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Feature Splitting and Sub Feature Refinement in Software Development

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Abstract

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This thesis was done for the Nokia Mobile Network (MN) L1 organization. The objective of the thesis was to study feature splitting and sub feature refinement processes and study how to improve the long lead time of SW development entity items, which are used by the MN L1 organization. The problem statement was that it takes several SW development feature builds before it is possible to start testing the functionality of the feature. In many earlier customer features sub feature splitting and refinement were not done based on the latest MN way of working processes, and SW development entity items were split horizontally by different components, instead of vertically based on e-2-e feature functionality point of view.

The actual study was carried out using three selected 5G FOT pilot features in the 22R1 System program. During the pilot features, it was tested and assessed how the actual feature splitting and sub feature refinement processes are working in practice based on the Nokia MN processes and guidelines, and if any improvements and/or process changes are required.

The outcome of this study is that the feature splitting and sub feature refinement SW Development processes mainly exist, but the processes are not well known by different MN organizations. Based on that, new training and communication sessions are recommended to improve the current situation. Also based on defined KPI targets, my conclusion is that the long lead time of SW development entity items in the MN L1 organization is caused by the long competence area items.

The recommendation of the needed process changes is included in this study to ensure that feature splitting and sub feature refinement in SW development is working as planned in the future according to the Nokia MN processes.

Keywords: AGILE, CDIT-D, FB, FOT, R&D, SW, 5G

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Tämä YAMK opinnäytetyö tehtiin Nokia Mobile Networks (MN) L1 organisaatiolle. Opinnäytetyön tavoitteena oli tutkia SW tuotekehityksen ominaisuuksien jakamista pienempiin toiminnallisiin kokonaisuuksiin ja parantaa toiminnallisuuksien suunnitteluprosessia. Tavoitteena oli lyhentää ominaisuuksien tuotekehitysaikaa MN L1 organisaatiossa. Tutkimuksen lähtökohtaisena ongelmana oli, että tarvittiin useita erillisiä tuotekehitysjaksoja ennen kuin oli mahdollista aloittaa toiminnollisuuksien testaaminen kokonaisuudessaan. Aikaisemmissa toimituksissa ominaisuuksien jakamista pienempiin toiminnallisiin kokonaisuuksiin ei oltu tehty Nokia MN organisaation ohjeiden mukaisesti. SW ominaisuuksien jakaminen oli suunniteltu aikaisemmin komponenttipohjaisesti eikä kokonaistoiminnallisuuden kannalta.

Varsinainen tutkimustyö tehtiin käyttäen kolmea 5G FOT pilotti asiakasprojektia, jotka olivat osana 22R1 systeemiohjelmaa. Asiakasprojektien aikana testattiin ja arvioitiin, miten eri SW tuotekehitys ominaisuuksien jako pienempiin toiminnallisiin osiin toimi käytännössä annettujen Nokian MN prosessien ja ohjeiden mukaisesti. Tavoitteena oli selvittää tarvitaanko olemassa oleviin ohjeisiin ja prosesseihin muutoksia tai parannuksia.

Tämän tutkimuksen tuloksena on, että ominaisuuksien jakaminen ja aliominaisuuksien SW tuotekehitysprosessit ovat pääosin käytössä, mutta prosessit eivät ole riittävän hyvin tiedossa Nokian eri MN organisaatioissa. Tämän perusteella suositellaan uusia koulutus- ja viestintätilaisuuksia nykytilanteen parantamiseksi. Määriteltyjen KPI tavoitteiden perusteella johtopäätökseni on, että eri SW tuotekehitysyksiköiden aliominaisuuksien kehitysjaksot ovat liian pitkiä verrattuna annettuihin ohjearvoihin.

Tähän tutkimukseen sisältyy suositus tarvittavista prosessimuutoksista, jotta asiakasominaisuuksien jakaminen ja aliominaisuuksien käyttö SW tuotekehityksessä toimii tulevaisuudessa Nokia MN ohjeiden mukaisesti.

Avainsanat: AGILE, CDIT-D, FB, FOT, R&D, SW, 5G

Contents

List of Abbreviations

5G: Fifth Generation Technology Standard for Broadband Cellular Networks.

ABIL: Nokia Airscale Unit.

AGILE: Agile SW Development Model.

APO: Area Product Owner.

Backlog: Backlog Contain all Features.

BG: Business Group of Nokia.

BPM: Business Product Management.

BTS: Base Transceiver Station.

BU: Business Group of Nokia.

CA: Competence Area.

CDIT-D: Continuous, Development, Integration, and Deployment.

CFAM: Common Feature Analysis Mode is the Specification Process from System Level to Entity Level.

CFAML: Common Feature Analysis Mode Leader.

C-Plane: Control Plane.

CPRI: Common Public Radio Interface.

CP1: CFAM check point: Feature Scope & System Level User Scenario Ready.

CP2: CFAM Check Point: System Level Ready.

CP3: CFAM Check Point: Development Can Start.

CP4: CFAM Check Point: Specification Are Complete.

CRUD: Create, Retrieve, Update, Delete.

CT: Release Milestone: Trial Available.

CuDo: Customer Documentation.

C5: Release Decision Point: Release Available

DFMEA: Design Failure Mode and Effect Analysis.

DL: Down Link.

DMRS: Demodulation Reference Signal.

DoD: Definition of Done.

Doors: Updated by SE, Contains Details of Features Requirements.

DU: Development Unit.

eCPRI: Enhanced Common Public Radio Interface.

EE: Effort Estimate.

EFS: Entity Level Functional Specification.

EI: Entity Item.

eNB: Evolved Node B.

ET: Entity Testing.

E-2-E: End to End.

FB: Feature Build.

FDD: Frequency-Division Duplexing.

FFB: Feature Backlog.

FiVe: Field Verification.

FLEA: Feature Leadtime and Execution Analyse.

FOT: Feature Owner Team.

FOTL: Feature Owner Team Leader.

FPB: Product Backlog.

FPGA: Field Programmable Gate Array.

FSP: Feature Screening Decision: Ready for Publishing.

FS1TA: Feature Screening Decision: Technical Analyses.

FS2: Feature Screening Decision: Business Plan Verified.

FS3: Feature screening Decision: Feature Development Started, allocated to release.

FS4: Feature Screening Decision: Available for Releasing.

FTL: Feature Test leader.

FTS: Feature Test Strategy.

gNB: giga Node B = 5G Node B.

KPI: Key Performance Indicator.

LE: Latest Estimates.

LPO: Local Product Owner. Product owner of feature team.

LTE: Long-Term Evolution.

MN: Mobile Networks.

OSS: Operation Support System.

P7: Program Milestone: Ready for Pilots.

P8: Program Milestone: Ready for Deliveries.

PLM: Product Line Management.

P-milestone: Program Milestone.

Pronto: Fault Management Tool.

PUSCH: Physical Uplink Shared Channel.

RAO: Requirement Area Owner.

R&D: Research & Development.

RAN: Radio Access Network.

SFS: System Level Functional Specification.

SI: System Integration.

SPM: System Program Manager.

SiSo: Site Solution.

ST: System Testing.

SW: Software Development.

TDD: Time-Division Duplexing.

TCO: Total Cost of Ownership.

UE: User Equipment.

UL: Up Link.

U-Plane: User Plane.

Waterwall: The waterfall Model is a Breakdown of Project Activities into Linear Sequencies Phases, Where Each Phase Depends on the Deliveries of the Previous One and Corresponds to a Specialization of Tasks.

WoW: Way of Working.

1 Introduction

The purpose of this master's thesis was to study, how feature splitting and sub feature refinement processes and the way of working practices are working in the MN organization. The problem statement was that it takes several SW development feature builds (FBs) before it is possible to start testing the sub-functionality, which is the part of the system item in the feature. Based on the previous releases, feature slitting and sub feature refinements were not done based on the latest MN way of working processes and guidelines. Features and sub features are often too large to complete work within one feature build, therefore the feature needs to be split into small pieces of work, which can be implemented and e-2-e tested in the agreed timeline.

The objective of this thesis included also studying MN R&D feature development processes, tools, and related processes, which are needed to complete successful feature splitting and sub feature refinement in the 22R1 system program features.

The actual study was done using three selected 5G Feature Operation Team (FOT) pilot features in the 22R1 system program. During the three FOT pilot features were tested and evaluated, how the feature splitting and sub feature refinement processes are working and how the actual feature splitting can be done in practice. Based on the 5G way of working processes, all FOT features should be split into small e-2-e testable entity (EI) items based on the agreed system item split in the CFAM. In addition to that FOT features should be working in CDIT-D (Continuous Development, Integration, and Deployment) mode and deliver tested increment of work in every feature build.

In all three FOT pilot features evaluated in this thesis the feature splitting and sub feature refinements were done according to the MN FOT WoW processes and practices. All sub features splitting structures are presented in this thesis including challenges and problems found during the pilot features. The

recommended MN process changes and /or modifications are included in the study to make feature slitting and sub feature refinement working better in the future.

As feature splitting and sub feature refinement KPIs were available for the year 2021, all three pilot FOT feature KPIs results will be evaluated including the 22R1 system program and MN L1 organization result based on the target KPIs.

2 MN R&D Processes

2.1 Create Process

The Nokia Create process describes how products, solutions, and services are defined, developed, and managed throughout their lifecycle. The Nokia Create process provides a common framework comprising of its process architecture and decision-making model for consistent implementation across different Business Groups. It is facilitating a harmonized approach for Nokia while providing the needed flexibility to allow for Business Groups tailoring to suit their specific needs.

2.2 Feature Screening Process

Feature screening is a process that evaluates the business potential and value of a feature request/proposal for customers as well as for Nokia before development. The feature screening process is mandatory for products/systems decisions.

2.3 MN Release Commitment Process

Release commitment means the feature must be delivered within the committed schedule in a certain system/product program. The release commitment process starts early by tagging features in the product backlog and is applied incrementally until milestones are reached. During the release commitment phase, there could be changes in the Product management release backlog then requested higher priority features to be added to the release content. (Kadziewitcz, 2022, MN Commitment Process.)

2.4 Release Committed Features Splitting Process

The release committed feature splitting requirements are:

- The scope of the work covered under the system split is not changed.
- Applies to both entity-level splitting's as well as to new already committed system splits.
- Related system split is already committed to the relevant release.

The system- and entity item split changes are allowed only when newly created split will become immediately committed with the same schedule as the original system split. (Kadziewitcz, 2022, Release Committed Features Splitting Process.)

The FOTL ensures the following tasks are done:

1. FOT Leader (FOTL) agrees a new system split scope, schedule, and commitment with involved lead APOs.
2. FOTL ensures an agreed system/entity split is created.
3. Lead APOs (via all involved BU/DU LPOs) agreed to update plans for a newly created split.

4. FOTL makes a sure commitment for a newly created split is marked in the product backlog. (Kadziewitcz, 2022, Release Committed Features Splitting Process.)

2.5 Agile Model

Nokia is using the agile model for its R&D development projects. During this study, the aim is to focus more on the Nokia main R&D development processes linked to the new 5G features instead of Agile SW development in detail. Therefore, I will indicate the general Agile development model for the SW development i.e., the agile-vs-waterfall-model. (Agile-vs-waterfall-model.)

Agile development methodology and testing practices have worked for several organisations with positive aspects. Some important main points about the agile models are indicated below:

- Agile focuses on customer feedback, collaboration, small and rapid releases.
- It’s a perfect model to manage complex development projects.
- The agile model can quickly adapt according to the changes needed during the development project lifetime.
- The interaction of the customer is very high, as after each iteration an incremental model is deployed to a customer or internal testing teams. (Agile-vs-waterfall-model.)

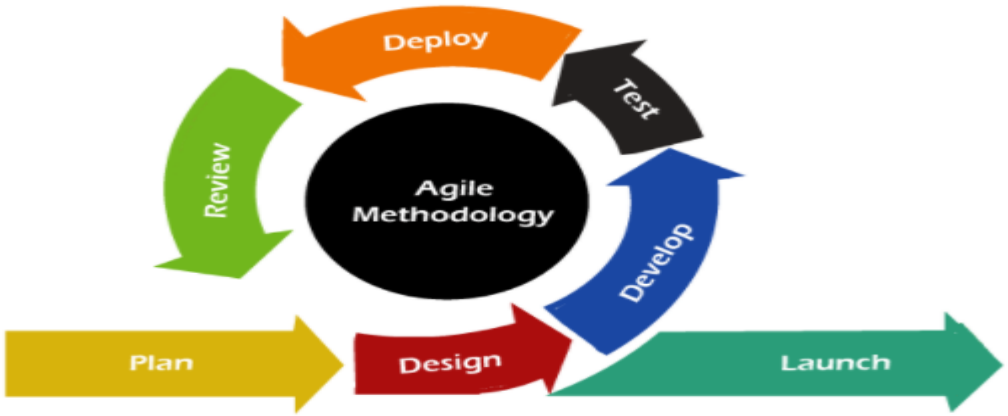


Figure 1. The Agile model. (Agile vs waterfall model.)

2.6 Waterfall Model

The waterfall model is one of the easiest and most traditional models to manage. Its traditional development nature and each phase has specific deliverables and a review process. It's working well in smaller size projects, where requirements are easily understandable. In the waterfall model, the whole SW development is divided into various phases as shown in the below picture. (Agile-vs-waterfall-model.)

Figure 2. The waterfall model. (Agile vs waterfall model.)

Some important main points about the waterfall model are indicated below:

- The waterfall model is not ideal to develop large-scale SW development projects.
- The requirement for the development projects should be clear at the beginning of the time.
- It’s difficult to move back into the development project to make changes in the previous phase or any required corrections there.

The testing phase and verification start only after the completion of development. (Agile-vs-waterfall-model.)

2.7 Common Feature Analysis Module

Common feature analysis module (CFAM) describes the common process for feature specification. It will be applied cross all Nokia development units (DUs) and technologies. It is also designed to facilitate common analysis for features commonly used by different Nokia products. It is connected to the Feature screening process owned by Business management.

CFAM specification work will start after FS2 approval is done. The CFAM document analyses impacts and requirements for system and product entity changes introduced by a feature. The CFAM content and maintenance will be focused on a single release. The CFAM development process includes:

- Refinement of a feature scope, it’s impact and dependency upon other features.
- A definition of derived sub-features.
- A comprehensive analysis of the new functionality and external behaviour impacts.
- A definition of impacts to OSS products functionality.
- A detailed BTS design impact analysis.

The following diagram illustrates the CFAM development activity in relation to the feature lifecycle.

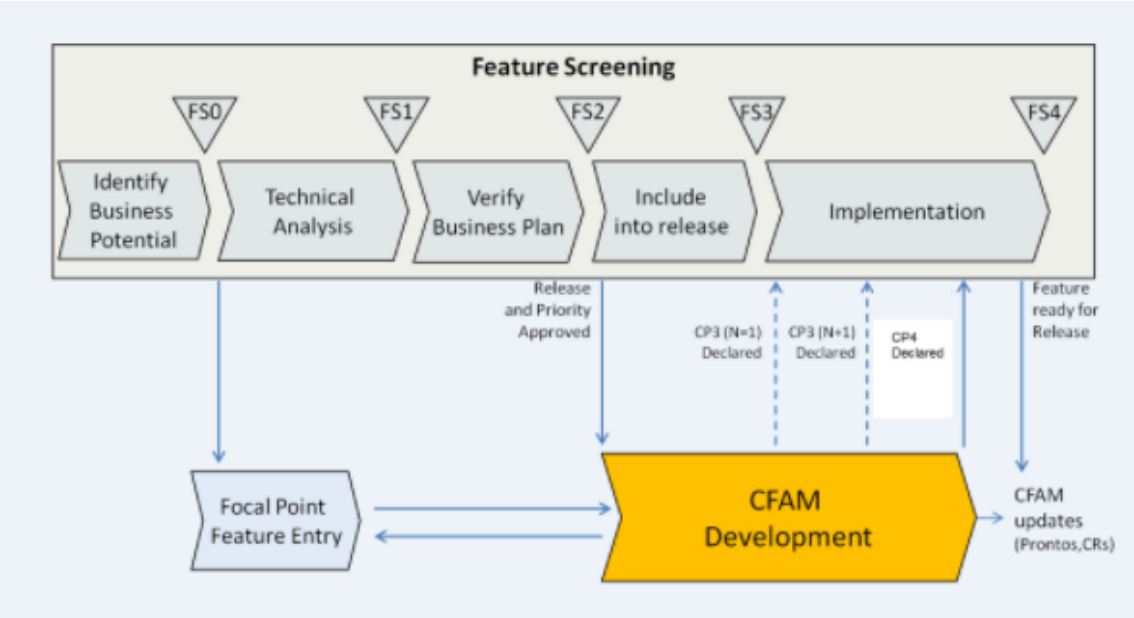


Figure 3. Feature screening process. (Schopp 2021, Introduction.)

