DCC Comms Hub Firmware Management Overview

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Abbreviations & Acronyms

This document uses standard terminology but for the avoidance of doubt, the meanings of abbreviations and acronyms are shown below.

Abbreviation	Definition
ASN	Advanced Shipping Notification
Comms Hub	Communications Hub
CSP	Communications Service Provider
CPL	Central Products List
DCC	Data Communications Company
DPL	Deployed Products List
OA	Operational Acceptance
OTA	Over-The-Air
PIT	Pre-Integration Testing
SI	System Integrator
SIT	System Integration Testing
UIT	User Integration Testing

1.   Executive Summary

This document provides an overview of the principles and processes DCC will apply in the delivery of new firmware for Communication Hubs (Comms Hubs) into production.

The aim of sharing this document is to provide DCC Customers and other key stakeholders clarity on the overall process.

2.   Introduction

2.1. Overview

The end to end delivery lifecycle of Comms Hub firmware sits across and impacts multiple stakeholders. DCC is accountable across this lifecycle to ensure that firmware provides the required functionality to be deployed onto the production estate, although other key stakeholders like the CSPs and DCC Customers also play a crucial role. DCC Customers manage their device estate independently of these processes and are therefore out of scope for this document.

2.2. Key Stages

The delivery of new Comms Hub Firmware is split across four key stages:

- o **Firmware Content Agreement and Communication**
    - o Regular meetings and associated artefacts for all key stakeholders in the delivery of Comms Hub firmware
    - o Governance and processes for key stakeholders within DCC and Service Delivery Partners to agree the content of Comms Hub firmware releases
    - o Central source for timelines and information for proposed firmware content, releasing Comms Hub Firmware Product Roadmaps

- o **Firmware Development and Testing**
    - o Firmware developed by CH Manufacturer and verified by CSP Pre-Integration Test (PIT) assurance processes. Where practicable, real devices are used for testing
    - o Firmware is submitted for System Integration Testing (SIT) with the System Integrator. Where practicable, real devices are used for testing
    - o DCC teams support CSPs and provide assurance at key gates after PIT and SIT

- Comms Hub firmware is released into the User Integration Testing (UIT) environments for a defined period to enable DCC Customers to gain confidence through testing. This allows DCC to capture vital information and feedback to support Comms Hub firmware go-live decisions

- DCC teams support DCC Customers across the whole test lifecycle e.g. engage with Test Participants, assist with equipment installation in DCC Lab, test communication and chair various meetings

- **Firmware OTA Deployment**

  - DCC, CSPs and DCC Customers undertake pilot deployment of Comms Hub firmware onto the production estate

  - After successful completion of pilot(s) DCC provides Operational Approval for mass deployment to the production estate

- **Manufacturing and Supply Chain**

  - DCC and the CSPs decide when a firmware version is promoted for manufacturing use, via stages in the Operational Acceptance process

  - Multiple factors contribute to the Operational Acceptance decision, e.g. adherence to technical specifications, resolution of critical defects or production incidents

