behavior in P&R tools again puts a limit on achievable accuracy of interconnect predictions.

*Epilogue.* We add a final "epilogue" regarding the earlier comment, "be careful what you ask for" (in terms of predictions). A wellknown challenge for prediction is to bridge the gap between the post-synthesis netlist and the post-P&R netlist which has undergone sizing, buffering, hold fix, and many other physical synthesis and optimization transforms. Physical designers and methodologists universally agree that bridging this gap will improve timing and routability convergence. We ask the question, "Is it helpful to know *exactly* what the final post-P&R netlist will be?" Then, a trivial experiment takes a final post-P&R(&Opt) netlist and feeds it back

_		AES				JPEG				
Parameter	Noise ( $\Delta$ )	P&F	<u>1</u>	P&I	<u>2</u>	P&I	<u>1</u>	P&I	R_2	
		WNS (ns)	TNS (ns)	WNS (ns)	TNS (ns)	WNS (ns)	TNS (ns)	WNS (ns)	TNS (ns)	
	-3 ps	-0.232	-58.262	-0.230	-29.233	-0.064	-9.332	-0.026	-10.991	
	-2 ps	-0.240	-58.440	-0.227	-29.745	-0.040	-12.319	-0.024	-8.659	
Cleak Daried	-1 ps	-0.229	-56.220	-0.223	-29.221	-0.051	-10.270	-0.034	-15.317	
Clock Period	+0 ps	-0.235	-56.502	-0.244	-30.112	-0.038	-8.939	-0.052	-10.733	
	+1 ps	-0.236	-56.306	-0.226	-30.314	-0.039	-8.955	-0.030	-9.221	
	+2 ps	-0.229	-56.717	-0.220	-29.523	-0.045	-13.505	-0.024	-8.248	
	+3 ps	-0.231	-55.345	-0.230	-29.302	-0.034	-8.859	-0.026	-10.252	
	-3 ps	-0.234	-56.518	-0.224	-28.752	-0.033	-9.448	-0.031	-11.650	
	-2 ps	-0.233	-56.//0	-0.224	-29.634	-0.038	-14.466	-0.024	-8.400	
Cloal Uncortainty	-1 ps	-0.240	-56.046	-0.232	-29.877	-0.040	-9.995	-0.033	-8.519	
Clock Uncertainty	+0 ps	-0.235	-56.502	-0.245	-30.663	-0.038	-8.939	-0.054	-11.020	
	+1 ps	-0.235	-56.120	-0.224	-29.988	-0.041	-10.839	-0.031	-8.128	
	+2 ps	-0.232	-58.406	-0.232	-29.638	-0.046	-11.91/	-0.026	-/.406	
	+5 ps	-0.238	-57.927	-0.234	-29.011	-0.042	-8.540	-0.031	-11.410	
	-3 ps	-0.236	-50.588	-0.230	-29.396	-0.041	-10.002	-0.033	-9.132	
	-2 ps	-0.257	-30.130	-0.235	-32.322	-0.038	-10.015	-0.039	-9.014	
IO Delay	-1 ps	-0.235	-5/.233	-0.220	-29.723	-0.042	-9.862	-0.031	-8.500	
10 Delay	+0 ps	-0.235	-50.502	-0.248	-30.401	-0.038	-0.939	-0.001	-11.030	
	+1 ps	-0.228	-50.762	-0.230	-29.000	-0.039	-11.289	-0.052	-9.144	
	+2 ps	-0.241	-50.007	-0.221	-28.934	-0.045	-9.510	-0.040	-10.451	
	+5 ps	-0.232	-56.770	-0.225	-28.393	-0.044	-10.285	-0.036	-7.905	
	-0.03	-0.243	-56.916	-0.229	-29.404	-0.039	-10.310	-0.027	-10.028	
	-0.02	-0.229	-58.337	-0.222	-30.464	-0.029	-5.623	-0.028	-9.841	
Aspect Ratio	-0.01	-0.235	-50.502	-0.225	-29.705	-0.039	-12.495	-0.070	-101.280	
Aspect Ratio	+0.00	-0.235	-50.502	-0.234	-30.820	-0.038	-0.939	-0.054	-9.934	
	+0.01	-0.228	-38.038	-0.220	-51.509	-0.038	-9.545	-0.038	-11.58/	
	+0.02	-0.233	-58.890	-0.228	-29.209	-0.038	-10.984	-0.035	-11.803	
	+0.05	-0.250	-58.067	-0.240	-50.619	-0.041	-8.330	-0.031	-10.055	
	-5 %	-0.255	-57.550	-0.257	-29.5/4	-0.035	-10.812	-0.051	-9.890	
	-2 %	-0.230	-5/.392	-0.224	-28.910	-0.037	-/./55	-0.022	-8.901	
Placement Util	-1%	-0.227	-56.38/	-0.224	-29.526	-0.037	-8.4//	-0.023	-/./6/	
i lacement Oth	+0 %	-0.235	-56.502	-0.243	-30.5/1	-0.038	-8.939	-0.036	-9.819	
	+1%	-0.237	-57.808	-0.227	-30./8/	-0.044	-11.394	-0.058	-10.013	
	+2%	-0.239	-59.136	-0.231	-30.060	-0.042	-12.405	-0.034	-10.882	
	+3 %	-0.233	-56.937	-0.231	-30.093	-0.039	-9.086	-0.027	-12.468	
Best	-	-0.227	-55.345	-0.220	-28.393	-0.029	-5.623	-0.022	-7.406	
Worst	-	-0.250	-59.136	-0.248	-32.322	-0.064	-14.466	-0.070	-101.280	
Delta	-	0.023	3.791	0.028	3.929	0.035	8.843	0.048	93.874	
	1	1	SweRV	wrapper			Black	Parrot		
Parameter	Noise (A)	P&I	SweRV_	wrapper	<b>R</b> 2	D.g.	Black	Parrot	R 2	
Parameter	Noise ( $\Delta$ )	P&I	SweRV_ R_1	wrapper P&	$R_2$	P&	Black	Parrot	$R_2$	
Parameter	Noise (Δ)	P&I WNS (ns)	SweRV_ R_1 TNS (ns)	wrapper P& WNS (ns)	R_2   TNS (ns)	P& WNS (ns)	Black R_1 TNS (ns)	Parrot P& WNS (ns)	R_2 ∣TNS (ns)	
Parameter	Noise ( $\Delta$ )	P&I WNS (ns) -0.257	SweRV_ R_1 TNS (ns) -339.301	wrapper P& WNS (ns) -0.502	R_2 TNS (ns) -278.424	P& WNS (ns) -0.123	Black R_1 TNS (ns) -15.197	Parrot P& WNS (ns) -0.194	R_2 TNS (ns) -60.090	
Parameter	Noise (Δ) -3 ps -2 ps	P&I WNS (ns) -0.257 -0.225	SweRV_ R_1 TNS (ns) -339.301 -291.141	wrapper P& WNS (ns) -0.502 -0.793	R_2 TNS (ns) -278.424 -241.234	P& WNS (ns) -0.123 -0.126	Black R_1 TNS (ns) -15.197 -49.392	Parrot P& WNS (ns) -0.194 -0.107	R_2 TNS (ns) -60.090 -41.889	
Parameter	Noise (Δ) -3 ps -2 ps -1 ps	P&1 WNS (ns) -0.257 -0.225 -0.265	SweRV_ R_1 TNS (ns) -339.301 -291.141 -336.346	wrapper P&: WNS (ns) -0.502 -0.793 -0.682	R_2 TNS (ns) -278.424 -241.234 -280.573	P& WNS (ns) -0.123 -0.126 -0.139	Black R_1 TNS (ns) -15.197 -49.392 -18.283	Parrot P& WNS (ns) -0.194 -0.107 -0.122	R_2 TNS (ns) -60.090 -41.889 -64.540	
Parameter Clock Period	Noise (Δ) -3 ps -2 ps -1 ps +0 ps	P&1 WNS (ns) -0.257 -0.225 -0.265 -0.204	SweRV_ R_1 TNS (ns) -339.301 -291.141 -336.346 -244.887	wrapper P&: WNS (ns) -0.502 -0.793 -0.682 -0.566 -0.566	R_2 TNS (ns) -278.424 -241.234 -280.573 -163.356	P& WNS (ns) -0.123 -0.126 -0.139 -0.128	Black R_1 TNS (ns) -15.197 -49.392 -18.283 -21.676	Parrot P&: WNS (ns) -0.194 -0.107 -0.122 -0.121 -0.121	R_2 TNS (ns) -60.090 -41.889 -64.540 -32.079	
Parameter Clock Period	Noise (Δ) -3 ps -2 ps -1 ps +0 ps +1 ps	P&I WNS (ns) -0.257 -0.225 -0.265 -0.204 -0.212 -0.212	SweRV_ R_1 TNS (ns) -339.301 -291.141 -336.346 -244.887 -287.519	wrapper P&: WNS (ns) -0.502 -0.793 -0.682 -0.566 -0.608	R_2 TNS (ns) -278.424 -241.234 -280.573 -163.356 -205.182	P& WNS (ns) -0.123 -0.126 -0.139 -0.128 -0.111	Black R_1 TNS (ns) -15.197 -49.392 -18.283 -21.676 -10.723	Parrot P& WNS (ns) -0.194 -0.107 -0.122 -0.121 -0.108	R_2 TNS (ns) -60.090 -41.889 -64.540 -32.079 -45.347	
Parameter Clock Period	Noise (Δ) -3 ps -2 ps -1 ps +0 ps +1 ps +2 ps	P&I WNS (ns) -0.257 -0.265 -0.204 -0.212 -0.224	SweRV_ R_1 -339.301 -291.141 -336.346 -244.887 -287.519 -318.609	wrapper P& WNS (ns) -0.502 -0.793 -0.682 -0.566 -0.608 -0.710	R_2 TNS (ns) -278.424 -241.234 -280.573 -163.356 -205.182 -228.354 -228.354	P& WNS (ns) -0.123 -0.126 -0.139 -0.128 -0.111 -0.159	Black R_1 TNS (ns) -15.197 -49.392 -18.283 -21.676 -10.723 -50.867	Parrot P& WNS (ns) -0.194 -0.107 -0.122 -0.121 -0.108 -0.167	R_2 TNS (ns) -60.090 -41.889 -64.540 -32.079 -45.347 -78.630	
Parameter Clock Period	Noise (Δ) -3 ps -2 ps -1 ps +0 ps +1 ps +2 ps +3 ps	P&l WNS (ns) -0.257 -0.265 -0.265 -0.204 -0.212 -0.224 -0.216	SweRV_ R_1 -339.301 -291.141 -336.346 -244.887 -287.519 -318.609 -245.109	wrapper P& WNS (ns) -0.502 -0.793 -0.682 -0.566 -0.608 -0.710 -0.528	R_2 TNS (ns) -278.424 -241.234 -280.573 -163.356 -205.182 -228.354 -232.646	P& WNS (ns) -0.123 -0.126 -0.139 -0.128 -0.111 -0.159 -0.115 -0.115	Black R_1 TNS (ns) -15.197 -49.392 -18.283 -21.676 -10.723 -50.867 -7.891	Parrot P&: WNS (ns) -0.194 -0.107 -0.122 -0.121 -0.108 -0.167 -0.115	R_2 TNS (ns) -60.090 -41.889 -64.540 -32.079 -45.347 -78.630 -32.865	
Parameter Clock Period	Noise (Δ) -3 ps -2 ps -1 ps +0 ps +1 ps +2 ps +3 ps -3 ps	P&1 WNS (ns) -0.257 -0.265 -0.265 -0.204 -0.212 -0.224 -0.216 -0.221	SweRV_ R_1 TNS (ns) -339.301 -291.141 -336.346 -244.887 -287.519 -318.609 -245.109 -347.686	wrapper P&: WNS (ns) -0.502 -0.793 -0.682 -0.566 -0.608 -0.710 -0.528 -0.679	R_2 TNS (ns) -278.424 -241.234 -280.573 -163.356 -205.182 -228.354 -228.354 -228.354 -232.646 -211.716	P& WNS (ns) -0.123 -0.126 -0.139 -0.128 -0.111 -0.159 -0.115 -0.135	Black R_1 TNS (ns) -15.197 -49.392 -18.283 -21.676 -10.723 -50.867 -7.891 -118.041	Parrot P&: WNS (ns) -0.194 -0.107 -0.122 -0.121 -0.108 -0.167 -0.115 -0.111	R_2 TNS (ns) -60.090 -41.889 -64.540 -32.079 -45.347 -78.630 -32.865 -31.143	
Parameter Clock Period	Noise (Δ) -3 ps -2 ps -1 ps +0 ps +1 ps +2 ps +3 ps -3 ps -2 ps	P& WNS (ns) -0.257 -0.225 -0.265 -0.204 -0.212 -0.224 -0.216 -0.221 -0.210	SweRV_ R_1 TNS (ns) -339.301 -291.141 -336.346 -244.887 -287.519 -318.609 -445.109 -347.686 -265.114	wrapper P&: WNS (ns) -0.502 -0.793 -0.682 -0.566 -0.608 -0.710 -0.528 -0.679 -0.619 -0.619	R_2 TNS (ns) -278.424 -241.234 -280.573 -163.356 -205.182 -228.354 -232.646 -211.716 -211.716	P& WNS (ns) -0.123 -0.126 -0.139 -0.128 -0.111 -0.159 -0.115 -0.135 -0.104	Black R_1 TNS (ns) -15.197 -49.392 -18.283 -21.676 -10.723 -50.867 -7.891 -118.041 -15.631	Parrot P&: WNS (ns) -0.194 -0.107 -0.122 -0.121 -0.108 -0.167 -0.115 -0.111 -0.117	R_2 TNS (ns) -60.090 -41.889 -64.540 -32.079 -45.347 -78.630 -32.865 -31.143 -42.325	
Parameter Clock Period	Noise (Δ) -3 ps -2 ps -1 ps +0 ps +1 ps +2 ps +3 ps -3 ps -2 ps -1 ps	P&2 WNS (ns) -0.257 -0.225 -0.265 -0.204 -0.212 -0.224 -0.216 -0.221 -0.221 -0.221 -0.221	SweRV_ R_1 TNS (ns) -339.301 -291.141 -336.346 -244.887 -287.519 -318.609 -245.109 -347.686 -265.114 -285.039 -245.039 -245.039 -245.049 -24	wrapper P& WNS (ns) -0.502 -0.793 -0.682 -0.566 -0.608 -0.710 -0.528 -0.679 -0.619 -0.602 -0.602	R_2 TNS (ns) -278.424 -241.234 -280.573 -163.356 -205.182 -228.354 -232.646 -211.716 -169.827 -259.697	P& WNS (ns) -0.123 -0.126 -0.139 -0.128 -0.111 -0.159 -0.115 -0.104 -0.145 -0.104	Black R_1 TNS (ns) -15.197 -49.392 -18.283 -21.676 -10.723 -50.867 -7.891 -118.041 -15.631 -69.956 91.777	Parrot P&: WNS (ns) -0.194 -0.107 -0.122 -0.121 -0.108 -0.167 -0.115 -0.111 -0.117 -0.117 -0.117	R_2 TNS (ns) -60.090 -41.889 -64.540 -32.079 -45.347 -78.630 -32.865 -31.143 -42.325 -48.378	
Parameter Clock Period Clock Uncertainty	Noise (Δ) -3 ps -2 ps -1 ps +0 ps +1 ps +2 ps +3 ps -3 ps -2 ps -1 ps +0 ps +1 ps +0 ps +3 ps -2 ps -1 ps +0 ps +1 ps +0 ps +0 ps +1 ps +0	P&3 WNS (ns) -0.257 -0.225 -0.265 -0.204 -0.212 -0.224 -0.216 -0.221 -0.221 -0.220 -0.220 -0.236 -0.204	SweRV_ R_1 -339.301 -291.141 -336.346 -244.887 -287.519 -318.609 -245.109 -347.686 -265.114 -285.039 -244.887 -284.887 -285.039 -244.887 -285.039 -244.887 -285.039 -244.887 -285.039 -244.887 -285.039 -244.887 -285.039 -244.887 -285.039 -244.887 -285.039 -244.887 -285.039 -244.887 -285.039 -244.887 -285.039 -244.887 -285.039 -244.887 -285.039 -244.887 -285.039 -244.887 -285.039 -244.887 -285.039 -24	wrapper P& WNS (ns) -0.502 -0.793 -0.682 -0.566 -0.608 -0.710 -0.528 -0.679 -0.619 -0.602 -0.580 -0.580	R_2 TNS (ns) -278.424 -241.234 -280.573 -163.356 -205.182 -228.354 -232.646 -211.716 -169.827 -259.697 -180.897 -259.697	P& WNS (ns) -0.123 -0.126 -0.139 -0.128 -0.111 -0.159 -0.115 -0.135 -0.104 -0.145 -0.128	Black R_1 TNS (ns) -15.197 -49.392 -18.283 -21.676 -10.723 -50.867 -7.891 -118.041 -5.631 -69.956 -21.676 -21.676	Parrot P&: WNS (ns) -0.194 -0.107 -0.102 -0.121 -0.108 -0.167 -0.115 -0.111 -0.117 -0.117 -0.117 -0.119	R_2 TNS (ns) -60.090 -41.889 -64.540 -32.079 -45.347 -78.630 -32.865 -31.143 -42.325 -48.378 -29.889 -29.889 -29.889	