2.8 Feature Owner Team

A feature owner team (FOT) is a team of representatives from all units to the development (planning, analysis, development, and test) of a feature. There is typically one FOT member per system component (e.g., L1, L2, L3, BOAM, ET, ST…) and the FOT member is representing all the squads from this area in the FOT meeting to keep the size of the FOT meeting manageable. The FOT leader (FOTL) and FOT members plan and synchronize all needed work together and participate in the FOT meetings that are facilitated by the FOT leader. The teams (squads) that are developing the feature are called a FOT community. The responsibilities of FOT are shown here: (Kowalczyk 2020, what is a FOT.)

- Aligns work to optimize the development flow and aim to deliver integrated and tested incremental product level functionality for every feature build (FB).

- Focus on commonly enabling entity and system-level integration.
- Clarifying requirements makes global design decisions and solves them quickly.
- Helps to set up direct communication links between the “Backoffice” squad members (FOT community) that work on the feature.
- FOTs are used for customer and internal features.
- FOT features are usually permanent for the FOT lifecycle, substitutes are sent in case of absences. (Kowalczyk 2020, what is a FOT.)

The following diagram illustrates the FOT setup:

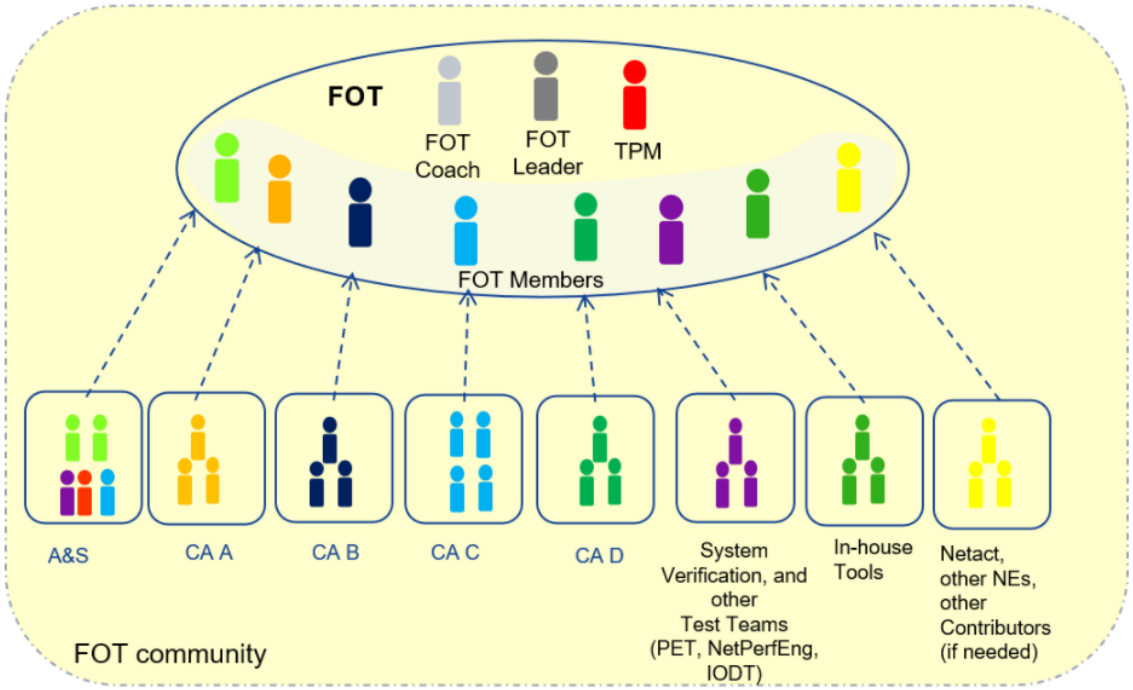


Figure 4. FOT setup. (Kowalczyk 2020, what is a FOT.)

2.8.1 FOT Lifetime

- FOT’s are started after FS2 together with CFAM and follow the just-in-time principle, i.e., development shall start based on Business priority and estimated lead time.

- A FOT kick-off meeting will be organized at the beginning of the FOT with all needed participants from the impacted development units and/or CA groups.
- FOT's are active between FOT start until FS4/C5.
- At FS4/C5 FOT goes to the "passive" phase (maintenance support) only and no regular FOT weekly meeting is needed anymore (only need bases). (Kowalczyk 2020, FOT lifetime.)

2.8.2 Setting up FOTs

- FOT and CFAM leaders are assigned at FS2 within FiVe working days. CFAM is seen as an integral part of a FOT, i.e., the FOT is started at the same time as CFAM to guarantee sufficient information exchange between CFAM authors, SW development, and test experts. The CFAM is a sub-team of the FOT, that contributes to the feature. To set up FOT and CFAM, the FOT leader and A&S domain planners work together to get FOT members and CFAM members nominated. FOT members are nominated with the help of lead Area product owners (LPO's). (Kowalczyk 2020, Setting up FOT.)

- The FOT leader request CFAM lead via A&S lead APO.
- The FOT leader and the CFAM lead find FOT/CFAM members with help of APOs from impacted areas.
- The CFAM lead finds A&S contributors for CFAM via domain planners from other domains.
- The FOT leader finds specification engineers (also called CP3/EFS authors) and SyVe and ET CFAM contributors from all needed DUs.
- The FOT leader and the CFAM lead will invite a kick-off meeting (normally separate FOT/CFAM kick-off meeting to be organized due to different meeting participants)
- FOT and CFAM meeting will be started. (Kowalczyk 2020, Setting up FOT.)

FOT leader assignment is described in the diagram below.

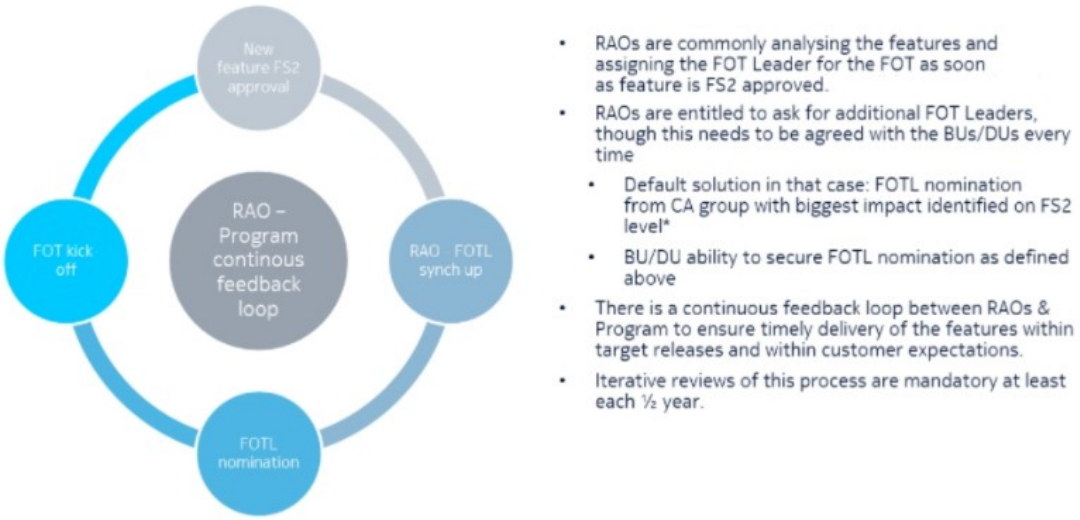


Figure 5. FOT leader assignment. (Kowalczyk 2020, FOT leader assignment.)

2.8.3 FOT Interworking with Product Management

The Product Management Feature Owner (PMFO) of the feature that is developed by FOT works closely with FOT to optimize customer value. The PMFO role is usually assigned to a technical product manager. This includes

- Presentation of the feature scope during FOT kick-off.
- Helping define the development order of the feature.
- To be available for questions that occur during the development.
- Support in case descoping of the feature is needed. (Kowalczyk 2020, FOT leader assignment.) (Kowalczyk 2020, FOT interworking.)

2.8.4 FOT Feature Planning and Tracking

The FOT leader creates the initial development plan for a feature together with the FOT members and takes care that the feature plan is updated in the Product backlog. The actual backlog maintenance is usually performed by the LPOs of each system component. The key principle is that the feature plan shows the “real” bottom-up plan of the FOT all the time. The development backlog always needs to have a complete plan for the feature, but the planning granularity depends on the analysis state of the feature. It is expected that the next three feature builds have a detailed plan. At feature build entry the work for the upcoming feature build is committed in a product backlog. (Kowalczyk 2020, Feature Planning and Tracking.)

The initial development plan can be just a placeholder item that contains the FS2 effort estimates (EE) and the planned end feature build based on the lead time estimate for the feature. Feature splitting should happen incrementally, and feature planning is continuous in FOT. Once the first System-level split is agreed in the CFAM and System-level user scenarios are available, the FOT starts with Sub feature planning meetings to agree on aligned sub-feature plans which are based on detailed FB planning and commitments. (Kowalczyk 2020, Feature Planning and Tracking.)

2.8.5 System and Entity-level Split

As FOT focuses on enabling entity tests (ET) and system tests (ST) as early as possible, the split of a feature into System-level items and System-level user scenarios shall optimize the test integration flow and overall lead time. The FOT leader is responsible for, the system level split follows this principle as indicated below:

- System level splitting is carried out by a cross-functional team including CFAM authors, technical product management, System verification, and entity test experts as a minimum.

- System level split can be done incrementally starting the CFAM CP1 phase.
- Additional splitting refinement can occur during CFAM CP2 phases.
- Every System level item needs to be testable by System verification.
- To ensure this test architects and PET verification architects shall be involved.
- Around CFAM CP1 at least one initial System level split needs to be available because CP2 phase specifications are done per System level.
- Entity items should be small enough to be completed in one item feature build.
- Entity items are further broken down into competence area items and team level items. (Kowalczyk 2020, System and Entity Level Split.)

2.8.6 Feature Dependencies Planning and Tracking

Feature dependencies between contributing teams e.g., interface changes are synchronized in FOT meetings and documented in the meeting minutes of the FOT page and the backlog. If the FOT identifies dependencies to other features, then the FOT must set up an appropriate communication channel to the other FOTs it depends on. As the feature dependencies are very important and will impact FOT's end-to-end testing plan and actual testing, very close co-operation between dependency FOTs is needed to align testing activities. It is also very important for sub features splitting and e2e testing point of view in the FOT's. (Kowalczyk 2020, Feature Dependencies and Tracking.)

2.8.7 FOT Documentation and Reporting

Each FOT maintains a so-called FOT page, i.e., a SharePoint or Confluence page to store FOT meeting minutes and all feature relevant information, e.g., system/entity level splits, a link to the FOT page is provided in the product backlog. The feature plan of the FOT is documented in the product backlog. The

FOT also updates all needed technical documents (CFAM, technical specifications, feature test specifications, …) as required by the DoD and System component-specific guidelines. FOT reporting towards System programs and Requirement area reports are product specific. (Kowalczyk 2020, FOT Documentation.)

3 R&D Tools

3.1 Product Backlog

The product backlog consists of projects that share common configurations. There are two common MN-wide projects – FFB and FPB – and unit-specific projects – FCA projects. The program has been initiated to create and deploy a single backlog tool and way of working (WoW) for entire Mobile Networks. All MN R&D developments works are done using the product backlog.

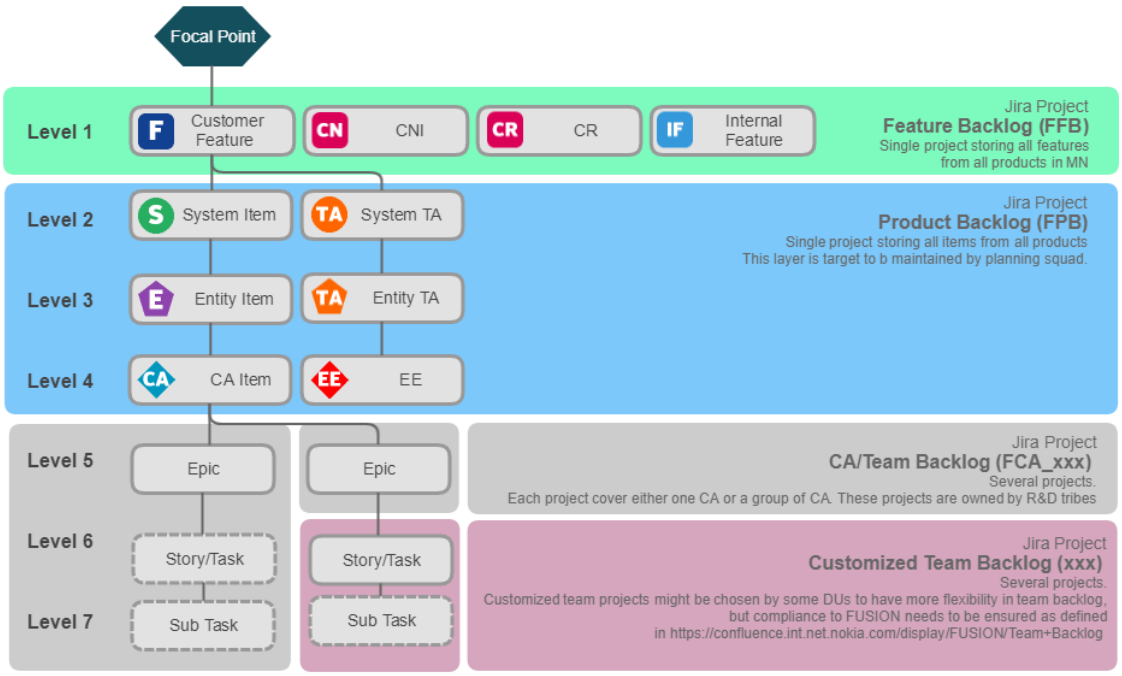


Figure 6. Product backlog project structure and issue hierarchy. (Kela 2019, Issue Type Hierarchy.)

The picture below illustrates a practical example of the product backlog structure including System item (SI) structure of one of the Pilot features in this thesis. The feature name is CB007798 -5G Aperiodic reporting on PUSCH for non-beamforming FDD cells – ABIL.

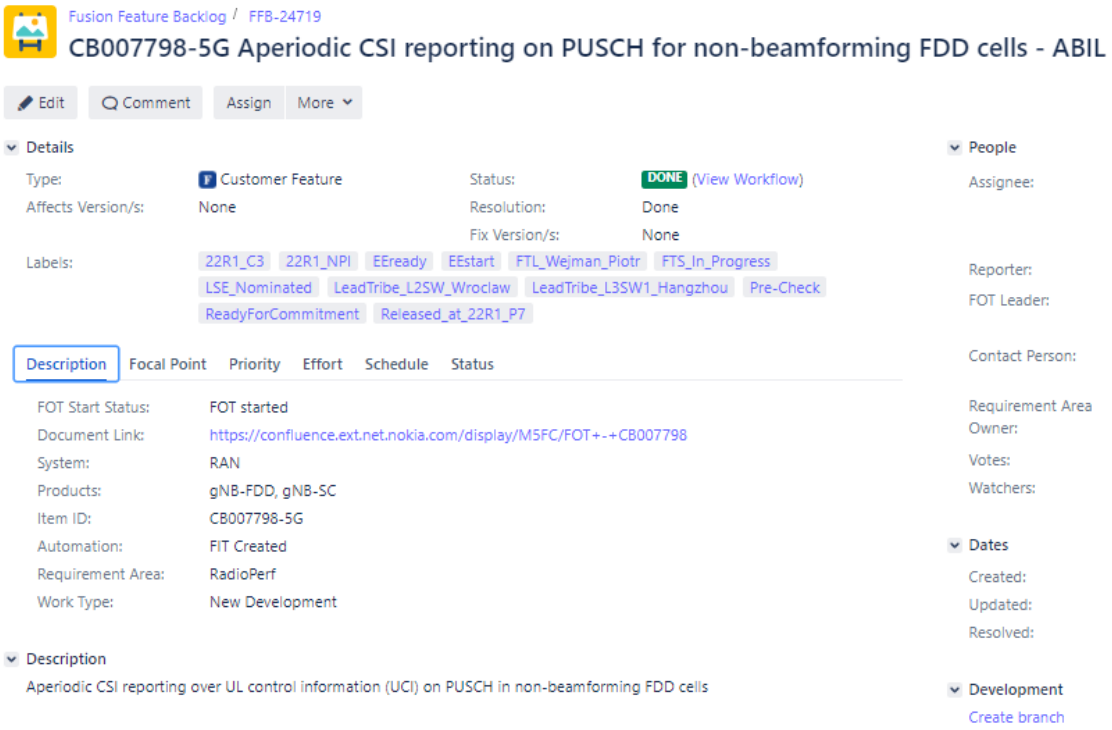


Figure 7. Product backlog picture for the CB007798-5G feature.

