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Crew and Stock Systems – Task and Finish Group Final Technical Report

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Synopsis

This document summarises the findings of a cross-industry Crew and Stock System Task and Finish Group tasked with addressing some of the system constraints highlighted in the Crew and Stock System Concept of Operations, published by the Rail Delivery Group (RDG) in 2018. The group reported to the National Task Force Better Operations Programme Board with meetings held between October 2018 and March 2019.

Issue record

Issue	Date	Comments
1.0	May 2019	First industry release.

Contents

Executive Summary

A Task and Finish Group, reporting to the National Task Force Better Operations Programme Board, was set up to address some of the system constraints highlighted in the Crew and Stock System Concept of Operations, published by the Rail Delivery Group (RDG) in 2018. The group considered:

- Interactions with Traffic Management,
- Additional Layered Information Exchange (LINX) messages,
- Interfaces with other systems,
- Legacy file formats,
- Who owns the interface requirements etc.

The outputs of the group were: creating this report, summarising the findings of the group, creating Process Maps to describe the interactions with Traffic Management and updating the Concept of Operations to reflect the group's findings.

Findings from the group include:

- There are 28 messages required for the interactions between Traffic Management and Crew and Stock Systems. More detailed work is required to develop those messages that currently do not exist.
- Rather than developing legacy file and data formats, the industry needs to migrate to more modern formats.
- Standard message formats are of benefit to the industry.
- Planning coordination between Traffic Management systems is not mature at this stage. A National Planning Layer may be required.
- The need for a National Geography Model, which is common across Infrastructure Manager (IM) and Railway Undertaking (RU) systems, is becoming more pressing.
- To support the roll-out of Traffic Management, C-DAS and Crew and Stock Systems, it is critical that the outputs of the timetabling process deliver the granularity that these systems require.
- It is difficult to release resources to test systems / new processes, particularly in Control.
- Developing direct links from ETCS to Crew and Stock Systems is not recommended for future work at this time. There may be a case for a connection between Automatic Train Operation systems and Crew and Stock systems, but this will require further detailed investigation.
- C-DAS systems should be procured 'LINX message ready' so that it may take information inputs from multiple systems including Traffic Management and Crew and Stock Systems.

Section 8 of this report highlights future risks and proposes a series of future actions to continue development around Crew and Stock Systems. Initial steps include a group of experts building on the work undertaken by the Task and Finish Group to: determine LINX message 'payloads' (i.e. decisions around what data to include in each message) and building a business case for the creation of the messages (balancing creation costs against business / industry benefits). Post creation, the messages and how they are used will be documented in a Rail Industry Standard (RIS).

Group Attendees:

The Rail Delivery Group gratefully acknowledge the joint work of the following people in the creation of this report.

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1 Purpose:

The purpose of this paper is to summarise the findings of the Crew and Stock System Task and Finish Group which reports to the National Task Force Better Operations Programme Board (NTF BOPB). 5 meetings were held between October 2018 and March 2019.

2 Background:

Operators today have differing control and train planning systems for stock and traincrew management. Systems and procedures used today can range from pen and paper and verbal communications to digitised systems. Where digital systems are used, they are not fully connected to others so when changes are made, those changes are communicated verbally or via email or fax. During times of perturbation, the fast and continually changing demands of command and control can lead to operators being unable to maintain service expectations and keep track of alterations to the crew, stock and the service - the greater the perturbation the more likely that the plans will be suboptimal.

Crew and Stock systems aim to modernise existing processes and technology used in TOC / FOC businesses. It is a database of all known information about rolling stock, train crews, train schedules & diagrams, and live rail operational data but has an intuitive user interface to aid decision making by operational staff in time-critical situations and allows for quick data alteration. It is conceptualised that the system can be used for daily rail operations and planning over longer timescales, including traincrew resourcing and timetable planning (including Long-Term Planning). Open data formats also allow the of sharing data and information with Traffic Management, other industry systems and other TOC / FOC business systems.

After cross-industry consultation, the Rail Delivery Group have published:

- A Concept of Operations in April 2018.
- A set of Common System Capabilities in July 2018.

As part of this, a number of constraints for system deployments were identified and additional work was recommended (see Section 9 of the Concept of Operations). In September 2018, the Rail Delivery Group proposed to the National Task Force Better Operations Programme Board that a Task & Finish Group (T&FG) be set up to study Crew and Stock system deployment constraints and propose an industry position on how Crew and Stock systems should interact with others, most notably Traffic Management. The full remit for the group is reiterated in Section 3 of this report.