Parameter Clock Period Clock Uncertainty	Noise (Δ) -3 ps -2 ps -1 ps +0 ps +1 ps +2 ps -3 ps -2 ps -1 ps +0 ps +1 ps +1 ps +2 ps -3 ps -2 ps -1 ps -2 ps -1 ps -2 ps -1 ps +1 ps +2 ps -3 ps -2 ps -1 ps +2 ps -3 ps -2 ps -3 ps -2 ps -1 ps +2 ps -3 ps -2 ps -1 ps -1 ps -2 ps -1 ps -2 ps -1 ps -1 ps -2 ps -1 ps -1 ps -2 ps -1 ps -1 ps -1 ps -2 ps -1 p	P&3 WNS (ns) -0.257 -0.205 -0.205 -0.204 -0.212 -0.224 -0.216 -0.221 -0.221 -0.236 -0.204 -0.204 -0.207	SweRV R 1 -393.301 -391.411 -336.346 -244.887 -287.519 -318.609 -245.109 -347.686 -265.114 -285.039 -244.887 -332.116 -244.887 -332.116 -244.887 -332.116 -244.887 -332.116 -244.887 -332.116 -244.887 -332.116 -244.887 -245.039 -244.887 -245.039 -244.887 -245.039 -244.887 -245.039 -245	wrapper P& WNS (ns) -0.502 -0.793 -0.682 -0.668 -0.608 -0.710 -0.528 -0.679 -0.602 -0.580 -0.561 -0.561 -0.561	R_2 TNS (ns) -278.424 -241.234 -280.573 -163.356 -205.182 -228.354 -232.646 -211.716 -169.827 -259.697 -180.897 -290.598 -290.598	P& WNS (ns) -0.123 -0.126 -0.139 -0.128 -0.111 -0.159 -0.115 -0.135 -0.104 -0.145 -0.128 -0.128 -0.139	Black R_1 TNS (ns) -15.197 -49.392 -18.283 -21.676 -10.723 -50.867 -7.891 -118.041 -15.631 -69.956 -21.676 -24.162 -24.162	Parrot P&: WNS (ns) -0.194 -0.107 -0.122 -0.121 -0.108 -0.167 -0.115 -0.111 -0.117 -0.117 -0.119 -0.143	R_2 TNS (ns) -60.090 -41.889 -64.540 -32.079 -45.347 -78.630 -32.865 -31.143 -42.325 -48.378 -29.889 -32.522 -32.522	
Parameter Clock Period Clock Uncertainty	Noise (Δ) -3 ps -2 ps -1 ps +0 ps +1 ps +2 ps +3 ps -3 ps -2 ps -1 ps +0 ps +1 ps +2 ps +3 ps -2 ps -1 ps +0 ps +2 ps -1 ps +0 ps +2 ps -2 ps -1 ps +2 ps -2 ps -1 ps +2 ps -2 ps -2 ps -1 ps +2 ps -2 p	P&2 WNS (ns) -0.257 -0.225 -0.204 -0.212 -0.224 -0.212 -0.221 -0.221 -0.221 -0.221 -0.220 -0.207 -0.204 -0.207 -0.254	SweRV R_1 -339.301 -291.141 -336.346 -244.887 -287.519 -318.609 -245.109 -347.686 -265.114 -285.039 -244.887 -332.116 -315.494 -332.116	wrapper P& WNS (ns) -0.502 -0.502 -0.682 -0.668 -0.608 -0.710 -0.528 -0.679 -0.619 -0.602 -0.580 -0.561 -0.620 -0.561 -0.620	R_2 TNS (ns) -278.424 -241.234 -280.573 -163.356 -205.182 -228.354 -232.646 -1159.827 -259.697 -180.897 -290.598 -282.778 -290.598 -282.778	P& WNS (ns) -0.123 -0.126 -0.139 -0.128 -0.111 -0.159 -0.115 -0.104 -0.145 -0.128 -0.128 -0.123 -0.123 -0.123	Black R_1 TNS (ns) -15.197 -49.392 -18.283 -21.676 -10.723 -50.867 -7.891 -118.041 -15.631 -69.956 -21.676 -24.162 -23.965 -23.965	Parrot P&: WNS (ns) -0.194 -0.107 -0.122 -0.121 -0.108 -0.167 -0.115 -0.117 -0.117 -0.117 -0.119 -0.143 -0.154	R_2 TNS (ns) -60.090 -41.889 -64.540 -32.079 -45.347 -78.630 -32.865 -31.143 -42.325 -48.378 -29.889 -32.522 -30.463	
Parameter Clock Period Clock Uncertainty	Noise (Δ) -3 ps -2 ps -1 ps +0 ps +1 ps +2 ps -3 ps -2 ps -1 ps +0 ps +1 ps +2 ps +3 ps -3 ps -2 ps -3 ps -2 ps -3 ps -3 ps -3 ps -3 ps -3 ps -3 ps -2 ps -3 ps -3 ps -3 ps -3 ps -2 ps -3 ps -3 ps -3 ps -2 ps -3 ps -3 ps -3 ps -2 ps -3 ps -3 ps -2 ps -1 ps +0 ps +0 ps +0 ps -3 ps -2 ps -1 ps +0 ps +0 ps -2 ps -1 ps +0 ps +0 ps +0 ps -2 ps -1 ps +0 ps +1 ps +0 ps +1 ps +0 ps +0 ps +1 ps +0 ps +0 ps +1 ps +0 ps +1 ps +3 ps -3 ps -2 ps -3 p	P&2 WNS (ns) -0.257 -0.265 -0.204 -0.212 -0.224 -0.221 -0.221 -0.221 -0.221 -0.226 -0.204 -0.207 -0.207 -0.254 -0.233	SweRV_ R_1 -339.301 -291.141 -336.346 -244.887 -287.519 -318.609 -245.109 -347.686 -265.114 -285.039 -244.887 -332.116 -315.494 -328.919	wrapper P& WNS (ns) -0.502 -0.793 -0.682 -0.566 -0.608 -0.710 -0.528 -0.679 -0.619 -0.602 -0.580 -0.561 -0.620 -0.871	R_2 TNS (ns) -278.424 -241.234 -280.573 -163.356 -205.182 -228.354 -232.646 -169.827 -259.697 -180.897 -290.598 -282.778 -252.655	P& WNS (ns) -0.123 -0.126 -0.139 -0.128 -0.111 -0.159 -0.115 -0.135 -0.104 -0.145 -0.128 -0.139 -0.123 -0.123 -0.123 -0.123 -0.123	Black R_1 TNS (ns) -15.197 -49.392 -18.283 -21.676 -10.723 -50.867 -7.891 -118.041 -5.631 -69.956 -21.676 -24.162 -23.965 -11.075 -11.075	Parrot P&: WNS (ns) -0.194 -0.107 -0.102 -0.121 -0.108 -0.167 -0.115 -0.117 -0.117 -0.117 -0.119 -0.143 -0.154 -0.154 -0.112	R_2 TNS (ns) -60.090 -41.889 -64.540 -32.079 -45.347 -78.630 -32.865 -31.143 -42.325 -48.378 -29.889 -32.522 -30.463 -39.416	
Parameter Clock Period Clock Uncertainty	Noise (Δ) -3 ps -2 ps -1 ps +0 ps +1 ps +2 ps -3 ps -2 ps -1 ps +0 ps +1 ps +2 ps -3 ps -3 ps -2 ps -3 p	P&2 WNS (ns) -0.257 -0.205 -0.204 -0.212 -0.224 -0.212 -0.221 -0.221 -0.221 -0.236 -0.204 -0.204 -0.254 -0.233 -0.225	SweRV R 1 -39.301 -291.141 -336.346 -244.887 -287.519 -318.609 -245.109 -347.686 -265.114 -285.039 -244.887 -332.116 -315.494 -328.919 -279.308 -279.308	wrapper P& WNS (ns) -0.502 -0.793 -0.682 -0.668 -0.608 -0.710 -0.528 -0.679 -0.619 -0.602 -0.580 -0.561 -0.620 -0.578 -0.578	R_2 TNS (ns) -278.424 -241.234 -280.573 -163.356 -205.182 -228.354 -232.646 -211.716 -169.827 -259.697 -180.897 -290.598 -282.778 -222.655 -224.9777 -244.9777 -244.9777 -245.977 -245.9777 -245.97	P&: WNS (ns) -0.123 -0.126 -0.139 -0.128 -0.111 -0.159 -0.115 -0.135 -0.104 -0.145 -0.128 -0.128 -0.123 -0.123 -0.121 -0.123 -0.123	Black 1 TNS (ns) -15.197 -49.392 -18.283 -21.676 -10.723 -50.867 -7.891 -118.041 -15.631 -69.956 -21.676 -24.162 -23.965 -11.075 -13.286 -52.609	Parrot P&: WNS (ns) -0.194 -0.107 -0.122 -0.121 -0.108 -0.167 -0.111 -0.117 -0.117 -0.119 -0.154 -0.154 -0.131 -0.131	R_2 TNS (ns) -60.090 -41.889 -64.540 -32.079 -45.347 -78.630 -32.865 -31.143 -42.325 -48.378 -29.889 -32.522 -30.463 -39.416 -50.011 -50.011	
Parameter Clock Period Clock Uncertainty	Noise (Δ) -3 ps -2 ps -1 ps +0 ps +1 ps +2 ps +3 ps -3 ps -2 ps -1 ps +0 ps +1 ps +2 ps +3 ps -2 ps -1 ps -2 ps -1 ps +0 ps +0 ps +1 ps +2 ps -2 ps	P&2 WNS (ns) -0.257 -0.225 -0.204 -0.212 -0.224 -0.212 -0.221 -0.221 -0.221 -0.221 -0.221 -0.221 -0.207 -0.204 -0.207 -0.233 -0.225 -0.242 -0.242	SweRV R 1 -339.301 -291.141 -336.346 -244.887 -244.887 -245.109 -347.686 -245.109 -347.686 -265.114 -285.039 -244.887 -332.116 -315.494 -328.919 -279.308 -313.851 -279.308 -313.851 -299.308 -299.508 -299	wrapper P& WNS (ns) -0.502 -0.793 -0.682 -0.668 -0.608 -0.710 -0.528 -0.679 -0.619 -0.602 -0.580 -0.561 -0.620 -0.871 -0.578 -0.451 -0.578	R_2 TNS (ns) -278.424 -241.234 -280.573 -163.356 -205.182 -228.354 -232.646 -211.716 -169.827 -259.697 -180.897 -259.697 -282.778 -252.655 -224.977 -225.109	P& WNS (ns) -0.123 -0.126 -0.139 -0.128 -0.111 -0.159 -0.115 -0.104 -0.145 -0.128 -0.128 -0.123 -0.123 -0.123 -0.1247 -0.147 -0.147	Black R_1 TNS (ns) -15.197 -49.392 -18.283 -21.676 -10.723 -50.867 -7.891 -118.041 -15.631 -69.956 -21.676 -24.162 -23.965 -11.075 -11.075 -11.075 -13.286 -58.600	Parrot P&: WNS (ns) -0.194 -0.107 -0.122 -0.121 -0.108 -0.167 -0.115 -0.117 -0.117 -0.119 -0.143 -0.154 -0.112 -0.111 -0.112 -0.113 -0.111 -0.111 -0.112	R_2 TNS (ns) -60.090 -41.889 -64.540 -32.079 -45.347 -78.630 -32.865 -31.143 -42.325 -48.378 -29.889 -32.522 -30.463 -39.416 -50.011 -84.830	
Parameter Clock Period Clock Uncertainty	Noise (Δ) -3 ps -2 ps -1 ps +0 ps +1 ps +2 ps +3 ps -3 ps -2 ps -1 ps +0 ps +1 ps +2 ps +3 ps -3 ps -2 ps -1 ps +0 ps +1 ps +2 ps -1 ps +0 ps +1 ps +2 ps -1 ps +0 ps +1 ps +2 ps +1 ps +2 ps -1 ps +0 ps +1 ps +2 ps -1 ps +0 ps +1 ps +2 ps -1 ps +0 ps +1 ps +2 ps -1 ps +0 ps +1 ps +2 ps -1 ps +2 ps -1 ps +2 ps -1 ps +3 ps -2 ps -1 ps +2 ps -1 p	P&2 WNS (ns) -0.257 -0.225 -0.265 -0.204 -0.212 -0.224 -0.216 -0.221 -0.221 -0.221 -0.221 -0.221 -0.224 -0.204 -0.207 -0.254 -0.225 -0.242 -0.225 -0.242 -0.254 -0.225	SweRV R 1 -339.301 -291.141 -336.346 -244.887 -287.519 -318.609 -245.109 -347.686 -265.114 -285.039 -244.887 -332.116 -315.494 -328.919 -279.308 -313.851 -332.225 -344.697	wrapper P&: WNS (ns) -0.793 -0.682 -0.566 -0.608 -0.710 -0.528 -0.679 -0.619 -0.602 -0.580 -0.561 -0.620 -0.578 -0.451 -0.724	R_2 TNS (ns) -278.424 -241.234 -280.573 -163.356 -205.182 -228.354 -232.646 -211.716 -169.827 -259.697 -180.897 -290.598 -282.778 -252.655 -224.977 -225.109 -215.154	P& WNS (ns) -0.123 -0.126 -0.139 -0.128 -0.111 -0.159 -0.115 -0.104 -0.145 -0.104 -0.123 -0.141 -0.147 -0.147 -0.147 -0.152	Black 1 TNS (ns) -15.197 -49.392 -18.283 -21.676 -10.723 -50.867 -7.891 -118.041 -15.631 -69.956 -21.676 -24.162 -23.965 -11.075 -13.286 -3.2860 -44.178 -58.600 -44.178 -58.600 -44.178 -1.779	Parrot P&: WNS (ns) -0.194 -0.107 -0.122 -0.121 -0.108 -0.167 -0.115 -0.117 -0.117 -0.117 -0.117 -0.114 -0.143 -0.154 -0.131 -0.131 -0.094	R_2 TNS (ns) -60.090 -41.889 -64.540 -32.079 -45.347 -78.630 -32.865 -31.143 -42.325 -48.378 -29.889 -32.522 -30.463 -39.416 -50.011 -84.830 -28.919 -84.91	
Parameter Clock Period Clock Uncertainty IO Delay	Noise (Δ) -3 ps -2 ps -1 ps +0 ps +1 ps +2 ps -3 ps -2 ps -1 ps +0 ps +1 ps +2 ps -3 ps -2 ps -1 ps -3 ps -2 ps -1 ps -1 ps -2 ps -2 ps -1 ps -2 ps -2 ps -1 ps -2 ps -2 ps -3 ps -2 ps -2 ps -3 ps -2 ps -1 ps -1 ps -2 ps -1 ps -1 ps -1 ps -1 ps -1 ps -1 ps	P&2 WNS (ns) -0.257 -0.205 -0.204 -0.212 -0.224 -0.216 -0.221 -0.221 -0.226 -0.204 -0.207 -0.254 -0.203 -0.225 -0.242 -0.250 -0.204	SweRV R 1 TNS (ns) -339.301 -291.141 -336.346 -244.887 -287.519 -318.609 -245.109 -347.686 -265.114 -285.039 -244.887 -332.116 -315.494 -328.919 -279.308 -313.851 -332.225 -244.887	wrapper P& WNS (ns) -0.502 -0.793 -0.682 -0.668 -0.608 -0.710 -0.528 -0.679 -0.619 -0.602 -0.580 -0.561 -0.620 -0.561 -0.578 -0.451 -0.724 -0.566	R_2 TNS (ns) -278.424 -241.234 -280.573 -163.356 -205.182 -228.354 -232.646 -211.716 -169.827 -259.697 -290.598 -282.778 -282.778 -222.655 -224.977 -225.109 -215.154 -170.578	P&: WNS (ns) -0.123 -0.126 -0.139 -0.128 -0.111 -0.159 -0.115 -0.135 -0.104 -0.145 -0.128 -0.123 -0.123 -0.123 -0.123 -0.123 -0.141 -0.147 -0.152 -0.125 -0.128	Black I I TNS (ns) -15.197 -49.392 -18.283 -21.676 -10.723 -50.867 -7.891 -118.041 -15.631 -69.956 -21.676 -24.162 -23.965 -11.075 -13.286 -58.600 -44.178 -21.278 -21.278	Parrot P&: WNS (ns) -0.194 -0.107 -0.122 -0.121 -0.108 -0.167 -0.115 -0.111 -0.117 -0.119 -0.143 -0.154 -0.112 -0.131 -0.111 -0.094 -0.112	R_2 TNS (ns) -60.090 -41.889 -64.540 -32.079 -45.347 -78.630 -32.865 -31.143 -42.325 -48.378 -32.522 -30.463 -39.416 -50.011 -84.830 -28.919 -61.921 -64.921 -64.921 -64.921 -64.921 -64.921 -64.921 -64.921 -64.921 -64.921 -64.94 -64.94 -64.94 -64.94 -64.94 -64.94 -64.94 -64.94 -64.94 -64.94 -64.94 -64.94 -64.94 -78.630 -32.079 -31.143 -42.325 -48.378 -32.522 -30.463 -39.416 -50.011 -84.830 -28.919 -61.921 -64.94 -64.94 -64.94 -78.630 -79.750 -78.630 -79.750 -78.630 -79.7500 -79.750 -79.750 -79.75000 -79.75000 -79.75000 -79.75000 -79.75000 -79.75000 -79.75000 -79.75000 -79.75000 -79.75000 -79.75000 -79.750000 -79.750000 -79.75000 -79.750000000 -79.750000000000000000000000	
