GameBench

Performance Discovery Sample Report

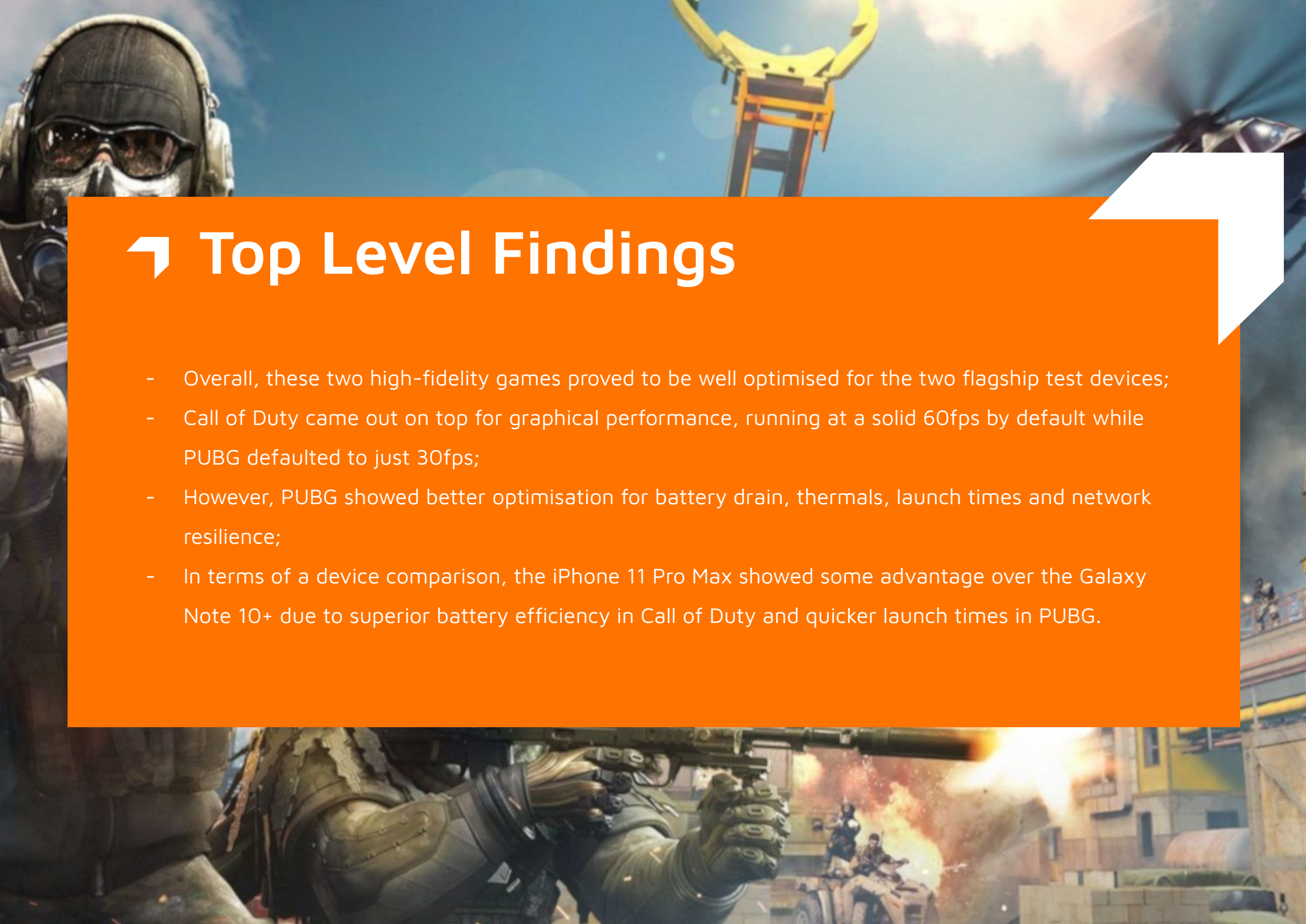
Call of Duty Mobile vs. PUBG Mobile

Tested Feb 2020 on:

- iPhone 11 Pro Max
- Galaxy Note 10+ 5G

This is a sample report using existing "off the shelf" devices and games.