As Crew and Stock Systems have been specified in the South Eastern and West Coast Partnership Franchise Invitation to Tenders (ITTs) and are likely to feature in future ITTs, it is increasingly important for there to be a coordinated, industry-wide standpoint on how Crew and Stock systems interact with other systems and how current deployment hindrances can be resolved. Without this, there are risks that: individual deployments design systems differently, multiple yet similar Layered Information Exchange (LINX) messages are developed at unnecessary cost and suppliers are unclear on what the industry wants and may develop bespoke solutions.

LINX is an interface layer which provides the means to exchange data and information between Traffic Management and other systems (which may be in external organisations). Data sent between systems is packaged into ‘messages’ or files – this report will use the word ‘message’ throughout. LINX uses a ‘publish-subscribe’ messaging pattern whereby senders of messages (publishers) do not specifically code which systems they would like to receive the message. Instead, published messages are categorised into ‘classes’ with receiving systems (subscribers) deciding which classes they would like to receive (subscribe to) from LINX which brokers the message. This means that systems only receive information that is of interest rather than large amounts of information and filtering out irrelevancies. Corresponding publish and subscribe messages are termed ‘message flows’ and a catalogue of all defined flows is published and maintained by Network Rail. At this time, LINX supports standard protocols for data exchange including IBM MQ [Message Queue] and XML [Extensible Markup Language] and FTP [File Transfer Protocol] for larger file transfers.

3 Group Remit:

The remit for the Task and Finish Group outlines the aims to:

- Reach an industry position on the interactions with Traffic Management. This would be at a detailed level and consider what each system can provide, what information can be passed to which system and which can make decisions with the data available.
- Facilitate the above industry position, consider what new Layered Information Exchange (LINX) messages may be required (with assistance from the Network Rail LINX team).
- Define how Crew and Stock systems could interact with systems that were out of scope for the Concept of Operations, e.g. Connected Driver Advisory Systems (C-DAS), the European Train Control System (ETCS) and Incident Management Systems (IMS).
- Reflect on current 'legacy file formats' and make recommendations as to where improvements could be made (e.g. can the RU provide more information to Network Rail than is currently allowed for?) This ties in with Digital Railway's Timetable Requirements development work.
- Consider how requirements made by other organisations / systems should be handled and documented. Who should be the overall requirements (and concept) owner(s)? This will focus on the interface with other systems rather than the system itself.

To fulfil the group's aims, the following outputs were planned:

- Create a report with recommendations for how Crew and Stock systems interact with others – for validation with the wider industry. This includes improvements to other systems that facilitate the deployment of Crew and Stock systems. *[This document is the report]*
- Agreed positions will be used to create a new iteration of the Concept of Operations. *[To be completed once this report is endorsed]*
- A report considering how requirements for Crew and Stock systems could be best managed with particular focus on the interfaces with other systems. *[Included in this report]*

4 Interactions with Traffic Management:

4.1 Rationale:

The Concept of Operations (ConOps) notes that whilst the presence of a Traffic Management system is not essential for Crew and Stock Systems to function, there are some constraints around how the two systems could interact. This is highlighted specifically as part of Section 9.1 in the ConOps. Most relevant is clause 9.1.4 which is reiterated below for note:

9.1.4 The Crew and Stock system may interact with Traffic Management systems where available, or as a standalone system with the capability for future connectivity to a Traffic Management system. Under current/planned implementations, data from Crew and Stock systems would be published to the Layered Information Exchange (LINX) and be subscribed to by Traffic Management, and vice versa. Optimisation of the bandwidth between the two systems will, therefore, be an important consideration and possible constraint. Two possible implementations have been theorised at this stage - this document has been written so as to not preclude either implementation:

a) Relevant information from the Crew and Stock system is transferred to Traffic Management the night before with live updates published to Traffic Management when information changes (and vice versa). 'Relevant' information will depend on the implementation of the Traffic Management system although it is anticipated to be information pertinent for making regulation or routing decisions. No personal or commercially sensitive data is expected to be shared. For data queries, Traffic Management would use the information it already has rather than query the Crew and Stock system via LINX. This could reduce query response *times but requires accurate and consistent information to be within both systems. The volume of live updates and their file size to be passed over LINX could be a constraint. This implementation is discussed further in the Digital Railway Early Contractor Involvement (ECI) workstream report [RD2].*

b) Data contained within the Crew and Stock and Traffic Management systems remain segregated with each system publishing information to LINX for the other system to query when necessary. This published data should reflect the latest information in either system. Whilst this implementation would not require a large transfer of information the night before, it could slow query response times and generate a larger number of queries for the LINX layer as up-to-date data is not held in Traffic Management.

