The ESS EPICS Environment e3
Its build and deployment

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Why Environment is Needed

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Complexity

- Each Site or Person follows various ways to develop, maintain, and configure modules and applications.
- Each Site uses a different HW and SW architecture
- Site-wide subsystems to be monitored by EPICS IOCs have their own requirements

Consistency

- Consistency for users and developers and even more for ESS Facility is the key to develop, operate, and maintain the control system from its initial conception through its retirement within the ESS's life cycle.
- ESS (or each site) needs its own Environment. (For FRIB, NSLS-II, Debian Packaging System / For ITER, CODAC / PSI, the original version of e3 / ...)
- **e3** was designed to achieve it.

Why e3 is needed : Global Prospective

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- Quality management of IOCs
  - EPICS full freedom : good for small groups
  - e3 limited freedom : good for ICS who has to provide a consistent environment to any stakeholders in ICS, Accelerator, Target, and Neutron Science
- Common source code management problems:
  - varying quality of modules (open source): code, documentation, & styles
  - version changes of base, modules, etc.
  - customized patch files, while keeping in sync with the EPICS community
  - platform variability
  - inconsistent version management overall in EPICS community
- Have to consider different EPICS users over ESS life time
  - advanced users: can manage their own IOC details
  - device integration focused (time limited) users: want to avoid low level development, compiling code etc.
  - less experienced users : benefit from pre-selection and prepared modules
  - core development users

Why e3 is needed : Local Prospective

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Users

- avoid re-building IOCs from scratch
- do not care about internal dependency among EPICS base, and modules
- focus more on the IOC functionality and post-processing of signals for each sub-system
- focus more on the user specific functionality (post-process, data analysis, user interface, and so on)
- transfer some IOC development effort to a team of e3 Architects (currently, only one)
- use the ESS specific version rules consistently on EPICS base, and modules independent upon external sources
- avoid incompatible version combinations
- have the future migration process over EPICS base versions is less likely to cause problems

Desideratum for e3

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Source Code Changes

- site, community, both patch files
- a time interval for possible merging activities
- rejection from community sources
- files, clone, fork, and branch ....

Maintain, maintain, and maintain

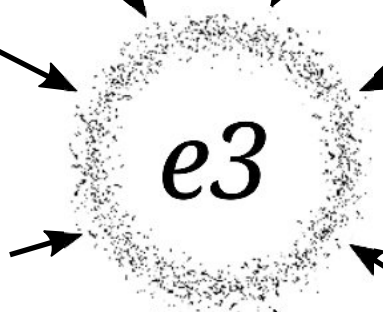
- clear structure to understand its dependencies
- easily retire unused base, modules within the ESS life cycle
- duplicate a specific version of the e3 production in any places
- add new base, new modules into the production and into a development
- easily distinguish between e3 at different time domains

Release Version Numbers

- handle various version numbers (e.g., R1-0, v1.1, s7plc_1_4_0, no version)
- define ESS version for all of them (1.0.0, test, ae5d083, han-4am)

Increase Degree of Freedom for Users

- Allow to have multiple e3 versions in a single host with the standard EPICS environment.
- Allow to install e3 in any other Linux flavors (CentOS, Debian, Ubuntu, Fedora, Raspbian, ...)
- Allow to setup the standard EPICS env with e3
- Allow to have the entire setup locally



Disk and Network Resources

- Separate src files from installed files in order to save disk and network resources (e3 source files ~ 2 GiB)
- Isolate system specific applications in different locations

Quantized Integration / Deployment Continuously

- Deploy only the quantized version of the combination of all components (base, require, all other modules), since EPICS base is the long-standing one.
- Save resources to resolve potential overheads and to focus IOC functionality.

Users, Users, and Users

- can run only working IOCs
- can integrate an existent EPICS module into e3
- can develop a module within e3
- can develop a non-existent EPICS module with EPICS, and integrate into e3
- can develop an application with the existent e3 modules
- can deploy any of them in an emergency situtation (4am) with limited resources and environment

Mimicked EPICS Building System

- Mimic the EPICS building system
  * Makfile, configuration, rules, and so on
- In the future, will design the ESS rules, and configuration for the Standard EPICS building system.