3.2 Focal Point

Focal Point is the Nokia global Product and Portfolio Management tool used for feature screening and Release planning. It provides a harmonized way of working (WoW) strengthened by a common structure. It is easy to use and includes common IF to FUSION&DOORS and other tools with minimal changes for integration.

Focal Point is commonly used for all Nokia features, and it's always up-to-dated e.g., about the latest status of the different features and functionalities. The below

pictures illustrate partial Focal Point information for tone of the pilot FOT features in this study.

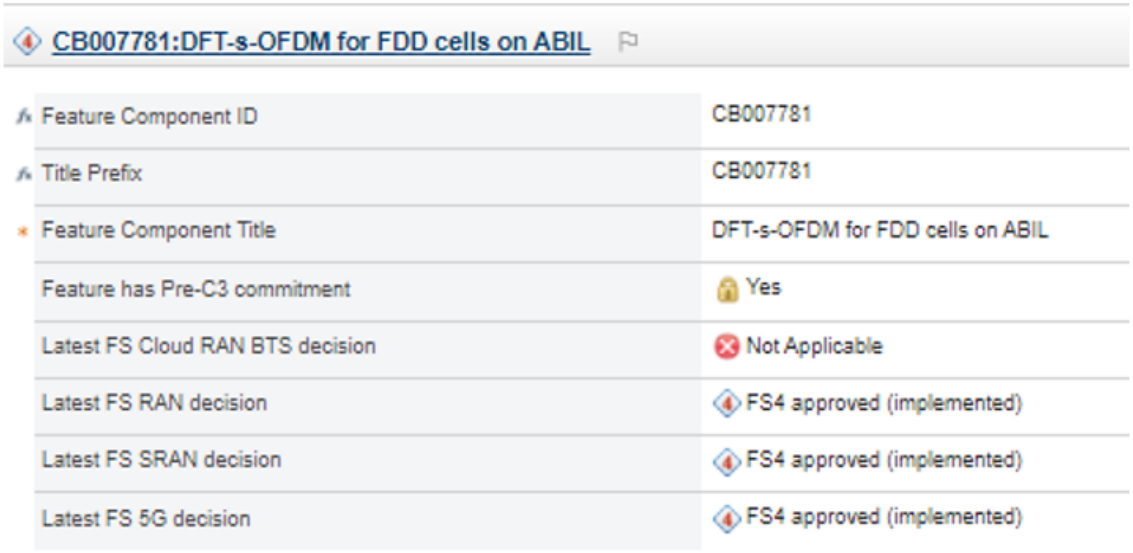


Figure 8. Focal Point view for the CB007781-5G feature.

3.3 Quality Center

Nokia is currently using ALM Quality Center (QC) Enterprise Edition version 15.0. Quality Center (QC) can be used for managing all kind of testing and it's used globally in R&D, IT, SAP, and SOX testing

- In software, hardware, solutions, and services testing
- In traditional and agile development process
- Supports both manual and automated testing

Nokia QC projects are based on harmonization – meaning that it's possible to use common tools and test assets can be shared easily between projects. Quality Center service support model is based on Global Support Concept: including LO and Key-user network. All Feature test cases are placed and tracked in the Quality Center (Hirsimäki, 2021, 3-9.)

3.4 Pronto Case Handling Tool

Pronto is a web-based tool for managing faults found in Nokia products. It provides a view with a controlled way to manage the correction of faults and keep the status of corrections and the information flow continuously visible.
The faults found by end customers or by internal testing are reported to Pronto by customer service, Nokia personnel, or collaborators (e.g., testers). Nokia personnel or collaborators then investigate and correct the reported faults. Pronto is used in all phases of this process to keep track of the processing of the faults. Pronto also provides a tool for smooth communication between customers, coordinators, and engineer testers. (Malo, 14-19.)

4 Feature Splitting Processes

4.1 Feature Splitting Introduction

Feature Splitting is performed in iterative development when features are too “BIG” on one feature Build in MN. Features should be split into “Customer-centric” sub features. Customer-centric means that the split should have a customer value, the split items are functionally self-contained and can be tested individually at a product level or system level. Features mean customer features of a RAN products in MN, but Nokia have also a lot of internal features and internal development, where the feature splitting should be done in the same way. (Brocek 2020, Introduction.)

Below pictures illustrate different levels of feature splitting:

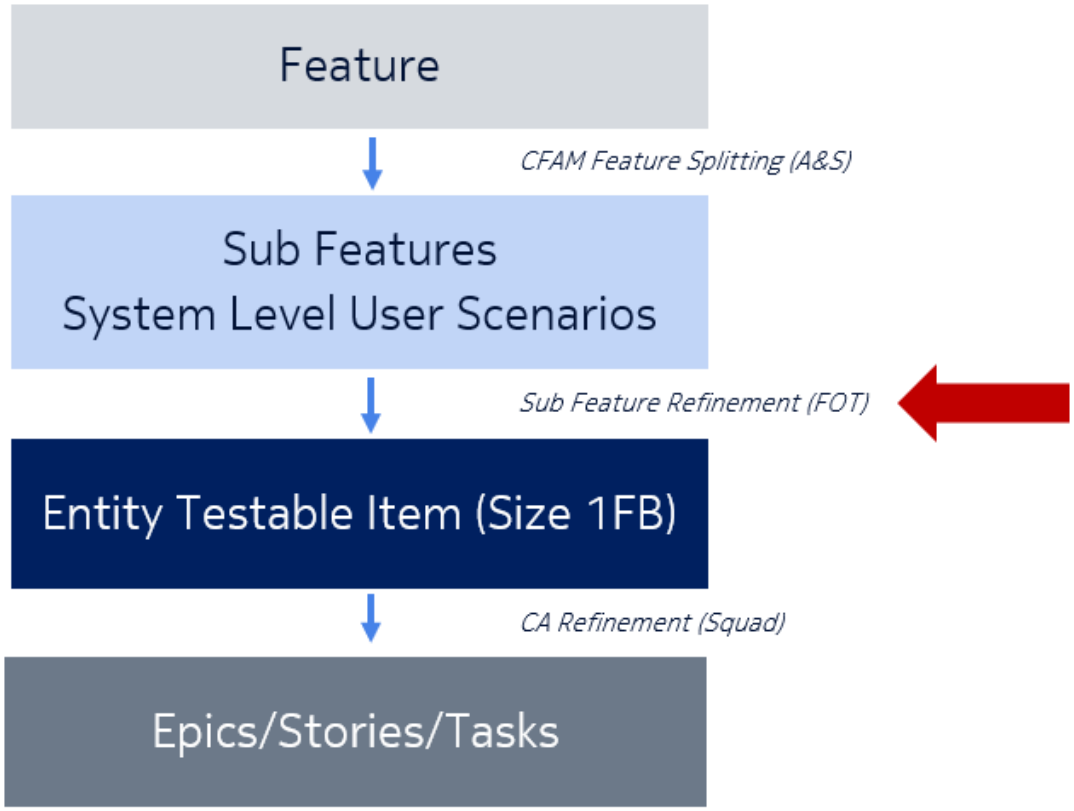


Figure 9. Different level of feature splitting. (Brocek 2020, Introduction.)

Functional System level splits are defined in CFAM around CP1. It is possible to define System level items incrementally especially for bigger features aligned with the analyses state. System level items will be split into entity items in FOT during Sub feature refinement. Feature splitting is done incrementally as a feature analyses process. To have a complete development plan in Fusion after the FS2 feature initial tree is created which contains placeholder items for the FS2 effort estimates (EE). The placeholder items should also show the currently planned End Feature build (FB) for the feature development.

4.2 Customer Features

Generally, customer features shall be defined in such a way that they describe End-to-End functionality on an MN product such as a gNB or eNB including a Radio Unit that can independently be released to customers. Customer features are defined beyond the scope of the splitting guidelines. Feature definition is

owned by Product Management, but R&D provides feedback during FS1TA and CFAM phases to define the scope that the R&D needs to be considered. (Brocek 2020, Splitting levels.)

4.3 Splitting Levels

Features are split in three different levels based on functional splits: System level-, entity item- and Competence area level splits. They are called functional because they describe functionality of the product under development. There are also so-called “Special System Level Splits”, which describe work (types) and are described below. (Brocek 2020, Splitting levels.)

4.3.1 System Level Items

System level item splits are defined by CFAM authors together with System verification and entity item experts during CFAM close to CP1 milestone. System level part of a feature can be released individually if needed when System tests of items are completed.

A system level items consist of a set of System level user scenarios that define together the scope of the System level item. System level user scenarios are not visible in the backlogs but are documented in the System level user module in Doors. (Brocek 2020, System level items.)

4.3.2 Entity Level Items

Entity level items split one System level item into smaller functionality which can be integrated and tested at the entity item level. The work effort/duration for completing the entity item must be small enough that all work that is required for the item and its Competence area (CA) level items can be completed within 4 weeks (CW). Entity level items implement a part of System or entity level user scenarios and must have acceptance criteria that provide details on how to

verify/test the needed functionality. Entity level items are defined as part of Sub feature refinement in FOT. (Brocek 2020, Entity level items.)

4.3.3 Competence Area (CA) Items

Competence area (CA) items split the work of an entity level item into multiple teams (e.g., L1, L2, BOAM, ET, Test tools,.) that need to contribute to the entity level item. Each entity item consists of a single Competence area (CA) item per impacted CA for complete CA commitment/schedule/DoD management. The work to implement CA items is synchronized in FOT to establish a continuous flow of done entity level items. (Brocek 2020, CA level items.)

4.4 Feature Build Exit and Entry

A feature build (FB) is 4 weeks, time-boxed iteration that forms the main development cadence of 5G product development. At feature build exit (the end of the FB) it is checked which of the planned backlog items have been done. The event is like the sprint review meeting in Scrum, but the scope of FB exit is the whole 5G products, i.e., the result of all teams that are working for the 5G product is evaluated.

During the feature build entry events, the 5G development plan is updated considering changes due to the intrinsic variability of Product development and changes in the priority of features. Each FOT provides an updated plan in the product backlog for all the features that are assigned to them and commits to the work of the next FB. FOT’s also provide an update to the detailed plans for the work of the next 2 FBs for the remaining part of the feature until the minimum marketable part is reached.

5 Sub Feature Refinement

5.1 Sub Feature Refinement Introduction

Sub feature refinement is the process of splitting System level sub features into entity level items. This is part of overall feature splitting, and it is done after splitting customer features into system level sub features. The content of each split item shall be described well e.g., as in user story format. Checkpoints define the criteria to verify the behaviour in the entity test. Doing so, the FOT aligns the content that shall be implemented step-by-step by the development teams, while the entity test team receives a blueprint for the test plan. (Meier 2020, Introduction.)

5.2 CDIT-D Mode Used in FOT

FOT should work in CDIT-D mode (Continuous Development, Integration, Testing & Deployment) and deliver a tested increment for every FB's. Features and System level sub-features are often way too large to be completed within one feature build. That is why a feature needs to be split into small pieces of work which can be implemented and tested step by step in the agreed timeframe. The CDIT-D SW delivery process can be seen in picture 16.

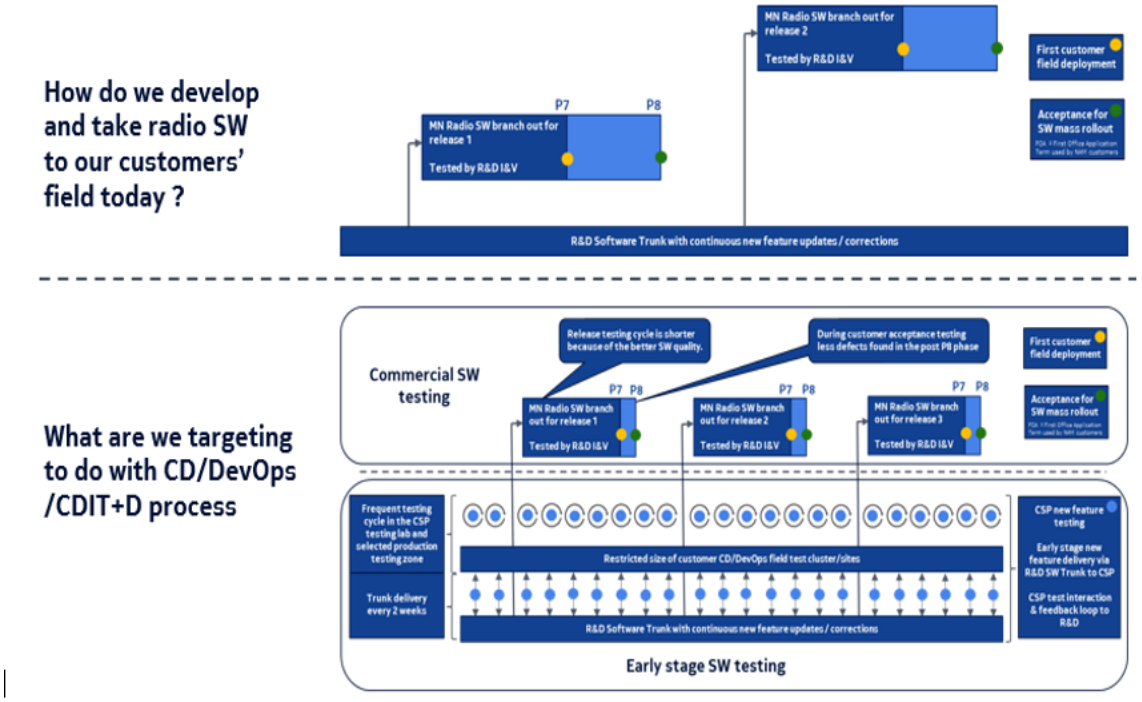


Figure 10. The CDIT-D SW delivery process.

5.3 Splitting the Work Vertically

Typically, the FOT investigate one system level scenario after one other. If the system level user scenario is too large to be finished within one feature build, then the FOT explores possibilities to split work in e-2-e entity testable integration steps. Such integration step must be e-2-e testable on entity test level. Sub feature refinement is focusing on the items that are scheduled for implementation next. Below is a good example of how sub-feature refinement should be done. (Meier 2020, Splitting the work vertically.)

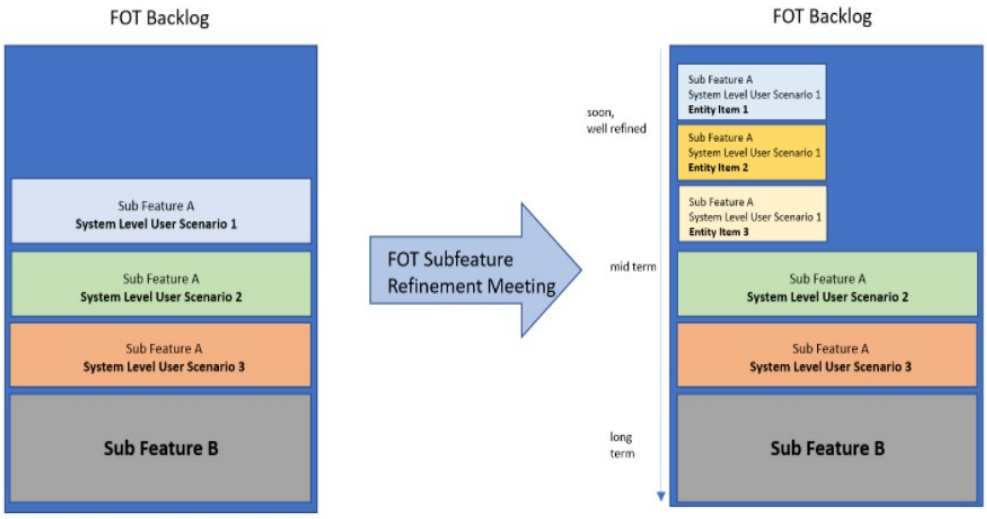


Figure 11. FOT Backlog before and after the sub-feature refinement. (Meier 2020, Splitting the work vertically.)

A split by component, aka horizontally split, is not allowed during sub feature refinement. Vertical split means, that every impacted component must contribute to enabling entity testing of the integration step. The FOT should split the system level user scenarios vertically through the system. Every component will only deliver exactly the chunk of work to enable the integration step. This technique is known as Tracer Bullet and reduces the lead time for each competence area and enables incremental delivery, early entity testing, and quick feedback. Refined/split items are represented in Fusion as entity items. The picture below illustrates the wrong and correct way for entity testable items.