A client report that Gamebench has prepared will always be confidential.



Top Level Findings

- Overall, these two high-fidelity games proved to be well optimised for the two flagship test devices;
- Call of Duty came out on top for graphical performance, running at a solid 60fps by default while PUBG defaulted to just 30fps;
- However, PUBG showed better optimisation for battery drain, thermals, launch times and network resilience;
- In terms of a device comparison, the iPhone 11 Pro Max showed some advantage over the Galaxy Note 10+ due to superior battery efficiency in Call of Duty and quicker launch times in PUBG.

Overall Ratings

Call of Duty Mobile vs. PUBG Mobile

	iPhone 11 Pro Max	Galaxy Note 10+	iPhone 11 Pro Max	Galaxy Note 10+
Performance				
Image Consistency				
Battery Life				
Thermals				
Launch Time				
Network Resilience				

What these badges show

- In terms of performance, Call of Duty beat PUBG on these test devices, achieving a solid 60fps -- but PUBG at least achieved a steady 30fps.

- Image rendering was consistent across all tests. The Note 10 suffered none of the degradation previously found on the Note 8.

- Battery life good, but both games caused significant heating -- with PUBG on the Galaxy Note 10+ being the only exception.

- Our ratings highlight poor launch times on Call of Duty, on both iOS and Android. PUBG launched more quickly, particularly on the iPhone 11 Pro Max.

- PUBG's PvP gameplay worked well even in our worst connectivity scenario, achieving Ultra for network resilience, while Call of Duty was more network dependent.

GameBench

Methodology

- Our data reflects the experience of real gamers who are playing to win, i.e. no bots, scripts or device farms;
- The "testing" part of what we do is accomplished using objective GameBench tools, with no reliance on traditional testers or subjective opinions;
- Although we have validated our metrics using multiple independent methods, GameBench tools nevertheless rely to some extent on the accuracy of underlying metrics produced by the Android and iOS operating systems;
- Each gamer follows a strict methodology that does not interfere with natural gameplay but does ensure that certain parameters are matched across tests (e.g. game and device configuration, game scenarios covered etc);
- Our data represents 15 minutes of gameplay after a 15-minute warm-up period;
- We use real-world, unrooted / non-jailbroken devices to reflect real-world devices as closely as possible, with minimal overhead (<1.5% added CPU load) from the use of GameBench tools and minimal interference from other aspects of instrumentation.
- Although we simulate network connectivity scenarios, these scenarios are based on a real-world connectivity environments that gamers are likely to encounter such as 3G/HSPA+ areas, as well as weak and congested public WiFi hotspots.
- To help simplify our results, we apply colour-coded badges (such as "Ultra" or "Smooth") to experiences that meet key thresholds of user experience. These badges are always relative to the specific context of the test and are never absolute. For example, iPhone 11 Max cannot considered an "Ultra" device, because an Ultra badge can only apply to a specific experience, i.e., a specific build of a specific game running with specific settings on a specific OS version in a specific network environment etc.

GameBench

Glossary

- **Game-device pair**: Every gaming experience relies on hardware and software working in harmony, so GameBench Labs only rates "game-device pairs" -- it does not rate products individually.
- **Verified Results**: Objective measurements of the quality of a game-device pair that were captured under GameBench supervision following our strict methodology requirements;
- **Gameplay:** Our ratings cover the core, interactive component of a game, excluding load screens, menu screens, adverts etc.
- **Target Frame rate (fps)** -- The number of frames per second that the device and/or game product makers tell gamers product makers promise their game successfully rendered and displayed by a game-device pair, reflecting the visual fluidity of a gaming experience;
- **Median frame rate** -- A key GameBench metric representing the centre-most frame rate during gameplay and therefore the typical visual fluidity that the gamer experienced (Note: Higher is better);
- **Minimum frame rate** -- The worst frame rate experienced during gameplay, which typically happens during a moment of heightened gamer activity or a computational bottleneck (Note: Higher is better);
- **Frame rate variability** -- The average jump between consecutive frame rate readings taken each second, reflecting the amount of variation in visual fluidity that a gamer experienced (Note: Lower is better);
- **Image Consistency** -- GameBench only awards Ultra ratings to experiences that achieve industry-leading fluidity while still delivering image quality that is as good as what we see on other devices.