EPICS IOC vs e3 IOC in the simplest case

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EPICS IOC	e3 IOC
Run makeBaseApp	
Define Base, Modules in RELEASE	
Add database and protocol files	Add database and protocol files
Update Makefile	
Build	
Edit st.cmd	Write st.cmd[1]
Run	Run *iocsh.bash*

[1] define modules

IOC : EPICS vs e3

EPICS IOC

configure/RELEASE

```
EPICS_BASE=${EPICS_PATH}/epics-base/3.15.5
ASYN=${EPICS_MODULES}/asyn/4.33
STREAM=${EPICS_MODULES}/stream/2.7.7
devIocStats=${EPICS_MODULES}/iocStats/1856ef5
```

```
#!../../bin/linux-x86_64/gconpi

epicsEnvSet(P, "ICS")
epicsEnvSet(R, "E3TRNG")
epicsEnvSet("IOC",   "$(P):$(R)")
epicsEnvSet("IOCST", "$(IOC):IocStats")

epicsEnvSet("TOP","/..../gconpi")
epicsEnvSet("STREAM_PROTOCOL_PATH", ".:${TOP}/db")

cd "${TOP}"

dbLoadDatabase "dbd/gconpi.dbd"
gconpi_registerRecordDeviceDriver pdbbase

drvAsynIPPortConfigure("CGONPI", "127.0.0.1:9999", ...)
dbLoadRecords("db/gconpi-stream.db", "SYSDEV.....")
dbLoadRecords("db/iocAdminSoft.db", "IOC=${IOCST}")

cd "${TOP}/iocBoot/${IOC}"
iocInit
```

e3 IOC

source setE3env.bash

put the asyn dependency within stream dependency

```
require stream,2.7.7
require iocStats,1856ef5

epicsEnvSet(P, "ICS")
epicsEnvSet(R, "E3TRNG")
epicsEnvSet("IOC",   "$(P):$(R)")
epicsEnvSet("IOCST", "$(IOC):IocStats")

epicsEnvSet(TOP, "$(E3_CMD_TOP)")
epicsEnvSet("STREAM_PROTOCOL_PATH", ".:${TOP}/db")
```

where the startup script exists, gives us the absolute path

put specific dbd load, and registerRecordDeviceDriver in behind scene

```
drvAsynIPPortConfigure("CGONPI", "127.0.0.1:9999", 0, 0, 0)
dbLoadRecords("${TOP}/db/gconpi-stream.db", "SYSDEV=...")
iocshLoad("$(iocStats_DIR)/iocStats.iocsh","IOCNAME=${IOCST}")


iocInit
```

e3 Anatomy and Requirements

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Building

source codes
configure
customize
patch files
compile
install

- versioning
- bi-sync with community's work
- track down changes
- kernel driver installation
- userspace libraries
- vendor libraries
- system libraries
- how to get source codes (git, hg, svn, tar, ...)
- various targets
- global configuration
- special makefile
- useful makefile rules

Static

directory structure

- multiple NFS shared paths
- decouple production from unused old directories
- transparency from IOCs
- global environment
- local environment
- emergency environment
- easy to duplicate
- define the dependency among base, modules, and others

Running

find
load
check
monitor

- find dynamic loadable libraries, dbd, db files
- load all sources code dependent modules
- define the absolute path within an IOC
- check running base and module versions
- set multiple e3 in any forms
- select global or local envrionment in multiple options
- simply run iocsh.bash

e3 : Require from PSI, heavily customized one

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- Require is an `EPICS` module with its own Makefile, and more
- ESS require[2] at `https://github.com/icshwi/require-ess`
- synced with latest changes of the PSI one as much as we can
- to benefit from 10+ years experience of PSI, and customize it to meet the ESS own requirements

e3 Anatomy	**PSI**	**ESS**
Building & Static		e3 Front End
Static & Running	require	require-ess†
Building	driver.Makefile	driver.Makefile†
Running	iocsh	iocsh.bash ‡

