Design Docs at Google

11 min read. 85 comments

One of the key elements of Google's software engineering culture is the use of defining software designs through design docs. These are relatively informal documents that the primary author or authors of a software system or application create before they embark on the coding project. The design doc documents the high level implementation strategy and key design decisions with emphasis on the trade-offs that were considered during those decisions.

As software engineers our job is not to produce code per se, but rather to solve problems. Unstructured text, like in the form of a design doc, may be the better tool for solving problems early in a project lifecycle, as it may be more concise and easier to comprehend, and communicates the problems and solutions at a higher level than code.

Besides the original documentation of a software design, design docs fulfill the following functions in the software development lifecycle:

- Early identification of design issues when making changes is still cheap.
- Achieving consensus around a design in the organization.
- Ensuring consideration of cross-cutting concerns.
- Scaling knowledge of senior engineers into the organization.
- Form the basis of an organizational memory around design decisions.

5331

designer(s).

Anatomy of a design doc #

Design docs are informal documents and thus don't follow a strict guideline for their content. Rule #1 is: Write them in whatever form makes the most sense for the particular project.

Having said that, a certain structure has established itself as really useful.

Context and scope

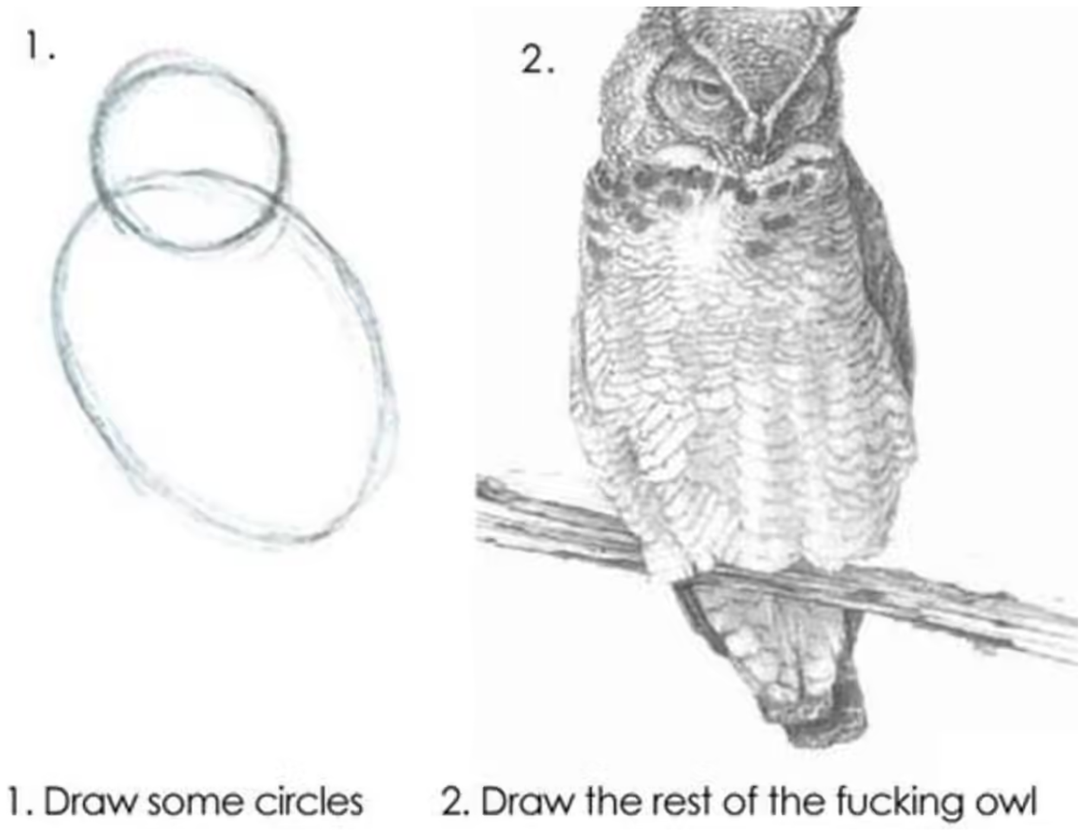
This section gives the reader a very rough overview of the landscape in which the new system is being built and what is actually being built. This isn't a requirements doc. Keep it succinct! The goal is that readers are brought up to speed but some previous knowledge can be assumed and detailed info can be linked to. This section should be entirely focused on objective background facts.