Ratings Explainer

	Performance	Image Consistency	Battery
Ultra:	•60fps gameplay; •Median ⩾58fps, Minimum ⩾54fps; Variability ⩽2fps, •No sustained drops below 54fps during non-gameplay interaction. •No Image Quality compromise.	•Jaggy Index ⩽0.2; •Complexity Index on par with the best in the sample.	•7+ hours of expected gameplay on a charge
Smooth:	•30fps interaction (interaction median > 29fps) •Variance < 3fps •No sustained drops below 27fps during gameplay or non-gameplay interaction.	•Jaggy Index ⩽0.5; •Complexity Index on par with the best in the sample.	•5-7 hours of expected gameplay on a charge
Basic:	•Gameplay median at least 20fps with no drops below 18fps. •No sustained drops below 30fps during non-gameplay interaction.	•Jaggy Index ⩽0.7; •No Complexity requirement.	•3-5 hours of expected gameplay on a charge
Poor:	•Everything else	•Everything else	•Less than 3 hours of expected gameplay on a charge

Ratings Explainer

	Launch Time	Network Conditions	Thermals
Ultra:	Less than 10 seconds for cold launch, from tapping icon to first interactive screen	Able to be played without issue with 120Kbps up/down bandwidth and 100ms latency.	•Hottest part of the device is less than 35 degrees Celsius after 20 minutes of gameplay..
Smooth:	10-15 seconds cold launch time	Able to be played without issue with 300Kbps and 80ms added latency.	•Hottest part of the device is less than 37.5 degrees Celsius after 20 minutes of gameplay.
Basic:	15-20 seconds cold launch time	Able to be played without issue with 600Kbps and 60ms added latency.	•Hottest part of the device is less than 40 degrees Celsius after 20 minutes of gameplay.
Poor:	Over 20 seconds cold launch time	Any greater compromise to network condition hurts the gaming experience.	•Hottest part of the device is more than 40 degrees Celsius after 20 minutes of gameplay.

Performance Ratings

Call of Duty Mobile vs. PUBG Mobile

iPhone 11 Pro Max		
Galaxy Note 10+ 5G		

Key Performance Findings

- Call of Duty Mobile beats PUBG on visual fluidity, when played at Default settings.

- Call of Duty Mobile targets 60fps and achieves this consistently, while PUBG only targets and achieves 30fps.

- The games ran equally smoothly on the two test devices, with the iPhone 11 Pro Max and Galaxy Note+ 5G achieving the same badge ratings.

Performance Metrics

	Call of Duty Mobile	PUBG Mobile
iPhone 11 Pro Max		
Median FPS / Target	59 / 58	31 / 29
Minimum FPS / Target	55 / 54	29 / 27
FPS Variability / Target	0.8 / 2	0.4 / 3
Performance Rating	Ultra	Smooth
Galaxy Note 10+ 5G		
Median FPS / Target	60 / 58	30 / 29
Minimum FPS / Target	55 / 54	29 / 27
FPS Variability / Target	0.3 / 2	0.3 / 2
Performance Rating	Ultra	Smooth