As part of the "Further Work Identified" (ConOps Section 9.3), clauses 9.3.9 states:

9.3.9 As part of the document, the following interactions with Traffic Management systems have been identified – each require detailed analysis as to what Traffic Management and Crew and Stock systems will do, what LINX messages will need to be developed [9.1.5] and which system makes the decision. In this version, the interactions are shown as a list – it is intended to develop this into a full appendix with significantly more information in later versions:

- *Are stock and/or crew allocated to a service and can depart?*
- *Cancelation of service(s).*
- *Alterations to train schedules to avoid conflict(s).*
- *Provide train running forecasts.*
- *Check if any stock, crew or route restrictions / conflicts apply, should a service be diverted from its booked route.*
- *Calculate the impact of non-train running activities to provide better train running predictions (and customer information).*
- *What are the impacts on subsequent workings and diagrams should a service be altered?*
- *Inform Traffic Management when the Crew and Stock system alters a diagram or train service association.*

The aim of the Task and Finish Group is to further expand on these interactions and develop a more detailed industry view on which systems have which responsibilities – to be completed via a set of Process Maps.

The following assumptions are made around Traffic Management – these are equivalent to the Concept of Operations:

- Traffic Management systems have the capability to revise (with RU approval), and accept revised, schedules and alter the routing of trains within its control area.
- The European Train Control System (ETCS), Traffic Management systems, Driver Advisory Systems (DAS) and Automatic Train Operation (ATO) are not fitted or available over the entirety of the RU's operating area.
- The user experience of a Crew and Stock System is similar whether or not Traffic Management is present in the RU's operating area. From the perspective of the Crew and Stock System, there is only one Traffic Management system. Coordination between different Traffic Management systems is handled by the IM and is transparent to the RU.

4.2 Approach:

The list of interactions was reorganised into a set of scenarios with specific outcomes – it was agreed that the Process Maps should be able to describe how each of the outcomes could be achieved. For note, the scenarios are listed below.

Are stock and/or crew allocated to a service and can depart?

1. *Crew and Stock System informs Traffic Management that crew/stock are allocated*

Provide train running forecasts.

2. *Forecast from Traffic Management / legacy system to Crew and Stock System.*
3. *Forecast from Crew and Stock System (e.g. late running crew, 'impact of non-train running activities') to LINX and Traffic Management.*

Cancelation of service(s) / path(s).

4. *Cancel / part-cancel a Service (RU Initiated)*
5. *Cancel / part-cancel a Path (Signaller / Traffic Management Actioned)*

Inform Traffic Management when Crew and Stock system alters an association / diagram.

6. *Change Service Association (assuming crew and stock are suitable for the new associations)*
7. *Change crew association (assuming crew and stock are suitable for the new associations)*
8. *Change stock association (assuming crew and stock are suitable for the new associations)*

Path Changes

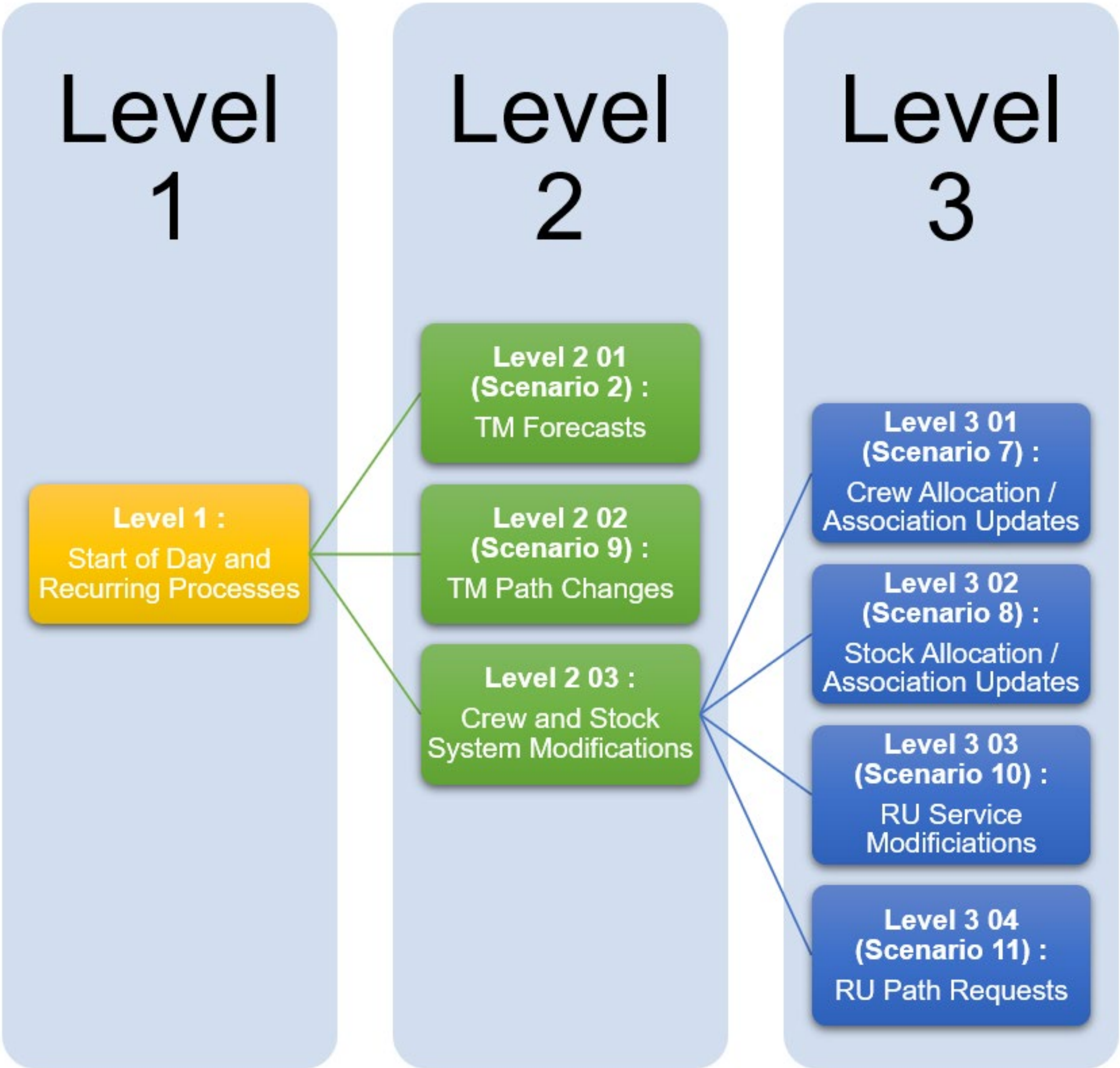
9.
    a. *Traffic Management slightly alters path (assuming no crew or stock impact or restrictions)*