†: ESS customized one
‡: Redesigned and rewritten

[2] from the PSI require `https://github.com/paulscherrerinstitute/require`

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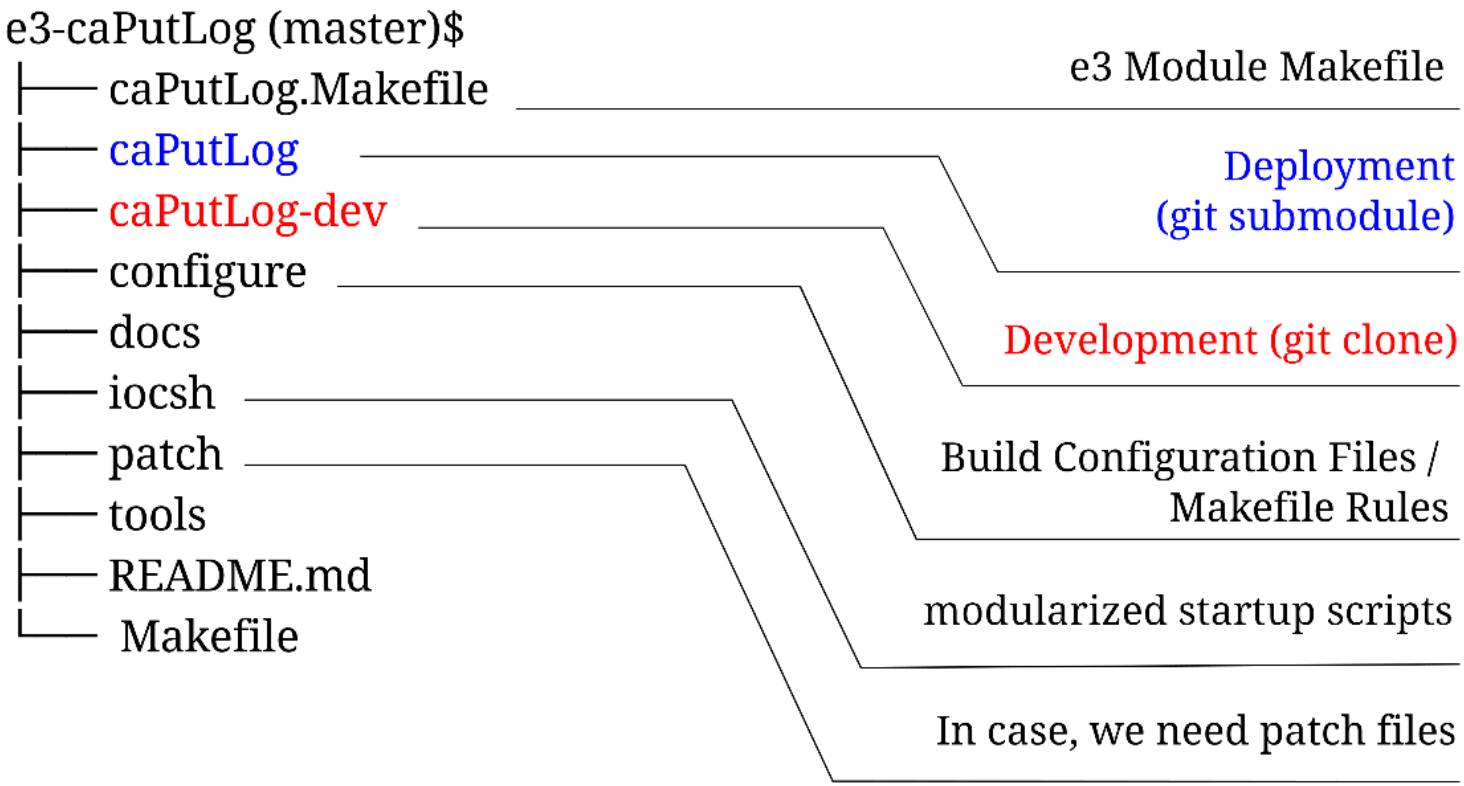
A Real Example e3 Structure for caPutLog



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Complicated?

```
$ bash e3TemplateGenerator.bash -m modules_conf/caputlog.conf
```

caputlog.conf
EPICS_MODULE_NAME:=caPutLog
EPICS_MODULE_URL:=https://github.com/epics-modules
E3_TARGET_URL:=https://github.com/icshwi
E3_MODULE_SRC_PATH:=caPutLog

e3 Tools

`https://github.com/icshwi/e3-tools`

- e3 Template Generator
- Linux RT PREEMPT Kernel configuration tool
- e3 Release tools
- Others