Goals and non-goals

A short list of bullet points of what the goals of the system are, and, sometimes more importantly, what non-goals are. Note, that non-goals aren't negated goals like "The system shouldn't crash", but rather things that could reasonably be goals, but are explicitly chosen not to be goals. A good example would be "ACID compliance"; when designing a database, you'd certainly want to know whether that is a goal or non-goal. And if it is a non-goal you might still select a solution that provides it, if it doesn't introduce trade-offs that prevent achieving the goals.

The actual design

This section should start with an overview and then go into details.



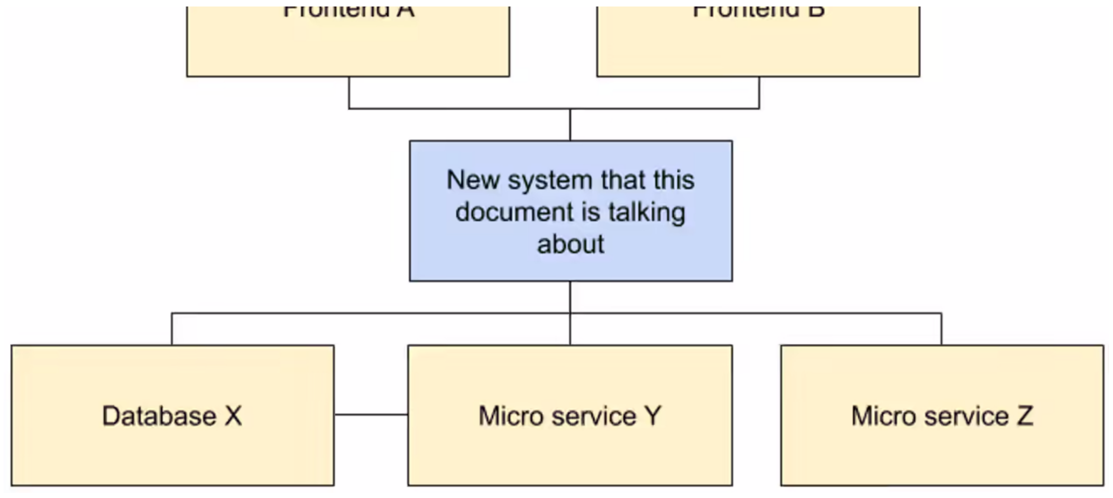
The design doc is *the place to write down the trade-offs* you made in designing your software. Focus on those trade-offs to produce a useful document with long-term value. That is, given the context (facts), goals and non-goals (requirements), the design doc is the place to suggest solutions and show why a particular solution best satisfies those goals.

The point of writing a document over a more formal medium is to provide the flexibility to express the problem set at hand in an appropriate manner. Because of this, there is no explicit guidance for how to actually describe the design.

Having said that, a few best practices and repeating topics have emerged that make sense for a large percentage of design docs:

System-context-diagram #

In many docs a *system-context-diagram* can be very useful. Such a diagram shows the system as part of the larger technical landscape and allows readers to contextualize the new design given its environment that they are already familiar with.



Example of a system-context-diagram.

APIs

If the system under design exposes an API, then sketching out that API is usually a good idea. In most cases, however, one should withstand the temptation to copy-paste formal interface or data definitions into the doc as these are often verbose, contain unnecessary detail and quickly get out of date. Instead focus on the parts that are relevant to the design and its trade-offs.

Data storage

Systems that store data should likely discuss how and in what rough form this happens. Similar to the advice on APIs, and for the same reasons, copy-pasting complete schema definitions should be avoided. Instead focus on the parts that are relevant to the design and its trade-offs.

Code and pseudo-code

Design docs should rarely contain code, or pseudo-code except in situations where novel algorithms are described. As appropriate, link to prototypes that show the implementability of the design.

Degree of constraint

One of the primary factors that would influence the shape of a software design and hence the design doc, is the degree of constraint of the solution space.

we know are the goals, and the solution can be whatever makes the most sense. Such a document may be wide-ranging, but it also needs to quickly define a set of rules that allow zooming in on a manageable set of solutions.

On the other end are systems where the possible solutions are very well defined, but it isn't at all obvious how they could even be combined to achieve the goals. This may be a legacy system that is difficult to change and wasn't designed to do what you want it to do or a library design that needs to operate within the constraints of the host programming language.