Check if any crew, stock or route restrictions / conflicts apply, should a service be diverted from its booked route.

    b. *Divert a Path (Signaller / Traffic Management Initiated)*

10. *Divert a Service (RU Initiated)*

However, between each of the scenarios, there was repetition – making the maps large, complex and difficult to follow. As a result, the maps were reorganised into 'Levels' with series of interrelated tasks forming part of each level – see diagram below. There are cross-references within the tasks/levels to avoid the repetition noted above.



4.3 Process Maps:

The full set of 8 Process Maps are included in Appendix 1 of this document.

4.4 LINX Messages:

The Process Maps detail where information/data is passed between different systems – where this is to be via LINX, an assessment has been carried out as to whether:

- An existing message is already available in the LINX Service Catalogue.
- An existing message is already available in the LINX Service Catalogue but requires alteration.
- A message to fulfil this function is not available in the LINX Service Catalogue at this time. Where possible, nomenclature from the European Telematics Applications for Freight/Passenger Services Technical Specification for Interoperability (TAF TAP TSI) has been used to give an indication of the messages' content.

The Process Maps demonstrate that there are 28 messages required for the interactions between the two systems. The table below highlights the number of messages which fall into the categories listed above.

Message Availability	Number of Messages
LINX message already available	13
Current LINX message requires alteration	2
New LINX message required	13

The following table lists of all the messages used in the Process Maps, grouped by message availability. The map in which the message is used is also included as well as: whether the message is subscribed to or published from the Crew and Stock System and the message maturity (as defined by Network Rail).

LINX MESSAGE	PROCESS MAP	C&S PUBLISHES OR SUBSCRIBES?	MATURITY	COMMENT
LINX message already available				
TM Train Running Forecast	2 01	SUBSCRIBES	Built, not tested	
CS Train Running Forecast	2 01	SUBSCRIBES	Live	
TM Train Running Information	2 01	SUBSCRIBES	Built, not tested	
CS Train Running Information	2 01	SUBSCRIBES	Live	
CS Train Activation	2.01	SUBSCRIBES	Live	
TM Train Running Interruption	2 01	SUBSCRIBES	Built, not tested	
TM Train Journey Modification	2 02	SUBSCRIBES	Live	
CS Train Journey Modification	2 02	SUBSCRIBES	Live	
TM Change of Track / Platform	2 02	SUBSCRIBES	Built, not tested	
Passenger Train Allocation and Consist	3 02	PUBLISHES	Built, not tested	
Freight Train Consist	3 02	PUBLISHES	Live	
TM VSTP Path Details	Not shown	N/A	Live	Not shown, part of TM VSTP process
CS VSTP Path Details	Not shown	N/A	Live	Not shown, part of TM VSTP process
Current LINX message requires alteration				
Crew Allocation	3 01	PUBLISHES	Built, not tested	Longer term aspiration
Path Details [including Path Details : Modification]	3 04	PUBLISHES AND SUBSCRIBES	Built, not tested	*Continued below*