3.   Governance

3.1. Governance Overview

The following figure illustrates the governance performed on the production Comms Hub end to end firmware lifecycle:
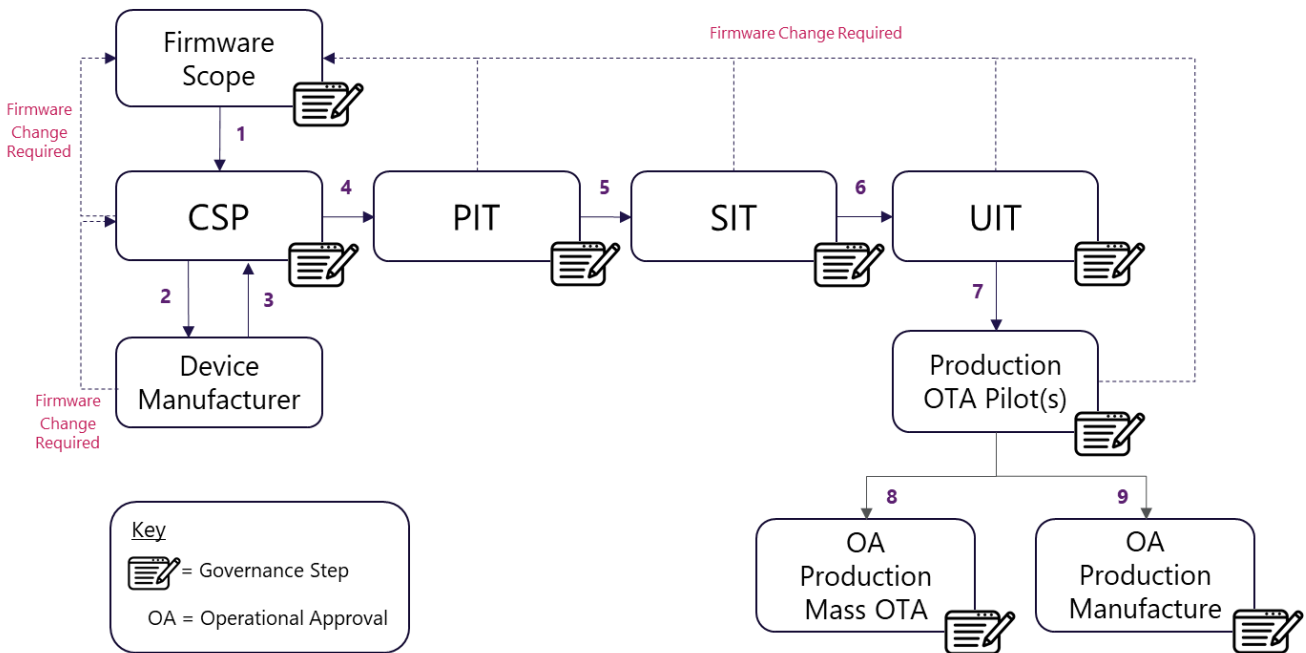
3.2. Governance Steps

The table below provides an overview of all the major and minor governance steps which are followed to gain overall confidence before Comms Hub firmware is deployed onto the production estate. The table provides the high level, whereas the remaining sections in the document provide more detail.

Governance	Governance Description	Responsibility
Firmware Scope	Multiple DCC teams, work closely with CSPs to agree scope for firmware releases. This governance process controls the content to be delivered and provides the single source for information like product roadmaps	DCC, CSP
Manufacturer Testing	CH Manufacturer test to confirm the new firmware performs in line with product specifications. DCC does not directly oversee this but the CSPs manage this as part of their overall assurance and quality processes	CSP

Pre-Integration Testing (PIT)	CSPs conduct this testing to verify that the new firmware version delivers functional and non-functional requirements and that the firmware successfully integrates with CSP systems. CSPs and DCC ensure that the firmware meets PIT exit criteria before it can progress	DCC, CSP
System Integration Testing (SIT)	The System Integrator (SI) conducts SIT to ensure the new Comms Hub firmware operates with overall DCC Systems and HAN devices representative of the production estate. The SI ensures the firmware meets SIT exit criteria and DCC assures this before the firmware is approved for SIT exit	DCC, SI
User Integration Testing (UIT)	DCC defines a UIT window to provide DCC Customers the opportunity to verify the new Comms Hub firmware with their devices and in accordance with their test scenarios. DCC Customers conduct the testing and DCC analyses any issues raised. The SI also conducts UIT Proving prior to release to DCC Customers.	DCC Customers, DCC, SI
Operational Approval - Production OTA Pilot(s)	Should all test stage criteria be met DCC grants Operational Acceptance for the firmware to be used for pilot OTA deployment to the production estate. Pilots are conducted in partnership with DCC Customers to achieve additional confidence in the new firmware. Where necessary, DCC may request an additional small volume OTA phase, called a micro pilot, during the UIT window to assist with Operational acceptance. Primarily this would seek to gain assurance on scenarios which cannot be recreated in test environments	DCC, CSP
Operational Approval (Mass OTA)	Should the Pilot OTA phase be completed successfully in partnership with DCC Customers then DCC grants Operational Approval for the firmware to be deployed to all applicable devices in the production estate	DCC, CSP
Operational Approval (Manufacture)	The CSP is responsible for the manufacturing process and the decision to commit a firmware version for manufacturing is made using DCCs Operational Acceptance process. The OA process considers the contributing factors for the firmware to enter device manufacturing and the timing required to commit this. DCC will maintain communication throughout the processes described above and particularly will inform DCC Customers once manufacturing decisions are made	DCC, CSP

4.   Firmware Content Agreement and Communication

4.1. Overview

The priority in this stage is to maintain the governance framework and processes for all delivery stakeholders to manage Comms Hub firmware releases. As a result, clear delivery priorities can be established for all DCC Comms Hub products and all key stakeholders of Comms Hub firmware have clear visibility of the forward schedule of change with artefacts like product roadmaps and associated timelines.