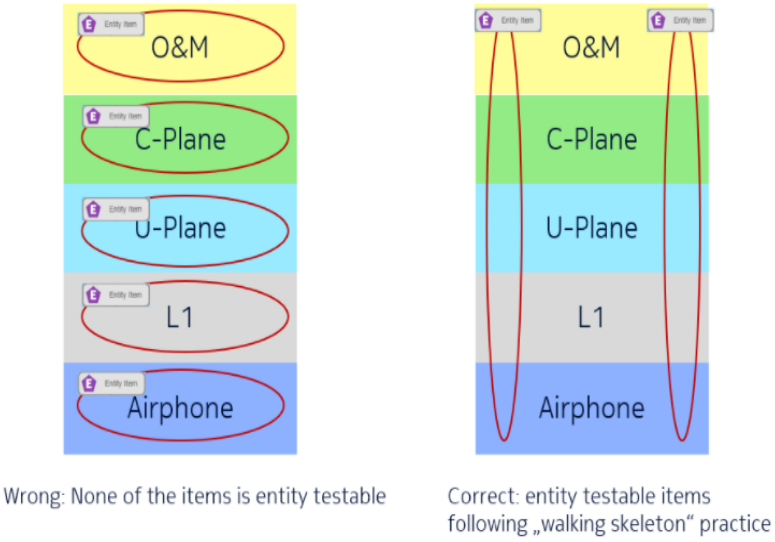


Figure 12. Horizontal and Vertical split examples. (Meier 2020,10.)

5.4 Sub Feature Refinement Strategies

The following list gives examples of different refinement strategies, that can be used for the sub feature refinement. The different refinement strategies can be mixed. (Meier 2020, Refinement strategies.)

- Scenario steps: Setup Cell, Setup UE, start traffic, set-up next UE, …
- Configuration: First TDD, Then FDD
- Use cases: First HARD, then on CSI reporting, scheduling request
- CRUD: Create, Retrieve, Update, Delete
- Knowledge: Start with what you know
- Acceptance Criteria: Refine one item per Acceptance Criteria from the item under refinement
- Fail fast: Refine firstly things needed for working e2e prototype. (Meier 2020, Refinement strategies.)

5.5 Sub Feature Refinement in Practise

A FOT team aligns Sub feature refinement work to optimize the development flow and aim to deliver integrated and tested incremental product level functionality in every feature build.

The FOT leader nominates Lead specification engineer in the FOT team. He/she is coming normally from the most impacted components and where the biggest work estimates are in the feature. Lead specification engineer role includes:

- Acting as the CP3 author from the most impacted component.
- Aligning specification activities after CP2, after CFAM is completed.
- Facilitating technical sub-streams:
  - Sub feature refinement meetings.
  - Technical alignment across all components.
- Ensuring that the FOT team talks about content and is technically aligned.
- Offloading weekly FOT- and CFAM meetings.

Below is an example of FOT sub feature refinement meeting structure

	SubFeature Refinement (on demand or 1-2x per Feature Build, max. 2h per session)
Who?	• Lead Entity Specification Engineer as facilitator • FOT Members from all areas (Spec, Dev, ET, SyVe) • Technical experts from the squads • CP2 (SFS) Authors • FOT Leader (optional)
In	• CP2 Spec (SFS) with certain stable parts • System Level User Stories • Well prepared FOT members
Out	• Entity Items that can be implemented and tested in 1 FB • Check Points • Clarified Dependencies • Risks
Methodologies	• User Stories • ATDD • Definition of Ready (DoR) • DFMEA Light (Training link) • Interaction! f2f meeting if possible

Figure 13. Refinement meeting structure. (Meier 2020,11.)

The lead specification engineer is a key role to enable incremental delivery. He/she starts to facilitate sub feature retirement meetings in the FOT and invites all FOT members into the meetings. The main aim is to ensure, that the sub feature refinement will be done according to the MN FOT refinement and planning guidelines. All features are always unique, but the main aim of the sub feature refinement is to plan e2e testable entity items which can be delivered in the one feature build (FB). The picture below illustrates well how actual sub feature refinement should be done.

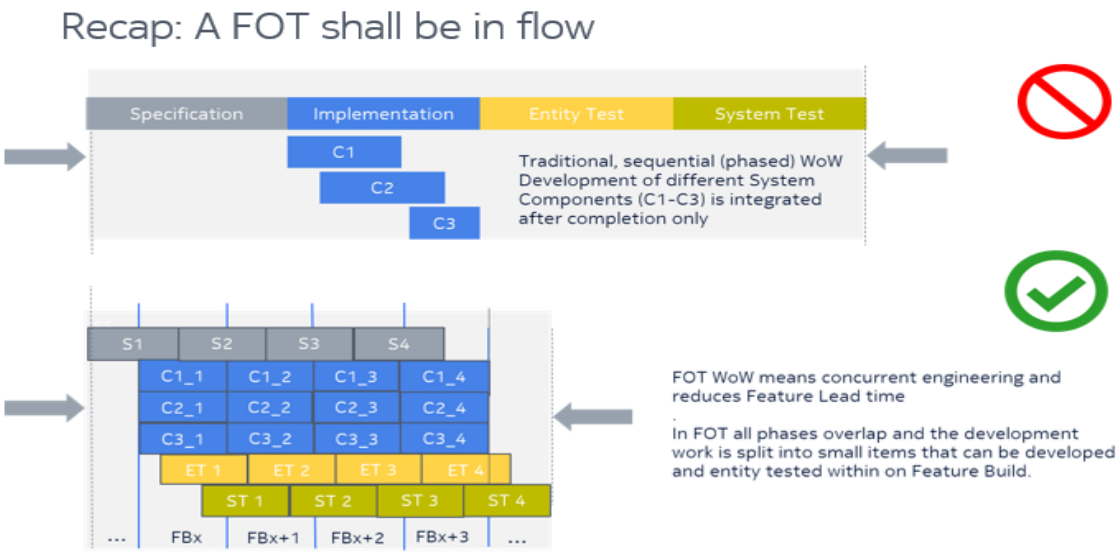


Figure 14. Sub feature refinement example. (Kowalczyk 2020, Alignment of work to optimize lead time.)

5.6 Common Mistakes of Sub Feature Refinement

There are different options for how to split system level user scenarios into entity items. Therefore, each split is a case-by-case decision that must be taken by the FOT team members. Here are the most common mistakes done for the sub-feature refinements:

- The split has been done by a single person.
    - The split shall be done by the FOT team members. Besides creating smaller batches of work, the purpose of the refinement/split activity is to transfer knowledge into the FOT. This happens in a dialog with the active participation of the FOT members.
- The split has been done by the wrong person.
    - The split shall be done by a group of technical experts from the different competence areas.
- Horizontal split.
    - A sub feature shall be split into e2e entity testable deliveries. That requires splitting the work vertically through all the components.
    - Entity items are not e2e testable in entity test.
    - This is usually caused by the previous point “horizontal split”. An entity item shall be testable on the entity test level.
- Unclarity.
    - The content of the entity item is not understood by the FOT members.
- Too big content, as the entity item shall ideally be completed within one feature build. (Meier 2020, Anti-Pattern.)

6 Key Roles for Feature Splitting Operation Teams

The following feature operation team key roles are essential for the successful feature splitting and Sub feature refinement for the FOT features.

6.1 Feature Operation Team leader (FOTL) - Role Description

The FOTL is responsible for ensuring that feature splitting and sub feature refinement will be done for the FOT feature.

The main responsibilities of the FOTL are the following:

- Lead the execution of an FOT through its phases against agreed program targets.
- Leads e2e feature development and delivery across all virtual teams contributing to the FOT.
- Facilitates splitting of Feature plan to Competence Area (CA)/team backlogs with FOT members and product owners, ensuring commitments to the feature delivery plan.
- Checks and manages interfaces and dependencies to other features and FOTs.
- Represent FOT and makes commitments towards the program on behalf of FOT.
- Single point of contact towards Program management and towards Requirement Area Owners (RAO).
- Facilitates FOT meetings.
- Ensure FOT follows up all needed processes (CFAM, Backlog Management, Coding Guidelines).
- Risk Management for the feature.
- Documented FOT improvements. (Kukkonen 2021, FOT leader – role description.)

6.2 CFAM Leader - Role Description

The main responsibilities of the CFAM leader are the following:

- Responsible for managing CFAM content and feature scope.
- Responsible for CFAM generation for each checkpoint.
- Lead feature scope and system level discussions.
- Leads system level DFMEA evaluation of system level user scenarios.
- Incorporates the user stories into the CFAM DOORS module.
- Responsible for CFAM kick-off meeting.

6.3 Feature Test lead - Role Description

The main responsibilities of the feature test lead are the following:

- Feature Test Lead (FTL role) to facilitate the work of Feature test strategy (FTS) creation and ensure feature splitting and Sub feature refinement for testing point of view.
- FTS to initiate together with FOT leader the discussion for the test teams (test levels) selection for FTS work and feature slitting.
- To facilitate the creation of the FTS document according to the contents defined in the FTS template.
- To report testing risks, as one of FTS outputs to FOT leader. (Kukkonen 2021, Feature Test Lead (FTL).

6.4 Lead Specification Engineer - Role description

The lead specification engineer is the key role to enable sub-feature refinement. It is a technical leading role in software entity/element level for feature development. FOTL is responsible for explicitly indicating that this role is active in the FOT. (Meier 2021, Lead Entity Specification Engineer.)

The main responsibilities of the lead specification engineer are the following:

- Drives the sub feature refinement.
- Ensures entity level technical alignment across all components, by working collaboratively and closely with all EFS authors.
- Creates entity level functional specifications (EFS) mapping customer user stories to requirements.
- Specifies requirements for testing.
- Usually, the CP3 author from the most impacted areas.
- Facilitation of technical sub-streams as example sub-feature refinement and technical alignment across the different components/organizations.

- Are mandatory members of Feature Owner Team (FOT). (Meier 2021, Lead Entity Specification Engineer.)

6.5 FOT Member – Role Description

The main responsibilities of FOT members are the following:

- Representative of Competence Area, SW domain or organisational unit that contributes to a feature for technical, planning and WoW aspects.
- Support and participate feature splitting and sub feature refinement activities.
- Contributes for feature planning, requirement clarifications, functional feature split global design decisions and quick problem solving.
- Participates in all relevant/Mandatory FOT meetings.
- Links his/her team/organisation/unit members with other team members that work together for a feature to align work directly. (Kukkonen 2021, FOT member – role description.)

7 FOT Pilot Feature Introduction

7.1 CB007781-5G - General Feature Induction

The CB007781-5G feature introduces DFT-s-OFDM as an additional waveform in the uplink for PUSCH.

- Products: gNB and gNB SC.
- Feature ID: CB007781-5G.
- Planned System release: 22R1.

7.2 CB007794-5G - General Feature Induction

The CB007794-5G feature introduces compression for CPRI fronthaul links between capability unit and TDD radio units.

- Products: gNB and gNB SC.
- Feature ID: CB007794-5G.
- Planned System release: 22R1.

7.3 CB007798-5G - General Feature Induction

The CB007798 feature introduces the aperiodic CSI reporting based on periodic CSI-RS resources for the FDD cells on ABIL.

- Products: gNB and gNB SC.
- Feature ID: CB007798-5G.
- Planned System release: 22R1.

8 Sub Feature Refinement Structure for Pilot FOT Features

Sub feature splitting WoW and Refinement guidelines were used to verify how sub feature splitting works in practice in these selected pilot FOT features. At the beginning of each FOT feature key roles were nominated as defined in the guidelines. After the lead Specification engineers were nominated, we started to organize Sub feature refinement meetings with all three different FOT pilot features.

8.1 CB007781-5G – Sub Feature Refinement Structure

The following System item structure was agreed for the CB007781 feature in the CFAM, and it was used as a baseline for Sub feature refinement work. The CB007781-5G – CFAM-CP1 and the CB007781-5G – FS1TA items were their own system items and not part of the Sub feature refinement work.

System item structure:

- CB007781-5G - A -DFT-s-OFDM for FDD cells on ABIL.
- CB007781-5G - B -DFT-s-OFDM for FDD cells on ABIL – Performance and Capability.
- CB007781-5G – CFAM-CP1 DFT-s-OFDM for FDD cells on ABIL.
- CB007781-5G – FS1TA DFT-s-OFDM for FDD cells on ABIL.

Sub feature Refinement was done based on the agreed System split. The following Sub feature refinement were agreed upon for the CB007781 feature within the FOT team. The CB007781-5G – CFAM-CP1 and CB007781-5G – FS1TA system items

Sub feature refinement structure for -A entity items:

- CB007781-A-B7: Enable/Disable DFT-s-OFDM feature from O&M.
- CB007781-A-B8: Generate DMRS sequence for DFT-s-OFDM and add to Transform precoding block.
- CB007781-A-B9: Generate PTRS sequence for DFT-s-OFDM and send PTRS with DFT-s-OFDM enabled.
- CB007781-A-B10: Switch from CP-OFDM to DFT-s-OFDM waveform and vice versa.

The product backlog below illustrates an agreed entity items structure for the CB007781 feature. Separate entity items were created for Airphone, Customer documentation (CuDo), and Field verification (FiVe), but they were not part of Sub feature refinement in the CB007781 feature, as Sub feature spitting was not possible to do for them.

FPB-531586	CB007781-5G-A-CFAM-CP2 - DFT-s-OFDM for FDD cells on ABIL	DONE	Tuovinen, Jukka (Nokia - FI/Espoo)
FPB-538786	CB007781-5G-A-SyVe - DFT-s-OFDM for FDD cells on ABIL	DONE	Tuovinen, Jukka (Nokia - FI/Espoo)
FPB-565385	CB007781-5G-A-FiVe - DFT-s-OFDM for FDD cells on ABIL	DONE	Tuovinen, Jukka (Nokia - FI/Espoo)
FPB-574167	CB007781-5G-A-CuDo - DFT-s-OFDM for FDD cells on ABIL	DONE	Kawa, Katarzyna (Nokia - PL/Wroclaw)
FPB-578626	CB007781-5G-A - [Airphone] DFT-s-OFDM for FDD cells on ABIL	DONE	Tuovinen, Jukka (Nokia - FI/Espoo)
FPB-580314	CB007781-5G-A-B7 Enable and Disable DFT-s-OFDM for FDD cells on ABIL	DONE	Tuovinen, Jukka (Nokia - FI/Espoo)
FPB-580340	CB007781-5G-A-B8 Generate DMRS sequence for DFT-s-OFDM and add Transform precoding block	DONE	Tuovinen, Jukka (Nokia - FI/Espoo)
FPB-580343	CB007781-5G-A-B9 Generate PTRS sequence for DFT-s-OFDM and send PTRS with DFT-s-OFDM enabled	DONE	Tuovinen, Jukka (Nokia - FI/Espoo)
FPB-580345	CB007781-5G-A-B10 Switch from CP-OFDM to DFT-s-OFDM waveform and vice versa	DONE	Tuovinen, Jukka (Nokia - FI/Espoo)

Figure 15. Entity item structure for -A system item in the product backlog.

Here is the agreed sub feature refinement structure for the competence area under the CB007781-A-B7 entity item. Done means that the specific CA items have been completed and all development work is completed. Obsolete means that the specific CA items, where obsoleted, are not needed.

FPB-412172	CB007781-5G-A-B7 Enable and Disable DFT-s-OFDM for FDD cells on ABIL	DONE
FPB-412259	CB007781-5G-A-B7 Enable and Disable DFT-s-OFDM for FDD cells on ABIL	OBSOLETE
FPB-412260	CB007781-5G-A-B7 Enable and Disable DFT-s-OFDM for FDD cells on ABIL	DONE
FPB-412261	CB007781-5G-A-B7 Enable and Disable DFT-s-OFDM for FDD cells on ABIL	DONE
FPB-412262	CB007781-5G-A-B7 Enable and Disable DFT-s-OFDM for FDD cells on ABIL	DONE
FPB-412263	CB007781-5G-A-B7 Enable and Disable DFT-s-OFDM for FDD cells on ABIL	DONE
FPB-412264	CB007781-5G-A-B7 Enable and Disable DFT-s-OFDM for FDD cells on ABIL	DONE
FPB-412265	CB007781-5G-A-B7 Enable and Disable DFT-s-OFDM for FDD cells on ABIL	OBSOLETE
FPB-545554	CB007781-5G-A-B7 Enable and Disable DFT-s-OFDM for FDD cells on ABIL	DONE
FPB-582931	CB007781-5G-A-B7-ET Enable and Disable DFT-s-OFDM for FDD cells on ABIL	DONE
FPB-588072	CB007781-5G-A-B7-SyVe Enable and Disable DFT-s-OFDM for FDD cells on ABIL	DONE
FPB-591602	CB007781-5G-A-B7-ET-Preparation	DONE

Figure 16. Competence area structure for the CB007781-A-B7 entity item.