New LINX message required				
Train Ready to Go	1 01, 3 03	PUBLISHES	Not built	3 03 adds 'Train Ready Time'
TM Path Request / Modification	2 02	SUBSCRIBES	Not built	
Path Accepted	2 02	PUBLISHES	Not built	
Path Rejected	2 02	PUBLISHES	Not built	
Crew Shift Allocation	3 01	PUBLISHES	Not built	Analogous to Crew Diagram - change name
(RU) Path Request : Modification	3 02, 3 04	PUBLISHES	Not built	
RU Train Running Interruption	3 03	PUBLISHES	Not built	
RU Train Journey Modification Request	3 03	PUBLISHES	Not built	
RU Very Short-Term Plan (VSTP) Path Details	3 04	PUBLISHES	Not built	
Path Confirmed	3 04	PUBLISHES	Not built	
Path Confirmation Acknowledge	3 04	SUBSCRIBES	Not built	May not be required
Path Details Refused	3 04	PUBLISHES	Not built	
Path Not Available	3 04	SUBSCRIBES	Not built	

Beyond these messages, further work is required around the exchange of data between the two systems (and LINX) at the start of the day of operation. As highlighted in Process Map ‘Level 1’, large volumes of information need to be exchanged between Traffic Management and Crew and Stock and vice versa – there needs to be consideration around how this is most efficiently done at a system deployment stage. Similarly, there is no current LINX message to pass Traffic Management’s ‘Current Plan’ to other systems – a future methodology needs to be created/agreed.

Note also that there may be further LINX messages created that, whilst not required for direct communications between Traffic Management and Crew and Stock Systems, may be useful for Crew and Stock Systems to subscribe to (e.g. messages originating in the Possession Planning System, PPS). This is discussed in further detail in Section 5.4 but demonstrates that the above list of messages may be non-exhaustive in the long term and will need to be revisited at a later date.

As noted in Section 4.1, it is assumed that from an RUs perspective, the boundaries between Traffic Management systems should be transparent. However, the exact methodology of how Traffic Management systems coordinate is not mature at this time. This has become a concern for RUs crossing multiple Traffic Management boundaries, particularly as these boundaries do not align to timetabled services (they are geographic in nature). This report highlights this as a risk and will become increasingly important as further Traffic Management and Crew and Stock Systems near deployment – a National Planning Layer may be required in the group’s opinion.

It should also be noted that the set of messages described are specifically tailored to Network Rail’s LINX layer. Other Infrastructure Managers may choose to use a different set of messages or rely direct system-to-system communications.

Key Finding:

Should this be the case, it is recommended that other IMs follow a similar approach (in relation to what data goes to which system) to ensure a level to consistency for RUs. It is recognised that coordination between different IMs may be a future risk to Traffic Management and Crew and Stock System deployments and may require future work – however, GB coordination via an industry standard(s) and European coordination via the Telematics Applications for Passengers and Freight Technical Specification for Interoperability (TAP TAF TSI) could mitigate this.

Findings and Future Actions / Risks are noted in Sections 7 and 8 respectively.

5 Interactions with Other Systems:

5.1 Rationale:

The Concept of Operations deliberately excluded interactions with the European Train Control System (ETCS), Driver Advisory Systems (DAS), Connected Driver Advisory Systems (C-DAS) and Incident Management Systems (IMS) from the document scope. Clause 9.3.6 (in ‘Further Work Identified’) notes that more work is required around the interaction with ETCS and DAS – see below.

9.3.6 Details of how Crew and Stock data is communicated to and used by ETCS and DAS, including C-DAS, will need to be examined [9.1.7].

The specific constraints around ETCS and DAS are described in Clause 9.1.7:

9.1.7 Crew and Stock data may be used to provide information to both ETCS on-board systems and DAS (including connected DAS [C-DAS] systems).

- *ETCS on-board systems may use Crew and Stock data to minimise the amount of data entry required by the driver – in line with the Operational Concept for ERTMS. It could also be used for the ETCS in-built DAS system. It is unknown how the ETCS on-board will receive any information from the Crew and Stock system and what safety or performance implications there may be for ETCS being reliant on an external system. Considering the safety critical nature of ETCS, identifying how the two systems could interact may be a* *substantial amount of work and thus the specifics of their interaction are considered out of the scope for this document.*