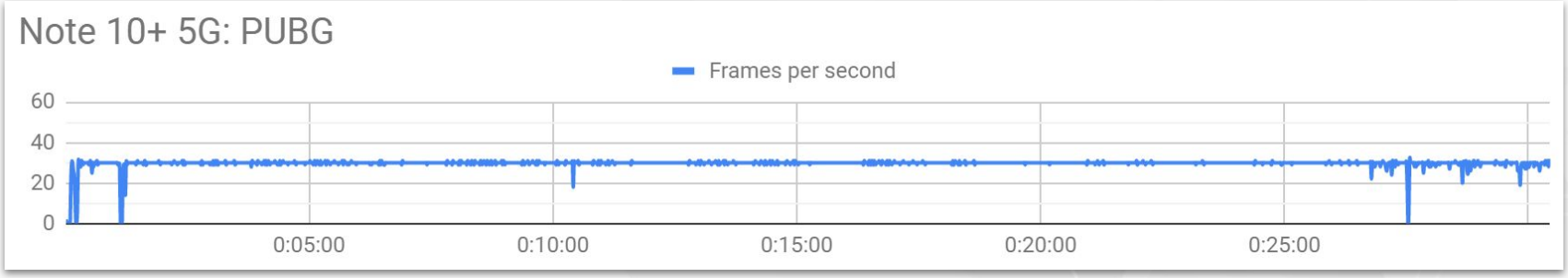
Performance Metrics Explainer

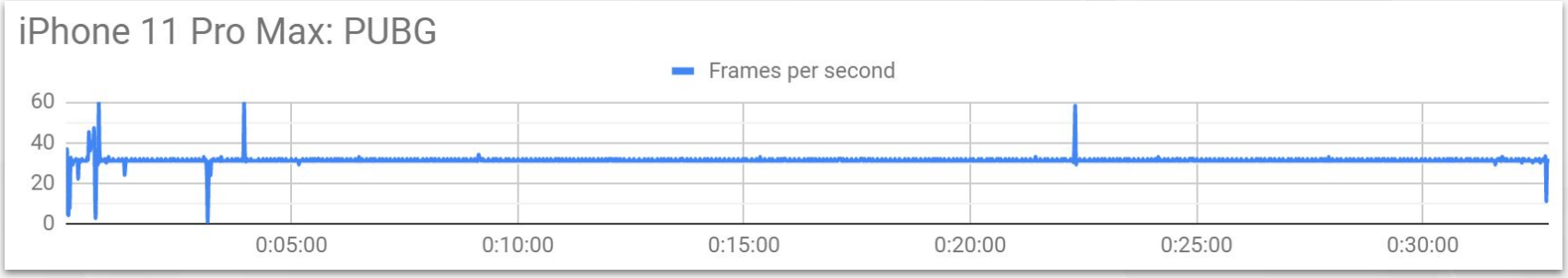
- This table shows key frame rate metrics relative to the target thresholds for the badge that was achieved.

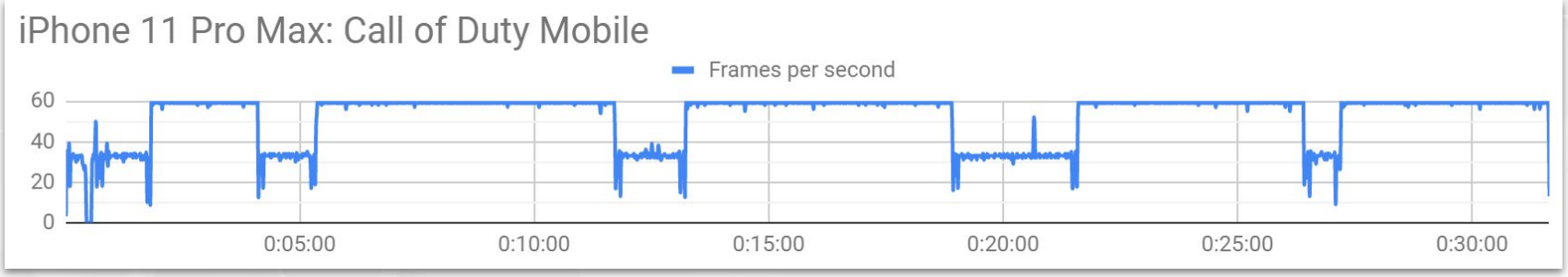
- All of these metrics can be seen in the frame rate charts on the GameBench Web Dashboard using the session links (See Session Links section below).

- Our performance badges are always relative to specific test scenarios. For example, in the scenarios covered here, we tested the games and devices on default settings. Had we tested on max settings or a device's "high performance mode," we might have seen different badges.