Various Modes on E3

Modes for build and installation

Type	Deployment	Development	Cell[3]
Files	RELEASE CONFIG_MODULE	RELEASE_DEV CONFIG_MODULE_DEV	
make	init	devinit	both
make	build	devbuild	both
make	install	devinstall	cellinstall
make	vars	devvars	cellvars
make	uninstall	devuninstall	celluninstall
make	rebuild	devrebuild	NA

Modes for running an IOC

- Normal : `iocsh.bash`
- Cell : `iocsh.bash -l ${CELLPATH}`
- Realtime : `iocsh.bash -rt`

[3] Emergency case, usually 3am on-call service, however, it can be used in any development stage.

E3 Front End Example : e3-mrfioc2

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```
jhlee@hadron: e3-mrfioc2 (master)$ tree -L 1
.
├── [jhlee    4.0K]  cmds
├── [jhlee    4.0K]  configure
├── [jhlee    4.0K]  dkms
├── [jhlee    4.0K]  docs
├── [jhlee    4.0K]  iocsh
├── [jhlee     949]  Makefile
├── [jhlee    4.0K]  mrfioc2
├── [jhlee    4.0K]  mrfioc2-dev
├── [jhlee    9.1K]  mrfioc2.Makefile
├── [jhlee    4.0K]  opi
├── [jhlee    4.0K]  patch
├── [jhlee    1.7K]  README.md
├── [jhlee    4.0K]  template
└── [jhlee    4.0K]  tools

11 directories, 3 files
```

DKMS (Dynamic Kernel Module Support) configuration

https://github.com/javicereijo/mrfioc2

https://github.com/epics-modules/mrfioc2

e3 specific submakefile for mrfioc2

ESS specific mrfioc2 substitutions files

mrf related tools

E3 Front End Example : e3-mrfioc2

```
jhlee@hadron: e3-mrfioc2 (master)$ tree  template/
template/
├── [jhlee    4.3K]  cpci-evg230-ess.substitutions
├── [jhlee    4.2K]  evg-cpci-230-ess.substitutions
├── [jhlee     33K]  evm-mtca-300-ess.substitutions
├── [jhlee    7.0K]  evr-cpci-230-ess.substitutions
├── [jhlee     291]  evr-delayModule-ess.substitutions
├── [jhlee     403]  evr-event-ess.substitutions
├── [jhlee     17K]  evr-mtca-300-ess.substitutions
├── [jhlee     15K]  evr-mtca-300u-ess.substitutions
└── [jhlee     15K]  evr-pcie-300dc-ess.substitutions


jhlee@hadron: e3-mrfioc2 (master)$ bash tools/get_pciaddr.bash
Usage: get_pciaddr.bash possible_devices [cpcievr220|cpcievr230
                                          |cpcievr300|pcieevr300
                                          |mtcaevr300|cpcievg220
                                    |cpcievg230|cpcievg300|mtcaevm300]

jhlee@hadron: e3-mrfioc2 (master)$ cd mrfioc2 && git remote -v && cd ..
origin  git@github.com:javicereijo/mrfioc2 (fetch)
origin  git@github.com:javicereijo/mrfioc2 (push)

jhlee@hadron: e3-mrfioc2 (master)$ cd mrfioc2-dev && git remote -v && cd ..
origin  git@github.com:epics-modules/mrfioc2 (fetch)
origin  git@github.com:epics-modules/mrfioc2 (push)
```

E3 Front End Example : e3-mrfioc2