- *DAS implementations, which do not receive live updates during journeys (Standalone or Networked DAS), may require the Crew and Stock system to be connected to the RU's trackside DAS system. The Crew and Stock data could be used by DAS to provide more up to date information and decrease the amount of data entry for the driver. It may also decrease the number of manual updates that need to be entered into the RU trackside DAS system when plans change. It is unknown how the Crew and Stock system and RU DAS trackside may be connected and is likely to be supplier dependant.*
- *Connected DAS (C-DAS), which is provided with live schedule updates from Traffic Management (via LINX, the IM and RU DAS trackside) may also make use of the Crew and Stock data. At the time of writing, it is unknown whether the data should be provided via LINX or whether the Crew and Stock system is connected directly to the RU DAS trackside (as per above), although the former seems most likely. Again, this is likely to be supplier dependant but may require further work. Schedule updates from Traffic Management could also be passed from LINX to the C-DAS RU trackside via the C-DAS IM trackside or via the Crew and Stock system (if the direct connection is provided). This may pose a risk if the systems do not hold corresponding information (e.g. one system updates the schedule information more quickly than the other).*

During the writing of the Concept of Operations, the exact functionalities of IMSs were not clear and because of this, interactions were excluded from scope. With functionalities now slightly clearer and the interactions between TM and IMS now being considered, it is possible to now consider what benefits IMSs could bring to Crew and Stock Systems.

5.2 ETCS:

During the Start of Mission setup for ETCS, the driver is required to enter information about the train. For passenger trains, this is based on 'Gamma' models where pre-set braking characteristics are already pre-programmed into the train – the driver needs to select the correct train formation from the pre-defined list. For freight locomotives, further details need to be entered around the formation of the train, weights etc. which can take time to complete. The characteristics entered affect how the ETCS on-board calculates the safety critical braking curves for the train.

The Crew and Stock System could provide some of the information that is required by the ETCS on-board, particularly as it knows the unit allocated to the service. This could eliminate some data entry by the driver – becoming more of a data validation process. However, there are constraints on this:

- The ETCS on-board uses the GSM-R radio to communicate to off-board systems (e.g. the Radio Block Centre, RBC) – the Crew and Stock System would likely have to provide the data to the on-board via the GSM-R network. However, to provide this information to the train, the train must first be registered with the GSM-R network so that the system knows which train specific information to pass across. When using ETCS, to complete the registration process, the train specific information would have already been entered. It would be difficult to pass the information beforehand.
- For fixed formation passenger trains (using the Gamma models), the amount of time saved would be minimal. Similarly, there may be safety implications of the driver just accepting what the Crew and Stock system may have passed across rather than considering what the formation of the train is via the pre-defined options.
- As ETCS is a Safety Integrity Level 4 (SIL4) system, a similar standard may be expected of the Crew and Stock System. An increase in safety level would likely increase the cost of Crew and Stock Systems – for the advantages presented, it is unlikely there would be a business case for this.

Considering these constraints, developing direct links between ETCS and Crew and Stock Systems is currently not recommended for further investigation at this time.

However, more recent baselines of ETCS have a set of interfaces specified to Automatic Train Operation (ATO) systems (both on-board and trackside) which can pass information to the train. The ATO system receives schedule information from Traffic Management, with the specifics of this interface specified at a European level. Further consideration is given to this interface in Section 5.3 under Interoperable C-DAS.

5.3 Driver Advisory Systems:

As part of this section, there are 4 different types of Driver Advisory Systems (DAS) considered. For clarity, each are defined briefly below:

- **Standalone-DAS (DAS or S-DAS):** timetable information is downloaded to the train at or prior to journey start. It remains static for the entire journey, not receiving any updates once the journey has started. Should the train be delayed, or route changed, most advisory information is no longer useful to the driver.
- **Networked-DAS (N-DAS):** capable of communicating with one or more RU control systems, thus enabling provision of data to the train, including updates for schedule or routing information. This may not be communicated to the train in near real time.
- **Connected-DAS (C-DAS):** provision of information updates to trains in near real time, currently conceptualised to be from Traffic Management systems. C-DAS also offers the potential for the control system to use data received from trains to inform regulation decisions (e.g. location data). Note that outside of Traffic Management areas of control, the system reverts to S-DAS style of operation (no further updates are received).
- **Interoperable C-DAS:** the provision of C-DAS functionality via an Automatic Train Operation (ATO) over ETCS system. The requirements and architecture are defined in the relevant European Technical Standards for Interoperability, currently under development.

As noted in Section 5.1 (Rationale), S-DAS and N-DAS implementations can have data provided by existing RU systems. A possible implementation is to connect a Crew and Stock System directly to the RU DAS Trackside (which then feeds the on-train unit (DAS On-board)). N-DAS may benefit from this setup as the Crew and Stock System can provide updated schedules to the train as the RU makes alterations to its own services (without Traffic Management). Specific instances could be: additional stop orders, not to stop orders, part-cancellations and operational re-timings (that are within the gift of the RU). The group notes that for single train operator areas with no ETCS or Traffic Management, the deployment of N-DAS with a Crew and Stock System has benefits akin to a full C-DAS implementation.