Here is the agreed sub feature refinement structure for the competence area under the CB007781-A-B8 entity item in the product backlog. All CA items were completed as planned.

FPB-580629	CB007781-5G-A-B8 Generate DMRS sequence for DFT-s-OFDM and add Transform precoding block	DONE
FPB-580632	CB007781-5G-A-B8 Generate DMRS sequence for DFT-s-OFDM and add Transform precoding block	DONE
FPB-580635	CB007781-5G-A-B8 Generate DMRS sequence for DFT-s-OFDM and add Transform precoding block	DONE
FPB-580638	CB007781-5G-A-B8 Generate DMRS sequence for DFT-s-OFDM and add Transform precoding block	DONE
FPB-580641	CB007781-5G-A-B8 -SOC BB TOP -Generate DMRS sequence for DFT-s-OFDM and add Transform precoding block	DONE
FPB-580646	CB007781-5G-A-B8 -SOCLAB- Generate DMRS sequence for DFT-s-OFDM and add Transform precoding block	DONE
FPB-582934	CB007781-5G-A-B8-ET Generate DMRS sequence for DFT-s-OFDM and add Transform precoding block	DONE
FPB-588071	CB007781-5G-A-B8-SyVe Generate DMRS sequence for DFT-s-OFDM and add Transform precoding block	DONE

Figure 17. Competence area structure for the CB007781-A-B8 entity item.

Here is the agreed sub feature refinement structure for the competence area under the CB007781-A-B9 entity item in the product backlog. All CA items were completed as planned.

FPB-580630	CB007781-5G-A-B9 Generate PTRS sequence for DFT-s-OFDM and send PTRS with DFT-s-OFDM enabled	DONE
FPB-580633	CB007781-5G-A-B9 Generate PTRS sequence for DFT-s-OFDM and send PTRS with DFT-s-OFDM enabled	DONE
FPB-580636	CB007781-5G-A-B9 Generate PTRS sequence for DFT-s-OFDM and send PTRS with DFT-s-OFDM enabled	DONE
FPB-580639	CB007781-5G-A-B9 Generate PTRS sequence for DFT-s-OFDM and send PTRS with DFT-s-OFDM enabled	DONE
FPB-580644	CB007781-5G-A-B9 -SOC BB TOP -Generate PTRS sequence for DFT-s-OFDM and send PTRS with DFT-s-OFDM enabled	DONE
FPB-580648	CB007781-5G-A-B9 -SOCLAB - Generate PTRS sequence for DFT-s-OFDM and send PTRS with DFT-s-OFDM enabled	DONE
FPB-582937	CB007781-5G-A-B9-ET Generate PTRS sequence for DFT-s-OFDM and send PTRS with DFT-s-OFDM enabled	DONE
FPB-588070	CB007781-5G-A-B9-SyVe Generate PTRS sequence for DFT-s-OFDM and send PTRS with DFT-s-OFDM enabled	DONE

Figure 18. Competence area structure for the CB007781-A-B9 entity item.

Here is the agreed sub feature refinement structure for the competence area under the CB007781-A-B10 entity item in the product backlog. All CA items were completed as planned.

FPB-580631	CB007781-5G-A-B10 Switch from CP-OFDM to DFT-s-OFDM waveform and vice versa	DONE
FPB-580634	CB007781-5G-A-B10 Switch from CP-OFDM to DFT-s-OFDM waveform and vice versa	DONE
FPB-580637	CB007781-5G-A-B10 Switch from CP-OFDM to DFT-s-OFDM waveform and vice versa	DONE
FPB-580640	CB007781-5G-A-B10 Switch from CP-OFDM to DFT-s-OFDM waveform and vice versa	DONE
FPB-580645	CB007781-5G-A-B10 -SOC BB TOP - Switch from CP-OFDM to DFT-s-OFDM waveform and vice versa	DONE
FPB-580649	CB007781-5G-A-B10 -SOCLAB-Switch from CP-OFDM to DFT-s-OFDM waveform and vice versa	DONE
FPB-582938	CB007781-5G-A-B10-ET Switch from CP-OFDM to DFT-s-OFDM waveform and vice versa	DONE
FPB-588069	CB007781-5G-A-B10-SyVe Switch from CP-OFDM to DFT-s-OFDM waveform and vice versa	DONE

Figure 19. Competence area structure for the CB007781-A-B10 entity item.

Sub feature splitting structure for the CB00771-B system items are shown below. System item B includes two entity items. A separate item for CFAM CP2 work and the own item for System verification (SyVe) testing. Sub feature retirement was done only for System verification testing entity items. The actual R&D development work was done under different EPIC items in the product backlog based on the Sub feature refinement agreement for -B.

- CB007781-B-B1: Throughput performance with PTRS disabled.
- CB007781-B-B2: Coverage and cell Edge performance and PTRS disabled.
- CB007781-B-B3: Throughput performance with PTRS disabled.

- CB007781-B-B4: Coverage and cell Edge performance and PTRS disabled.
-

Figure 20. Entity-, CA- and EPIC item structure for the CB007781-B system item.

8.2 CB007794-5G - Sub Feature Refinement Structure

The follow following system item structure was agreed for the CB007794 feature in the CFAM, and it was used as a baseline for Sub feature refinement work. The separate System items were created for FS1TA, CFAM CP, and CB007794-5G-A. Sub feature refinement was done for the CB007794-5G-A System item. Agreed system item structure is shown below.

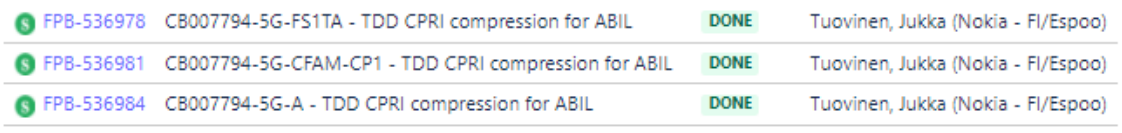


Figure 23. System item structure for the CB007794 feature.

The following entity item structure was agreed upon for the CB007798-A system item in the picture below. Sub feature refinement was done based on configuration, first TDD, and the FDD based on different retirement strategies. Agreed sub feature refinement structure for -A entity items are shown below:

TDD:

- CB007794-A-B1-FDD CPRI - 20 MHz IQC (UL/DL).
- CB007794-A-B10-TDD CPRI - 20MHz IQC + DS (UL/DL).
- CB007794-A-B11-TDD CPRI – other BW (40/50/60/70/80/90/100 MHz (IQC only, UL/DL).

FDD:

- CB007794-A-B4-FDD CPRI - 15/20 MHz IQC (UL/DL).
- CB007794-A-B12-FDD CPRI – 15 MHz IQC (UL/DL), 20 MHz IQC + DS (UL/DL).

The product backlog picture below illustrates an agreed entity items structure for the CB007794 feature in the product backlog. Separate entity items were created for Airphone, CFAM CP1, Customer documentation (CuDo), and Field verification (FiVe). CFAM and Customer documentation are never part of the Sub feature refinements as they are always separate work items. Field verification testing can be part of the Sub feature refinement, but normally it takes only around one week to complete FiVe testing. In this feature, we left the FiVe testing out from the Sub feature refinement work.

FPB-530895	CB007794-5G-A-B1- TDD CPRI - 20 MHz IQC (UL/DL)	DONE
FPB-536985	CB007794-5G-A-CFAM-CP2 - TDD CPRI compression for ABIL	DONE
FPB-542408	CB007794-5G-A-SyVe - TDD CPRI compression for ABIL	OBSOLETE
FPB-554594	CB007794-5G-A-B9 - FDD CPRI - 15/20 MHz IQC (UL/DL)	DONE
FPB-564521	CB007794-5G-A [Airphone] - TDD CPRI compression for ABIL / ABIO / ASOE	OBSOLETE
FPB-571147	CB007794-5G-A-PET - TDD CPRI compression for ABIL	OBSOLETE
FPB-574977	CB007794-5G-A-BOAM - TDD CPRI compression for ABIL	OBSOLETE
FPB-575802	CB007794-5G-A-FiVe - TDD CPRI compression for ABIL	OBSOLETE
FPB-579620	CB007794-5G-A-CuDo - TDD CPRI compression for ABIL	OBSOLETE
FPB-589566	CB007794-5G-A-B2 - TDD CPRI - 20 MHz IQC + DS (UL/DL)	DONE
FPB-589567	CB007794-5G-A-B3 - TDD CPRI - Other BW [40/50/60/70/80/90/100 MHz] (IQC only) (UL/DL)	DONE
FPB-589568	CB007794-5G-A-B10 - FDD CPRI - 15 MHz IQC (UL/DL), 20 MHz IQC+DS (UL/DL)	DONE

Figure 24. Entity item structure for the CB007794-A system item.

Competence area structures are planned under each agreed entity item based on Sub feature retirement agreements. All R&D development work are done under competence area items. Below is visible the CA structure for the CB007794-5G-A-B1 entity item.

FPB-531238	CB007794-5G-A-B1-20 MHz IQC (UL/DL)	DONE
FPB-531239	CB007794-5G-A-B1-20 MHz IQC (UL/DL)	OBSOLETE
FPB-531240	CB007794-5G-A-B1-20 MHz IQC (UL/DL)	DONE
FPB-531241	CB007794-5G-A-B1-20 MHz IQC (UL/DL)	DONE
FPB-531242	CB007794-5G-A-B1-20 MHz IQC (UL/DL)	DONE
FPB-531243	CB007794-5G-A-B1-20 MHz IQC (UL/DL)	DONE
FPB-531244	CB007794-5G-A-B1-20 MHz IQC (UL/DL)	DONE
FPB-531245	CB007794-5G-A-B1-20 MHz IQC (UL/DL)	DONE
FPB-574355	CB007794-5G-A-BOAM - TDD CPRI compression for ABIL BOAM_EFS	DONE
FPB-574356	CB007794-5G-A-BOAM - TDD CPRI compression for ABIL BOAM_BTS_SPF_LO	DONE
FPB-574357	CB007794-5G-A-BOAM - TDD CPRI compression for ABIL BOAM_FRONTHAUL	DONE
FPB-574368	CB007794-5G-A CB007794-5G TDD CPRI compression for ABIL BOAM_PIT	DONE
FPB-592407	CB007794-5G-A-B1-SyVe-20 MHz IQC (UL/DL)	OBSOLETE
FPB-621823	CB007794-5G-A-B1- TDD CPRI - BPF2	DONE
FPB-621910	CB007794-5G-A-B1- TDD CPRI - BPF1	DONE

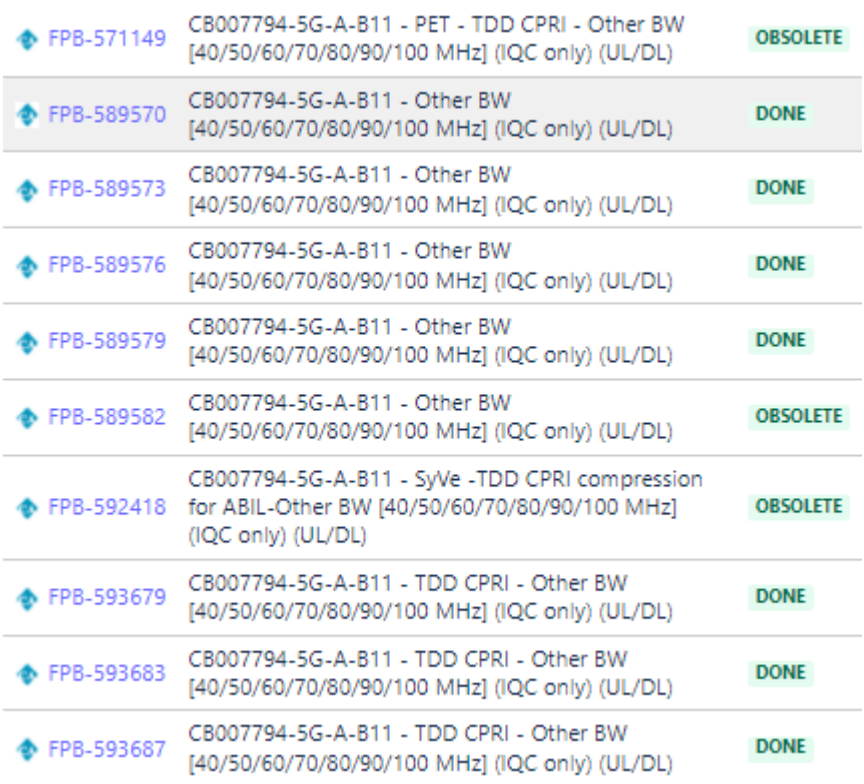
Figure 25. CA structure for the CB007794-5G-A-B1 entity item.

CB007794-5G-A-B10 TDD CA structure is shown below.

FPB-589569	CB007794-5G-A-B10 - 20 MHz IQC + DS (UL/DL)
FPB-589574	CB007794-5G-A-B10 - 20 MHz IQC + DS (UL/DL)
FPB-589577	CB007794-5G-A-B10 - 20 MHz IQC + DS (UL/DL)
FPB-589580	CB007794-5G-A-B10 - 20 MHz IQC + DS (UL/DL)
FPB-589583	CB007794-5G-A-B10 - 20 MHz IQC + DS (UL/DL)
FPB-592416	CB007794-5G-A-B10 -SyVe -TDD CPRI compression for ABIL- 20 MHz IQC + DS (UL/DL)
FPB-593678	CB007794-5G-A-B10 - TDD CPRI - 20 MHz IQC + DS (UL/DL)
FPB-593682	CB007794-5G-A-B10 - TDD CPRI - 20 MHz IQC + DS (UL/DL)
FPB-593686	CB007794-5G-A-B10 - TDD CPRI - 20 MHz IQC + DS (UL/DL)

Figure 26. CA structure for the CB007794-5G-A-B10 entity item.

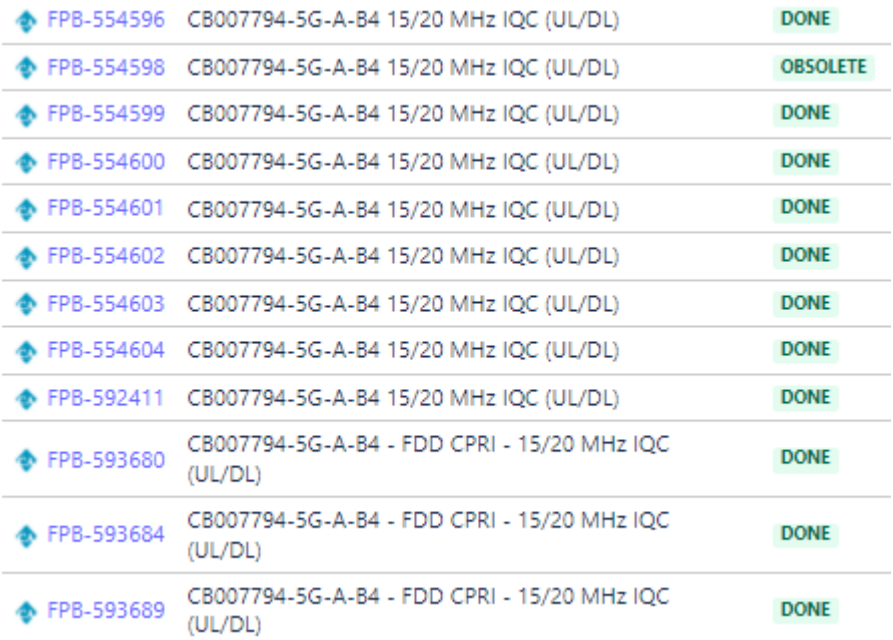
CB007794-5G-A-B3 TDD CA structure is shown below.