The key principles in this stage are:

- o   All delivery partners across the lifecycle of firmware have governance and processes agreed
- o   Regular engagement between all delivery partners

4.2. Process Details

There are multiple drivers which can result in new firmware for Comms Hubs, the most frequent being:

- o   Mandated Technical Specification uplifts;
- o   Testing defects, operational incidents, production problems, technical issue resolution; and
- o   Manufacturer product enhancement

To manage the multiple demands into new firmware for any given Comms Hub product DCC has created the governance mechanisms within this stage of the firmware delivery lifecycle. This allows DCC and service delivery partners to determine the content of Comms Hub firmware releases and this in turn creates the framework to provide clear visibility for the forward schedule of change. As part of this governance, consideration is given to key elements e.g. inputs from the drivers of change into the DCC Change Process, demands of the business and changes in priority.

Regular engagement and governance has been established between all key internal DCC stakeholders and our service delivery partners. Primarily this engagement either discusses upcoming required change or ratifies content decisions before they are committed for technical delivery. The meetings also discuss the priority of functionality being developed and the associated delivery timelines with the decisions being made. Where agreements necessitate Comms Hub firmware changes are required, the development, testing and release of the firmware are planned to align with the appropriate SEC System Release, Planned Maintenance Release or Unplanned Maintenance Release.

Should the need arise governance and delivery processes for emergency or security releases are also managed within this framework. Such events inevitably require previous agreements to be

reprioritized and re-planned, the key stakeholders involved in this process assess the options available and recommend the course of action. The governance process has decision making capability, but decisions are reviewed and endorsed by DCC and Service Delivery Partner leaders, as well as dealing with any contentions which require resolution. The "Firmware OTA Deployment" stage describes Comms Hub firmware deployment but it is worth stating that Comms Hub firmware OTA deployments will not target specific release windows across the whole deployed estate, as the firmware will be deployed to the estate systematically over a period of time.

5. Firmware Development and Testing

Details of development and testing processes are beyond the remit of this document and this section provides a high-level overview of how Comms Hub firmware is developed and tested. One of the key principles is to discover critical defects as early as possible in the development and testing cycles so that they can be resolved in updated firmware versions before production use.

5.1. Overview

The end to end testing life cycle will normally follow a sequential pass through PIT, SIT and UIT respectively, where exit criteria must be met at key governance gates. However, where there is an operational need for delivering expedited change, the PIT, SIT and UIT phases may overlap.

Pre-Integration Testing (PIT)

Comms Hub manufacturers develop new firmware in line with their own development cycles and processes. The manufacturer conducts their own testing before delivering it to the CSP for PIT testing. The purpose of PIT is to ensure that the new firmware has resolved the issues or provides the new functionality intended, that the firmware integrates with the CSP systems and has not introduced any regression in capability.

At the PIT exit stage, the test evidence is reviewed to determine if the new Comms Hub firmware is operating satisfactorily and provides the expected functionality. When these conditions are met the firmware is approved for PIT exit by the CSP, with the test evidence assured by DCC.

System Integration Testing (SIT)

DCC with the support of the System Integrator (SI) and CSP will confirm that the SIT entry criteria have been established before DCC approves that the SIT phase can commence. SIT provides comprehensive integration testing with DCC Systems using both emulators and devices. As part of incremental improvement SIT now uses real devices for testing, where practicable, to validate Comms Hubs against a subset of devices representative of those which customers have deployed in production. In addition, the SI also conducts UIT Proving prior to releasing the firmware to DCC Customers.

SIT focuses testing on business case scenarios to test real life operations rather than simple, functional tests. SIT follows an agreed DCC Test Scope, that once concluded is documented for assurance. The SIT exit review verifies that the SIT test documentation meets the required SIT exit criteria and if the criteria is met DCC approve the firmware.