Parameter Clock Period Clock Uncertainty IO Delay	Noise (Δ) -3 ps -2 ps -1 ps +0 ps +1 ps +2 ps +3 ps -2 ps -1 ps +0 ps +1 ps +2 ps +3 ps -2 ps -1 ps +1 ps +2 ps +3 ps -2 ps -1 ps +0 ps +1 ps +2 ps +1 ps +2 ps +1 ps +2 ps -1 ps +0 ps +0 ps +0 ps +1 ps +2 ps -1 ps +1 ps +2 ps -1 ps +0 ps +1 ps +2 ps +1 ps +2 ps -1 ps +0 ps +1 ps +2 ps -2 ps -1 ps -2 ps -1 ps -2 ps -1 ps -2 ps -1 ps -2 ps -1 ps	P&2 WNS (ns) -0.257 -0.225 -0.204 -0.212 -0.224 -0.212 -0.221 -0.221 -0.221 -0.221 -0.210 -0.236 -0.204 -0.207 -0.254 -0.233 -0.225 -0.242 -0.250 -0.204 -0.250 -0.204 -0.204 -0.240 -0.240 -0.240 -0.240 -0.255 -0.245 -0.245 -0.255 -0.245 -0.255 -0.255 -0.245 -0.215 -0.215 -0.215 -0.215 -0.215 -0.215 -0.215 -0.215 -0.215 -0.215 -0.215 -0.215 -0.215 -0.215 -0.215 -0.225 -0.225 -0.225 -0.225 -0.204 -0.212 -0.212 -0.225 -0.225 -0.225 -0.225 -0.204 -0.212 -0.225 -0.255 -0.	SweRV R 1 -339.301 -291.141 -336.346 -244.887 -287.519 -318.609 -245.109 -347.686 -265.114 -285.039 -244.887 -332.116 -315.494 -279.308 -313.851 -332.225 -244.887 -291.155 -291	wrapper P& WNS (ns) -0.502 -0.793 -0.682 -0.668 -0.608 -0.710 -0.528 -0.679 -0.619 -0.602 -0.580 -0.561 -0.620 -0.871 -0.578 -0.451 -0.724 -0.566 -0.697	R_2 TNS (ns) -278.424 -241.234 -280.573 -163.356 -205.182 -228.354 -232.646 -211.716 -169.827 -259.697 -282.778 -252.655 -224.977 -225.109 -215.154 -170.578 -179.544	P& WNS (ns) -0.123 -0.126 -0.139 -0.128 -0.111 -0.159 -0.115 -0.104 -0.145 -0.128 -0.128 -0.123 -0.123 -0.123 -0.141 -0.147 -0.128 -0.124 -0.128 -0.124 -0.124 -0.128 -0.124 -0.124 -0.124 -0.124 -0.124 -0.125 -0.125 -0.125 -0.125 -0.125 -0.125 -0.128 -0.111 -0.159 -0.125 -0.104 -0.128 -0.126 -0.128 -0.111 -0.159 -0.128 -0.126 -0.128 -0.111 -0.126 -0.128 -0.111 -0.129 -0.125 -0.104 -0.128 -0.128 -0.128 -0.128 -0.128 -0.128 -0.128 -0.128 -0.128 -0.128 -0.128 -0.128 -0.128 -0.128 -0.128 -0.128 -0.124 -0.128 -0.128 -0.124 -0.128 -0.128 -0.124 -0.128 -0.127 -0.124 -0.128 -0.128 -0.127 -0.147 -0.147 -0.147 -0.147 -0.147 -0.147 -0.147 -0.147 -0.128 -0.1	Black 1 TNS (ns) -15.197 -49.392 -18.283 -21.676 -10.723 -50.867 -7.891 -118.041 -15.631 -69.956 -21.676 -24.162 -23.965 -11.075 -11.075 -13.286 -58.600 -44.178 -58.600 -44.178 -50.005 -20.055 -20.0	Parrot P&: WNS (ns) -0.194 -0.107 -0.122 -0.121 -0.108 -0.167 -0.115 -0.117 -0.117 -0.119 -0.1143 -0.154 -0.112 -0.111 -0.112 -0.111 -0.112 -0.111 -0.112 -0.111 -0.112 -0.111 -0.112 -0.112 -0.112 -0.112 -0.114 -0.112 -0.114 -0.112 -0.114 -0.115 -0.115 -0.115 -0.117 -0.117 -0.117 -0.117 -0.117 -0.119 -0.117 -0.117 -0.117 -0.119 -0.119 -0.117 -0.119 -0.119 -0.110 -0.111 -0.111 -0.119 -0.119 -0.111 -0.111 -0.111 -0.111 -0.112 -0.112 -0.111 -0.112 -0.114 -0.112 -0.112 -0.114 -0.112 -0.114 -0.115 -0.112 -0.112 -0.114 -0.115 -0.112 -0.112 -0.112 -0.114 -0.112 -0.112 -0.112 -0.112 -0.112 -0.112 -0.114 -0.112 -0.112 -0.112 -0.112 -0.112 -0.112 -0.112 -0.112 -0.112 -0.112 -0.112 -0.112 -0.112 -0.112 -0.112 -0.112 -0.112 -0.112 -0.111 -0.112 -0.111 -0.112 -0.114 -0.112 -0.112 -0.114 -0.112 -0.114 -0.112 -0.112 -0.114 -0.112 -0.114 -0.112 -0.114 -0.112 -0.114 -0.112 -0.114 -0.144 -0.144 -0.144 -0.144 -0.144 -0.144	R_2 TNS (ns) -60.090 -41.889 -64.540 -32.079 -45.347 -78.630 -32.865 -31.143 -42.325 -48.378 -29.889 -32.522 -30.463 -39.416 -50.011 -84.830 -28.919 -61.921 -36.972	
Parameter Clock Period Clock Uncertainty IO Delay	Noise (Δ) -3 ps -2 ps -1 ps +0 ps +1 ps +2 ps +3 ps -3 ps -2 ps -1 ps +0 ps +1 ps +2 ps +3 ps -3 ps -3 ps -3 ps -3 ps -2 ps -1 ps +0 ps +1 ps +2 ps +2 ps +1 ps +2 ps +1 ps +2 ps +2 ps +1 ps +2 ps +1 ps +2 ps +1 ps +2 ps +1 ps +2 ps +1 ps +2 ps +1 ps +2 ps +2 ps +1 ps +2 p	P&2 WNS (ns) -0.257 -0.225 -0.265 -0.204 -0.212 -0.224 -0.216 -0.221 -0.221 -0.221 -0.221 -0.221 -0.221 -0.204 -0.204 -0.204 -0.225 -0.242 -0.254 -0.225 -0.242 -0.204 -0.204 -0.204 -0.204 -0.204 -0.204 -0.205	SweRV R 1 -339.301 -291.141 -336.346 -244.887 -287.519 -318.609 -245.109 -347.686 -265.114 -285.039 -244.887 -332.116 -315.494 -328.919 -279.308 -313.851 -332.225 -244.887 -291.155 -289.353 -289.353 -289.353 -289.353 -289.355 -289.555 -289.555 -289.555 -289.555 -289.555 -289.555 -289.555 -289.555 -289.555 -289.555 -289.555 -289.555 -289.555 -289.555 -289.555 -289.555 -289	wrapper P& WNS (ns) -0.502 -0.793 -0.682 -0.566 -0.608 -0.710 -0.528 -0.679 -0.619 -0.602 -0.561 -0.620 -0.578 -0.451 -0.724 -0.5697 -0.538	R_2 TNS (ns) -278.424 -241.234 -280.573 -163.356 -205.182 -228.354 -232.646 -211.716 -169.827 -259.697 -180.897 -259.697 -259.697 -259.697 -259.697 -259.697 -259.697 -10.578 -222.655 -224.977 -225.109 -215.154 -170.578 -170.574 -240.698 -2	P& WNS (ns) -0.123 -0.126 -0.139 -0.128 -0.111 -0.159 -0.115 -0.104 -0.145 -0.128 -0.123 -0.141 -0.147 -0.147 -0.128 -0.128 -0.124 -0.128 -0.128 -0.124 -0.128	Black 1 TNS (ns) -15.197 -49.392 -18.283 -21.676 -10.723 -50.867 -7.891 -118.041 -15.631 -69.956 -21.676 -24.162 -23.965 -11.075 -13.286 -34.162 -58.600 -44.178 -50.005 -31.646 -31	Parrot P&: WNS (ns) -0.194 -0.107 -0.122 -0.121 -0.108 -0.167 -0.115 -0.117 -0.117 -0.117 -0.119 -0.143 -0.154 -0.111 -0.131 -0.111 -0.112 -0.114 -0.112 -0.114 -0.112 -0.114 -0.111 -0.111 -0.114 -0.1114 -0.114	R_2 TNS (ns) -60.090 -41.889 -64.540 -32.079 -45.347 -78.630 -32.865 -31.143 -42.325 -48.378 -29.889 -32.522 -30.463 -39.416 -50.011 -84.830 -28.919 -61.921 -61.921 -36.972 -44.766	
Parameter Clock Period Clock Uncertainty IO Delay	Noise (Δ) -3 ps -2 ps -1 ps +0 ps +1 ps +2 ps -3 ps -2 ps -1 ps +0 ps +1 ps +2 ps -3 ps -2 ps -3 ps -2 ps -3 ps -3 ps -2 ps -1 ps -2 ps -3 ps -3 ps -2 ps -3 ps -3 ps -2 ps -3 ps -3 ps -2 ps -3 ps -2 ps -3 ps -2 ps -3 ps -2 ps -3 ps -3 ps -3 ps -2 p	P&2 WNS (ns) -0.257 -0.205 -0.204 -0.212 -0.224 -0.212 -0.221 -0.221 -0.210 -0.236 -0.204 -0.207 -0.254 -0.242 -0.250 -0.242 -0.250 -0.204 -0.240 -0.204 -0.240 -0.240 -0.240 -0.240 -0.240 -0.240 -0.240 -0.240 -0.240 -0.240 -0.240 -0.255 -0.245 -0.240 -0.255 -0.245 -0.245 -0.245 -0.226 -0.225 -0.226 -0.226 -0.226 -0.226 -0.226 -0.225 -0.225 -0.226 -0.	SweRV R 1 -393.301 -291.141 -336.346 -244.887 -287.519 -318.609 -245.109 -347.686 -265.114 -285.039 -244.887 -332.116 -315.494 -279.308 -313.851 -328.919 -279.308 -313.851 -322.225 -244.887 -291.155 -249.353 -292.142	wrapper P& WNS (ns) -0.502 -0.793 -0.682 -0.566 -0.608 -0.710 -0.528 -0.679 -0.619 -0.602 -0.580 -0.561 -0.620 -0.561 -0.578 -0.451 -0.724 -0.568 -0.697 -0.538 -0.667	R_2 TNS (ns) -278.424 -241.234 -280.573 -163.356 -205.182 -228.354 -228.354 -232.646 -211.716 -169.827 -259.697 -290.598 -282.778 -290.598 -282.778 -252.655 -224.977 -225.109 -215.154 -170.578 -179.544 -170.578 -179.544 -240.698 -331.423	P&: WNS (ns) -0.123 -0.126 -0.139 -0.128 -0.111 -0.159 -0.115 -0.135 -0.104 -0.145 -0.128 -0.123 -0.123 -0.141 -0.147 -0.147 -0.152 -0.128 -0.144 -0.140 -0.1440 -0.1440 -0.123	Black I I TNS (ns) -15.197 -49.392 -18.283 -21.676 -10.723 -50.867 -7.891 -118.041 -15.631 -69.956 -21.676 -24.162 -23.965 -11.075 -13.286 -58.600 -44.178 -21.278 -50.005 -31.646 -26.904	Parrot P&: WNS (ns) -0.194 -0.107 -0.122 -0.121 -0.108 -0.167 -0.115 -0.111 -0.117 -0.119 -0.143 -0.154 -0.112 -0.131 -0.112 -0.112 -0.111 -0.112 -0.112 -0.112 -0.112 -0.112 -0.112 -0.112 -0.112 -0.112 -0.112 -0.112 -0.112 -0.114 -0.115 -0.112 -0.119 -0.125 -0.117 -0.117 -0.119 -0.119 -0.117 -0.119 -0.119 -0.119 -0.119 -0.119 -0.119 -0.119 -0.119 -0.119 -0.119 -0.119 -0.119 -0.111 -0.119 -0.119 -0.119 -0.119 -0.111 -0.119 -0.119 -0.119 -0.119 -0.119 -0.119 -0.119 -0.119 -0.119 -0.119 -0.119 -0.111 -0.119 -0.111 -0.112 -0.111 -0.112 -0.112 -0.112 -0.112 -0.111 -0.112 -0.112 -0.112 -0.112 -0.112 -0.112 -0.114 -0.112 -0.114 -0.112 -0.114 -0.112 -0.114 -0.112 -0.114 -0.144 -0.144 -0.144 -0.144 -0.144 -0.144 -0.144 -0.144 -0.144	R_2 TNS (ns) -60.090 -41.889 -64.540 -32.079 -45.347 -78.630 -32.865 -31.143 -42.325 -48.378 -32.522 -30.463 -39.416 -50.011 -84.830 -28.919 -61.921 -36.972 -44.766 -53.538	
Parameter Clock Period Clock Uncertainty IO Delay	Noise (Δ) -3 ps -2 ps -1 ps +0 ps +1 ps +2 ps +3 ps -2 ps -1 ps +0 ps +1 ps +2 ps +3 ps -2 ps -1 ps +0 ps +1 ps +2 ps -2 ps -1 ps -2 ps -1 ps -2 ps -1 ps -2 ps -1 ps -2 ps -2 ps -1 ps -2 ps -1 ps -2 ps -2 ps -1 ps -2 ps -2 ps -1 ps -2 ps -2 ps -1 ps -2 ps -2 ps -1 ps -2 ps -0 ps -0 02 -0 0	P&2 WNS (ns) -0.257 -0.225 -0.204 -0.212 -0.224 -0.212 -0.224 -0.221 -0.210 -0.220 -0.204 -0.207 -0.250 -0.204 -0.250 -0.260 -0.204 -0.204 -0.204 -0.204 -0.204 -0.204 -0.205 -0.204 -0.205 -0.204 -0.205 -0.	SweRV R 1 -339.301 -291.141 -336.346 -244.887 -287.519 -318.609 -245.109 -347.686 -265.114 -285.039 -244.887 -332.116 -313.5494 -328.919 -279.308 -313.851 -332.225 -244.887 -291.155 -289.353 -292.142 -311.995 -292.142 -311.995 -292.142 -311.995 -292.142 -311.995 -292.142 -311.995 -292.142 -311.995 -292.142 -311.995 -292.142 -311.995 -292.142 -311.995 -292.142 -311.995 -292.142 -311.995 -292.142 -311.995 -292.142 -311.995 -292.142 -311.995 -292.142 -311.995 -292.142 -311.995 -292.142 -311.995 -292.142 -311.995 -292.142 -312.995 -292.142 -312.145 -312.145 -312.145 -312.145 -312.145 -32	wrapper P&: WNS (ns) -0.502 -0.793 -0.682 -0.668 -0.608 -0.710 -0.528 -0.679 -0.619 -0.602 -0.580 -0.561 -0.620 -0.5871 -0.578 -0.451 -0.578 -0.451 -0.578 -0.451 -0.566 -0.697 -0.538 -0.667 -0.572 -0.572	R_2 TNS (ns) -278.424 -241.234 -280.573 -163.356 -205.182 -228.354 -232.646 -211.716 -169.827 -259.697 -180.897 -290.598 -282.778 -252.655 -224.977 -225.109 -215.154 -170.578 -179.544 -240.698 -331.423 -218.755 -228.75 -229.65 -224.977 -225.109 -215.154 -170.578 -179.544 -240.698 -331.423 -218.755 -228.75 -228.55 -224.977 -225.109 -215.154 -240.698 -331.423 -218.755 -228.5	P& WNS (ns) -0.123 -0.126 -0.139 -0.128 -0.111 -0.159 -0.115 -0.104 -0.145 -0.104 -0.145 -0.128 -0.128 -0.123 -0.141 -0.147 -0.147 -0.147 -0.142 -0.128 -0.128 -0.124 -0.123 -0.124 -0.123 -0.124 -0.124 -0.125 -0.124 -0.125 -0.125 -0.125 -0.128 -0.111 -0.159 -0.125 -0.104 -0.128 -0.128 -0.128 -0.111 -0.159 -0.128 -0.1	Black 1 TNS (ns) -15.197 -49.392 -18.283 -21.676 -10.723 -50.867 -7.891 -118.041 -15.631 -69.956 -24.162 -23.965 -11.075 -13.286 -58.600 -44.178 -21.278 -50.005 -31.646 -26.904 -47.975 -37.222	Parrot P&: WNS (ns) -0.194 -0.107 -0.122 -0.121 -0.108 -0.167 -0.115 -0.117 -0.117 -0.117 -0.119 -0.143 -0.154 -0.112 -0.1131 -0.111 -0.112 -0.1131 -0.112 -0.114 -0.112 -0.112 -0.114 -0.112 -0.112 -0.112 -0.112 -0.112 -0.112 -0.112 -0.114 -0.112 -0.112 -0.114 -0.112 -0.112 -0.114 -0.112 -0.114 -0.112 -0.114 -0.112 -0.114 -0.112 -0.114 -0.112 -0.114 -0.112 -0.114 -0.112 -0.114 -0.112 -0.114 -0.112 -0.114 -0.112 -0.114 -0.112 -0.114 -0.112 -0.114 -0.112 -0.114 -0.112 -0.114 -0.112 -0.114 -0.144 -0.144 -0.144 -0.144 -0.144 -0.144 -0.144 -0.14	R_2 TNS (ns) -60.090 -41.889 -64.540 -32.079 -45.347 -78.630 -32.865 -31.143 -42.325 -48.378 -29.889 -32.522 -30.463 -39.416 -50.011 -84.830 -28.919 -61.921 -36.972 -44.766 -53.538 -77.5339 -77.5339	
Parameter Clock Period Clock Uncertainty IO Delay	Noise (Δ) -3 ps -2 ps -1 ps +0 ps +1 ps +2 ps +3 ps -3 ps -2 ps -1 ps +0 ps +1 ps +2 ps +3 ps -3 ps -1 ps -0 ps -1 ps -0 ps -0 ps -0 ps -0 ps -0 03 -0.02 -0.03 -0.02	P&2 WNS (ns) -0.257 -0.225 -0.204 -0.212 -0.224 -0.212 -0.224 -0.210 -0.221 -0.221 -0.221 -0.221 -0.207 -0.204 -0.207 -0.255 -0.242 -0.204 -0.204 -0.204 -0.204 -0.204 -0.217 -0.217 -0.216 -0.217 -0.216 -0.217 -0.216 -0.217 -0.225 -0.226 -0.226 -0.227 -0.225 -0.225 -0.225 -0.226 -0.226 -0.227 -0.225 -0.225 -0.225 -0.226 -0.226 -0.226 -0.225 -0.225 -0.226 -0.227 -0.226 -0.226 -0.227 -0.226 -0.226 -0.227 -0.226 -0.226 -0.227 -0.226 -0.227 -0.226 -0.227 -0.226 -0.227 -0.226 -0.226 -0.227 -0.226 -0.226 -0.227 -0.226 -0.226 -0.227 -0.226 -0.227 -0.226 -0.227 -0.226 -0.227 -0.227 -0.226 -0.227 -0.227 -0.226 -0.227 -0.226 -0.227 -0.227 -0.226 -0.227 -0.227 -0.226 -0.227 -0.227 -0.227 -0.227 -0.227 -0.227 -0.227 -0.227 -0.227 -0.227 -0.227 -0.226 -0.227 -0.227 -0.226 -0.227 -0.227 -0.227 -0.227 -0.227 -0.227 -0.227 -0.227 -0.227 -0.277 -0.277 -0.277 -0.277 -0.277 -0.277 -0.275 -0.277 -0.275 -0.	SweRV R 1 -339.301 -291.141 -336.346 -244.887 -287.519 -318.609 -245.109 -245.109 -245.109 -245.104 -265.114 -285.039 -244.887 -332.116 -315.494 -328.919 -279.308 -313.851 -332.225 -244.887 -291.155 -289.353 -292.142 -311.995 -338.009 -349.009 -349	wrapper P&: WNS (ns) -0.502 -0.502 -0.622 -0.668 -0.608 -0.710 -0.528 -0.679 -0.619 -0.620 -0.561 -0.620 -0.571 -0.578 -0.451 -0.578 -0.566 -0.697 -0.538 -0.667 -0.572 -0.572 -0.572 -0.708	R_2 TNS (ns) -278.424 -241.234 -280.573 -163.356 -205.182 -228.354 -232.646 -1159.827 -259.697 -180.897 -259.697 -259.697 -259.697 -259.697 -259.657 -224.977 -251.154 -725.109 -215.154 -240.698 -31.423 -218.755 -208.655 -208.655 -209.651 -209.651 -209.658 -218.755 -209.651 -209.651 -209.658 -218.755 -209.651 -209.655 -	P& WNS (ns) -0.123 -0.126 -0.139 -0.128 -0.111 -0.159 -0.115 -0.104 -0.145 -0.128 -0.128 -0.128 -0.128 -0.123 -0.141 -0.147 -0.128 -0.128 -0.128 -0.124 -0.128 -0.128 -0.124 -0.123 -0.114 -0.123 -0.114 -0.123 -0.114 -0.115	Black 1 TNS (ns) -15.197 -49.392 -18.283 -21.676 -10.723 -50.867 -7.891 -118.041 -15.631 -69.956 -24.162 -23.965 -11.075 -13.286 -32.278 -58.600 -44.178 -12.278 -50.005 -31.646 -26.904 -47.975 -37.853 -37	Parrot P&: WNS (ns) -0.194 -0.107 -0.122 -0.121 -0.108 -0.167 -0.115 -0.117 -0.117 -0.117 -0.117 -0.113 -0.143 -0.112 -0.114 -0.112 -0.114 -0.112 -0.123 -0.114 -0.121 -0.124 -0.124 -0.124 -0.121 -0.124 -0.124 -0.124 -0.124 -0.124 -0.124 -0.124 -0.125 -0.125 -0.125 -0.125 -0.125 -0.115 -0.115 -0.117 -0.115 -0.117 -0.117 -0.115 -0.117 -0.117 -0.117 -0.119 -0.116 -0.117 -0.119 -0.119 -0.117 -0.119 -0.119 -0.111 -0.111 -0.111 -0.111 -0.112 -0.111 -0.112 -0.111 -0.112 -0.114 -0.122 -0.114 -0.122 -0.124	R 2 TNS (ns) -60.090 -41.889 -64.540 -32.079 -45.347 -78.630 -32.865 -31.143 -42.325 -48.378 -29.889 -32.522 -30.463 -39.416 -50.011 -84.830 -28.919 -61.921 -36.972 -44.766 -53.538 -77.539 -40.504 -77.539 -40.504	