Performance Charts







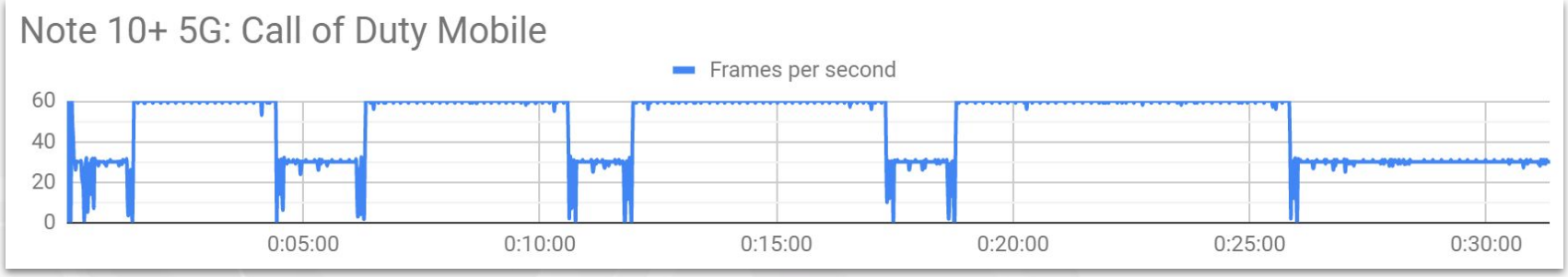
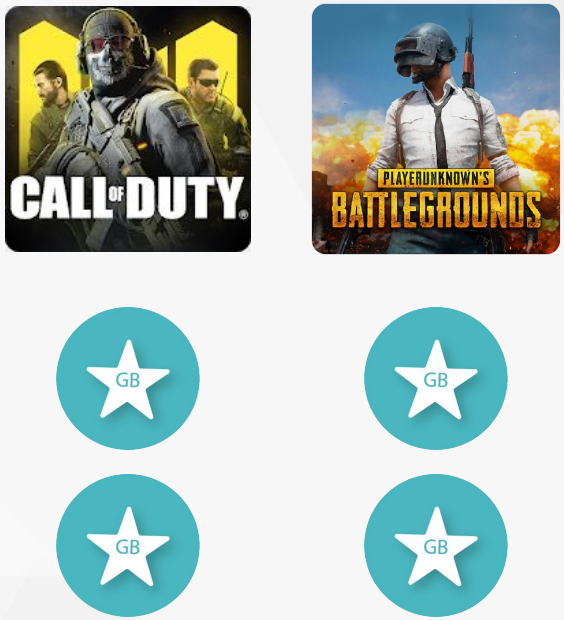


Image Consistency Ratings

Call of Duty Mobile vs. PUBG Mobile



Key Image Consistency Findings

- We observed no significant inconsistencies in the rendering of gameplay images across devices;
- This resulted in every game-device pair getting an Ultra rating by default;
- Note: We do not compare Image Consistency across games, because each game has its own art style;
- We only compare Image Consistency for each game across devices, in order highlight issues where a game looks worse on a particular device;
- Had any device shown worse image consistency, it would have dropped a badge for each 15% of measured degradation.

Image Consistency Metrics

	Call of Duty Mobile	PUBG Mobile
iPhone 11 Pro Max		
Jaggy Index / Target	0.39 / 0.32	0.38 / 0.34
Complexity Index 1 / Target	1.56 / 1.56	1.26 / 1.26
Complexity Index 2 / Target	2.80 / 2.95	2.68 / 2.77
Estimated Resolution / Target	720 / 720	720 / 720
Rating	Ultra	Ultra
Galaxy Note 10+ 5G		
Jaggy Index / Target	0.33 / 0.33	0.34 / 0.34
Complexity Index 1 / Target	1.54 / 1.56	1.23 / 1.26
Complexity Index 2 / Target	2.95 / 2.95	2.77 / 2.77
Estimated Resolution / Target	720 / 720	720 / 720
Rating	Ultra	Ultra