FPB-571149	CB007794-5G-A-B11 - PET - TDD CPRI - Other BW [40/50/60/70/80/90/100 MHz] (IQC only) (UL/DL)	OBSOLETE
FPB-589570	CB007794-5G-A-B11 - Other BW [40/50/60/70/80/90/100 MHz] (IQC only) (UL/DL)	DONE
FPB-589573	CB007794-5G-A-B11 - Other BW [40/50/60/70/80/90/100 MHz] (IQC only) (UL/DL)	DONE
FPB-589576	CB007794-5G-A-B11 - Other BW [40/50/60/70/80/90/100 MHz] (IQC only) (UL/DL)	DONE
FPB-589579	CB007794-5G-A-B11 - Other BW [40/50/60/70/80/90/100 MHz] (IQC only) (UL/DL)	DONE
FPB-589582	CB007794-5G-A-B11 - Other BW [40/50/60/70/80/90/100 MHz] (IQC only) (UL/DL)	OBSOLETE
FPB-592418	CB007794-5G-A-B11 - SyVe -TDD CPRI compression for ABIL-Other BW [40/50/60/70/80/90/100 MHz] (IQC only) (UL/DL)	OBSOLETE
FPB-593679	CB007794-5G-A-B11 - TDD CPRI - Other BW [40/50/60/70/80/90/100 MHz] (IQC only) (UL/DL)	DONE
FPB-593683	CB007794-5G-A-B11 - TDD CPRI - Other BW [40/50/60/70/80/90/100 MHz] (IQC only) (UL/DL)	DONE
FPB-593687	CB007794-5G-A-B11 - TDD CPRI - Other BW [40/50/60/70/80/90/100 MHz] (IQC only) (UL/DL)	DONE

Figure 27. CA structure for the CB007794-5G-A-B11 entity item.

CB007794-5G-A-B4 FDD CA structure is shown below.



FPB-554596	CB007794-5G-A-B4 15/20 MHz IQC (UL/DL)	DONE
FPB-554598	CB007794-5G-A-B4 15/20 MHz IQC (UL/DL)	OBSOLETE
FPB-554599	CB007794-5G-A-B4 15/20 MHz IQC (UL/DL)	DONE
FPB-554600	CB007794-5G-A-B4 15/20 MHz IQC (UL/DL)	DONE
FPB-554601	CB007794-5G-A-B4 15/20 MHz IQC (UL/DL)	DONE
FPB-554602	CB007794-5G-A-B4 15/20 MHz IQC (UL/DL)	DONE
FPB-554603	CB007794-5G-A-B4 15/20 MHz IQC (UL/DL)	DONE
FPB-554604	CB007794-5G-A-B4 15/20 MHz IQC (UL/DL)	DONE
FPB-592411	CB007794-5G-A-B4 15/20 MHz IQC (UL/DL)	DONE
FPB-593680	CB007794-5G-A-B4 - FDD CPRI - 15/20 MHz IQC (UL/DL)	DONE
FPB-593684	CB007794-5G-A-B4 - FDD CPRI - 15/20 MHz IQC (UL/DL)	DONE
FPB-593689	CB007794-5G-A-B4 - FDD CPRI - 15/20 MHz IQC (UL/DL)	DONE

Figure 28. CA structure for the CB007794-5G-A-B4 entity item.

CB007794-5G-A-B12 FDD CA structure is shown below.

FPB-589571	CB007794-5G-A-B12 - FDD CPRI - 15 MHz IQC (UL/DL), 20 MHz IQC+DS (UL/DL)	DONE
FPB-589572	CB007794-5G-A-B12 - FDD CPRI -SOC BB TOP - 15 MHz IQC (UL/DL), 20 MHz IQC+DS (UL/DL)	DONE
FPB-589575	CB007794-5G-A-B12 - FDD CPRI -SOCLAB- 15 MHz IQC (UL/DL), 20 MHz IQC+DS (UL/DL)	DONE
FPB-589578	CB007794-5G-A-B12 -FDD CPRI - 15 MHz IQC (UL/DL), 20 MHz IQC+DS (UL/DL)	DONE
FPB-589581	CB007794-5G-A-B12 - FDD CPRI - 15 MHz IQC (UL/DL), 20 MHz IQC+DS (UL/DL)	DONE
FPB-593681	CB007794-5G-A-B12 - FDD CPRI - 15 MHz IQC (UL/DL), 20 MHz IQC+DS (UL/DL)	DONE
FPB-593685	CB007794-5G-A-B12 - FDD CPRI - 15 MHz IQC (UL/DL), 20 MHz IQC+DS (UL/DL)	DONE
FPB-593690	CB007794-5G-A-B12 - FDD CPRI - 15 MHz IQC (UL/DL), 20 MHz IQC+DS (UL/DL)	DONE

Figure 29. CA structure for the CB007794-5G-A-B4 entity item.

8.3 CB007798-5G – Sub Feature Refinement Structure

The CB007798 feature was very complex, and it included a lot of different user scenarios and test cases, which are needed to test and verify the complete e2e functionality before the C5 milestone. The Sub feature refinement for the CB007798 feature was done a bit differently than the CB007781 feature and impacts for the other features were considered during the Sub feature retirement. The main reason is that all the FOT features are unique, and e.g., the feature structure and user scenarios are different based on customer requirements. The following System item structure was agreed for the CB007798 feature in the CFAM. Two separate system level items were created for CFAM and FS1TA and were not part of the Sub feature refinement work. Six different system level items were created for the feature development.

System item structure for the CB007798 feature in the product backlog is illustrated below.

FPB-536579	CB007798-5G-FS1TA - Aperiodic CSI reporting on PUSCH for non-beamforming FDD cells - ABIL	DONE	Tuovinen, Jukka (Nokia - FI/Espoo)
FPB-536583	CB007798-5G-CFAM-CP1 - Aperiodic CSI reporting on PUSCH for non-beamforming FDD cells - ABIL	DONE	Tuovinen, Jukka (Nokia - FI/Espoo)
FPB-536586	CB007798-5G-A: Basic A-CSI scheduler for non beamforming (FDD) cells without CA support – ABIL	DONE	Tuovinen, Jukka (Nokia - FI/Espoo)
FPB-563315	CB007798-5G-Z CB007798-5G Aperiodic CSI reporting on PUSCH for non-beamforming FDD cells - ABIL (effort placeholder)	OBSOLETE	Tuovinen, Jukka (Nokia - FI/Espoo)
FPB-569144	CB007798-5G-B - A-CSI scheduler for FDD cells with CA support – ABIL	DONE	Tuovinen, Jukka (Nokia - FI/Espoo)
FPB-569145	CB007798-5G-C - A-CSI reporting on PUSCH for FDD – ABIL	DONE	Tuovinen, Jukka (Nokia - FI/Espoo)
FPB-569147	CB007798-5G-D - A-CSI reporting on PUSCH for FDD with PUSCH mapping Type A for FR1 cells on ABIL	DONE	Tuovinen, Jukka (Nokia - FI/Espoo)
FPB-569149	CB007798-5G-W - Aperiodic CSI reporting on PUSCH for non-beamforming FDD cells - ABIL (Performance and Capacity)	DONE	Tuovinen, Jukka (Nokia - FI/Espoo)
FPB-569246	CB007798-5G-E - A-CSI reporting on PUSCH for FDD with PUSCH data and DMRS FDM - ABIL	DONE	Tuovinen, Jukka (Nokia - FI/Espoo)

Figure 30. System item structure for the CB007798 feature.

Sub feature refinement structure including System level scenarios, system requirements, and specifications and feature impacts:

- CB007798-5G-A-Basic A-CSI scheduler for non-beamforming FDD cells without CA support – ABIL.

  System level scenarios:

  1. A-CSI handing for single UE/single carrier with and without data transmission.
  2. A-CSI handing for a multi-UE's/single carrier with and without data transmission.

  Note:

  - PUSCH mapping type A is not configured (Type B is used.
  - PUSCH data and DMRS FDM is not configured.

  System requirements/Specifications:

  - Entity level.

- Impacts:
  - L1 (CB007798).
  - L2/L3 (5G001817)

- CB007798-5G-B-A-CSI scheduler for non-beamforming FDD cells with CA support – ABIL.

  System level scenarios:

  1. A-CSI handing for UE configured with CA in FDD.
     - Intra-band CA: FDD (2-4CC).
     - Inter-band CA: FDD (Pcell) + TDD FR1 (1Scell).

  Note:

  - PUSCH mapping type A is not configured (type B is used).
  - PUSCH data and DMRS FDM is not configured.

  System requirements/Specifications:

  - Entity level.
  - Impacts:
    - L1 (CB007798).
    - L2/L3 (5G001817).
  - Testing.

- CB007798-5G-C-A-CSI reporting on PUSCH for FDD – ABIL.

  System level scenarios:

  1. A-CSI handing single UE/single carrier with data transmission in FDD mode, dynamic beta offset supported in limited mode.
  2. A-CSI handing single UE/single carrier with data transmission in FDD mode, dynamic beta offset supported in full mode.
  3. A-CSI handing single UE/single carrier with high vs low DL data in FDD mode.
  4. A-CSI handing for single UE’s/single carrier with high vs low DL data in FDD mode.

5. A-CSI handing for single UE/single carrier with low UL data profile in FDD mode.

Note:

- PUSCH mapping type A is not configured (Type B is used)
- PUSCH data and DMRS FDM is not configured.

System requirements/Specifications:

- Entity level.
- Impacts:
  - L1 (CB007798)
  - L2/L3 (5G001817/CB008131)
- Testing.

- CB007798-5G-D-A-CSI reporting on PUSCH for FDD with PUSCH mapping type A for FR1 cells on ABIL.

System level scenarios:

1. A-CSI for FDD FR1, single UE, single carrier co-existence with PUSCH mapping type A.
2. A-CSI for FDD FR1, multiple UE, single carrier co-existence with PUSCH mapping type A.
3. A-CSI for FDD FR1, single UE, single carrier, dynamic beta offset supported in full mode and co-existence with PUSCH mapping type A.
4. A-CSI for FDD FR1, single UE, single carrier co-existence with PUSCH mapping type A and PUSCH 256 QAM.
5. A-CSI for FDD FR1, single UE, single carrier, co-existence with PUSCH mapping type A and DFT-s-OFDM.
   - Optional co-exist with PUSCH 256 QAM.
     - PUSCH 256 QAM is configured.
     - PUSCH 256 QAM capable is used.

System requirements/Specifications:

- Entity level.
- Impact:
  - PUSCH 256 QAM is configured.

        - PUSCH 256 QAM capable UE is used.
    - Testing.

- CB007798-5G-E-A-CSI reporting on PUSCH for FDD with PUSCH data and DMRS FDM – ABIL.

    System level scenarios:

    1. A-CSI for FDD FR1, single UE, single carrier with PUSCH data and DMRS FDM.
        - The nominal scenarios:
            - PUSCH mapping type A is not configured (Type B is used).
            - PUSCH data and DMRS FDM is configured.
        - The additional alternate scenarios:
            - PUSCH mapping type A is configured.
    2. A-CSI for FDD FR1, multi-UE, single carrier with PUSCH data and DMRS FDM.
        - The nominal scenarios:
            - PUSCH mapping type A is not configured (type A is used).
            - PUSCH data and DMRS FDM is configured.
        - The additional alternate scenarios:
            - PUSCH mapping type A is configured.
    3. A-CSI for FDD FR1, single UE, single carrier, dynamic beta offset supported in full mode with PUSCH data and DMRS FDM.
        - The nominal scenarios:
            - PUSCH mapping type A is not configured (type B is used).
            - PUSCH data and DMRS FDM is configured.
        - The additional alternate scenarios:
            - PUSCH mapping type A is configured.
            - Dynamic beta offset supported in limited mode.

4. A-CSI for FDD FR1, single UE, single carrier, with PUSCH data and DMRS FDM and co-existence with PUSCH 256 QAM.
    - The nominal scenarios:
        - PUSCH mapping type A is not configured (type B is used).
        - PUSCH data and DMRS FDM is configured.
        - PUSCH 256 QAM capable UE is used.
    - The additional alternate scenarios:
        - PUSCH mapping type A is configured.

System requirements/Specifications:

- Entity level.
- Impact:
    - L2/L3 (CN007798).
- Testing.

5. CB007798-5G-W- Aperiodic CSI reporting on PUSCH for non-beamforming FDD cells – ABIL (Performance and Capability).
    - No System requirement and specifications

The following entity item structure was agreed upon for the CB007798-A system item in the picture below. Separate entity items were created for Airphone, and CFAM CP2 but they were not part of Sub feature refinement in the CB007798-A feature, as Sub feature refinement was not possible to do for them.

FPB-536587	CB007798-5G-A-CFAM-CP2 -: Basic A-CSI scheduler for non beamforming (FDD) cells without CA support – ABIL	DONE
FPB-542406	CB007798-5G-A-SyVe -: Basic A-CSI scheduler for non beamforming (FDD) cells without CA support – ABIL	DONE
FPB-560605	CB007798-5G-A [Airphone] -: Basic A-CSI scheduler for non beamforming (FDD) cells without CA support – ABIL	DONE
FPB-565679	CB007798-5G-A-B5 - Basic A-CSI scheduler for non beamforming (FDD) cells without CA support – ABIL	DONE
FPB-565913	CB007798-5G-A-FiVe -: Basic A-CSI scheduler for non beamforming (FDD) cells without CA support – ABIL	DONE
FPB-574512	CB007798-5G-A-CuDo: Basic A-CSI scheduler for non beamforming (FDD) cells without CA support – ABIL	DONE

Figure 31. Entity item structure for the CB007798-A system item.

The following entity item split structure was agreed under the CB007798-B system item and it is illustrated in picture 29. Separate entity item was created for CFAM CP2 but it was not part of Sub feature refinement in the CB007798 feature.

FPB-569368	CB007798-5G-B-CFAM-CP2 - A-CSI scheduler for FDD cells with CA support – ABIL	DONE	Tuovinen, Jukka (Nokia - FI/Espoo)
FPB-571388	CB007798-5G-B-B2 - A-CSI scheduler for non-beamforming FDD cells with CA support – ABIL	DONE	Lahti, Reijo (Nokia - FI/Tampere)
FPB-589002	CB007798-5G-B-SyVe - A-CSI scheduler for non-beamforming FDD cells with CA support – ABIL	DONE	Tuovinen, Jukka (Nokia - FI/Espoo)

Figure 32. Entity item structure for the CB007798-B system item.

The following Entity item split structure was agreed under the CB007798-C system item and it is illustrated in picture 30. Separate entity items were created for CFAM CP2, but it was not part of Sub feature refinement in the CB007798 feature.

FPB-569371	CB007798-5G-C-CFAM-CP2 - A-CSI reporting on PUSCH for FDD – ABIL	DONE
FPB-571396	CB007798-5G-C-B2- A-CSI reporting on PUSCH for FDD – ABIL	DONE
FPB-589025	CB007798-5G-C-SyVe - A-CSI reporting on PUSCH for FDD – ABIL	DONE

Figure 33. Entity item structure for the CB007798-C system item.

The following entity item split structure was agreed under the CB007798-D system item and it is illustrated in picture 31. Separate entity item was created for CFAM CP2, and CFAM CP3 but they were not part of Sub feature refinement in the CB007798 feature.

FPB-569374	CB007798-5G-D-CFAM-CP2 - A-CSI reporting on PUSCH for FDD with PUSCH mapping Type A for FR1 cells on ABIL	DONE
FPB-570559	CB007798-5G-D-B2 - A-CSI reporting on PUSCH for FDD with PUSCH mapping Type A for FR1 cells on ABIL	DONE
FPB-589027	CB007798-5G-D-SyVe - A-CSI reporting on PUSCH for FDD with PUSCH mapping Type A for FR1 cells on ABIL	DONE
FPB-596367	CB007798-5G-D - L3/L2 RT Impact -A-CSI reporting on PUSCH for FDD with PUSCH mapping Type A for FR1 cells on ABIL	OBSOLETE
FPB-609590	CB007798-5G-D-CFAM-CP3	DONE

Figure 34. Entity item structure for the CB007798-D system item.

The following entity item split structure was agreed under the CB007798-E system item and it is illustrated in picture 32. Separate entity items were created for CFAM CP2, but it was not part of Sub feature refinement in the CB007798 feature.

FPB-569378	CB007798-5G-E-CFAM-CP2 - A-CSI reporting on PUSCH for FDD with PUSCH data and DMRS FDM - ABIL	DONE
FPB-570562	CB007798-5G-E-B2 - A-CSI reporting on PUSCH for FDD with PUSCH data and DMRS FDM – ABIL	DONE
FPB-589033	CB007798-5G-E-SyVe - A-CSI reporting on PUSCH for FDD with PUSCH data and DMRS FDM - ABIL	DONE

Figure 35. Entity item structure for the CB007798-E system item.

The following entity item split structure was agreed under the CB007798-E system item and it is illustrated in picture 33. Separate entity items were created for CFAM CP2, and PET but they were not part of Sub feature refinement in the CB007798 feature.

Figure 36. Entity item structure for the CB007798-W system item.