Parameter Clock Period Clock Uncertainty IO Delay	Noise (Δ) -3 ps -2 ps -1 ps +0 ps +1 ps +2 ps -3 ps -2 ps -1 ps +0 ps +1 ps +2 ps -3 ps -2 ps -3 ps -2 ps -1 ps +0 ps +1 ps +2 ps -3 ps -2 ps -3 ps -2 ps -1 ps +0 ps +1 ps +2 ps -3 ps -2 ps -1 ps +1 ps +2 ps -3 ps -2 ps -2 ps -1 ps +0 ps +1 ps +2 ps -3 ps -2 ps -2 ps -2 ps -1 ps +0 ps +1 ps +2 ps -3 ps -2 ps -0.03 -0.02 -0.02 -0.02	P&2) WNS (ns) -0.257 -0.225 -0.204 -0.212 -0.224 -0.221 -0.216 -0.221 -0.233 -0.254 -0.204 -0.254 -0.242 -0.254 -0.242 -0.242 -0.240 -0.240 -0.240 -0.240 -0.240 -0.240 -0.240 -0.240 -0.240 -0.240 -0.240 -0.240 -0.240 -0.255 -0.242 -0.255 -0.242 -0.255 -0.245 -0.255 -0.245 -0.255 -0.245 -0.255 -0.245 -0.257 -0.257 -0.257 -0.257 -0.245 -0.212 -0.257 -0.257 -0.245 -0.245 -0.257 -0.256 -0.204 -0.257 -0.256 -0.204 -0.257 -0.245 -0.245 -0.245 -0.254 -0.254 -0.245 -0.245 -0.245 -0.245 -0.245 -0.254 -0.254 -0.245 -0.245 -0.245 -0.245 -0.245 -0.245 -0.245 -0.245 -0.245 -0.245 -0.245 -0.245 -0.250 -0.240 -0.250 -0.240 -0.250 -0.240 -0.250 -0.266 -0.2658 -0.2658 -0.2658 -0.2658 -0.266 -0.266 -0.2658 -0.2654 -0.2658 -0.2654 -0.2658 -0.2654 -0.265	SweRV R 1 TNS (ns) -339.301 -291.141 -336.346 -244.887 -287.519 -318.609 -245.109 -347.686 -265.114 -285.039 -244.887 -332.116 -315.494 -328.919 -279.308 -313.851 -322.225 -244.887 -328.919 -329.308 -313.851 -329.225 -244.887 -291.155 -249.353 -292.142 -311.995 -338.009 -229.347 -338.009 -229.347 -338.009 -229.347 -338.009 -229.347 -347.456 -338.009 -229.347 -347.456 -338.009 -229.347 -347.456 -338.009 -229.347 -347.456 -348.457 -347.456 -347	wrapper P& WNS (ns) -0.502 -0.793 -0.682 -0.566 -0.608 -0.710 -0.528 -0.679 -0.619 -0.602 -0.580 -0.561 -0.620 -0.571 -0.578 -0.451 -0.724 -0.568 -0.697 -0.538 -0.667 -0.578 -0.579 -0.578 -0.578 -0.579 -0.578 -0.578 -0.578 -0.579 -0.578 -0.578 -0.579 -0.578 -0.578 -0.578 -0.579 -0.588 -0.567 -0.588 -0.578 -0.587 -0.578 -0.578 -0.588 -0.579 -0.588 -0.579 -0.588 -0.578 -0.578 -0.588 -0.579 -0.588 -0.578 -0.	R_2 TNS (ns) -278.424 -241.234 -280.573 -163.356 -205.182 -228.354 -228.354 -232.646 -111.716 -169.827 -259.697 -290.598 -282.778 -290.598 -282.778 -252.109 -215.154 -170.578 -179.544 -170.578 -179.544 -170.578 -222.611 -230.526 -222.611 -230.526	P&: WNS (ns) -0.123 -0.126 -0.139 -0.128 -0.111 -0.159 -0.115 -0.135 -0.104 -0.145 -0.128 -0.128 -0.128 -0.123 -0.141 -0.147 -0.147 -0.122 -0.128 -0.144 -0.140 -0.123 -0.144 -0.140 -0.123 -0.144 -0.115 -0.114 -0.115 -0.114 -0.115 -0.124 -0.124 -0.123 -0.125 -0.128 -0.111 -0.159 -0.128 -0.111 -0.159 -0.128 -0.111 -0.159 -0.128 -0.115 -0.128 -0.115 -0.126 -0.128 -0.111 -0.155 -0.104 -0.128 -0.	Black I I TNS (ns) -15.197 -49.392 -18.283 -21.676 -10.723 -50.867 -7.891 -118.041 -15.631 -69.956 -21.676 -24.162 -23.965 -11.075 -13.286 -58.600 -44.178 -21.278 -50.005 -31.646 -26.904 -47.975 -37.853 -30.131 -30.272 -37.853 -30.272 -37.853 -30.272 -37.85	Parrot P&: P&: WNS (ns) -0.194 -0.107 -0.122 -0.121 -0.108 -0.167 -0.115 -0.111 -0.117 -0.119 -0.143 -0.114 -0.114 -0.112 -0.114 -0.112 -0.114 -0.112 -0.114 -0.112 -0.121 -0.124 -0.125 -0.121 -0.125 -0.121 -0.125 -0.121 -0.125 -0.121 -0.125 -0.117 -0.125 -0.117 -0.117 -0.117 -0.127 -0.117 -0.117 -0.117 -0.117 -0.117 -0.117 -0.119 -0.117 -0.117 -0.117 -0.119 -0.117 -0.117 -0.119 -0.111 -0.117 -0.119 -0.111 -0.117 -0.111 -0.111 -0.111 -0.112 -0.111 -0.112 -0.121 -0.121 -0.111 -0.117 -0.111 -0.112 -0.121 -0.121 -0.111 -0.117 -0.112 -0.121 -0.121 -0.111 -0.117 -0.112 -0.121 -0.121 -0.111 -0.117 -0.121 -0.121 -0.111 -0.117 -0.112 -0.121 -0.121 -0.121 -0.121 -0.117 -0.112 -0.121 -0.121 -0.121 -0.121 -0.121 -0.121 -0.121 -0.121 -0.121 -0.121 -0.121 -0.121 -0.121 -0.121 -0.121 -0.121 -0.112 -0.121 -0.112 -0.112 -0.112 -0.112 -0.112 -0.112 -0.121 -0.121 -0.121 -0.121 -0.121 -0.121 -0.123 -0.121 -0.123 -0.121 -0.123 -0.121 -0.123 -0.121 -0.123 -0.121 -0.123 -0.121 -0.123 -0.121 -0.123 -0.121 -0.123 -0.121 -0.123 -0.121 -0.123 -0.121 -0.123 -0.121 -0.123 -0.121 -0.123 -0.121 -0.123 -0.121 -0.123 -0.121 -0.123 -0.121 -0.123 -0.121 -0.122 -0.125 -0	R_2 TNS (ns) -60.090 -41.889 -64.540 -32.079 -45.347 -78.630 -32.865 -31.143 -42.325 -48.378 -32.889 -32.522 -30.463 -39.416 -50.011 -84.830 -28.919 -61.921 -36.972 -44.766 -53.538 -77.539 -40.504 -55.700 -40.504 -55.700	
Parameter Clock Period Clock Uncertainty IO Delay Aspect Ratio	Noise (Δ) -3 ps -2 ps -1 ps +0 ps +1 ps +2 ps -3 ps -2 ps -1 ps +0 ps +1 ps +2 ps -3 ps -2 ps -1 ps +0 ps +1 ps +2 ps -3 ps -2 ps -1 ps -2 ps -1 ps -2 ps -1 ps +0 ps +1 ps +2 ps -2 ps -1 ps -2 ps -1 ps -2 ps -1 ps -2 ps -1 ps -2 ps -1 ps +0 ps +1 ps +2 ps -2 ps -1 ps -2 ps -1 ps +0 ps +1 ps +2 ps -2 ps -1 ps -2 ps -1 ps -2 ps -1 ps -2 ps -1 ps -2 ps -3 ps -2 ps -1 ps -2 ps -0.03 -0.02 -0.01 +0.001	P&3 WNS (ns) -0.257 -0.225 -0.265 -0.204 -0.212 -0.224 -0.216 -0.221 -0.221 -0.226 -0.204 -0.204 -0.250 -0.250 -0.265 -0.204 -0.268 -0.205 -0.205 -0.268 -0.205 -0.204 -0.268 -0.205 -0.205 -0.268 -0.205 -0.204 -0.268 -0.205 -0.205 -0.204 -0.205 -0.204 -0.221 -0.225 -0.225 -0.224 -0.226 -0.221 -0.221 -0.221 -0.221 -0.225 -0.224 -0.221 -0.221 -0.221 -0.221 -0.221 -0.221 -0.221 -0.221 -0.221 -0.221 -0.221 -0.221 -0.221 -0.221 -0.221 -0.221 -0.221 -0.221 -0.225 -0.204 -0.212 -0.225 -0.221 -0.225 -0.204 -0.212 -0.225 -0.204 -0.212 -0.225 -0.204 -0.221 -0.225 -0.204 -0.221 -0.225 -0.204 -0.221 -0.225 -0.204 -0.221 -0.225 -0.204 -0.204 -0.221 -0.225 -0.204 -0.204 -0.221 -0.224 -0.224 -0.225 -0.224 -0.225 -0.224 -0.225 -0.224 -0.225 -0.224 -0.225 -0.224 -0.225 -0.224 -0.225 -0.242 -0.226 -0.204 -0.250 -0.204 -0.250 -0.204 -0.226 -0.204 -0.226 -0.204 -0.250 -0.204 -0.260 -0.204 -0.260 -0.204 -0.260 -0.204 -0.260 -0.204 -0.260 -0.204 -0.260 -0.204 -0.260 -0.204 -0.260 -0.204 -0.260 -0.204 -0.205 -0.204 -0.206 -0.206 -0.204 -0.206 -0.205 -0.206 -0.206 -0.205 -0.206 -0.205 -0.206 -0.205 -0.206 -0.205 -0.206 -0.205 -0.206 -0.205 -0.205 -0.206 -0.205 -0.	SweRV TIS (ns) -339.301 -291.141 -336.346 -244.887 -287.519 -318.609 -245.109 -347.686 -265.114 -285.039 -244.887 -332.116 -315.494 -328.919 -279.308 -313.851 -332.225 -244.887 -291.155 -289.353 -292.142 -311.995 -338.009 -229.347 -244.887 -29.347 -244.887 -29.347 -244.887 -29.347 -244.887 -29.347 -244.887 -29.347 -244.887 -29.347 -244.887 -29.347 -244.887 -29.347 -244.887 -29.347 -244.887 -29.347 -244.887 -29.347 -244.887 -29.347 -244.887 -29.347 -244.887 -29.347 -244.887 -29.347 -244.887 -29.347 -244.887 -29.347 -244.887 -29.347	wrapper P&: WNS (ns) -0.502 -0.793 -0.682 -0.566 -0.608 -0.710 -0.528 -0.679 -0.619 -0.602 -0.580 -0.561 -0.620 -0.581 -0.578 -0.451 -0.578 -0.538 -0.667 -0.538 -0.667 -0.538 -0.667 -0.538 -0.6572 -0.538 -0.6572 -0.558 -0.557 -0.558	R_2 TNS (ns) -278.424 -241.234 -280.573 -163.356 -205.182 -228.354 -228.354 -232.646 -111.716 -169.827 -259.697 -259.697 -290.598 -282.778 -290.598 -282.778 -252.655 -224.977 -225.109 -215.154 -170.578 -179.544 -240.698 -331.423 -218.755 -202.611 -230.526 -169.131 -230.526 -169.131 -230.526 -169.131 -230.526 -169.131 -230.526 -169.131 -230.526 -169.131 -230.526 -169.131 -230.526 -169.131 -230.526 -169.131 -230.526 -169.131 -230.526 -169.131 -230.526 -169.131 -230.526 -169.131 -230.526 -169.131 -230.526 -169.131 -230.526 -169.131 -230.526 -169.131 -230.526 -169.131 -230.526 -169.131 -230.526 -169.527 -225.029 -	P& WNS (ns) -0.123 -0.126 -0.139 -0.128 -0.111 -0.159 -0.115 -0.104 -0.145 -0.128 -0.104 -0.128 -0.128 -0.123 -0.123 -0.123 -0.123 -0.124 -0.152 -0.128 -0.144 -0.123 -0.114 -0.123 -0.114 -0.123 -0.114 -0.123 -0.124 -0.124 -0.123 -0.124 -0.123 -0.124 -0.125 -0.124 -0.125 -0.125 -0.125 -0.125 -0.125 -0.125 -0.125 -0.125 -0.126 -0.128 -0.125 -0.128 -0.125 -0.125 -0.128 -0.125 -0.125 -0.128 -0.125 -0.128 -0.1	Black 1 TNS (ns) -15.197 -49.392 -18.283 -21.676 -10.723 -50.867 -7.891 -118.041 -15.631 -69.956 -21.676 -24.162 -23.965 -11.075 -13.286 -58.600 -44.178 -50.005 -31.646 -26.904 -47.975 -37.853 -30.131 -20.879 -59.26	Parrot P&: WNS (ns) -0.194 -0.107 -0.122 -0.121 -0.108 -0.167 -0.115 -0.117 -0.117 -0.117 -0.119 -0.143 -0.154 -0.112 -0.112 -0.112 -0.112 -0.112 -0.112 -0.112 -0.112 -0.112 -0.121 -0.129 -0.121 -0.129 -0.129 -0.129 -0.129 -0.129 -0.121 -0.121 -0.121 -0.121 -0.121 -0.121 -0.125 -0.121 -0.125 -0.121 -0.125 -0.117 -0.117 -0.117 -0.119 -0.125 -0.111 -0.117 -0.119 -0.121 -0.119 -0.121 -0.119 -0.121 -0.119 -0.121 -0.111 -0.111 -0.111 -0.112 -0.121 -0.121 -0.121 -0.121 -0.121 -0.121 -0.111 -0.117 -0.121 -0.122	R_2 TNS (ns) -60.090 -41.889 -64.540 -32.079 -45.347 -78.630 -32.865 -31.143 -42.325 -48.378 -29.889 -32.522 -30.463 -39.416 -50.011 -84.830 -28.919 -61.921 -36.972 -44.766 -53.538 -77.539 -40.504 -35.700 -68.511 -37.402 -40.504 -35.700 -68.511 -37.402 -40.504 -35.700 -68.511 -37.402 -40.504 -37.509 -40.504 -40.504 -40.504 -40.504 -50.505 -50.50	