In this situation you may be able to enumerate all the things you can do relatively easily, but you need to creatively put those things together to achieve the goals. There may be multiple solutions, and none of them are really great, and hence such a document should focus on selecting the best way given all identified trade-offs.

Alternatives considered

This section lists alternative designs that would have reasonably achieved similar outcomes. The focus should be on the trade-offs that each respective design makes and how those trade-offs led to the decision to select the design that is the primary topic of the document.

While it is fine to be succinct about solution that ended up not being selected, this section is one of the most important ones as it shows very explicitly why the selected solution is the best given the project goals and how other solutions, that the reader may be wondering about, introduce trade-offs that are less desirable given the goals.

Cross-cutting concerns

This is where your organization can ensure that certain cross-cutting concerns such as security, privacy, and observability are always taken into consideration. These are often relatively short sections that explain how the design impacts the concern and how the concern is addressed. Teams should standardize what these concerns are in their case.

Due to their importance, Google projects are required to have a dedicated privacy design doc, and there are dedicated reviews for

5331

completed by the time a project launches, it is best practice to engage with privacy and security teams as early as possible to ensure that designs take them into account from the ground up. In case of dedicated docs for these topics, the central design doc can, of course, reference them instead of going into detail.

The length of a design doc

Design docs should be sufficiently detailed but short enough to actually be read by busy people. The sweet spot for a larger project seems to be around 10-20ish pages. If you get way beyond that, it might make sense to split up the problem into more manageable sub problems. It should also be noted that it is absolutely possible to write a 1-3 page “mini design doc”. This is especially helpful for incremental improvements or sub tasks in an agile project–you still do all the same steps as for a longer doc, just keep things more terse and focused on a limited problem set.

When not to write a design doc.

Writing design docs is overhead. The decision whether to write a design doc comes down to the core trade-off of deciding whether the benefits in organizational consensus around design, documentation, senior review, etc. outweigh the extra work of creating the doc. At the center of that decision lies whether the solution to the design problem is ambiguous–because of problem complexity or solution complexity, or both. If it is not, then there is little value in going through the process of writing a doc.

A clear indicator that a doc might not be necessary are design docs that are really *implementation manuals*. If a doc basically says “This is how we are going to implement it” without going into trade-offs, alternatives, and explaining decision making (or if the solution is so obvious as to mean there were no trade-offs), then it would probably have been a better idea to write the actual program right away.

Finally, the overhead of creating and reviewing a design doc may not be compatible with prototyping and rapid iteration. However, most software projects do have a set of *actually known problems*. Subscribing to agile methodologies is not an excuse for not taking the time to get solutions

5331

part of the design doc creation. "I tried it out and it works" is one of the best arguments for choosing a design.

The design doc lifecycle

The steps in the lifecycle of a design document are:

1. Creation and rapid iteration
2. Review (may be in multiple rounds)
3. Implementation and iteration
4. Maintenance and learning

Creation and rapid iteration

You write the doc. Sometimes together with a set of co-authors.

This phase quickly evolves into a time of rapid iteration where the doc is shared with colleagues who have the most knowledge about the problem space (often belonging to the same team) and through their clarifying questions and suggestions drive the doc to a first relatively stable version.

While you certainly find engineers and even teams who prefer version control and code review tools for document creation, the vast majority of design docs at Google are created in Google Docs and make heavy use of its collaboration features.

Review

In the review phase a design doc gets shared with a wider audience than the original set of authors and close collaborators. Reviews can add a lot of value, but they are also a dangerous trap of overhead, so treat them wisely.

A review can take many shapes: The more lightweight version is simply sending out the doc to the (wider) team-list to give folks a chance to take a look. Discussion then primarily happens in comment threads in the document. On the heavy side of reviews, are formal design review meetings in which the author presents the doc (often via a dedicated presentation) to an often very senior engineering audience. Many teams engineers can sign up to for a review. Naturally waiting for such meetings to happen can significantly slow down the development process. Engineers can mitigate this by seeking the most crucial feedback directly and not blocking progress on wider review.

When Google was a smaller company, it was customary to send designs to a single central mailing list, where senior engineers would review them at their own leisure. This may very well be a great way to handle things for your company. One benefit was that it did establish a relatively uniform software design culture across the company. But as the company scaled to a much larger engineering team, it became infeasible to maintain the centralized approach.