9 Sub Feature Splitting KPI's and Reporting

9.1 Sub Feature Splitting KPI's Introduction

The MN is moving towards the CDIT + D model and introduces 3 releases per year. Today's average competence area (CA) item duration is around 2,5 FBs (FB= 4 weeks). In many places, overlaps between SW development and testing of different test phases are at the low level. Example: An average ST + ET testing overlap is 34% (data from May 2021). The following changes will be needed to make sub feature splitting deployment happen in the new features from the 22R1 program and onwards: (Figura 2021, 2.)

- Starting Feature builds (FBs) will be shorter starting in 2022.
- This will require better accuracy in planning.

- Teams will have more flexibility in planning and testing activities.
- Feature development in the FOTs needs to change their way of working as many of them are still using the old waterfall model and not iterative development.
- Change is required to comply with incoming guidance's/KPI's.

9.2 Feature Leadtime and Execution (FLEA) Agile Compliance KPI Reports

The following 4 KPIs (FLEA) reports were developed to monitor sub feature splitting KPIs for new features in the 22R1 and later programs in 2021 onwards. The two first KPIs (1 and 2) below (% of CA in 1FB and Average SW-ET overlap ratio) are the most important for the sub-feature refinement point of view and they are followed up more detail in this study. Two other KPI 3 and 4 results (%SI (ST max 1FB after ET and %SI (ST max 1FB after ET, no ET) will be evaluated, and the KPI results will be visible in the appendixes. A more detailed FLEA KPI description can be found below. (Figura 2021, 3.)

Measurement	Baseline from 2020	Desired value at the end of 2021
15% improvement vs baseline [in %] + positive Q3/Q4 trends		
% of CA in 1FB (4 weeks)	39.6%	45.5%
Average SW-ET overlap ratio	32%	36.8%
%SI (ST max 1FB after ET)	54.8%	63%
%SI (ST max 1FB after SW) [no ET]	32.2%	37%

Figure 37. FOT KPI targets in year 2021. (Figura 2021, 3.)

9.2.1 KPI 1 Details for % of CA in 1FB (4 weeks)

Baseline:

- Result from 2H/2020 (on FB level).

Targets (check once per FB – 4 weeks duration).

- % of CA in 1FB (4 weeks).

- Not worse than 45.5% (baseline from 2H2020 + 15% -> 15%* 39,6% =45.5%).
- Positive rolling average in 2H/2021. (Figura 2021, 9.)

9.2.2 KPI 2 Details for Average SW-ET Overlap Ratio

Baseline:

- Result from 2H/2020 (on FB level).
- Not worse than 36.8% (baseline from 2H2020 + 15% →15%* 32% + 32% = 36.8%).
- Positive rolling average in 2H/2021. (Figura 2021, 9.)

9.2.3 KPI 3 Details for % SI (ST max 1FB after ET)

Targets:

- % SI (ST max 1FB after ET).
- Not worse than 63% (Baseline from 2H2020 + 15% ->15%*54.8% +54.8% =63%).
- Positive rolling average in 2H/2021. (Figura 2021, 10.)

9.2.4 KPI 4 Details for % SI (ST max 1FB after SW, No ET)

Targets:

- % SI (ST max 1FB after SW, No ET).
- Not worse than 37% (Baseline from 2H2020 + 15% ->15%*32.2% +54.8% =37%).
- Positive rolling average in 2H/2021. (Figura 2021, 10.)

9.3 22R1 System Program FLEA KPI 1 and 2 Results

The below pictures illustrate 22R1 Program FLEA KPI 1 and 2 reports based on sub feature splitting in the feature leadtime and execution Power BI report.

Figure 38. 22R1 Program FLEA KPI 1 and 2 results.

9.4 22R1 MN L1 FLEA KPI 1 and 2 Results

Figure 39. 22R1 MN L1 FLEA KPI 1 and 2 results.

9.5 CB007781-5G FLEA KPI 1 and 2 Results

The below picture illustrates 22R1 Program FLEA KPI 1 and 2 reports for the CB007781-5G FOT pilot features based on sub feature splitting in the feature leadtime and execution Power BI report:

Figure 40. CB007781-5G KPI 1 and 2 results.

9.6 CB007794-5G FLEA KPI 1 and 2 Results

The below picture illustrates 22R1 Program FLEA KPI 1 and 2 reports for the CB007794-5G FOT pilot features based on sub feature splitting in the feature leadtime and execution Power BI report:

Figure 41. CB007794-5G KPI 1 and 2 results.

9.7 CB007798-5G FLEA KPI 1 and 2 Results

The below picture illustrates 22R1 Program FLEA KPI 1 and 2 reports for the CB007798-5G FOT pilot features based on sub feature splitting in the feature leadtime and execution Power BI report:

Figure 42. CB007798-5G KPI 1 and 2 results.

9.8 22R1 System Program and Pilot Feature KPI Conclusions

9.8.1 22R1 System Program KPI 1 and 2 Summary

Based on the Global 2021 KPI result shown in chapter 11.3, the conclusion is that the 22R1 System program didn't meet the 2021 KPI targets. Some of the 22R1 FOT features (only CNI's) met the given KPI targets in 2021, but the majority of features did not.

1. % of SW CA in 4 CW KPI 1 result was 35.9 % and the target was 45.5 %.
    - The 22R1 program result was 9.6 % behind the year 2021 target.
2. The average SW CA duration (SW) was 9.66 weeks, and the target was 4 weeks.
    - The 22 R1 program result was 5.66 weeks behind the year 2021 target.
3. The average SW-ET overlap ration result was 32.2% and the target was 36.8 %.
    - The 22R1 program result was 4.6 % behind the year 2021 target.
4. The average SW-ET CA duration is 9.40 weeks, and the target was 4 weeks.
    - The 22 R1 program result was 5.4 weeks behind the year 2021 target.

9.8.2 22R1 System Program KPI 3 and 4 Summary

Based on the Global 2021 KPI 3 and 4 result shown in appendix 1, the conclusion is that the 22R1 System program didn't meet the 2021 KPI targets. 2021 KPI result for the KPI 3 was 56.6 %, %SI (ST Max 4CV after SW), and KPI 4 target %SI (ST Max 4CV after SW, no ET) was 18.42 %.

1. KPI 3: %SI (ST Max 6CV after SW) result was 56.16, which is 6.4 % behind the target.
2. KPI 4: %SI (ST Max 6CV after SW) (No ET) was 18.42 %, which is 20.6 % behind the target.

9.8.3 22R1 MN L1 Program KPI 1 and 2 Summary

Based on the MN L1 organisation KPI 1 and 2 result shown in chapter 11.4, the conclusion is that the 22R1 RAN L1 targets didn't meet the 2021 KPI 1 and 2 targets. MN L1 results were lower than the 22R1 System level program KPI

results, which indicates that feature splitting and sub feature refinement is not working as planned in the MN L1 organization.

1. % of SW CA in 4 CW KPI 1 result was 27.1% and the target was 45.5 %.
    - The 22R1 MN L1 result was 18.4 % behind the year 2021 target.
2. The average SW CA duration (SW) was 11.46 weeks, and the target was 4 weeks.
    - The 22R1 MN L1 result was 7.46 weeks behind the year 2021 target.
3. The average SW-ET overlap ration result was 25.0 % and the target was 36.8 %.
    - The 22R1 MN L1 result was 11,8 % behind the year 2021 target.
4. The average SW-ET CA duration is 10.38 weeks, and the target was 4 weeks.
    - The 22R1 MN L1 result was 6.38 weeks behind the year 2021 target.

9.8.4 CB007781-5G Feature KPI 1 and 2 Summary

Based on the Global 2021 KPI result shown in chapter 11.5, the conclusion is that the CB007781-5G feature didn't meet the 2021 KPI 1 targets for % of SW CA in 4 weeks, as the KPI result was 10.4 weeks. The average SW-ET overlap ratio KPI 2 result was good, and the average SW-ET overlap ratio result was 62,5 %, which meet the target. But the average SW-ET CA duration result was 5,5 weeks, which was 1,5 weeks longer than the 4-week target.

The CB007781-5G feature SW development generally worked well, until we faced unexpected problems with the sub-feature splits B9 (test case FI00007) and B10 (test case FI00009), which delayed the SW development timeline for around two weeks. But we were able to continue testing with sub feature splits B7 (test case FI00001), B8 (test case FI00002), B9 (test case FI00008), and B10 (test case FI00010) and which can also be seen in the good KPI 2 results (the average SW-ET overlap ratio).

The CB007781-5G feature testing worked quite smoothly even though we had some problems and open Pronto's during the testing phase, but we were able to close all problems and defects before the P7 milestones.

The CB007781-5G KPI 1 and 2 summary can be found below:

1. % of SW CA in 4 CW KPI 1 results was 0% and the target was 45.5 %.
    - The CB007781-5G result was 45.5 % behind the target.
2. The average SW CA duration was 10.4 weeks, and the target was 4 weeks.
    - The CB007781-5G result was 6.4 weeks behind the year 2021 target.
3. The average SW-ET overlap ratio result was 62.5 % and the target was 36.8 %.
    - The CB007781-5G result was 25.7 % better than the year 2021 target.
4. The average SW-ET CA duration is 5.5 weeks, and the target was 4 weeks.
    - The CB007781-5G result was 1.4 weeks behind the year 2021 target

9.8.5 CB007781-5G feature KPI 3 and 4 Summary

Based on the Global 2021 KPI 3 and 4 results is shown in appendix 2, the conclusion is that the CB007781-5G feature didn't meet the KPI 3 target.

1. KPI 3: %SI (ST max 1CV after SW) result was 0%.
2. KPI 4: % SI (ST max 1FB after SW, No ET). The KP1 4 was not applicable.

9.8.6 CB007794-5G Feature KPI 1 and 2 Summary

Based on the Global 2021 KPI result shown in chapter 11.7, the conclusion is that the CB007794-5G feature didn't meet the 2021 KPI 1 and 2 targets. The KPI 1 % of SW CA in the 4CV result was 11.09 weeks (74,4 days), which is a long time. The average SW-ST overlap ratio KPI 2 result was 33.3 %, which was slightly below the targets. The average SW-ET CA duration was 6.67, which is behind the target, but the average SW-ET days (27.3) were better than the target. **Note:** The CB007794-5G feature was moved as an internal feature, as RF radio support was not available for it. Therefore, all possible tests couldn't be done as planned for this feature.

The CB007794-5G KPI 1 and 2 summary can be found below:

1. % of CA in 4 CW KPI 1 results was 9.1% and the target was 45.5 %.
    - The CB007794-5G result was 36.4 % behind the target.
2. The average CA duration was 11.09 weeks, and the target was 4 weeks.
    - The CB007794-5G result was 7.09 weeks behind the year 2021 target.
3. The average SW-ET overlap ratio result was 33.3 % and the target was 36.8 %.
    - The CB007794-5G was a 3.5 % lower than the year 2021 target.
4. The average SW-ET CA duration is 6.67 weeks, and the target was 4 weeks.
    - The CB007794-5G result was 2.67 weeks behind the year 2021 target

9.8.7 CB007794-5G feature KPI 3 and 4 Summary

Based on the Global 2021 KPI 3 and 4 result is shown in appendix 3, the conclusion is that the CB007794-5G feature meets the 2021 KPI target 3.

1. KPI 3: %SI (ST Max 6CV after SW) result was 100%.

2. KPI 4: % SI (ST max 1FB after SW, No ET). The KP1 4 was not applicable.

9.8.8 CB007798-5G Feature KPI 1 and 2 Summary

Based on the Global 2021 KPI 1 and 2 result shown in chapter 11.6, the conclusion is that the CB007798-5G feature didn't meet the 2021 KPI 1 and 2 targets. The KPI 1 % of SW CA in the 4CV result was 17 weeks (94,4 days), which is very long compared any other pilot features and the 22R1 system program results as well. The average SW-ET overlap ratio KPI 2 result was also very long based on the KPI targets in 2021.
The average SW-ET overlap ratio KPI 2 result was 0%, which means that there was no single CA's fitting in the target. The average SW-ET CA duration result was 8,8 weeks, which was 4,5 weeks longer than the 4-week target.

The main reason why the CB007798-5G feature didn't meet the KPI 1 and 2 targets was that we had problems with completing the SW in time. This caused some unexpected delays to start entity testing on time. Also, during the entity tests many unexpected errors were found and it took a long time to solve all problems and complete the testing. These issues can be seen in the CB007798-5G feature KPI 1 and 2 results.

The CB007798-5G KPI 1 and 2 summary can be found below:

1. % of SW CA in 4 CW KPI 1 results was 12.5% and the target was 45.5 %.
    - The CB007798-5G result was 33.0 % behind the target.
2. The average SW CA duration was 17 weeks, and the target was 4 weeks.
    - The CB007781-5G result was 13 weeks behind the year 2021 target.
3. The average SW-ET overlap ratio result was 0 % and the target was 36.8 %.
    - The CB007781-5G was a 36.8 % lower than the year 2021 target.

4. The average SW-ET CA duration is 8.8 weeks, and the target was 4 weeks.
    - The CB007781-5G result was 4.4 weeks behind the year 2021 target.

9.8.9 C007798-5G feature KPI 3 and 4 summary

Based on the Global 2021 KPI 3 and 4 results is shown in appendix 4, the conclusion is that the CB007798-5G feature meets the 2021 KPI target 3.

1. KPI 3: %SI (ST max 1FB after SW) result was 100.00%
2. KPI 4: % SI (ST max 1FB after SW, No ET). The KP1 4 was not applicable.

10 Problems Identified During the Three Pilot Features

The following problems were identified during the study of the selected three FOT features regarding feature splitting and sub feature refinement:

- 22R1 sub feature splitting and retirement pilots started too late e.g., 22R1 L1 organization feature planning was already done.
- In general, FOT members were not familiar with the sub feature splitting and refinement processes and WoW regardless of the organizations they were representing in FOT's.
- It was difficult to find experienced Lead specification engineers for all three FOT's in the beginning because nobody from the FOT participants had the feature splitting and sub feature refinement work experience from the past.
- All FOT team members and/or organization were not actively participating in the feature splitting and retirement work, and this slowed down the progress to get the final feature splitting structure agreed in the FOT team.
- Quite many of CA's owners and APO's didn't understand why they needed to re-plan their CA's and use only one entity item to build up entity testable items for all CA's.

- Feedback from CB007794 feature:

    - The feature on CB007794 does not get any benefits in the end.
    - The CB007794 is delivered as one step by Leka and consequently for all the phases in L1.
    - It’s difficult to consider feature splitting if the L1 R&D development work is already ongoing.
    - The new process changes should be done for ABIO instead of ABIL.

11 Feature Splitting and Sub Feature Refinement Benefits

During the study, there were a lot of questions about why feature splitting and sub feature refinement should be done for the FOT features and what are the key benefits of it. The most common benefits of the feature splitting and sub feature refinements were collected and listed below, which could be used for further communication purposes.

11.1 R&D Efficiently and Better SW Quality

- By breaking down the feature into manageable units, the R&D development team can focus on high-quality development, testing, and collaboration.
- By producing frequent SW builds and conducting testing during each iteration, quality is improved by findings and fixing defects quickly and identifying expectation mismatches earlier.
- A smaller feature split used of R&D e.g. (specification, SW development, testing) work in shorter cycles, which means better R&D efficiency and resource usage.
- Faster feedback from SW quality and testing means faster and more efficient SW corrections in case any problems occur.
- Release testing time is shorter because of the better SW quality as SW development is done in phases.

- Possibility to check feature progress via tests and closed items in the product backlog, not via effort spend.
- Better feature understanding and e2e testable feature splitting mean less surprises at the end of the feature development lifecycle.

11.2 Shorter SW Development Times

- As SW development and testing are done in the smaller SW packages and several phases and using the one entity item possible problems can be found earlier.
- Each entity item split including CA's/Epics should fit in one feature build (FB), as this will ensure e2e testable items earlier as defined in the sub feature refinement guidelines and 5G WoW.

11.3 Agile Model

- It is better to work in the agile mode than the waterwall model.

11.4 Early Fault Detection

- A shorter feature lifecycle means better feature splitting the earlier we can start testing.
- Use Agile incremental development methods to have more e2e testable items sooner i.e., to have testing spread thorough the development helps to catch errors and bugs sooner (rather than only at the end).
- During customer acceptance testing less defects were found in the pre-P8 phase.

11.5 Improve Case Handling Times

- As SW development and e2e testing is done in a smaller package, and some parts of the SW are already tested earlier, this will speed up problem solving time.

11.6 Practical Example of CB007781-5G Feature Benefits

The picture below illustrates how smaller and/ or partial deliveries can allow for the next steps of the development and testing pipeline to process.