Parameter Clock Period Clock Uncertainty IO Delay Aspect Ratio	Noise (Δ) -3 ps -2 ps -1 ps +0 ps +1 ps +2 ps -3 ps -2 ps -3 ps -2 ps -1 ps +0 ps +1 ps +2 ps +3 ps -3 ps -3 ps -2 ps -1 ps -3 ps -3 ps -2 ps -1 ps +0 ps +1 ps +2 ps +3 ps -3 ps -2 ps -1 ps +0 ps +1 ps +2 ps -3 ps -2 ps -1 ps -0 ps +0 ps +1 ps +2 ps -1 ps -0 ps -0 ps -0 ps -0 ps -0 ps -0 003 -0.002 -0.001 +0.000 +0.001 +0.0	P&2 WNS (ns) -0.257 -0.225 -0.204 -0.212 -0.224 -0.212 -0.224 -0.210 -0.221 -0.221 -0.221 -0.221 -0.207 -0.204 -0.207 -0.254 -0.204 -0.204 -0.204 -0.204 -0.204 -0.205 -0.204 -0.205 -0.204 -0.205 -0.204 -0.205 -0.204 -0.205 -0.204 -0.205 -0.204 -0.205 -0.205 -0.204 -0.217 -0.218 -0.218 -0.218 -0.218 -0.218 -0.221 -0.225 -0.224 -0.221 -0.221 -0.225 -0.224 -0.221 -0.225 -0.224 -0.225 -0.224 -0.225 -0.224 -0.225 -0.224 -0.225 -0.224 -0.2207 -0.225 -0.224 -0.207 -0.224 -0.207 -0.224 -0.207 -0.224 -0.207 -0.224 -0.207 -0.225 -0.224 -0.207 -0.225 -0.224 -0.207 -0.207 -0.225 -0.220 -0.207 -0.225 -0.220 -0.207 -0.225 -0.205 -0.205 -0.205 -0.204 -0.205 -0.204 -0.205 -0.204 -0.205 -0.204 -0.205 -0.204 -0.205 -0.204 -0.205 -0.204 -0.205 -0.204 -0.205 -0.204 -0.225 -0.204 -0.205 -0.204 -0.225 -0.204 -0.205 -0.204 -0.225 -0.204 -0.205 -0.205 -0.204 -0.205 -0	SweRV 1 -339.301 -291.141 -336.346 -244.887 -245.109 -347.686 -245.109 -245.109 -245.109 -245.109 -245.109 -245.109 -244.887 -332.116 -315.494 -279.308 -313.851 -332.225 -224.887 -291.155 -229.347 -291.425 -338.009 -229.347 -244.887 -244.87 -244.87 -244.887 -244.87	wrapper P& WNS (ns) -0.502 -0.793 -0.682 -0.668 -0.608 -0.710 -0.528 -0.679 -0.619 -0.602 -0.580 -0.561 -0.620 -0.871 -0.578 -0.451 -0.578 -0.451 -0.578 -0.566 -0.697 -0.538 -0.566 -0.697 -0.538 -0.568 -0.588 -0.588 -0.589 -0.573 -0.573 -0.573 -0.588 -0.573 -0.573 -0.589 -0.573 -0.573 -0.573 -0.573 -0.573 -0.573 -0.589 -0.573 -0.573 -0.573 -0.573 -0.573 -0.588 -0.573 -0.573 -0.573 -0.588 -0.573 -0.573 -0.573 -0.573 -0.573 -0.573 -0.573 -0.572 -0.578 -0.573 -0.572 -0.578 -0.572 -0.572 -0.578 -0.572 -0.572 -0.588 -0.573 -0.573 -0.5752 -0.566 -0.572 -0.572 -0.572 -0.572 -0.556 -0.572 -0.572 -0.572 -0.572 -0.572 -0.572 -0.572 -0.572 -0.572 -0.572 -0.572 -0.572 -0.556 -0.572 -0.5572 -0.556 -0.572 -0.556 -0.572 -0.556 -0.572 -0.556 -0.5572 -0.556 -0.5572 -0.556 -0.572 -0.556 -0.572 -0.556 -0.572 -0.556 -0.572 -0.556 -0.572 -0.556 -0.572 -0.556 -0.572 -0.558 -0.556 -0.5572 -0.558 -0.5572 -0.558 -0.5572 -0.558 -0.5572 -0.558 -0.5572 -0.558 -0.558 -0.5572 -0.558 -0.5572 -0.558 -0.5572 -0.558 -0.558 -0.5572 -0.558 -0.5572 -0.558 -0.558 -0.558 -0.558 -0.5575 -0.558 -0.558 -0.558 -0.5575 -0.558 -0.5575 -0.558 -0.5575 -0.5575 -0.5575 -0.5575 -0.5575 -0.5575 -0.5575 -0.5575 -0.5575 -0.55	R_2 TNS (ns) -278.424 -241.234 -280.573 -163.356 -205.182 -228.354 -232.646 -211.716 -169.827 -259.697 -180.897 -259.697 -282.778 -252.655 -224.977 -225.109 -215.154 -79.544 -240.698 -31.423 -218.755 -202.611 -230.526 -169.131 -230.526 -169.131 -236.3628 -236.3628 -24	P& WNS (ns) -0.123 -0.126 -0.139 -0.128 -0.111 -0.159 -0.104 -0.145 -0.104 -0.145 -0.128 -0.128 -0.141 -0.147 -0.147 -0.128 -0.123 -0.124 -0.123 -0.114 -0.123 -0.114 -0.123 -0.114 -0.123 -0.114 -0.123 -0.114 -0.128 -0.111 -0.159 -0.128 -0.127 -0.127 -0.128 -0.128 -0.128 -0.127 -0.128 -0.153 -0.154 -0.154 -0.155 -0.154 -0.154 -0.155 -0.154 -0.155 -0.154 -0.155 -0.154 -0.155 -0.1	Black 1 TNS (ns) -15.197 -49.392 -18.283 -21.676 -10.723 -50.867 -7.891 -118.041 -15.631 -69.956 -21.676 -24.162 -23.965 -11.075 -11.075 -13.286 -58.600 -44.178 -50.005 -31.646 -31.646 -34.162 -37.853 -30.131 -20.879 -52.868 -52.868	Parrot P&: WNS (ns) -0.194 -0.107 -0.122 -0.121 -0.108 -0.167 -0.115 -0.111 -0.117 -0.117 -0.113 -0.154 -0.112 -0.131 -0.112 -0.114 -0.112 -0.114 -0.112 -0.123 -0.121 -0.112 -0.124 -0.121 -0.124 -0.121 -0.115 -0.117 -0.112 -0.121 -0.122 -0.121 -0.122 -0.122 -0.122 -0.122 -0.122 -0.122 -0.122 -0.129 -0.129 -0.122 -0.129 -0.299	R_2 TNS (ns) -60.090 -41.889 -64.540 -32.079 -45.347 -78.630 -32.865 -31.143 -42.325 -48.378 -29.889 -32.522 -30.463 -39.416 -50.011 -84.830 -28.919 -61.921 -36.972 -44.766 -53.538 -77.539 -40.504 -53.538	
Parameter Clock Period Clock Uncertainty IO Delay Aspect Ratio	Noise (Δ) -3 ps -2 ps -1 ps +0 ps +1 ps +2 ps -3 ps -2 ps -1 ps +0 ps +1 ps +2 ps +3 ps -3 ps -2 ps -3 ps -2 ps -1 ps +0 ps +1 ps +2 ps -3 ps -2 ps -3 ps -2 ps -1 ps +0 ps +1 ps +2 ps -3 ps -2 ps -3 ps -2 ps -1 ps +0 ps +1 ps +2 ps -3 ps -2 ps -3 ps -2 ps -3 ps -2 ps -3 ps -2 ps -1 ps +0 ps +1 ps +2 ps +3 ps -2 ps -0.03 -0.02 -0.01 +0.00 +0.01 +0.02 -0.02	P&2           WNS (ns)           -0.257           -0.225           -0.204           -0.212           -0.212           -0.214           -0.215           -0.216           -0.217           -0.233           -0.254           -0.204           -0.205           -0.204           -0.205           -0.242           -0.254           -0.205           -0.240           -0.206           -0.217           -0.462           -0.268           -0.205           -0.204           -0.205           -0.204           -0.205           -0.206           -0.217	SweRV R 1 TNS (ns) -339.301 -291.141 -336.346 -244.887 -287.519 -318.609 -245.109 -347.686 -265.114 -285.039 -244.887 -332.116 -315.494 -328.919 -279.308 -313.851 -322.255 -244.887 -391.155 -244.887 -391.159 -322.255 -244.887 -291.155 -244.887 -291.155 -338.009 -229.347 -229.347 -244.887 -273.615 -244.578 -245.578 -245	wrapper P& WNS (ns) -0.502 -0.793 -0.682 -0.566 -0.608 -0.710 -0.528 -0.679 -0.619 -0.602 -0.580 -0.561 -0.620 -0.571 -0.578 -0.451 -0.724 -0.566 -0.697 -0.578 -0.697 -0.578 -0.697 -0.578 -0.578 -0.573 -0.5758 -0.572 -0.572 -0.572 -0.5758 -0.5758 -0.5758 -0.5758 -0.5758 -0.5758 -0.5758 -0.5758 -0.5758 -0.5758 -0.5758 -0.5758 -0.577 -0.578 -0.577 -0.578 -0.577 -0.578 -0.578 -0.578 -0.578 -0.578 -0.578 -0.577 -0.578 -0.5778 -0.578 -0.5778 -0.578 -0.5778 -0.578 -0.5778 -0	R_2 TNS (ns) -278.424 -241.234 -280.573 -163.356 -205.182 -228.354 -228.354 -232.646 -169.827 -259.697 -180.897 -290.598 -282.778 -252.655 -224.977 -225.109 -215.154 -170.578 -179.544 -170.578 -179.544 -230.526 -205.611 -230.526 -169.131 -230.526 -169.138 -263.628 -161.388 -265 -265 -265 -265 -224.977 -255.194 -278.54 -278.55 -224.977 -255.194 -255.194 -255.195 -222.611 -230.526 -169.131 -263.628 -161.388 -265 -265 -265 -265 -265 -224.977 -255.194 -278.55 -222.611 -230.526 -169.131 -263.628 -169.131 -263.628 -169.131 -263.628 -169.138 -265 -265 -265 -265 -265 -265 -265 -265 -265 -224.977 -255.194 -278.55 -224.977 -255.194 -278.55 -224.977 -255.194 -278.55 -224.977 -255.194 -278.55 -224.977 -255.194 -278.55 -224.977 -255.194 -278.55 -224.977 -255.194 -278.55 -224.977 -255.194 -278.55 -224.977 -255.194 -278.55 -224.977 -255.194 -278.55 -224.977 -255.194 -278.55 -222.611 -230.526 -169.131 -263.628 -161.388 -265 -26	P&: WNS (ns) -0.123 -0.126 -0.139 -0.128 -0.111 -0.159 -0.115 -0.135 -0.104 -0.145 -0.128 -0.128 -0.139 -0.123 -0.141 -0.147 -0.147 -0.128 -0.144 -0.140 -0.123 -0.144 -0.140 -0.123 -0.144 -0.123 -0.144 -0.123 -0.144 -0.123 -0.144 -0.123 -0.144 -0.123 -0.141 -0.153 -0.124 -0.153 -0.124 -0.153 -0.124 -0.125 -0.125 -0.125 -0.125 -0.125 -0.128 -0.125 -0.128 -0.125 -0.128 -0.125 -0.128 -0.	Black I TNS (ns) -15.197 -49.392 -18.283 -21.676 -10.723 -50.867 -7.891 -118.041 -15.631 -69.956 -21.676 -24.162 -23.965 -11.075 -13.286 -58.600 -44.178 -21.278 -53.1646 -26.904 -47.975 -31.646 -26.904 -47.975 -37.853 -30.131 -20.879 -52.868 -22.935 -52.868 -22.935 -52.868 -22.935 -52.868 -52.935 -52.95 -52.868 -52.935 -52.95 -52.868 -52.935 -52.95 -52.868 -52.935 -52.95 -52.868 -52.935 -52.95 -52.95 -52.868 -52.95 -52.95 -52.868 -52.95 -52.95 -52.868 -52.95 -52.95 -52.868 -52.95 -52.95 -52.868 -52.95 -52.95 -52.868 -52.95 -52.868 -52.95 -52.868 -52.95 -52.868 -52.95 -52.95 -52.85 -52.95 -52.85 -52.95 -52.95 -52.85 -52.95 -52.85 -52.95 -52.85 -52.95 -52.95 -52.85 -52.95 -52.95 -52.95 -52.85 -52.95 -52.85 -52.95 -52.95 -52.85 -52.95 -5	Parrot P&: P&: WNS (ns) -0.194 -0.107 -0.122 -0.121 -0.108 -0.167 -0.115 -0.111 -0.117 -0.119 -0.143 -0.154 -0.112 -0.114 -0.112 -0.114 -0.112 -0.114 -0.112 -0.121 -0.124 -0.121 -0.124 -0.125 -0.121 -0.125 -0.121 -0.127 -0.121 -0.127 -0.117 -0.117 -0.127 -0.127 -0.127 -0.117 -0.117 -0.127 -0	R_2 TNS (ns) -60.090 -41.889 -64.540 -32.079 -45.347 -78.630 -32.865 -31.143 -42.325 -48.378 -32.829 -32.522 -30.463 -39.416 -50.011 -84.830 -29.889 -32.522 -30.463 -39.416 -50.011 -84.830 -28.919 -61.921 -36.972 -44.766 -53.538 -77.539 -40.504 -53.5700 -68.511 -27.486 -36.148 -27.486 -36.148 -27.486 -36.148 -27.486 -36.148 -27.486 -36.148 -27.486 -36.148 -27.486 -36.148 -27.486 -36.148 -27.486 -36.148 -27.486 -36.148 -27.486 -36.148 -27.486 -36.148 -27.486 -36.148 -27.486 -36.148 -27.486 -36.148 -27.597 -27.5	
Parameter Clock Period Clock Uncertainty IO Delay Aspect Ratio	Noise (Δ) -3 ps -2 ps -1 ps +0 ps +1 ps +2 ps -3 ps -2 ps -1 ps +0 ps +1 ps +2 ps -3 ps -2 ps -1 ps 0 ps 1 ps 2 ps -3 ps -2 ps -0.03 -0.02 -0.01 +0.001 +0.002 +0.03 -0.02 -0.03 -0.03 -0.02 -0.03 -0.03 -0.02 -0.03 -0.03 -0.02 -0.03 -0.02 -0.03 -0.02 -0.03 -0.02 -0.03 -0.02 -0.03 -0.02 -0.03 -0.02 -0.03 -0.03 -0.02 -0.03 -0.03 -0.02 -0.03 -0.03 -0.03 -0.02 -0.03 -0.03 -0.03 -0.02 -0.03	P&3 WNS (ns) -0.257 -0.225 -0.265 -0.204 -0.212 -0.224 -0.216 -0.221 -0.221 -0.226 -0.204 -0.204 -0.250 -0.250 -0.260 -0.204 -0.250 -0.204 -0.268 -0.205 -0.204 -0.268 -0.205 -0.204 -0.221 -0.268 -0.205 -0.204 -0.223 -0.224 -0.223 -0.224 -0.221 -0.224 -0.221 -0.224 -0.224 -0.225 -0.224 -0.225 -0.224 -0.225 -0.224 -0.225 -0.225 -0.224 -0.225 -0.225 -0.224 -0.225 -0.225 -0.225 -0.225 -0.225 -0.225 -0.226 -0.226 -0.226 -0.226 -0.226 -0.226 -0.227 -0.256 -0.227 -0.226 -0.226 -0.227 -0.226 -0.227 -0.226 -0.227 -0.226 -0.227 -0.227 -0.227 -0.226 -0.227 -0.	SweRV TINS (ns) -339.301 -291.141 -336.346 -244.887 -287.519 -318.609 -245.109 -347.686 -265.114 -285.039 -347.686 -265.114 -285.039 -244.887 -332.116 -315.494 -328.919 -279.308 -313.851 -332.225 -244.887 -291.155 -289.353 -292.142 -311.995 -338.009 -229.347 -244.887 -273.615 -244.578	wrapper P&: WNS (ns) -0.502 -0.793 -0.682 -0.566 -0.608 -0.710 -0.528 -0.679 -0.619 -0.620 -0.580 -0.561 -0.620 -0.587 -0.578 -0.451 -0.578 -0.538 -0.667 -0.538 -0.667 -0.538 -0.538 -0.657 -0.538 -0.538 -0.5573 -0.5575 -0.5575 -0.5575 -0.5575 -0.5575 -0.5575 -0.5575 -0.5575	R_2 TNS (ns) -278.424 -241.234 -280.573 -163.356 -205.182 -228.354 -228.354 -228.354 -232.646 -169.827 -259.697 -290.598 -282.778 -290.598 -224.977 -225.109 -225.109 -211.716 -226.655 -224.977 -225.109 -211.716 -205.578 -226.655 -224.977 -225.109 -211.716 -211.716 -211.716 -226.655 -224.977 -225.109 -211.578 -170.578 -170.578 -170.578 -170.578 -170.578 -170.578 -170.578 -170.578 -170.578 -170.578 -170.578 -170.526 -218.755 -202.611 -230.526 -169.131 -263.628 -163.138 -255.692 -163.138 -255.692 -163.138 -255.692 -163.288 -	P& WNS (ns) -0.123 -0.126 -0.139 -0.128 -0.111 -0.159 -0.115 -0.104 -0.145 -0.128 -0.104 -0.123 -0.123 -0.123 -0.123 -0.123 -0.123 -0.123 -0.123 -0.123 -0.141 -0.152 -0.128 -0.144 -0.123 -0.141 -0.153 -0.141 -0.161 -0.153 -0.161 -0.153 -0.161 -0.153 -0.161 -0.153 -0.161 -0.153 -0.161 -0.153 -0.161 -0.153 -0.161 -0.153 -0.161 -0.153 -0.161 -0.153 -0.161 -0.153 -0.161 -0.152 -0.161 -0.155 -0.161 -0.155 -0.164 -0.175 -0.128 -0.175 -0.0	Black 1 TNS (ns) -15.197 -49.392 -18.283 -21.676 -10.723 -50.867 -7.891 -118.041 -15.631 -69.956 -21.676 -24.162 -23.965 -11.075 -13.286 -58.600 -44.178 -50.005 -31.646 -26.904 -47.975 -37.853 -30.131 -20.879 -52.868 -22.935 -34.448	Parrot P&: WNS (ns) -0.194 -0.107 -0.122 -0.121 -0.108 -0.167 -0.115 -0.111 -0.117 -0.117 -0.119 -0.143 -0.154 -0.112 -0.131 -0.112 -0.112 -0.112 -0.112 -0.112 -0.112 -0.121 -0.124 -0.121 -0.129 -0.122 -0.107 -0.129 -0.122 -0.107 -0.129 -0.121 -0.121 -0.121 -0.121 -0.117 -0.119 -0.121 -0.121 -0.117 -0.119 -0.121 -0.111 -0.117 -0.119 -0.121 -0.121 -0.111 -0.117 -0.119 -0.121 -0.121 -0.111 -0.112 -0.121 -0.129 -0.129 -0.107 -0.098 -0.110 -0.107 -0.098 -0.110 -0.107 -0.098 -0.121 -0.129 -0.122 -0.127 -0.129 -0.129 -0.121 -0.129 -0.129 -0.121 -0.129 -0.121 -0.129 -0.129 -0.129 -0.120 -0.129 -0.120	R_2 TNS (ns) -60.090 -41.889 -64.540 -32.079 -45.347 -78.630 -32.865 -31.143 -42.325 -48.378 -29.889 -32.522 -30.463 -39.416 -50.011 -84.830 -28.919 -61.921 -36.972 -44.766 -53.538 -77.539 -40.504 -55.700 -68.511 -27.486 -36.148 -42.620	