User Integration Testing (UIT)

Outside of Comms Hub firmware approval, UIT is where DCC Customers can conduct their chosen testing in the UIT environments, a testing service which is known as Device and User System Testing (DUST). Once new Comms Hub firmware has completed DCC testing, it is then passed to DCC Customers in UIT who undertake testing for a defined period of time. UIT is not a mandatory test phase and DCC engages directly with those DCC Customers who request to take part.

UIT enables DCC Customers to test and validate the Comms Hub firmware against a wider range of device combinations than used in the SIT stage. This enables DCC Customers to have the opportunity to feedback any identified issues, alongside any information on progress and experience. Any issue found with firmware after UIT would be classified as production incidents and be resolved by DCC as part of standard incident or problem management processes.

Scenarios have been identified where defects cannot be recreated in testing and the resolution has had to be proven in pilots in production. On these occasions the precursory UIT step may need to be delayed for the firmware to be piloted with customers in production however even on these occasions the UIT verification period would still be opened for all key stakeholders to gain full confidence in the new firmware.

Firmware Approval

At the end of the defined UIT phase DCC will complete its Operational Acceptance activities which will assess the collected test evidence against agreed acceptance criteria. If the criteria are proven then the OA will approve the firmware for production deployment, approving the CPL submission to be completed. At this stage approval would only be for pilot deployments, mass deployment approval is granted once successful pilots have been completed.

If DCC identifies sufficient risk of the Comms Hub firmware impacting production service, then it will not be promoted for production use. High severity defects will require new firmware to be developed which needs to pass through all the governance previously discussed to return to this point in the approval process, i.e. the end to end life cycle must be repeated.

Operational Acceptance is also completed for mass OTA and at the decision to commit the new firmware for manufacturing. The following sections provide more detail on this.

6.   Firmware OTA Deployment

6.1. Overview

The priority of this stage is to manage the successful introduction of new Comms Hub firmware onto the production Comms Hub Estate through initial pilots before mass deployment commences.

The key principles in this stage are:

- o   Before Comms Hub firmware is approved for mass deployment DCC will run pilots in partnership with DCC Customers. The aim is to allow DCC Customers and DCC to gain a final level of confidence with the new Comms Hub firmware that it does not contain any critical defects or production incidents which could impact service

- o   Coupled with all previous test approval the successful completion of pilots is used for the Operational Approval for mass deployment to the remaining production estate to commence

- o   DCC are committed to piloting Comms Hub firmware in production. The nature of change across firmware versions can vary so DCC will adjust pilot durations, checkpoints and other related variables to ensure the pilot provides the confidence required. DCC will communicate and work in partnership with all key stakeholders to ensure the success of the pilot

6.2. Process Details

Piloting Comms Hub firmware in partnership with DCC Customers in production is one of the key steps in the introduction of new firmware to the production Comms Hub estate. The pilots provide DCC an opportunity to monitor the performance of the new firmware in the production environment and provide DCC Customers the opportunity to verify the new firmware in relation to the production device combinations they are operating at that time. Significant confidence in the Comms Hub firmware is established in the testing phases described in the Firmware Development and Testing stage, firmware is not granted operational approval if quality criteria has not been met. However, the pilots during the Firmware OTA Deployment stage are crucial in establishing final confidence that the new firmware can be deployed to the production Comms Hub estate.

DCC will aim to undertake the roll out of new Comms Hub firmware in partnership with customers so that any impact can be assessed before mass roll out begins. The intention is to follow this pilot approach for as many new Comms Hub firmware releases as possible, however in exceptional circumstances in order to manage the production estate effectively DCC may need to roll out emergency or security releases without pilots. DCC will do its upmost not to remove this vital phase unless required to do so and would still work as closely with DCC Customers before any such deployment. DCC will ensure that the key role of customers and communication is not affected so that these exceptional events can be managed in partnership to deliver successful deployment of any new firmware.