However, should there be either; multiple train operators, ETCS or Traffic Management, it is more difficult for N-DAS (and S-DAS) to be effective. In single train operator areas, the operator can clearly see where there would be conflicts with other services as they are their own services. The RU can then choose to alter particular operational schedules to prioritise a certain train over another, for example, which would then be pushed to the N-DAS screen in front of the driver. Where there are multiple train operators over the same infrastructure, the IM, as the arbitrator of paths on the network, would decide how schedules could be altered and the RU (within the Crew and Stock System) would have limited control of this.

Under C-DAS implementations, schedules decisions made by the IM via a Traffic Management system are directly passed to the RU DAS Trackside and Crew and Stock System via LINX (rather than the Crew and Stock System feeding DAS). This leads to a juxtaposition where S-DAS and N-DAS are reliant on the Crew and Stock System yet C-DAS is not. The group considered two possible architectures for the setup of C-DAS systems – shown in the diagrams below. Figure 1 depicts each of the systems connected via LINX and the RU DAS trackside is able to access information via either system. Figure 2 describes a more linear flow of information where information to the RU DAS trackside only comes from the Crew and Stock System, although this may have received its information from Traffic Management via LINX.

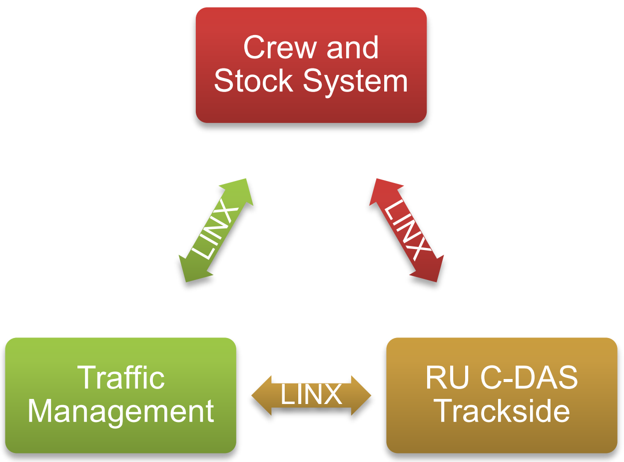


Figure 1

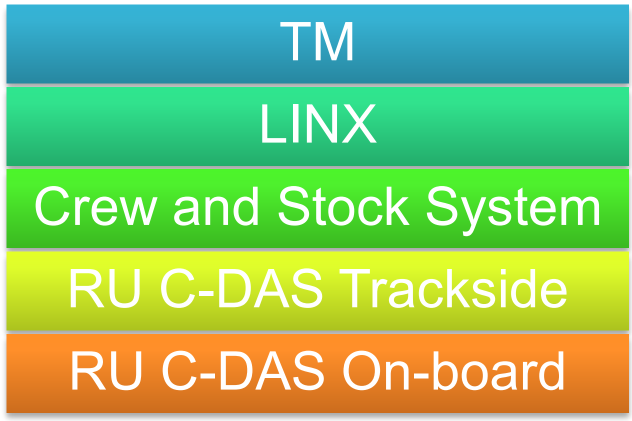


Figure 2

The group acknowledged that the Figure 2 architecture would keep the consistency with S-DAS and N-DAS implementations with the Crew and Stock System being the only source of information for the RU DAS trackside. However, the Figure 1 architecture would provide more flexibility with the RU free to decide which system it wanted to feed information to the RU DAS Trackside (by subscribing or not subscribing to certain LINX messages). It may also allow a form of redundancy or cross-checking should one of the systems have a fault/connection issue.

Both architectures have the Crew and Stock System connected to the RU DAS trackside and would allow the RU to develop further functionalities and interactions between the two systems. For example, the on-board DAS screen could be used to transmit: some operational messages to the driver, performance and delay attribution information, driver acknowledgement messages and GPS information.

Key Finding:

It is the opinion of the group that the Figure 1 architecture should be the industry position on C-DAS implementations. This is also consistent with Digital Railway's strategies for C-DAS architecture.

For areas where Traffic Management is not yet available, the group also recommend that any DAS system procured should be 'LINX message ready' to ease any transition from S-DAS or N-DAS (fed by Crew and Stock Systems) to C-DAS (partially fed by Traffic Management) – as the LINX messages would be the same.

Interoperable C-DAS requires a slightly different architecture as the C-DAS functionality is provided as part of the on-board ATO system (which is also linked to the ETCS on-board). As such, rather than the RU DAS trackside exchanging data with the RU DAS on-board, it communicates directly with the ATO system. DAS information can then be displayed on the ETCS DMI (Driver Machine Interface) where required, noting that DAS information is generally not displayed when ATO is engaged.

The European specifications for ETCS have widened to include the interfaces between ETCS, the ATO system (on-board and trackside) and Traffic Management (described as TMS in this section). The diagram below notes the various interfaces between the systems and the ETCS subsets that define the specification. Of particular interest is Subset-131 – the interface between Traffic Management and the ATO trackside.