Parameter Clock Period Clock Uncertainty IO Delay Aspect Ratio	Noise (Δ) -3 ps -2 ps -1 ps +0 ps +1 ps +2 ps -3 ps -2 ps -1 ps +0 ps +1 ps +2 ps +3 ps -3 ps -0.03 -0.02 -0.01 +0.00 +0.01 +0.02 +0.03 -3 ps -3 ps -3 ps -3 ps -0.03 -0.02 -0.03 -0.02 -0.03 -0.02 -0.03 -0.02 -0.03 -0.02 -0.03 -0.02 -0.03 -0.02 -0.03 -0.02 -0.03 -0.03 -0.02 -0.03 -0.02 -0.03 -0.0	P&2 WNS (ns) -0.257 -0.225 -0.204 -0.212 -0.224 -0.212 -0.224 -0.210 -0.221 -0.221 -0.221 -0.221 -0.204 -0.207 -0.254 -0.204 -0.205 -0.204 -0.206 -0.205 -0.204 -0.205 -0.204 -0.214 -0.212 -0.212 -0.225 -0.224 -0.257 -0.240 -0.212 -0.206 -0.206 -0.212 -0.225 -0.225 -0.225 -0.225 -0.221 -0.225 -0.226 -0.225 -0.255 -0.225 -0.255 -0.225 -0.255 -0.255 -0.225 -0.255 -0.	SweRV 1 -339.301 -291.141 -336.346 -244.887 -244.887 -245.109 -347.686 -265.114 -285.039 -245.108 -245.108 -332.116 -315.494 -279.308 -313.851 -332.225 -244.887 -291.155 -289.353 -292.142 -311.995 -338.009 -229.347 -273.615 -244.578 -273.615 -244.578 -231.320 -260.962 -200.962 -200.9	wrapper P& WNS (ns) -0.502 -0.793 -0.682 -0.566 -0.608 -0.710 -0.528 -0.679 -0.619 -0.602 -0.561 -0.620 -0.561 -0.620 -0.578 -0.578 -0.697 -0.578 -0.667 -0.578 -0.572 -0.588 -0.588 -0.589 -0.573 -0.622 -0.623 -0.622 -0.623 -0.625	R_2 TNS (ns) -278.424 -241.234 -280.573 -163.356 -205.182 -228.354 -232.646 -211.716 -169.827 -259.697 -180.897 -259.697 -225.109 -225.154 -224.977 -225.109 -215.154 -240.698 -31.423 -218.755 -202.611 -230.526 -169.131 -263.628 -163.88 -161.388 -255.692 -284.832 -255.692 -284.832 -255.692 -284.832 -255.692 -284.832 -255.692 -284.832 -255.692 -284.832 -255.692 -284.832 -255.692 -284.832 -285.692 -28	P& WNS (ns) -0.123 -0.126 -0.139 -0.128 -0.111 -0.159 -0.115 -0.104 -0.145 -0.128 -0.128 -0.128 -0.128 -0.123 -0.141 -0.147 -0.147 -0.147 -0.147 -0.128 -0.144 -0.144 -0.144 -0.144 -0.144 -0.153 -0.144 -0.153 -0.141 -0.161 -0.186	Black 1 TNS (ns) -15.197 -49.392 -18.283 -21.676 -10.723 -50.867 -7.891 -118.041 -15.631 -69.956 -21.676 -24.162 -23.965 -11.075 -13.286 -58.600 -44.178 -50.005 -31.646 -26.904 -47.975 -37.853 -30.131 -20.879 -52.868 -22.935 -34.448 -62.789 -34.448 -64.789 -34.48 -64.789 -34.48 -64.789 -34.48 -64.789 -34.48 -64.789 -34.48 -64.789 -34.48 -64.789 -34.48 -3	Parrot P&: WNS (ns) -0.194 -0.107 -0.122 -0.121 -0.108 -0.167 -0.115 -0.111 -0.117 -0.117 -0.119 -0.143 -0.154 -0.112 -0.114 -0.112 -0.114 -0.112 -0.114 -0.112 -0.114 -0.112 -0.114 -0.112 -0.112 -0.122 -0.121 -0.112 -0.114 -0.112 -0.122 -0.121 -0.112 -0.112 -0.112 -0.121 -0.112 -0.114 -0.112 -0.112 -0.112 -0.112 -0.112 -0.112 -0.112 -0.112 -0.112 -0.114 -0.112 -0.112 -0.112 -0.114 -0.112 -0.129 -0.110 -0.110 -0.110 -0.110 -0.112 -0.112 -0.112 -0.129 -0.129 -0.129 -0.129 -0.110 -0.110 -0.110 -0.110 -0.110 -0.110 -0.112 -0.112 -0.112 -0.112 -0.112 -0.112 -0.112 -0.112 -0.112 -0.112 -0.112 -0.129 -0.112 -0.110 -0.100 -0.110 -0.110 -0.110 -0.110 -0.110 -0.110 -0.110	R_2 TNS (ns) -60.090 -41.889 -64.540 -32.079 -45.347 -78.630 -32.865 -31.143 -42.325 -48.378 -29.889 -32.522 -30.463 -39.416 -50.011 -84.830 -28.919 -61.921 -61.921 -61.921 -61.921 -61.921 -61.921 -61.921 -77.539 -40.504 -35.530 -77.539 -40.504 -35.5700 -68.5111 -27.486 -36.148 -42.620 -28.408 -29.408 -29.	
Parameter Clock Period Clock Uncertainty IO Delay Aspect Ratio	Noise (Δ) -3 ps -2 ps -1 ps +0 ps +1 ps +2 ps -3 ps -2 ps -1 ps +0 ps +1 ps +2 ps +3 ps -3 ps -2 ps -3 ps -2 ps -3 ps -2 ps -1 ps +0 ps +1 ps +2 ps -3 ps -2 ps -2 ps -3 ps -2 ps -3 ps -2 ps -3 ps -2 ps -2 ps -3 ps -2 ps -3 ps -2 ps -0.03 -0.02 -0.01 +0.00 +0.03 -2 ps -2 ps -2 ps -2 ps -2 ps -2 ps -0.03 -2 ps -2 ps -2 ps -2 ps -2 ps -0.03 -2 ps -2 ps -2 ps -0.03 -2 ps -2 ps -2 ps -0.03 -2 ps -2 ps -2 ps -2 ps -2 ps -2 ps -0.03 -2 ps -2 p	P&2           WNS (ns)           -0.257           -0.225           -0.204           -0.212           -0.212           -0.214           -0.215           -0.224           -0.233           -0.254           -0.205           -0.204           -0.207           -0.233           -0.225           -0.242           -0.250           -0.204           -0.205           -0.240           -0.268           -0.205           -0.206           -0.2072           -0.208           -0.201           -0.202           -0.203           -0.204           -0.205           -0.204           -0.201           -0.202           -0.203           -0.204           -0.204           -0.204           -0.204           -0.204           -0.201           -0.2020           -0.2020	SweRV R 1 TNS (ns) -339.301 -291.141 -336.346 -244.887 -287.519 -318.609 -245.109 -347.686 -265.114 -285.039 -244.887 -332.116 -315.494 -328.919 -279.308 -313.851 -322.225 -244.887 -291.155 -244.887 -291.155 -244.887 -292.142 -311.995 -338.009 -229.347 -244.878 -313.809 -229.347 -244.878 -313.809 -229.347 -244.878 -313.809 -229.347 -244.878 -231.320 -246.952 -246.952 -246.952 -246.952 -246.952 -246.952 -246.952 -246.952 -246.952 -246.952 -246.952 -255.333 -260.962 -250.333	wrapper P& WNS (ns) -0.502 -0.793 -0.682 -0.566 -0.608 -0.710 -0.528 -0.679 -0.619 -0.602 -0.580 -0.620 -0.561 -0.620 -0.578 -0.451 -0.578 -0.451 -0.578 -0.697 -0.538 -0.667 -0.578 -0.578 -0.578 -0.578 -0.578 -0.578 -0.573 -0.573 -0.622 -0.623 -0.623 -0.625 -0.625 -0.623 -0.625 -0.625 -0.625 -0.625 -0.625 -0.625 -0.625 -0.625	R_2 TNS (ns) -278.424 -241.234 -280.573 -163.356 -205.182 -228.354 -228.354 -232.646 -69.827 -259.697 -259.697 -290.598 -282.778 -290.598 -282.778 -252.109 -215.154 -170.578 -179.544 -170.578 -179.544 -230.526 -169.131 -230.526 -224.977 -224.977 -225.109 -224.977 -225.109 -224.977 -225.109 -224.977 -225.109 -224.977 -225.109 -224.977 -225.109 -224.977 -225.109 -224.977 -226.11 -230.526 -169.131 -230.526 -169.131 -230.526 -224.832 -217.232 -21	P&: WNS (ns) -0.123 -0.126 -0.139 -0.128 -0.111 -0.159 -0.115 -0.135 -0.104 -0.145 -0.128 -0.123 -0.141 -0.147 -0.147 -0.144 -0.147 -0.144 -0.140 -0.123 -0.144 -0.144 -0.123 -0.144 -0.153 -0.144 -0.128 -0.153 -0.141 -0.153 -0.141 -0.153 -0.141 -0.153 -0.141 -0.153 -0.141 -0.158 -0.153 -0.141 -0.153 -0.141 -0.153 -0.141 -0.158 -0.153 -0.141 -0.153 -0.141 -0.158 -0.153 -0.141 -0.158 -0.153 -0.141 -0.158 -0.153 -0.141 -0.158 -0.153 -0.141 -0.158 -0.153 -0.141 -0.158 -0.153 -0.141 -0.158 -0.155 -0.158 -0.155 -0.128 -0.128 -0.128 -0.155 -0.128 -0.128 -0.155 -0.128 -0.155 -0.128 -0.155 -0.128 -0.128 -0.155 -0.128 -0.151 -0.141 -0.128 -0.151 -0.141 -0.158 -0.150 -0.	Black I TNS (ns) -15.197 -49.392 -18.283 -21.676 -10.723 -50.867 -7.891 -118.041 -15.631 -69.956 -21.676 -24.162 -23.965 -11.075 -13.286 -58.600 -44.178 -21.278 -50.005 -31.646 -26.904 -47.975 -31.646 -32.935 -30.131 -20.879 -39.364 -32.935 -34.448 -32.935 -34.448 -32.935 -34.448 -32.935 -34.448 -32.935 -34.448 -32.935 -34.448 -32.935 -34.448 -32.935 -34.448 -34.9 -34.92 -34.448 -34.9 -34.92 -34.448 -34.9 -34.92 -34.448 -34.9 -34.92 -34.448 -34.9 -34.92 -34.448 -34.9 -3	Parrot P&: P&: WNS (ns) -0.194 -0.107 -0.122 -0.121 -0.108 -0.167 -0.115 -0.117 -0.117 -0.119 -0.143 -0.154 -0.111 -0.112 -0.111 -0.112 -0.131 -0.112 -0.143 -0.121 -0.124 -0.124 -0.124 -0.125 -0.111 -0.125 -0.111 -0.124 -0.124 -0.127 -0.124 -0.127 -0.107 -0.100 -0.110 -0.127 -0.028 -0.100 -0.100 -0.107 -0.027 -0.027 -0.028 -0.027 -0.028 -0.100 -0.107 -0.027 -0.028 -0.028 -0.027 -0.028 -0	R_2 TNS (ns) -60.090 -41.889 -64.540 -32.079 -45.347 -78.630 -32.865 -31.143 -42.325 -48.378 -39.416 -50.011 -84.830 -29.889 -32.522 -30.463 -39.416 -50.011 -84.830 -28.919 -61.921 -36.972 -44.766 -53.538 -77.539 -44.766 -53.538 -77.539 -44.2620 -28.408 -34.864 -28.408 -29.408 -28.4	
Parameter Clock Period Clock Uncertainty IO Delay Aspect Ratio	Noise (Δ) -3 ps -2 ps -1 ps +0 ps +1 ps +2 ps -3 ps -2 ps -1 ps +1 ps +2 ps +3 ps -3 ps -2 ps -3 ps -2 ps -3 ps -2 ps -3 ps -2 ps -3 ps -2 ps -3 ps -3 ps -2 ps -3 ps -3 ps -3 ps -2 ps -3 ps -3 ps -2 ps -3 ps -3 ps -3 ps -2 ps -3 ps -0.03 -0.02 -0.01 +0.002 +0.01 +0.02 +0.03 -2 % -1 %	P&3 WNS (ns) -0.257 -0.225 -0.265 -0.204 -0.212 -0.224 -0.216 -0.221 -0.221 -0.226 -0.204 -0.207 -0.250 -0.204 -0.250 -0.204 -0.250 -0.204 -0.225 -0.268 -0.204 -0.227 -0.268 -0.205 -0.204 -0.223 -0.225 -0.204 -0.221 -0.268 -0.205 -0.204 -0.221 -0.228 -0.224 -0.221 -0.224 -0.224 -0.224 -0.225 -0.224 -0.225 -0.204 -0.225 -0.224 -0.225 -0.224 -0.225 -0.224 -0.225 -0.224 -0.225 -0.224 -0.225 -0.224 -0.225 -0.224 -0.225 -0.224 -0.225 -0.224 -0.225 -0.224 -0.225 -0.224 -0.225 -0.224 -0.225 -0.224 -0.225 -0.224 -0.225 -0.224 -0.225 -0.224 -0.225 -0.224 -0.225 -0.224 -0.225 -0.224 -0.224 -0.225 -0.224 -0.225 -0.224 -0.225 -0.224 -0.225 -0.224 -0.225 -0.225 -0.224 -0.225 -0.224 -0.225 -0.224 -0.225 -0.224 -0.225 -0.224 -0.225 -0.224 -0.225 -0.224 -0.225 -0.224 -0.225 -0.224 -0.225 -0.224 -0.225 -0.224 -0.225 -0.224 -0.225 -0.224 -0.226 -0.224 -0.225 -0.224 -0.225 -0.224 -0.225 -0.224 -0.225 -0.225 -0.224 -0.225 -0.225 -0.224 -0.225 -0.225 -0.224 -0.225 -0.224 -0.225 -0.225 -0.224 -0.227 -0.226 -0.224 -0.227 -0.226 -0.224 -0.225 -0.224 -0.225 -0.224 -0.225 -0.224 -0.225 -0.224 -0.225 -0.224 -0.225 -0.224 -0.225 -0.224 -0.225 -0.224 -0.225 -0.224 -0.225 -0.224 -0.225 -0.224 -0.225 -0.224 -0.225 -0.224 -0.225 -0.224 -0.225 -0.224 -0.225 -0.224 -0.225 -0.224 -0.225 -0.225 -0.224 -0.225 -0.225 -0.224 -0.225 -0.	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Parameter Clock Period Clock Uncertainty IO Delay Aspect Ratio Placement Util	Noise (Δ) -3 ps -2 ps -1 ps +0 ps +2 ps +3 ps -3 ps -2 ps -1 ps +0 ps +1 ps +2 ps +3 ps -3 ps -1 ps -0.03 -0.02 -0.01 +0.00 +0.02 +0.03 -3 % -2 % -1 % -1 % -1 % -2 % -1 % -1 % -1 % -2 % -1 % -1 % -3 % -2 % -1 % -1 % -1 % -2 % -1 % -1 % -2 % -1	P&2           WNS (ns)           -0.257           -0.225           -0.225           -0.204           -0.212           -0.224           -0.210           -0.221           -0.204           -0.210           -0.236           -0.207           -0.204           -0.207           -0.204           -0.204           -0.207           -0.204           -0.205           -0.242           -0.250           -0.204           -0.204           -0.204           -0.204           -0.204           -0.204           -0.204           -0.205           -0.206           -0.207           -0.208           -0.204           -0.204           -0.204           -0.204           -0.204           -0.204           -0.204           -0.204           -0.204           -0.204           -0.204           -0.204           -0.204           -0.	SweRV 1 -339.301 -291.141 -336.346 -244.887 -287.519 -318.609 -245.109 -347.686 -265.114 -285.039 -244.887 -322.116 -315.494 -328.919 -279.308 -313.851 -332.225 -244.887 -291.155 -244.887 -291.155 -244.887 -291.155 -244.887 -291.425 -244.887 -273.615 -244.578 -244.578 -273.615 -244.578 -231.320 -260.962 -250.333 -232.827 -244.887 -232.827 -244.887 -250.333 -232.827 -244.887 -232.320 -260.962 -250.333 -232.827 -244.887 -232.827 -244.887 -232.320 -260.962 -250.333 -232.827 -244.887 -232.827 -244.887 -232.827 -244.887 -245.320 -260.962 -250.337 -232.827 -244.887 -242.827 -244.887 -242.827 -244.887 -242.827 -244.887 -242.827 -244.887 -242.827 -244.887 -242.827 -244.887 -242.827 -244.887 -242.827 -244.887 -242.827 -244.887 -242.827 -244.887 -242.827 -244.887 -245.827 -244.887 -244.8	wrapper P& WNS (ns) -0.502 -0.793 -0.682 -0.668 -0.608 -0.710 -0.528 -0.679 -0.619 -0.602 -0.561 -0.620 -0.561 -0.620 -0.577 -0.578 -0.451 -0.578 -0.451 -0.578 -0.667 -0.578 -0.589 -0.623 -0.622 -0.623 -0.623 -0.634 -0.637 -0.575 -0.637 -0.575 -0.637 -0.575 -0.637 -0.575 -0.637 -0.575 -0.637 -0.575 -0.575 -0.637 -0.575 -0.575 -0.637 -0.575 -0.528 -0.566 -0.578 -0.579 -0.578 -0.579 -0.580 -0.578 -0.558 -0.557 -0.558 -0.557 -0.558 -0.557 -0.558 -0.557 -0.558 -0.557 -0.558 -0.557 -0.577 -0.	