The primary value that such reviews add is that they form an opportunity for the combined experience of the organization to be incorporated into a design. Most consistently, ensuring that designs take cross-cutting concerns such as observability, security and privacy into account is something that can be ensured in a review stage. The primary value of the review isn't that issues get discovered per-se, but rather that this happens relatively early in the development lifecycle when it is still relatively cheap to make changes.

Implementation and iteration

When things have progressed sufficiently to have confidence that further reviews are unlikely to require major changes to the design, it is time to begin implementation. As plans collide with reality, it is inevitable that shortcomings, unaddressed requirements, or educated guesses that turned out to be wrong surface, and require changing the design. It is strongly recommended to update the design doc in this case. As a rule of thumb: If the designed system hasn't shipped yet, then definitely update the doc. In practice we humans are bad at updating documents, and for other practical reasons changes are often isolated into new documents. This leads to an eventual state more akin to the US constitution with a bunch of amendments rather than one consistent piece of documentation. Links to such amendments from the original doc can be immensely helpful for the poor future maintenance programmer trying to understand their target system through design doc archaeology.

5331

When Google engineers get confronted with a system that they hadn't previously touched their first question often is "Where is the design doc?". While design docs, like all documentation, tend to get out of sync with reality over time, they still often present the most accessible entry point to learn about the thinking that guided the creation of the system.

As the author, do yourself a favor and re-read your own design docs a year or 2 later. What did you get right? What did you get wrong? What would you do to decide differently today? Answering these questions is a great way to advance as an engineer and improve software design skills over time.

Conclusions #

Design docs are a great way to gain clarity and achieve consensus around solving the hardest problems in a software project. They save money, because they avoid going down coding rabbit holes that fail to achieve project goals and could have been avoided using upfront investigation; and they cost money, because creation and review take time. So, choose wisely for your project!

When considering writing a design doc, think about these points:

- Are you unsure about the right software design, and would it make sense to spend upfront time to gain certainty?
- Relatedly, would it help to involve senior engineers, who might not be able to review every code-change, in the design?
- Is the software design ambiguous or even contentious such that achieving organizational consensus around it would be valuable?
- Does my team sometimes forget to consider privacy, security, logging or other cross-cutting concerns in the design?
- Is there a strong need for documents that provide high-level insights into the design of legacy systems in the organization?

probably a great method to start your next software project.

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Comments

> Gergely Orosz said: A good overview of how software design docs are used and written at Google: . A recommended read. At Uber, we have a similar approach, previously called RFCs, now ERDs (Engineering Review Docs).
> Some interesting parts from the article:
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> Bryan Cantrill said: To the point of this piece, the first thing we actually built at @oxidecomputer was infrastructure for design documentation and discussion -- which, like many problems, is peskier than it might seem!
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> Ben Werdmuller said: This is a super-interesting exploration of how design documents are used at Google. I use something a little more cut down, so this was food for thought for me. Both contain "non-goals", which I think is one of the most important sections.
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> Clay Walker said: I'm a strong believer in the value of design docs, and @cramforce has written some great guides on how

5331

Thread

Amir Salihefendić said: "As software engineers our job is not to produce code per se, but rather to solve problems. Unstructured text, like in the form of a design doc, may be the better tool for solving problems early in a project lifecycle..."— Applies also to design and product

Bret Mogilefsky said: Terrific balance between the need for oversight and the need for agility.

karan⚡ said: 1/n This is such a well-written post by @cramforce
A short summary 👇🏽
Thread

Dean Henrichsmeyer said: This is a very well articulated article on design documents - what is in them, why you have them, and when to use them. The one thing I would add is that in a distributed organization, they are even more critical. -
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Flying Belarusian 🤍❤️🤍 said: "As software engineers our job is not to produce code per se, but rather to solve problems."
Thread

Richard Seroter said: Where @cramforce explains "design docs at Google" by laying out the structure, and when you don't need to write one ...
Thread

Henry Robinson said: I know this did the rounds a short while ago, but what an excellent, concise and insightful write up of the benefits of design docs.
Writing well is a superpower for engineers, and is a skill that reliably tracks with seniority IME.

Fabien Townsend 🐌 said: Here is three resources about design doc in software that I find out helpful:
- by @cramforce

5331

- by @clemminal

Sofiya said: Starting my first (professional) design doc and using this 👇 as a model.
How do you structure your design docs?