```
jhlee@hadron: e3-mrfioc2 (master)$ make dep
require mrfioc2,2.2.0-rc5
< configured ...
DEVLIB2_DEP_VERSION = 2.9.0
> generated ...
devlib2 2.9.0

jhlee@hadron: e3-mrfioc2 (master)$ make vers
EPICS_MODULE_TAG:=tags/2.2.0-ess-rc5
E3_MODULE_VERSION:=2.2.0-rc5

jhlee@hadron: e3-mrfioc2 (master)$ make existent
/epics/base-3.15.6/require/3.1.0/siteMods/mrfioc2
└── 2.2.0-rc5
    ├── configure_sequencer_14Hz.bash
    ├── db
    ├── dbd
    ├── evr-mtca-300.iocsh
    ├── evr-pcie-300dc.iocsh
    ├── evr-standalone-mode.iocsh
    ├── include
    ├── lib
    ├── mtca-evr-FP0-output.iocsh
    └── univ0-ttl-output.iocsh
5 directories, 6 files
```

E3 Front End Example : e3-mrfioc2

```
jhlee@hadron: e3-mrfioc2 (master)$ make devdep
require mrfioc2,develop
< configured ...
DEVLIB2_DEP_VERSION = 2.9.0
> generated ...
devlib2 2.9.0

jhlee@hadron: e3-mrfioc2 (master)$ make devvers
EPICS_MODULE_TAG:=master
E3_MODULE_VERSION:=develop

jhlee@hadron: e3-mrfioc2 (master)$ make existent LEVEL=1
/epics/base-3.15.6/require/3.1.0/siteMods/mrfioc2
├── 2.2.0-rc5
└── develop

jhlee@hadron: e3-mrfioc2 (master)$ tree -L 2 /epics/base-3.15.6/require/3.1.0/siteMods/mrfioc2/2.2.0-rc5/lib/
/epics/base-3.15.6/require/3.1.0/siteMods/mrfioc2/2.2.0-rc5/lib/
├── [root     4.0K]  linux-corei7-poky
│   ├── [root     1.1M]  libmrfioc2.so
│   └── [root       45]  mrfioc2.dep
├── [root     4.0K]  linux-ppc64e6500
│   ├── [root     1.4M]  libmrfioc2.so
│   └── [root       45]  mrfioc2.dep
└── [root     4.0K]  linux-x86_64
    ├── [root      13M]  libmrfioc2.so
    └── [root       45]  mrfioc2.dep
```

E3 Status

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Base Support List

- Base 3.15.5 / **3.15.6**
- Base 7.0.1.1 / 7.0.2 / 7.0.2.1

Modules Support List

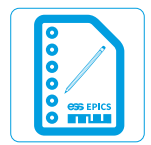
- Almost all EPICS modules (iocStats, autosave, caPutLog, asyn, busy, modbus, ipmiComm, sequencer, sscan, std, ip, calc, delaygen, StreamDevice, s7plc, recsync, MCoreUtils, devlib2, mrfioc2, motor, ecmc, ethercatmc, ...)
- Area Detector (ADSupport, ADCore, ADSimDetector, ADCSimDetector, NDDriverStdArrays, ADAndor, ADAndor3, ADPointGrey, ADProsilica, ...)
- EPICS V4 modules (pvData, pvAccess, pva2pva, pvDatabase, normativeTypes, pvaClient) for Base 3.15.X

Where E3 is

Clone It Today!