R_2 TNS (ns) -278.424 -241.234 -280.573 -163.356 -205.182 -228.354 -222.646 -211.716 -169.827 -259.697 -180.897 -282.778 -252.655 -224.977 -225.109 -215.154 -70.578 -179.544 -240.698 -331.423 -218.755 -202.611 -230.5612 -169.131 -236.3628 -169.131 -236.464 -247.28 -247.28 -247.28 -248.482 -219.109 -172.473 -264.44 -246.44 -2	P& WNS (ns) -0.123 -0.126 -0.129 -0.128 -0.111 -0.159 -0.115 -0.104 -0.145 -0.104 -0.145 -0.128 -0.128 -0.123 -0.123 -0.123 -0.141 -0.147 -0.147 -0.147 -0.147 -0.144 -0.144 -0.128 -0.144 -0.153 -0.144 -0.153 -0.141 -0.161 -0.156 -0.128 -0.150 -0.128 -0.150 -0.128 -0.147 -0.147 -0.147 -0.140 -0.145 -0.140 -0.147 -0.147 -0.140 -0.141 -0.147 -0.141 -0.141 -0.147 -0.128 -0.128 -0.141 -0.147 -0.128 -0.128 -0.141 -0.147 -0.128 -0.128 -0.141 -0.152 -0.141 -0.152 -0.141 -0.150 -0.141 -0.150 -0.128 -0.141 -0.150 -0.128 -0.141 -0.150 -0.128 -0.141 -0.150 -0.119 -0.128 -0.128 -0.128 -0.141 -0.150 -0.119 -0.128 -0.128 -0.128 -0.128 -0.141 -0.128 -0.128 -0.141 -0.128 -0.128 -0.128 -0.128 -0.128 -0.128 -0.128 -0.128 -0.141 -0.128 -0.1	Black I I TNS (ns) -15.197 -49.392 -18.283 -21.676 -10.723 -50.867 -7.891 -118.041 -15.631 -69.956 -21.676 -24.162 -23.965 -11.075 -13.286 -58.600 -44.178 -50.005 -31.646 -26.904 -47.975 -37.853 -30.131 -20.879 -52.868 -22.935 -34.448 -62.789 -79.364 -30.741 -21.278 -30.741 -21.278 -30.741 -21.278 -30.741 -31.278 -31	Parrot P&: P&: WNS (ns) -0.194 -0.107 -0.122 -0.121 -0.108 -0.167 -0.115 -0.117 -0.117 -0.117 -0.119 -0.143 -0.154 -0.112 -0.1131 -0.112 -0.114 -0.112 -0.129 -0.122 -0.122 -0.121 -0.114 -0.112 -0.129 -0.122 -0.107 -0.129 -0.122 -0.121 -0.121 -0.114 -0.115 -0.111 -0.112 -0.121 -0.122 -0.121 -0.122 -0.121 -0.122 -0.122 -0.122 -0.122 -0.122 -0.107 -0.098 -0.110 -0.112 -0.122 -0.122 -0.122 -0.122 -0.122 -0.122 -0.122 -0.122 -0.123 -0.122 -0.122 -0.122 -0.122 -0.122 -0.122 -0.123 -0.122 -0.123 -0.122 -0.122 -0.123 -0.123 -0.122 -0.123 -0.123 -0.123 -0.124 -0.124 -0.124 -0.127 -	R_2 TNS (ns) -60.090 -41.889 -64.540 -32.079 -45.347 -78.630 -32.865 -31.143 -42.325 -48.378 -29.889 -32.522 -30.463 -39.416 -50.011 -84.830 -28.919 -61.921 -36.972 -44.766 -53.538 -77.539 -40.504 -55.538 -77.539 -40.504 -55.538 -77.486 -36.148 -42.620 -28.408 -34.864 -50.131 -41.080 -59.071	
Parameter Clock Period Clock Uncertainty IO Delay Aspect Ratio Placement Util	Noise (Δ) -3 ps -2 ps -1 ps +0 ps +1 ps +2 ps -3 ps -2 ps -1 ps +0 ps +1 ps +2 ps +3 ps -3 ps -2 ps -1 ps +0 ps +1 ps +3 ps -3 ps -2 ps -1 ps +0 ps +1 ps +2 ps +3 ps -3 ps -2 ps -1 ps +0 ps +1 ps +2 ps +3 ps -2 ps -1 ps +0 ps +1 ps +2 ps -3 ps -2 ps -1 ps +0 ps +1 ps -2 ps -1 ps -2 ps -1 ps -2 ps -1 ps +0 ps +1 ps -2 ps -1 ps -2 ps -1 ps -2 ps -1 ps +0 ps +1 ps -2 ps -1 ps -0.03 -0.02 -0.01 +0.00 +0.001 +0.02 +0.03 -2 ps -1 ps -2 ps -2 ps -2 ps -2 ps -0.03 -2 ps -2 ps -2 ps -2 ps -2 ps -2 ps -0.03 -2 ps -2 ps -2 ps -2 ps -2 ps -2 ps -2 ps -0.03 -2 ps -2	P&2           WNS (ns)           -0.257           -0.225           -0.265           -0.204           -0.212           -0.214           -0.216           -0.223           -0.236           -0.204           -0.216           -0.237           -0.254           -0.207           -0.254           -0.225           -0.242           -0.250           -0.206           -0.217           -0.462           -0.268           -0.204           -0.205           -0.204           -0.205           -0.206           -0.217           -0.462           -0.268           -0.201           -0.202           -0.203           -0.2172           -0.200           -0.197           -0.228           -0.204           -0.204           -0.204           -0.204	SweRV R 1 TNS (ns) -339.301 -291.141 -336.346 -244.887 -287.519 -318.609 -245.109 -347.686 -265.114 -285.039 -244.887 -332.116 -315.494 -328.919 -279.308 -313.851 -322.225 -244.887 -291.155 -289.353 -292.142 -311.995 -338.009 -229.347 -244.887 -273.615 -244.578 -231.320 -260.962 -250.333 -228.276 -260.962 -260	wrapper P& WNS (ns) -0.502 -0.793 -0.682 -0.566 -0.608 -0.710 -0.528 -0.679 -0.619 -0.620 -0.580 -0.578 -0.620 -0.578 -0.451 -0.578 -0.451 -0.578 -0.697 -0.578 -0.697 -0.578 -0.697 -0.578 -0.627 -0.578 -0.623 -0.623 -0.623 -0.625 -0.623 -0.625 -0.623 -0.625 -0.625 -0.623 -0.625 -0.578 -0.578 -0.578 -0.578 -0.578 -0.578 -0.627 -0.578 -0.578 -0.578 -0.627 -0.578 -0.627 -0.578 -0.578 -0.627 -0.578 -0.627 -0.578 -0.627 -0.578 -0.627 -0.578 -0.627 -0.578 -0.627 -0.578 -0.627 -0.578 -0.578 -0.627 -0.578 -0.578 -0.578 -0.627 -0.578 -0.575 -0.625	R_2 TNS (ns) -278.424 -241.234 -280.573 -163.356 -205.182 -228.354 -228.354 -232.646 -69.827 -259.697 -259.697 -290.598 -282.778 -290.598 -282.778 -252.109 -215.154 -170.578 -179.544 -170.578 -179.544 -230.526 -169.131 -230.526 -224.977 -224.977 -224.977 -226.414 -230.526 -224.977 -226.412 -226.427 -2	P&X WNS (ns) -0.123 -0.126 -0.139 -0.128 -0.111 -0.159 -0.115 -0.135 -0.104 -0.145 -0.128 -0.123 -0.141 -0.147 -0.123 -0.141 -0.147 -0.123 -0.144 -0.140 -0.123 -0.144 -0.140 -0.123 -0.144 -0.123 -0.144 -0.123 -0.144 -0.123 -0.144 -0.128 -0.153 -0.141 -0.153 -0.141 -0.153 -0.141 -0.158 -0.153 -0.141 -0.128 -0.153 -0.141 -0.128 -0.128 -0.121 -0.128 -0.123 -0.123 -0.123 -0.141 -0.123 -0.123 -0.141 -0.123 -0.123 -0.141 -0.123 -0.123 -0.141 -0.123 -0.124 -0.123 -0.124 -0.123 -0.123 -0.124 -0.123 -0.124 -0.123 -0.124 -0.123 -0.124 -0.123 -0.124 -0.125 -0.125 -0.125 -0.125 -0.125 -0.125 -0.125 -0.125 -0.125 -0.125 -0.128 -0.125 -0.128 -0.125 -0.128 -0.123 -0.123 -0.123 -0.141 -0.152 -0.128 -0.127 -0.128 -0.123 -0.141 -0.147 -0.128 -0.128 -0.128 -0.123 -0.123 -0.141 -0.147 -0.128 -0.221 -0.	Black I TNS (ns) -15.197 -49.392 -18.283 -21.676 -10.723 -50.867 -7.891 -118.041 -15.631 -69.956 -21.676 -24.162 -23.965 -11.075 -13.286 -58.600 -44.178 -21.278 -53.646 -26.904 -47.975 -31.646 -26.904 -47.975 -31.646 -26.904 -47.975 -34.448 -62.789 -79.364 -30.741 -21.278 -119.503 -31.9292 -32.925 -32.925 -32.925 -32.4448 -32.935 -34.448 -32.935 -34.448 -32.935 -34.448 -34.278 -34.448 -34.278 -34.448 -34.278 -34.24 -34.278 -34.24 -34.278 -34.24 -34.278 -34.24	Parrot P&: P&: WNS (ns) -0.194 -0.107 -0.122 -0.121 -0.108 -0.167 -0.115 -0.111 -0.117 -0.117 -0.119 -0.143 -0.154 -0.111 -0.112 -0.111 -0.112 -0.131 -0.122 -0.122 -0.122 -0.122 -0.122 -0.122 -0.122 -0.122 -0.122 -0.121 -0.124 -0.124 -0.125 -0.111 -0.125 -0.111 -0.125 -0.111 -0.117 -0.124 -0.124 -0.124 -0.124 -0.127 -0.124 -0.124 -0.127 -0.124 -0.124 -0.124 -0.127 -0.124 -0.124 -0.121 -0.124 -0.127 -0.124 -0.127 -0.124 -0.127 -0.124 -0.122 -0.107 -0.107 -0.107 -0.107 -0.107 -0.107 -0.107 -0.107 -0.107 -0.107 -0.107 -0.107 -0.107 -0.107 -0.110 -0.110 -0.110 -0.110 -0.110 -0.110 -0.110 -0.110 -0.110 -0.110 -0.110 -0.111 -0.110 -0.110 -0.110 -0.110 -0.111 -0.110 -0.110 -0.111 -0.111 -0.110 -0.110 -0.111 -0.127 -0.131 -0.121 -0.127 -0.131 -0.143 -0.121 -0.127 -0.131 -0.143 -0.143 -0.143 -0.141 -0.143 -0.143 -0.143 -0.143 -0.143 -0.143 -0.144 -0	R_2 TNS (ns) -60.090 -41.889 -64.540 -32.079 -45.347 -78.630 -32.865 -31.143 -42.325 -48.378 -32.522 -30.463 -39.416 -50.011 -84.830 -28.919 -61.921 -36.972 -44.766 -53.538 -77.539 -40.504 -35.700 -68.511 -27.486 -36.148 -42.620 -28.408 -34.864 -50.0131 -27.486 -34.864 -50.0131 -28.408 -34.864 -50.0131 -41.080 -28.975	
Parameter Clock Period Clock Uncertainty IO Delay Aspect Ratio Placement Util	Noise (Δ) -3 ps -2 ps -1 ps +0 ps +1 ps +2 ps -3 ps -2 ps -1 ps +1 ps +2 ps +3 ps -3 ps -2 ps -1 ps +1 ps +2 ps +3 ps -3 ps -2 ps -3 ps -2 ps -3 ps -2 ps -3 ps -3 ps -2 ps -3 ps -3 ps -2 ps -3 ps -3 ps -3 ps -2 ps -3 ps -3 ps -2 ps -3 ps -0.03 -0.02 -0.01 +0.00 +0.01 +0.02 +0 % +1 % +2 ms -1 % -2 % -1 % -3 % -2 % -1 % -1 % -2 % -2 % -1 % -2	P&2           WNS (ns)           -0.257           -0.225           -0.204           -0.212           -0.224           -0.216           -0.226           -0.227           -0.236           -0.204           -0.236           -0.207           -0.254           -0.207           -0.254           -0.204           -0.225           -0.204           -0.205           -0.204           -0.204           -0.205           -0.204           -0.205           -0.204           -0.205           -0.204           -0.205           -0.204           -0.205           -0.204           -0.205           -0.204           -0.205           -0.204           -0.205           -0.204           -0.205           -0.204           -0.202           -0.203           -0.204           -0.202           -0.203           -0.204           -0.	SweRV R 1 -393.301 -291.141 -336.346 -244.887 -287.519 -318.609 -245.109 -347.686 -265.114 -285.039 -244.887 -332.116 -315.494 -328.919 -279.308 -313.851 -332.225 -244.887 -291.155 -338.009 -299.347 -244.887 -291.457 -338.009 -29.347 -244.887 -273.615 -344.887 -273.615 -344.887 -273.615 -244.887 -273.615 -244.887 -273.615 -244.887 -273.615 -244.887 -273.615 -244.887 -273.615 -244.887 -273.615 -244.887 -273.615 -244.887 -273.615 -244.887 -273.615 -244.887 -244.887 -273.615 -244.887 -233.320 -260.962 -244.887 -244.	wrapper P& WNS (ns) -0.502 -0.793 -0.682 -0.566 -0.608 -0.710 -0.528 -0.679 -0.619 -0.620 -0.561 -0.620 -0.578 -0.451 -0.578 -0.451 -0.578 -0.578 -0.578 -0.578 -0.578 -0.578 -0.578 -0.578 -0.578 -0.578 -0.578 -0.578 -0.578 -0.578 -0.573 -0.575 -0.573 -0.575 -0.625 -0.625 -0.625 -0.625 -0.625 -0.625 -0.625 -0.625 -0.625 -0.625 -0.625 -0.625 -0.625 -0.634 -0.675 -0.672	R_2 TNS (ns) -278.424 -241.234 -280.573 -163.356 -205.182 -228.354 -228.354 -228.354 -232.646 -169.827 -259.697 -259.697 -290.598 -282.778 -290.598 -290.598 -290.598 -290.598 -290.598 -290.598 -290.598 -290.598 -290.598 -290.598 -222.695 -224.977 -225.109 -211.54 -170.578 -170.578 -170.578 -170.578 -170.578 -170.578 -170.578 -170.578 -170.578 -169.131 -263.628 -169.131 -263.628 -169.131 -263.628 -217.232 -219.109 -172.473 -216.844 -187.814 -1	P& WNS (ns) -0.123 -0.126 -0.139 -0.128 -0.111 -0.159 -0.115 -0.104 -0.145 -0.128 -0.104 -0.128 -0.123 -0.141 -0.123 -0.141 -0.152 -0.128 -0.144 -0.153 -0.144 -0.123 -0.144 -0.153 -0.153 -0.154 -0.153 -0.150 -0.150 -0.150 -0.128 -0.150 -0.150 -0.128 -0.150 -0.151 -0.153 -0.151 -0.154 -0.153 -0.151 -0.153 -0.151 -0.153 -0.151 -0.153 -0.151 -0.152 -0.153 -0.151 -0.153 -0.151 -0.152 -0.153 -0.151 -0.153 -0.151 -0.153 -0.151 -0.153 -0.151 -0.153 -0.151 -0.152 -0.153 -0.128 -0.128 -0.128 -0.128 -0.128 -0.128 -0.128 -0.128 -0.128 -0.128 -0.128 -0.128 -0.128 -0.128 -0.128 -0.128 -0.128 -0.126 -0.128 -0.221 -0.221 -0.221 -0.225 -0.255 -0.255 -0.255 -0.255 -0.255 -0.255 -0.255 -0.255 -0.255 -0.2	Black I I TNS (ns) -15.197 -49.392 -18.283 -21.676 -10.723 -50.867 -7.891 -18.041 -15.631 -69.956 -24.162 -23.965 -11.075 -13.286 -58.600 -44.178 -51.646 -26.904 -47.975 -37.853 -30.131 -20.879 -52.868 -62.789 -52.868 -62.789 -79.364 -30.741 -21.278 -50.2801 -30.280 -30.280	Parrot P&: P&: WNS (ns) -0.194 -0.107 -0.122 -0.121 -0.108 -0.167 -0.115 -0.111 -0.117 -0.119 -0.143 -0.154 -0.112 -0.112 -0.112 -0.112 -0.112 -0.112 -0.121 -0.121 -0.124 -0.121 -0.121 -0.121 -0.124 -0.121 -0.121 -0.125 -0.121 -0.127 -0.126 -0.127 -0.127 -0.121 -0.127 -0.127 -0.128 -0.121 -0.129 -0.121 -0.121 -0.129 -0.121 -0.121 -0.129 -0.121 -0.121 -0.129 -0.121 -0.121 -0.121 -0.124 -0.121 -0.121 -0.124 -0.121 -0.121 -0.124 -0.121 -0.121 -0.121 -0.124 -0.121 -0.121 -0.121 -0.121 -0.124 -0.121 -0.131 -0.112 -0.131 -0	R_2 TNS (ns) -60.090 -41.889 -64.540 -32.079 -45.347 -78.630 -32.865 -31.143 -42.325 -48.378 -29.889 -32.522 -30.463 -39.416 -50.011 -84.830 -28.919 -61.921 -36.972 -44.766 -53.538 -77.539 -40.504 -35.700 -68.511 -27.486 -36.148 -42.620 -28.408 -34.864 -50.131 -41.080 -52.975 -32.278 -32.278	