Dino A. Dai Zovi said: How Google does design docs:

Miguel Filipe said: Two cool articles:
1. debugging oncall incidents -
2. design docs

Marcel Neidinger said: Just came across this great read on design docs in software engineering. Covers why, when & how you should do them. Plus: How to draw a owl in two easy steps.

Sai said: Figuring out what/how to document technical design, and how detailed it should be, while creating #code has always been part of the evolution of a #SoftwareEngineer. #100DaysofCode #Developer Good article on Design docs at Google:

julien lind said: A quick and nice read if you are thinking or have ever though about design documentation for your software!

Victor Lee said: I like the "How to draw an owl" image so much...
And sometimes, I feel like the request is on step 0, "Please draw a bird for me", and even not telling me that it should be an owl.
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Tony Vlachakis said: I learned from the following people last week:
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@microwisdoms
@btantheman
@BeyondInvestor
@pashabitz

5331

@cramforce
@HustleWithRoss
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Emil Rasmussen said: 1/ There is something about how @basecamp uses The Pitch () that resonates with me on how @googledevs uses Design Docs
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Ivan Velichko said: Probably the only right way to make major changes in big tech departments.

arianfront said: Design Docs at @Google The end of RCFs or Technical Proposals?

Marvel said: "The decision whether to write a design doc comes down to the core trade-off of deciding whether the benefits in organizational consensus around design, documentation, senior review, etc. outweigh the extra work of creating the doc." by @cramforce

Christian Hartmann said: UX: Design Docs at Google by @cramforce – one of the key elements of Google's software engineering culture is the use of defining software designs through design docs »

Akaash Patnaik said: Google's Technical Writing courses:
Divio's Documentation System:
Design docs at Google:

Rafat Sarosh said: How to write design document

Quality not innovation. said: A good description, but this works well only when the problem is well understood, otherwise you're better off beginning by taking some time to write a prototype in //experimental.
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5331

with a system that they hadn't previously touched, their first question often is "Where is the design doc?"
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Atelier Lumikha said: A really great approach to thinking through the problem:

rolgalan said: Nice summary by @cramforce about the best points and benefits of Google's Design Docs. At Glovo we follow the same process, but called them Request For Comments as (Uber used to). I find it quite valuable and a great engineering practice.
Thread

Tiago Vignatti said: "design docs fulfill the following functions in the software development lifecycle:
- Early identification of design issues when making changes is still cheap.
- Achieving consensus around a design in the organization... "
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Esther Schindler said: Why design documents are useful and what they should include.

Code Climate said: "Design docs are a great way to gain clarity and achieve consensus around solving the hardest problems in a software project." - @cramforce shares Google's design doc framework:

Ryan McAdams said: A great read about #design docs at

Bernie Goldbach said: If it looks out of place on screen, perhaps you need a Design Doc:

Pablo Lara H said: Design Docs at @Google by @cramforce

Kelly Smith said: "Besides the original documentation of a software design, design docs fulfill the following functions in the software development lifecycle: Early identification of

5331

practical stuff for everyone.

#Soapbox said: I'm constantly evolving our design docs and will certainly add this to my arsenal. >> Design Docs at Google

Dave Crossland said: @thomas_lord Writing the design doc(*) is a part time one person job that I expect I can commission you on
*
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顧客課題pickup電話ピクポンCEOのyobata said: Design Docs at GoogleOne of the key elements of Google's software engineering culture is the use of defining so...

James Le said: One of the key elements of Google’s software engineering culture is the use of defining software designs through design docs. @cramforce

Tony Vlachakis said: Unstructured text composed in a design document could be a useful tool before coding begins. @cramforce

Michael Bianco said: Great overview of how design docs are written at google

Mukul Kumar said: Good short read: "Design Docs at Google"

Larry Wright said: Great read on the importance of design documents.

Krishna Mehra said: A very useful reminder of the core purpose Design Doc serves in rigorous engineering cultures like that of @Cohesity (very much adapted from Google!) - something that's often lost in the process!

Scott said: The longer I work on loosely defined software projects, the more I like the idea of some soft of documentation.

5331

structured at Google when tackling complex software problems

Ben Dixon said: The piece itself is about design docs but includes some great insights into how to think about planning in the context of planning and agile development

Saha said: The decision whether to write a design doc comes down to the core trade-off of deciding whether the benefits in organizational consensus around design, documentation, senior review, etc. outweigh the extra work of creating the doc.