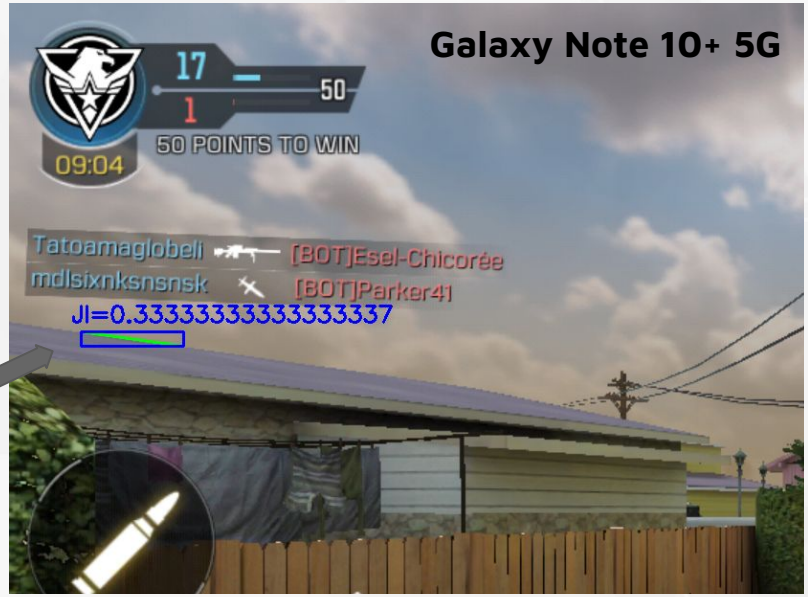
Image Consistency Explainer

- The GameBench Jaggy Index (lower is better) measures the degree to which low-res gameplay creates artefacts in geometrical elements containing straight lines;
- Two complexity indices (fractal and spatial, higher is better) help to spot differences like texture detail and lighting effects in a scene.
- Finally, we double-check for any differences in resolution / upscaling using manual estimation of effective resolution.
- If a game-device pair renders images that are consistent with others in our sample, then an Ultra badge is awarded. Any degradation >10% of the normalised maximum (in the case of jaggies) or the best result (in the case of complexity) will cost a badge.

Jaggy Index Example

Jaggy Explainer

- Our Jaggy Index (JI) algorithm measures near-horizontal lines that are likely to appear jaggy to the gamer; that are likely to be particularly noticeable to the gamer;
- The algorithm gets similar results of around 0.33-0.39 for both the Note 10 and iPhone 11 Pro Max, which reflects artefacts typical of upscaling from a 720p native image to a 1080p display image without effective anti-aliasing.
- Since both images show a similar Jaggy Index, both get Ultra badges.



Complexity Index Example

Complexity Explainer

- We found no differences in complexity between the iPhone 11 Pro Max and Galaxy Note 10+ 5G;
- To illustrate how the Complexity Index works, we've compared the Galaxy Note 10+ 5G to the older Note 8 instead;
- This older Note device played PUBG with low graphical quality by default (known in the game as "Balanced" mode), producing a low Type 1 Complexity Index of 1.07, reflecting reduced texture detail -- e.g., on the hillside in the picture to the left.
- The Galaxy Note 10+ 5G fixes this issue, running PUBG in HD mode by default, achieving a Type 1 Complexity Index of 1.23 and restoring full-detail textures as in the example.

Battery Ratings

Call of Duty Mobile vs. PUBG Mobile

iPhone 11 Pro Max

Galaxy Note 10+ 5G

Key Battery Findings

- PUBG Mobile showed more consistent battery life across devices -- possibly as a consequence of its frame rate cap;

- However, Call of Duty Mobile only fell behind on the Android device -- it managed to deliver excellent battery life on the iPhone 11 Pro Max despite running at 60fps.

- Overall, the iPhone 11 Pro Max stands out as the more power efficient device for playing these two games at default settings.