Parameter Clock Period Clock Uncertainty IO Delay Aspect Ratio Placement Util	Noise (Δ)	P&2           WNS (ns)           -0.257           -0.225           -0.225           -0.224           -0.212           -0.224           -0.210           -0.221           -0.224           -0.204           -0.210           -0.224           -0.204           -0.207           -0.250           -0.242           -0.250           -0.242           -0.204           -0.204           -0.204           -0.204           -0.204           -0.204           -0.204           -0.204           -0.204           -0.204           -0.204           -0.205           -0.204           -0.204           -0.205           -0.204           -0.204           -0.204           -0.204           -0.204           -0.204           -0.204           -0.204           -0.204           -0.204           -0.204           -0.204           -0.	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Parameter Clock Period Clock Uncertainty IO Delay Aspect Ratio Placement Util Best	Noise (Δ) -3 ps -2 ps -1 ps +0 ps +1 ps +2 ps -3 ps -2 ps -1 ps +0 ps +1 ps +2 ps +3 ps -3 ps -2 ps -1 ps +0 ps +1 ps +3 ps -3 ps -2 ps -1 ps +0 ps 1 ps 2 ps 3 ps -0 0 ps 1 ps 2 ps 3 ps -0.03 -0.02 -0.01 +0.00 +0.001 +0.002 +0.03 -2 % -1 % +1 % +2 % +3 % -2 % -1 % -2 % -3 % -2 % -2 % -3 % -2 % -1 % -2 % -3 % -2 % -3 % -2 % -1 % -1 % -2 % -1 % -2 % -1 % -1 % -2 % -1 % -1 % -0 % -	P&2           WNS (ns)           -0.257           -0.225           -0.204           -0.212           -0.214           -0.216           -0.221           -0.236           -0.236           -0.204           -0.236           -0.254           -0.254           -0.254           -0.254           -0.242           -0.250           -0.242           -0.250           -0.240           -0.268           -0.206           -0.217           -0.462           -0.268           -0.201           -0.202           -0.203           -0.214           -0.223           -0.204           -0.205           -0.201           -0.202           -0.202           -0.203           -0.2172           -0.200           -0.197           -0.228           -0.204           -0.204           -0.204           -0.204           -0.204           -0	SweRV R 1 TNS (ns) -339.301 -291.141 -336.346 -244.887 -287.519 -318.609 -245.109 -347.686 -265.114 -285.039 -244.887 -332.116 -315.494 -328.919 -279.308 -313.851 -332.225 -244.887 -332.125 -244.887 -293.457 -293.457 -244.578 -231.320 -250.333 -232.827 -244.887 -283.216 -260.962 -250.333 -232.827 -244.887 -283.216 -294.268 -293.47 -244.887 -283.216 -294.268 -294.268 -293.47 -244.887 -283.216 -294.268 -294.268 -293.47 -244.887 -283.216 -294.268 -294.268 -294.268 -293.47 -244.887 -283.216 -294.268 -294.268 -293.47 -244.887 -244.887 -244.887 -244.887 -244.887 -244.887 -244.887 -244.288 -244.288 -244.887 -244.288	wrapper P& WNS (ns) -0.502 -0.793 -0.682 -0.566 -0.608 -0.608 -0.710 -0.528 -0.679 -0.619 -0.620 -0.580 -0.561 -0.620 -0.871 -0.578 -0.451 -0.578 -0.697 -0.578 -0.697 -0.578 -0.697 -0.578 -0.623 -0.625 -0.634 -0.578 -0.625 -0.637 -0.578 -0.625 -0.637 -0.578 -0.625 -0.637 -0.578 -0.627 -0.578 -0.697 -0.578 -0.697 -0.578 -0.697 -0.578 -0.697 -0.578 -0.627 -0.578 -0.627 -0.578 -0.627 -0.578 -0.627 -0.578 -0.627 -0.578 -0.627 -0.578 -0.627 -0.578 -0.627 -0.578 -0.627 -0.578 -0.627 -0.724 -0.578 -0.623 -0.623 -0.623 -0.623 -0.623 -0.625 -0.623 -0.625 -0.623 -0.625 -0.623 -0.623 -0.625 -0.623 -0.623 -0.625 -0.623 -0.625 -0.623 -0.625 -0.623 -0.625 -0.623 -0.625 -0.623 -0.623 -0.625 -0.637 -0.623 -0.625 -0.637 -0.625 -0.637 -0.625 -0.637 -0.625 -0.637 -0.625 -0.637 -0.625 -0.637 -0.625 -0.637 -0.625 -0.637 -0.625 -0.637 -0.625 -0.637 -0.625 -0.637 -0.625 -0.637 -0.625 -0.637 -0.575 -0.672 -0.575 -0.	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Parameter         Clock Period         Clock Uncertainty         IO Delay         Aspect Ratio         Placement Util         Best Worst	Noise (Δ)	P&2           WNS (ns)           -0.257           -0.225           -0.204           -0.212           -0.224           -0.216           -0.226           -0.227           -0.236           -0.204           -0.216           -0.221           -0.236           -0.207           -0.254           -0.204           -0.207           -0.204           -0.205           -0.204           -0.204           -0.205           -0.204           -0.205           -0.204           -0.205           -0.204           -0.205           -0.204           -0.205           -0.204           -0.205           -0.205           -0.204           -0.205           -0.204           -0.205           -0.204           -0.204           -0.204           -0.204           -0.204           -0.204           -0.204           -0.208           -0.	SweRV R 1 -393.301 -291.141 -336.346 -244.887 -287.519 -318.609 -245.109 -347.686 -265.114 -285.039 -244.887 -332.116 -315.494 -328.919 -279.308 -313.851 -332.225 -244.887 -291.155 -338.009 -299.347 -244.887 -291.425 -338.009 -299.347 -244.887 -244.878 -231.320 -260.962 -250.333 -232.827 -244.887 -245.977 -246.977 -246.977 -247	wrapper P& WNS (ns) -0.502 -0.793 -0.682 -0.566 -0.608 -0.710 -0.528 -0.679 -0.619 -0.602 -0.580 -0.620 -0.561 -0.620 -0.871 -0.578 -0.451 -0.724 -0.578 -0.697 -0.538 -0.667 -0.578 -0.622 -0.578 -0.622 -0.623 -0.622 -0.623 -0.625 -0.623 -0.625 -0.625 -0.625 -0.625 -0.625 -0.625 -0.672 -0.575 -0.672 -0.709 -0.709 -0.451 -0.709 -0.451 -0.871 -0.871	R_2 TNS (ns) -278.424 -241.234 -280.573 -163.356 -205.182 -228.354 -228.354 -232.646 -111.716 -169.827 -259.697 -290.598 -282.778 -290.598 -282.778 -225.109 -215.154 -170.578 -179.544 -170.578 -179.544 -170.578 -230.526 -169.131 -240.638 -217.232 -217.232 -219.109 -172.473 -216.844 -187.814 -196.054 -161.388 -331.423	$\begin{array}{c} & P\&\\ \hline & WNS (ns)\\ -0.123\\ -0.126\\ -0.139\\ -0.126\\ -0.139\\ -0.128\\ -0.111\\ -0.159\\ -0.115\\ -0.135\\ -0.104\\ -0.145\\ -0.123\\ -0.141\\ -0.147\\ -0.152\\ -0.128\\ -0.144\\ -0.123\\ -0.144\\ -0.153\\ -0.144\\ -0.123\\ -0.144\\ -0.123\\ -0.144\\ -0.123\\ -0.144\\ -0.123\\ -0.144\\ -0.123\\ -0.144\\ -0.123\\ -0.144\\ -0.123\\ -0.144\\ -0.123\\ -0.144\\ -0.123\\ -0.144\\ -0.123\\ -0.144\\ -0.123\\ -0.144\\ -0.123\\ -0.144\\ -0.123\\ -0.144\\ -0.123\\ -0.144\\ -0.123\\ -0.144\\ -0.123\\ -0.123\\ -0.104\\ -0.235\\ -0.104\\ -0.241\\ -0.$	Black I I TNS (ns) -15.197 -49.392 -18.283 -21.676 -10.723 -50.867 -7.891 -118.041 -15.631 -69.956 -24.162 -23.965 -11.075 -13.286 -58.600 -44.178 -21.278 -50.005 -31.646 -26.904 -47.975 -37.853 -30.131 -20.879 -52.868 -62.935 -34.448 -62.789 -79.364 -30.741 -21.278 -119.503 -302.801 -122.664 -7.891 -302.802 -302.802 -302.802 -302.802 -302.802	Parrot           P&:           WNS (ns)           -0.194           -0.107           -0.121           -0.121           -0.111           -0.117           -0.117           -0.117           -0.117           -0.117           -0.117           -0.118           -0.119           -0.131           -0.112           -0.111           -0.121           -0.112           -0.112           -0.112           -0.112           -0.112           -0.112           -0.112           -0.112           -0.112           -0.121           -0.121           -0.121           -0.121           -0.121           -0.121           -0.121           -0.110           -0.111           -0.112           -0.112           -0.131           -0.131           -0.131           -0.131           -0.121           -0.131           -0.131           -0.	R_2 TNS (ns) -60.090 -41.889 -64.540 -32.079 -45.347 -78.630 -32.865 -31.143 -42.325 -48.378 -29.889 -32.522 -30.463 -39.416 -50.011 -84.830 -77.539 -40.504 -53.538 -77.539 -40.504 -35.700 -68.511 -27.486 -34.864 -50.131 -41.080 -28.408 -34.864 -50.131 -41.080 -52.975 -32.278 -36.651 -27.486 -84.830	

Table 4: Revisiting experiments of [7]. Chaotic behavior is studied in P&R tools.

Table 5: Overall post-routed result comparison with a shifted macro placement blockages on SweRV\_wrapper design. P&R\_1 is used. The bold font denotes min and max values.

Nois shiftX (um)	e (Δ) shiftY (um)	WNS (ns)	TNS (ns)	Wirelength (um)	DRC
	-18	-0.078	-12.579	1852592.927	268
	-12	-0.064	-6.356	1767687.207	322
	-6	-0.061	-9.672	1859084.593	155
0	+0	-0.085	-11.143	1712514.599	115
	+6	-0.050	-2.564	1660819.498	322
	+12	-0.088	-18.800	1909736.061	616
10	+18	-0.068	-8.538	1769723.536	280
-18		-0.087	-12.036	1/11466.//6	268
-12		-0.050	-2.364	1712514 500	322
-6	0	-0.085	-11.145	1712514.599	115
+0	0	-0.085	-11.145	1/12314.399	419
+0		-0.004	-14.756	187447 234	× 1000
+12		-0.095	-9.786	1777746 608	103
+10		-0.005	-9.780	177740.000	105
5	4 1723 0 (a)	14 13 12 26 10 25 21 18	22 23 5 12 16 27 6	18 9 7 8 25 (b)	10 15 2117
9 11 E		2223 2021 2425 4 9 1817 16 5 1413 12	9 11 10 22 14 1817	6 4 5 21232 1519 20 26 2725 24	8 7 16 13 12
	(c)			(d)	

Figure 4: Visualized macro placement solutions when a subset of macros are pre-placed on SweRV\_wrapper design. The center light blue square denotes macro placement blockages, and darker blue denotes fixed macros from original solutions. (a) original solution from P&R\_1. (b) lower-left, upperleft, upper-right macros are fixed from (a). (c) original solution from P&R\_2. (d) lower-right, upper-left, upper-right macros are fixed from (c).

to the P&R(&Opt) flow. The original P&R(&Opt) result serves as a constructive proof of the achievable QOR with this netlist. However, as shown in Table 6, the second run can have anywhere from 4% to 10% more routed wirelength than the first run.

#### 7 **CONCLUSION**

In this work, we have revisited the studies of tool noise and chaos by [10] [7], toward determining "noise floors" for interconnect prediction accuracy. We find that additional sources of tool noise now Table 6: P&R result comparison when post-route final netlist (.v) is fed back into the P&R(&Opt) flow, for the AES testcase. The target clock period is set as 450ps. In both tools, the wirelength is increased significantly in the second run, even though the result of the first run is a constructive proof of achievable QOR.

Tools	1st WNS(ns)	1st WL(um)	2nd WNS(ns)	2nd WL(um)
P&R_1	-0.061	101667.24	-0.050	112284.63
P&R_2	-0.064	110604.19	-0.075	114939.83

exist beyond what had been identified in the works of a decade ago, and that today's major vendor tools show qualitatively different susceptibilities to noise sources. We further identify a new source of tool noise: symmetry in the floorplan definition. And, we observe very large chaotic effects on auto-macro placement from the location of a small fixed obstacle. Finally, we ask the question, "How should predictions be used?" and show example scenarios where advance knowledge of physical design outcomes can potentially worsen noise and predictability. We show a potentially harmful effect of knowing part of a macro placement solution in advance. And, we show a somewhat trivial example of harm from knowing the post-route netlist in advance of P&R. Each of these examples reinforces a new caveat for prediction: "Be careful what you ask for."

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