DwaynePhillips said: How the software engineers at Google write design documents. These are useful and used

Jean-Marc Liotier said: Yes, choosing "agile" methods doesn't mean that writing proper design documents isn't useful anymore.

Paul Oliver ⁕ said: Does your organization write design docs before embarking on changing your software? I've come to love design docs because they force me to think thoroughly through the problem and it gives me invaluable feedback.

Senthil said: A neat pragmatic overview by @cramforce on how to approach design docs for software systems

Hamza ERBAY said: This is such a well-written article by @cramforce

Dan Kleiman said: Note, that non-goals aren’t negated goals like “The system shouldn’t crash”, but rather things that could reasonably be goals, but are explicitly chosen not to be goals.

Daisuke Shimamoto said: A easy to read introduction to Design Docs.
These points stood out for me.
- They are informal
- Earlier problems are easier to fix
- Scaling knowledge across organization

5331

standardizing on your company's design doc templates.

Divyanshu Maithani said: @cramforce really enjoyed the "Design docs at Google" article, lots of insights

Tina said: Great article about writing design documents, and why they are a good idea:

Jordi Abad said: "The design doc documents the high level implementation strategy and key design decisions with emphasis on the trade-offs that were considered during those decisions." Design Docs at Google

Hi, I'm Matt - artist, technologist, noodler said: This article by @cramforce is very good (a bunch of them are):

Nicola Zanon 🌏 ➡️ 📦 said: The design doc documents the high level implementation strategy and key design decisions with emphasis on the trade-offs that were considered during those decisions.

Sergiu Bodiu 🌏 said: Design docs
1. Early identification of design issues (cheap)
2. Achieving consensus around a design in the organization.
3. Ensuring consideration of cross-cutting concerns.
4. Acts as a summary artefact in the technical portfolio of the software and more

Nikesh Mistry said: Really enjoyed reading this. We recently started using design docs and it was a great way to get consensus on a solution without requiring 100s of zoom calls

Andrew Hansen said: A great breakdown of why design docs matter. Importantly, not all code needs one!

Colton J. McCurdy said: > Unstructured text, like in the form of a design doc, may be the better tool for solving problems early in a project lifecycle, as it may be more concise and easier to comprehend, and communicates the problems and solutions at

5331

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Moisés Vargas said: Writing technical docs minimize risks of poor design, security issues, lack of knowledge base when writing lasting software.
Why to embrace it in Software/Product Teams?. Good post about it

Venil Noronha said: An interesting read on how to write good design docs.

Jomel Imperio said: Concise and insightful overview of design docs at Google.
I'm already filing this to share with the team -- and inspire us to keep improving our own documentation!

Brian Alexander Lee said: I love great design docs and loathe bad ones. This post does a good job, I think, for describing how to make design docs I love.

Reuven Yagel said: Great intro to design docs at Google by @cramforce. We usually add also some info on project planning and risk mitigation

Meijiao Png said: Good read: @sunxperous

Felipe Hlibco said: Design Docs are great tools often underutilized. It especially shines in complex projects with non-obvious trade-offs.

Demand climate action said: Software is more than coding. Much more.

Gary J. Foreman said: Good overview of a lightweight process that can ultimately save a lot of time, or frustration for your future self!

Sebastian said: Technical design docs, RFCs or architectural decision records are super important for every organization.

5331

decisions on their own.

> Andre Oporto said: Great overview on “Design Docs at Google.” Agile teams still need these. This article discusses structure, benefits and when to write one.

> Dvir Segal said: A great thread summing up the @googledevs design docs process.
> The full article here:

> Nathaniel Morihara (MurphysDad) said: "As software engineers our job is not to produce code per se, but rather to solve problems. Unstructured text, like in the form of a design doc, may be the better tool for solving problems early in a project lifecycle..." -@cramforce
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> Vijay Nagarajan said: It's said that, ' Thou shall not covet '. But I'll be honest, articles like these do fill me with envy - of my cloud neighbours 😇

> Francisco Avila said: Scaling ideas is hard.
> I found helpful to see Design doc templates used by other engineers.
> A good one from Google (Design / Tech Spec / RFC)

> Ruslan Fomkin said: In #timescale I have learned to write design docs as an important step of #developing new complex functionality. Here is nice description of writing design docs at

> ExperTech Insights said: @cramforce describes in the structure @Google design docs and their function in the #SDL, a good example of how #Documentation is impactful

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5331

Malte Ubl