Battery Metrics

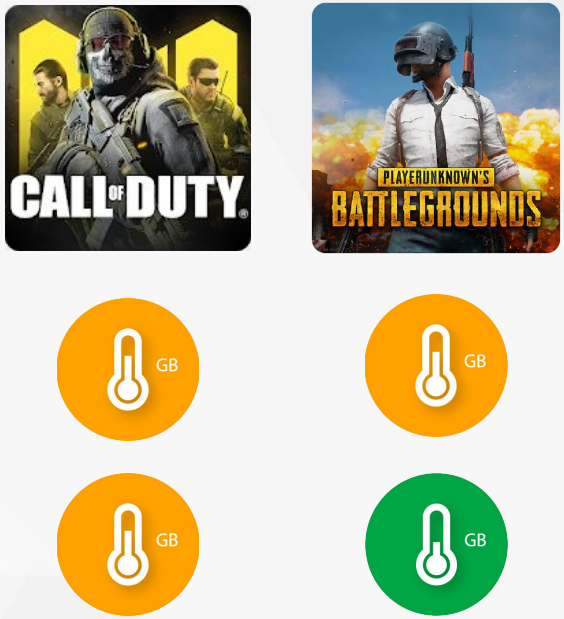
	Call of Duty Mobile	PUBG Mobile
iPhone 11 Pro Max		
Average Current Draw (mA)	433	438
Physical Battery Size	3969	3969
Expected Battery Life (Hrs) / Target	9.2 / 7	9.1 / 7
Battery Rating	Ultra	Ultra
Galaxy Note 10+ 5G		
Average Current Draw (mA)	681	615
Physical Battery Size (mAh)	4300	4300
Expected Battery Life (Hrs) / Target	6.3 / 5	7 / 7
Battery Rating	Good	Ultra

Battery Explainer

- GameBench measures the expected battery life of a game -- i.e., the expected number of hours of gameplay between starting play at 100 percent battery and finishing play when the device dies;
- This duration is based on dividing the physical battery capacity of the test device (in mAh) by the recorded average current draw of the game on that device (in mA);
- Ultra requires 7 hours, Good requires 5 hours, Basic requires 3 hours and Poor is anything below that.

Thermal Ratings

Call of Duty Mobile vs. PUBG Mobile



Key Thermal Findings

- As expected for this genre, both games caused significant heating on both test devices;

- However, PUBG on the Note 10+ stands out as the coolest experience, staying within our "Good" threshold of 37.5 degrees Celsius.

- The coolness of PUBG on the Note 10 likely stems from the mix of PUBG's low frame rate and battery drain combined with the Note 10's good thermal management, including its relatively low idle temperature.

Thermal Metrics

	Call of Duty Mobile	PUBG Mobile
iPhone 11 Pro Max		
0-Minute Temp (degrees C)	31.1	31.0
20-minute Temp (degrees C)	38.1 / 40	38.3 /40
Change / Target	7.0	7.3
Thermal Rating	Basic	Basic
Galaxy Note 10+ 5G		
0-Minute Temp (degrees C)	28.0	27.6
20-minute Temp (degrees C)	37.6 / 40	37.5 /37.5
Change	9.6	9.9
Thermal Rating	Basic	Good

Thermals Explainer

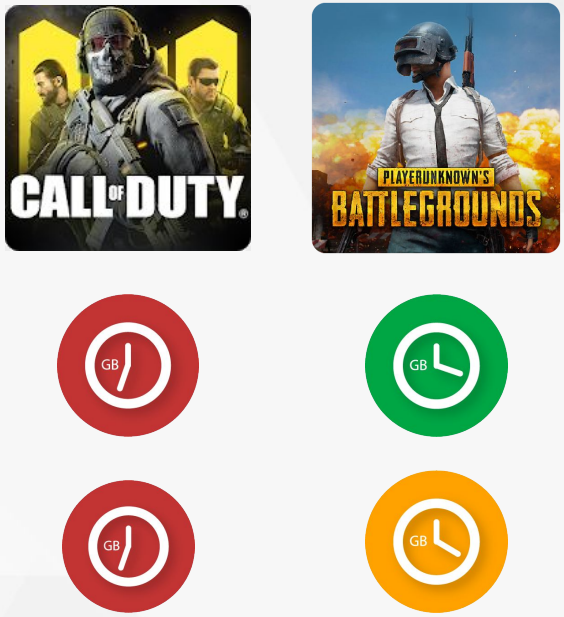
The hottest area of the rear of the device is measured after a period of 15-minutes screen-off idle time, and then measured again after 20 minutes of gameplay.

The second measurement is used to apply a badge, based on the idea that gamers prefer phones not to get noticeably hotter than body temperature during gameplay:

- Ultra for less than 35.0 degrees Celsius after gameplay;
- Good for less than 37.5 degrees Celsius after gameplay (i.e. body temperature);
- Basic for less than 40.0 degrees Celsius increase after gameplay;
- Poor for more than 40.0 degrees Celsius increase after gameplay.