The indicative high-level approach to be used during pilots has been outlined below so that customers can gain insight into the approach DCC would aim to follow. Based on experience of running pilots in production factors like change complexity, associated risk and volumes mean pilots need to be adjusted. As a result, variables like duration of pilot phases, number of phases, exit criteria and so on need to be set per firmware to ensure the pilots deliver the required confidence. DCC will communicate the details of each pilot plan with DCC Customers and other stakeholders and incorporate any additional changes which may be required. Communication is undertaken via the weekly Programme UIT review meetings. The purpose of the meetings is to:

- Provide customers with an updated view of the firmware release programme and UIT schedule

- Gain input as to the progress that has been made by customers during the UIT phase of testing

- Confirm and agree the scope of forthcoming pilots (including exit criteria, device combination selection, any exclusions)

- Provide a status report of any on-going pilots in terms of performance against the exit criteria; feedback received from customers involved in the pilot; incident analysis of any issues that have been seen

- Communicate to customers the plan for Mass OTA rollout upon successful conclusion of the pilot

The exit criteria are defined for each pilot on a release by release basis. The reason for this is that a particular release may include defect fixes or specific functionality which DCC will want to try and demonstrate is working as per design as part of the pilot plan; before the approval for mass rollout is given. There is broadly speaking a core set of criteria which we typically see for each pilot phase. These are subject to review and agreement each time in conjunction with the CSP's but typically include items such as:

- Volume of Comms Hubs upgraded and % success of firmware activation

- SRV success compared to the baseline of the previous firmware version

- Tracking of alert volumes (if required, specific to the release)

- Tracking and analysis of incidents raised to ensure that the path to resolution is understood

The indicative high level pilot approach would broadly align to the following three phases.

Phase 1 – DCC would agree with DCC Customers which Comms Hubs would be included in the initial deployment of firmware and would notify DCC Customers that phase 1 of the OTA deployment was to begin. Following phase 1 OTA deployment, an assessment is held between DCC and CSPs to discuss any defect, operational issue or critical issues raised. Should this be a Comms Hub firmware issue DCC will review the available resolution options. DCC and CSPs agree whether to progress to Phase 2 of the firmware deployment or not.

Phase 2 - On successful and agreed completion of phase 1, the DCC would conduct one or more phases of larger OTA deployments as agreed with DCC Customers. If the larger OTA deployments were deemed successful, then the Comms Hub firmware would move to the third and final stage of the OTA deployment process.

Mass Deployment - Successfully passing phase 1 and 2 of the OTA deployment should provide confidence that the Comms Hub firmware is fit for deployment to the remainder of the production estate. After Operational Approval has been granted Phase 3 would be the mass rollout phase where the firmware would be rolled out to upgrade all production Comms Hubs which require this latest firmware version. DCC will manage issues related to Comms Hub upgrades via Incident Management and Problem Management processes.

Upon conclusion of the mass rollout activity retries will continue to be performed for any Comms Hub which have not successfully been upgraded. The CSP's have processes in place which means that they regularly target Comms Hubs on older firmware versions for upgrade, unless there is an agreed reason for exclusion. Should that be the case customers would receive communication from DCC with regards to the reason why devices have been excluded either through direct comms or via the PMEL exclusion process which can be found on Sharepoint in the folders Information for SEC Parties > Regulatory > Performance Measures.

7. Manufacturing and Supply Chain

7.1. Overview

The priority in this stage is to manage the transition between the previous Comms Hub firmware approved for use in manufacturing to the next proven version. The aim of this is to provide DCC Customers with confidence and stability in terms of the firmware that is delivered and subsequently is to be installed per Comms Hub variant.

The key principles in this stage are:

- DCC and the CSPs decide when a firmware version is promoted for manufacturing use, via the Operational Acceptance process
- Multiple factors contribute to the Operational Acceptance decision, e.g. adherence to technical specifications, resolution of critical defects

7.2. Process Details

It is DCC's priority to ensure that the end to end firmware lifecycle has been followed before DCC and the CSPs decide to promote the firmware for manufacturing use.

This decision point determines when a new firmware version will be manufactured. The fixes in the new firmware or other conditions like adherence to specifications may mean that use of the new firmware for manufacturing may need to be mandated at some point but wherever possible DCC will endeavour to allow the selection process defined above to make the decision.

Comms Hub firmware that is deemed suitable for manufacturing will have:

- passed all DCC test phases (PIT / SIT)

- been tested by DCC Customers in UIT environments

- no high severity operational issues accepted against it

- DCC Operational Acceptance

Notification of firmware versions on delivery consignments can be viewed by accessing the Advanced Shipping Notification (ASN) file issued prior to the scheduled delivery date.