- The latest estimates for the feature delivery were fast approaching, 4/7 test cases were passing.
- Without feature splitting, the development of the entire feature would be delayed.
- But due to testing along with the entity testable splitting, -B7 and -B sub feature functionalities are passing, and they can be delivered without delay and ongoing development for -B9 and B10 can continue to ensure full feature delivery.
    - 50% on-time delivery is better than 0%.
    - Partial delivery is better than total delay.

Partial Delivery is better than Total Delay

Test Cases	Sub-Feature split	
FI0001	A-b (B7/8)	Passing on Leka 7.0.0
FI0002	A-b (B7/8)	Passing on Leka 7.0.0
FI0007	A-c (B9)	LONER-5830 is blocking
FI0008	A-c (B9)	Passing on Leka 7.0.0
FI0009	A-d (B10)	LONER-5830 is blocking
FI0010	A-d (B10)	Passing on Leka 7.0.0
FI0026	A-c (B9)	LONER-5830 and Loner-5931 is blocking

Figure 43. Example of the CB007781-5G feature splitting benefits.

12 Improvement Proposals and Process Changes

12.1 Improvement Proposals

The following improvement proposals have been identified during this study:

- The feature splitting and sub feature refinement guidelines will be mandatory for all FOT features from the 22R1 program onwards.
- Conduct and awareness feature splitting sessions will be organized for all MN organizations' unit planners including APOs and LPOs.
- Mandatory feature splitting and sub feature refinement trainings will be mandatory for all FOT members joining in the FOTs.
- Contributing FOT community members (R&D development &testing) should complete mandatory feature splitting and sub feature refinement trainings.
- Mandatory feature splitting and sub feature refinement guidance to be added in the FOT kick-off agenda topic.
- Feature splitting and sub feature KPI's to be defined and the KPIs will be followed monthly basis by MN organization unit planners.

12.2 MN CFAM/FOT Process Changes

Based on this study, the following process changes will be required to ensure the feature splitting and Sub feature refinement work as defined in the MN FOT/CFAM processes and WoW:

- The feature splitting and sub feature refinement work should be started much earlier as defined in the current MN FOT/CFAM processes, preferable already in CP1 or latest in the CP2 in the CFAM.
- A proper feature splitting and Sub feature refinement in FOTs should be completed in the CP2 milestone or latest in the CP3 milestone max 1-2 weeks after the CP2 milestone.

- Currently, CP3 milestone and/or sub feature refinement in FOTs are not followed up by the System program and therefore a new checkpoint is needed to follow their completion in the system program.
- CP3 milestone should be done max 1-2 weeks after CFAM CP2 milestone and tricker point added in the System program checklist.
- Clarify process interaction between CFAM and FOT WoW processes e.g., the specification output from sub feature refinement to be added to CFAM processes.

12.3 Recommended Trainings

The following training sessions are recommended for all FOT members and different employees working on the feature splitting and sub feature refinement topics in the MN organisations: (MN FOT Splitting, Refinement & Planning 2021.)

- FOT sub feature refinement and planning.
- CFAM Feature Splitting training.

13 Conclusions

The aim of this study was to evaluate feature splitting and sub feature refinement processes (and the other related MN processes) needed for the successful completion of the feature splitting and the sub feature refinement for the FOT features, including how to improve the high lead time of entity items used for the MN L1 organization.

Based on the study, my first conclusion is that the feature splitting and sub feature refinement processes are mainly in place, but still some process alignments and changes are required to make sub feature refinement work better in the future. In general, I would say that the feature splitting and sub feature refinement practices were not working as well as expected for the three pilots FOT features. One of the main problems was the awareness of the feature splitting and sub feature

refinement processes in general and the way of working practices in the MN organisations. Because of that, all FOT team members and/or organizations were not actively participated in the sub feature refinement work during the three pilot FOTs, and this caused delays in getting the final sub feature splitting structure finalized. It was also difficult to find experienced lead specification engineers to lead feature splitting and sub feature refinement work during the pilot FOT features as nobody had previous experience with the sub feature refinement. My recommendation is e.g., to organize more feature splitting and sub feature refinement communication sessions to the correct target groups in the MN organisations and add two identified sub feature refinement trainings as mandatory trainings for all CFAM/FOT members after the 22R1 system program.

Regarding the problem statement of this thesis how to improve the high lead time of entity items, based on the sub feature splitting KPI 1 and 2 results for the 22R1 system program, MN L1 organization, and all three pilots FOT features, the biggest problem area for all of them were the KPI 1 results. KPI 2 results were partially good for the two pilot features (an average of CA duration days), even though one of the pilot feature KPIs failed because of many problems during the entity testing phase. Based on the KPI 1 and 2 results in this study, my conclusion is that the high lead time of entity items is caused by the long CA-items. In order to improve the high lead time of entity items and shorter e2e test times for the different functionalities of the system items the CA items must be shorter than they were during the study.

During the study it was identified also that some of the MN FOT/CFAM process changes will be required. One of the main process changes will be needed, because the sub feature refinement should be finished at CP3 milestone based on the latest MN processes. The current problem statement with the CP3 milestone is that it is too late for the system program feature commitment point of view and currently the CP3 milestone is not followed up by the System level program. My recommendation is to start feature splitting and sub feature refinement processes already at the CFAM CP1&CP2 milestones, not as defined in the current processes, that it should be done at the CP3 milestone.

The main benefits to advance feature splitting and sub feature refinement processes and start it already in the CFAM CP1 and get it completely done by end of the CP2 will ensure that the sub feature refinement will be done for all the features early enough and before the feature commitment milestones. In this new scenario the CP3 milestone could be used for any needed CFAM CP3 specification and/or sub feature splitting alignment after the CP2 milestones. The CP3 milestones should be moved within 1-2 weeks after the CP2 including the system program checkpoint and these process changes will be needed at the same time.

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Appendices

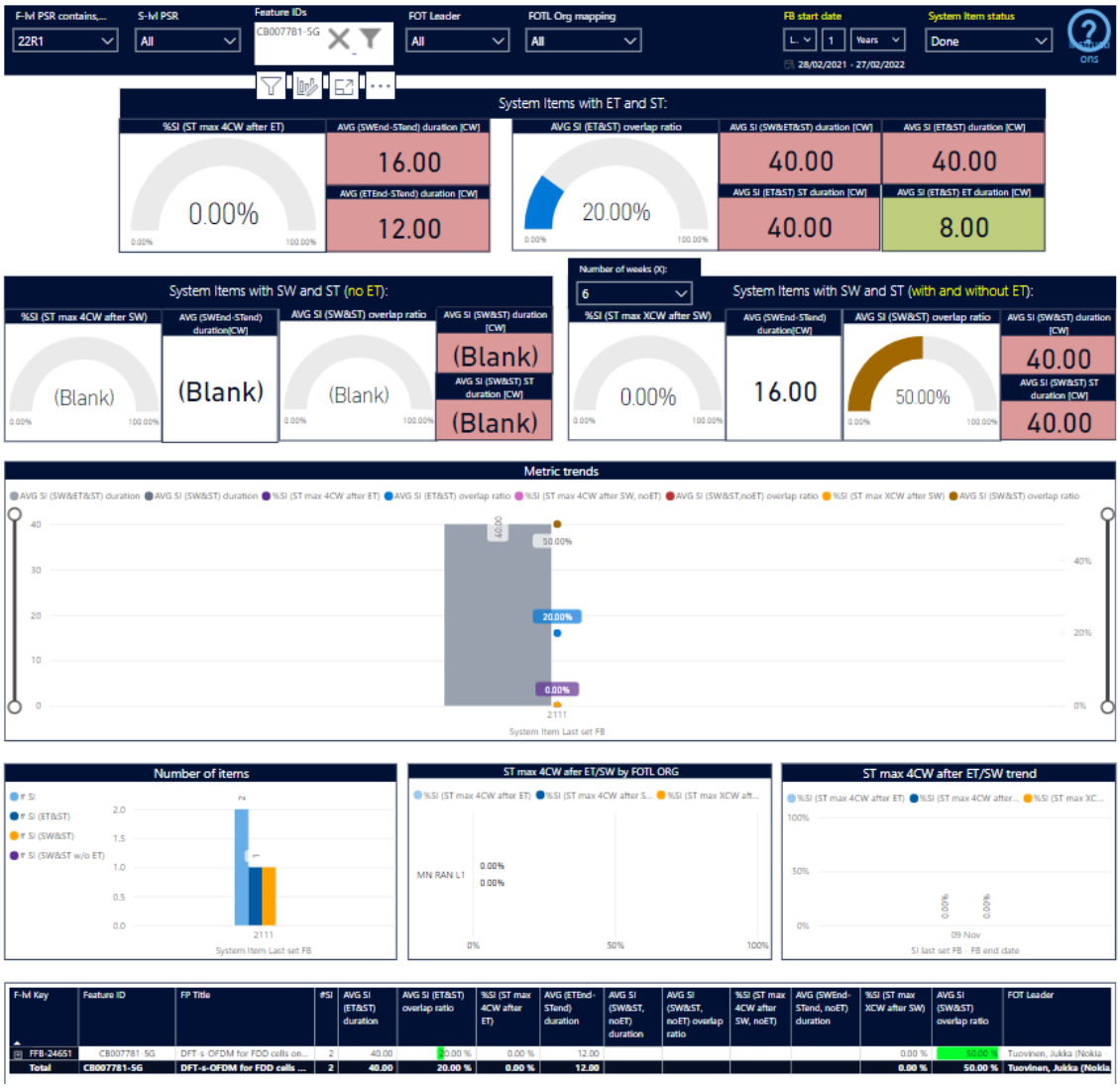
Appendix 1: 22R1 System Program KPI 3 and 4 Results
Appendix 2: CB007781-5G KPI 3 and 4 Results
Appendix 2: CB007794-5G KPI 3 and 4 Results
Appendix 2: CB007798-5G KPI 3 and 4 Results

Appendix 1

22R1 System Program KPI 3 and 4 KPI Results

Appendix 2

CB007781-5G KPI 3 and 4 Results



F-lvl Key	Feature ID	FP Title	#SI	AVG SI (ET&ST) duration	AVG SI (ET&ST) overlap ratio	%SI (ST max 4CW after ET)	AVG (ETEnd-STend) duration	AVG SI (SW&ST, noET) duration	AVG SI (SW&ST, noET) overlap ratio	%SI (ST max 4CW after SW, noET)	AVG (SWEnd-STend, noET) duration	%SI (ST max XCW after SW)	AVG SI (SW&ST) overlap ratio	FOT Leader
FFB-24651	CB007781-5G	DFT-s-OFDM for FDD cells on...	2	40.00	0.00 %	0.00 %	12.00					0.00 %	50.00 %	Tuovinen, Jukka (Nokia
Total	**CB007781-5G**	**DFT-s-OFDM for FDD cells ...**	**2**	**40.00**	**20.00 %**	**0.00 %**	**12.00**					**0.00 %**	**50.00 %**	**Tuovinen, Jukka (Nokia**

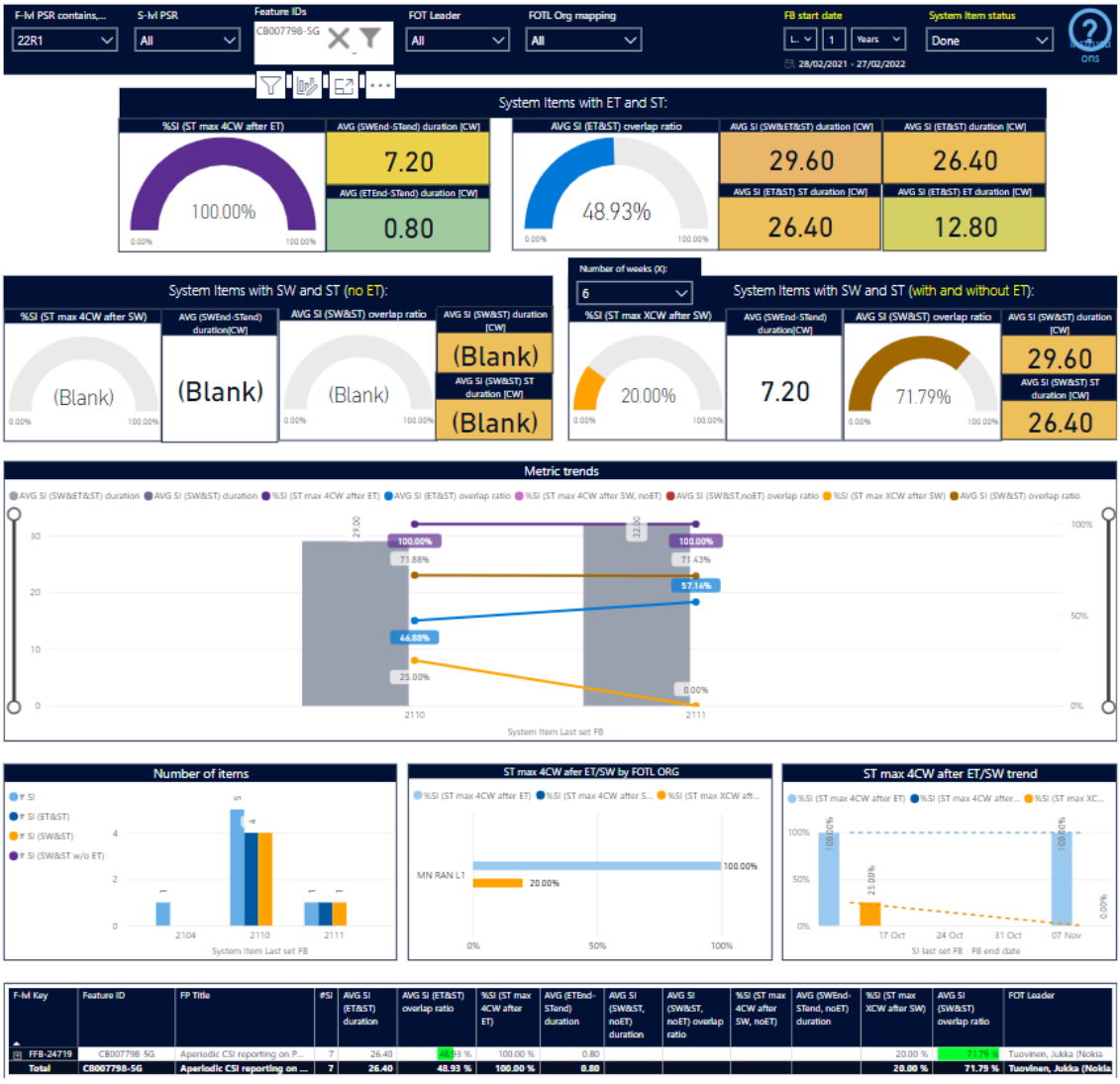
Appendix 3

CB007794-5G KPI 3 and 4 Results

F-M Key	Feature ID	FP Title	#SI	AVG SI (ET&ST) duration	AVG SI (ET&ST) overlap ratio	%SI (ST max 4CW after ET)	AVG (ETEnd-STend) duration	AVG SI (SW&ST, noET) duration	AVG SI (SW&ST, noET) overlap ratio	%SI (ST max 4CW after SW, noET)	AVG (SWEnd-STend, noET) duration	%SI (ST max XCW after SW)	AVG SI (SW&ST) overlap ratio	FOT Leader
FFB-24951	CB007794-5G	TDD CPRI compression for A&IL	2	24.00	0.00 %	100.00 %	4.00					100.00 %	0.00 %	Tuovinen, Jukka (Nokia
Total	**CB007794-5G**	**TDD CPRI compression for ...**	**2**	**24.00**	**0.00 %**	**100.00 %**	**4.00**					**100.00 %**	**0.00 %**	**Tuovinen, Jukka (Nokia**

Appendix 4

CB007798-5G KPI 3 and 4 Results



F-M Key	Feature ID	FP Title	#SI	AVG SI (ET&ST) duration	AVG SI (ET&ST) overlap ratio	%SI (ST max 4CW after ET)	AVG (ETEnd-STend) duration	AVG SI (SW&ST, noET) duration	AVG SI (SW&ST, noET) overlap ratio	%SI (ST max 4CW after SW, noET)	AVG (SWEnd-STend, noET) duration	%SI (ST max XCW after SW)	AVG SI (SW&ST) overlap ratio	FOT Leader
FFB-24719	CB007798-5G	Aperiodic CSI reporting on P...	7	26.40	48.93 %	100.00 %	0.80					20.00 %	71.79 %	Tuovinen, Jukka (Nokia
Total	**CB007798-5G**	**Aperiodic CSI reporting on ...**	**7**	**26.40**	**48.93 %**	**100.00 %**	**0.80**					**20.00 %**	**71.79 %**	**Tuovinen, Jukka (Nokia**