Launch Time Ratings

Call of Duty Mobile vs. PUBG Mobile



Key Launch Time Findings

- On the whole, PUBG loads much more quickly than Call of Duty;
- PUBG loads quickest on the iPhone, suggesting that either the iOS version of PUBG is better optimized or that the iPhone 11 Pro Max is able to handle the launch workload more quickly.
- Our ratings align with the prevalence of negative user reviews of Call of Duty that mention long launch times -- this is the most frequent topic of complaint among Call of Duty players on both Android and iOS.

Launch Time Metrics

	Call of Duty Mobile	PUBG Mobile
iPhone 11 Pro Max		
Launch Test 1 (s)	26.5	12.1
Launch Test 2 (s)	26.8	10.9
Launch Test 3 (s)	29	10.4
Average / Target (s)	Poor	Good
Rating		
Galaxy Note 10+ 5G		
Launch Test 1 (s)	32.7	17.5
Launch Test 2 (s)	32.0	16.4
Launch Test 3 (s)	32.4	17.9
Average / Target (s)	32.4	17.3
Rating	Poor	Basic

Launch Time Explainer

- GameBench measures the time from tapping a game icon on the phone home screen to seeing the first interactive screen in the game;
- Tests are repeated three times to account for an inevitable degree of variation based on CPU background processes and other variables;
- If readings are not consistent, we investigate further, but in this case all readings were consistent;
- To get Ultra, a game must launch in under 10s; Good is under 15s; Basic is under 20s; Poor is longer than 20s.

Network Ratings

Call of Duty Mobile vs. PUBG Mobile

iPhone 11 Pro Max		
Galaxy Note 10+ 5G		

Key Network Findings

- We checked PvP gameplay under different network scenarios and found the PUBG was significantly more resilient and able to play even in our toughest scenario, thus achieving our Ultra badge;
- PUBG peaked at just 66Kbps download during gameplay, vs 210Kbps for Call of Duty, showing why PUBG was able to deliver good gameplay even in our harshest bandwidth scenario of 120Kbps.
- Call of Duty was more susceptible to player position glitches as latency increased beyond 130ms, while PUBG maintained effective gameplay at 200ms of added latency.

Network Resilience Metrics

	Call of Duty Mobile	PUBG Mobile
iPhone 11 Pro Max		
Peak upload (Kbps)	30	37
Peak download (Kbps)	210	66
Latency breakpoint (ms)	130	200
Rating	Good	Ultra
Galaxy Note 10+ 5G		
Peak upload (Kbps)	46	35
Peak download (Kbps)	206	50
Latency breakpoint (ms)	130	200
Rating	Good	Ultra

Network Resilience Explainer

- Network Resilience is a category of test, reflecting how well different gaming experiences cope when network conditions get worse;
- For each test project, we define network scenarios that are relevant to the client and the use cases of their products;
- An Ultra badge is awarded to whichever experience can handle the toughest scenario, while Poor is for an experience which hits network bottlenecks even in the best scenario, and Smooth and Basic cover any scenarios in between;
- Our network resilience badges are therefore not absolute or transferable across projects or products, unless test scenarios happen to be matched across these projects.

Session IDs

These session IDs let you see read-only raw data on the GameBench dashboard. Please don't share externally.

Game	Device	Link
COD Mobile	iPhone 11 Pro Max	https://web.gamebench.net/shared/session/5a33e99a7b577f93aa21ff49dfae38364ac1a223
PUBG Mobile	iPhone 11 Pro Max	https://web.gamebench.net/shared/session/66e5f3305729fec454da49e5a79a1af5f28bff00
COD Mobile	Galaxy Note 10+ 5G	https://web.gamebench.net/shared/session/dee9ed4f5dbfe39b1cad76a439210878d0193a3e
PUBG Mobile	Galaxy Note 10+ 5G	https://web.gamebench.net/shared/session/b43138beea0a94eff03b5dfe3a11bc6c0180cef7

Next steps to discuss

- Discuss how you want to share the report internally?
- Discuss different ways in which we can present the data?
- Deep dive reports
- User Review Analysis
- Cadence and next reports

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