```
git clone https://github.com/icshwi/e3
```


```
git clone https://github.com/icshwi/e3training
```



Building and Running Tested on

- ESS Yocto Linux (Normal & PEEMPT RT Kernels and linux-corei7-poky, linux-ppc64e6500, & linux-x86_64)
  `https://gitlab.esss.lu.se/icshwi/yocto-ess`
- CentOS Linux (Normal and CERN PREEMPT RT Kernels)
- Debian Linux (Normal and PREEMPT RT Kernels)
- Raspbian Stretch, Ubuntu, LinuxMint, Fedora, and Arch Linux

Summary & Outlook

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Summary

- ESS has its own EPICS environment for ESS and many in-kind collaborations across Europe.
- Tried to cover various scenarios which we usually meet in different space-time domains in order to resolve issues consistently.
- Looks very promising when we work within the local environment and development phase.

Summary & Outlook

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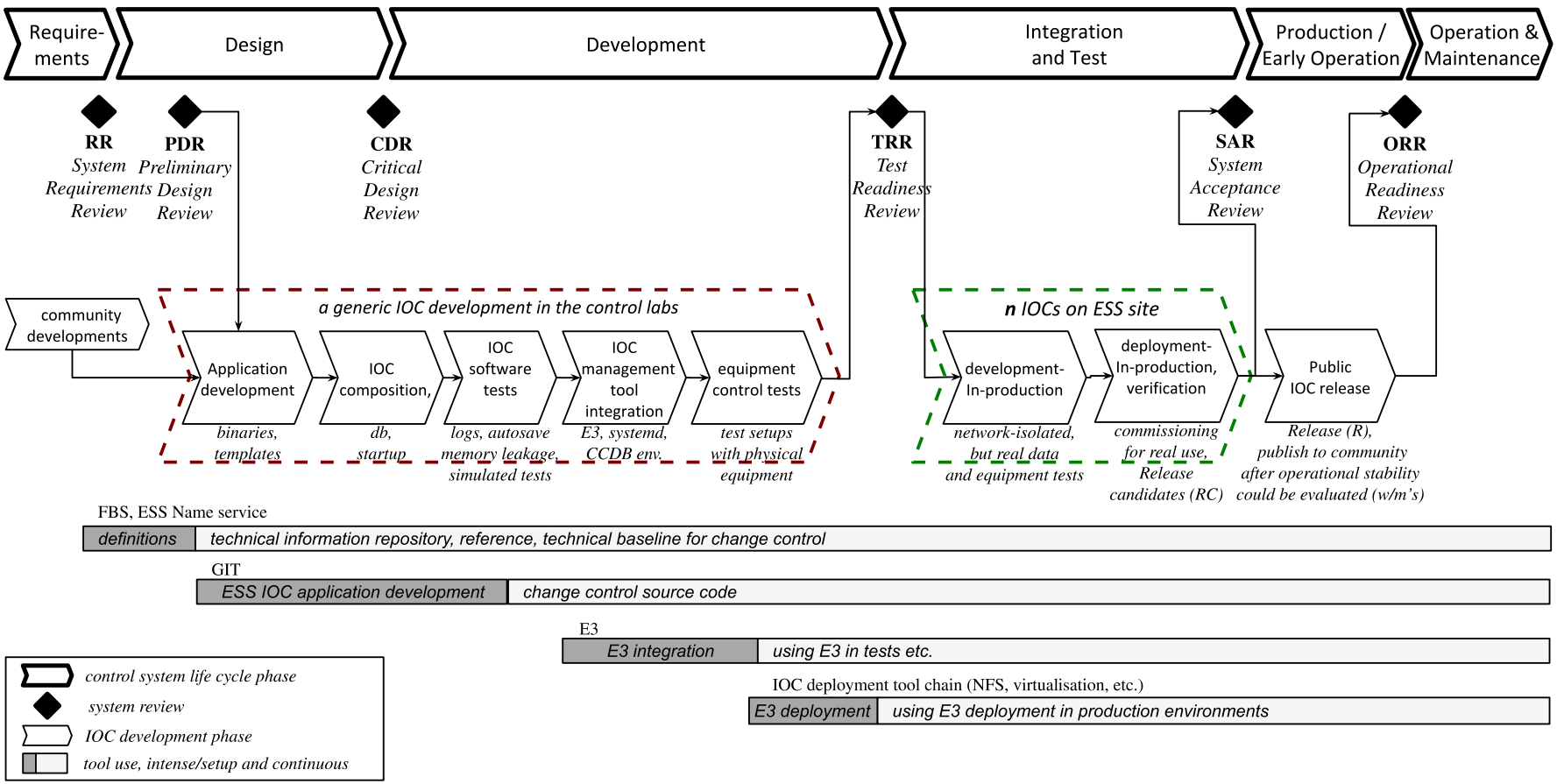
Outlook

- We are integrating e3 with NFS, procServ, systemd, conserver, site-wide configuration & life-cycle managements, and so on for final production.
- The early discussion within the system engineering procedure is in progress and is shown in the next ...

Summary & Outlook



Questions? And Comments ?

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```
Hmm, control, control. You must learn control!
```

Yoda (*The Empire Strikes Back*)

Merci!

감사합니다!

Kiitos!

ありがとうございました!

Thank you!

Dankeschön!

Tack!

☺