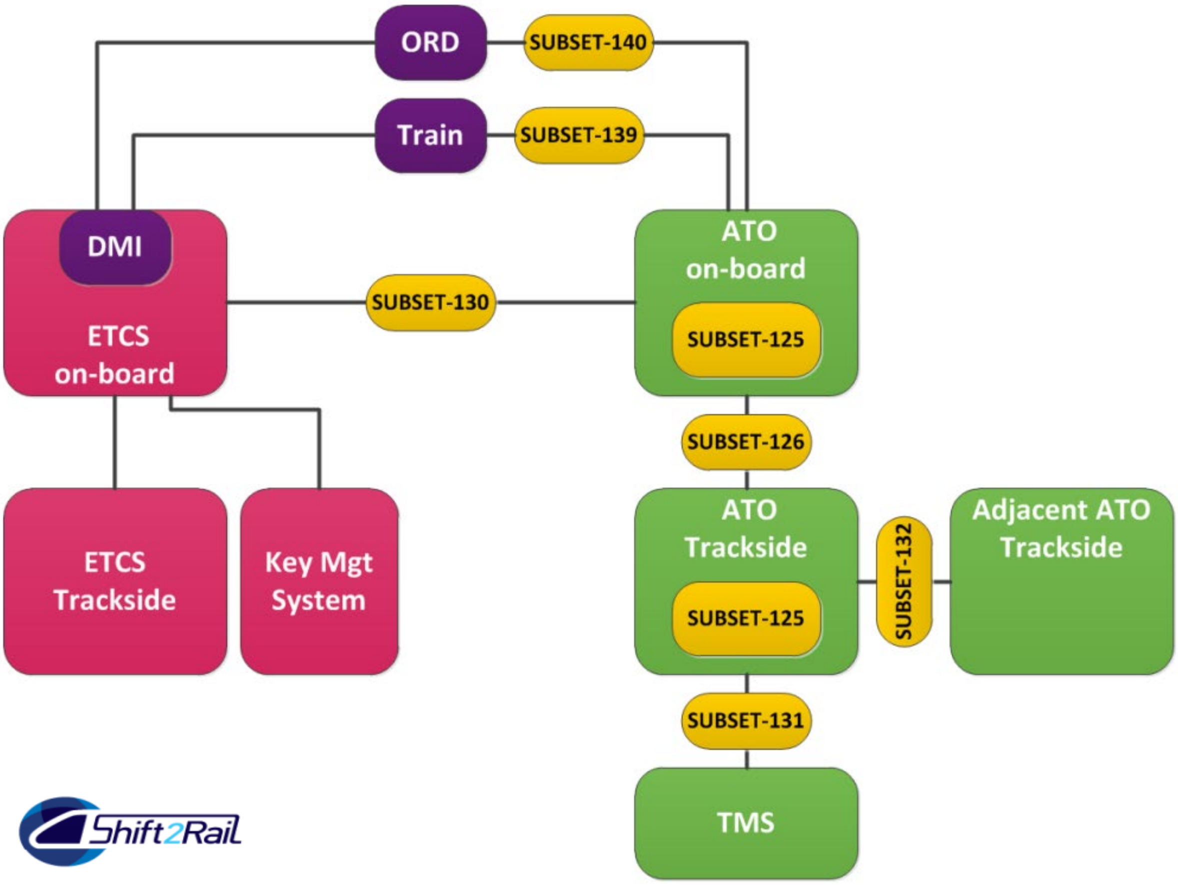


Figure 3: ETCS and ATO connections (with TSI subset numbers included where the system or interface is defined). Courtesy of Shift2Rail. Key Mgt = Key Management. DMI = Driver Machine Interface. ORD = On-board Recording Unit. TMS = Traffic Management System.

In this configuration, Traffic Management is only providing the schedule information directly to the ATO Trackside – at time of writing, it is unknown if it is intended to pass this information via LINX. Whilst a Crew and Stock system could provide schedule information to the ATO system (imitating Traffic Management), it appears likely that at an area with ETCS fitted would also have Traffic Management also installed – aligning with current GB policy.

The ATO on-board would be aware of what the train configuration is and as such could populate some of the ETCS 'start of mission' information itself (e.g. how long is the train etc.). If so, this reinforces the finding in Section 5.2 to not pursue a direct link between Crew and Stock Systems and ETCS – the ATO system can populate the information instead. This does raise the question of whether there would be benefit in connecting ATO to the Crew and Stock System – however, due to time constraints, this was not considered by the group and may form part of future work.

Key Finding:

Critical to the deployment of several digital systems, including DAS, ATO, ETCS, Traffic Management and Crew and Stock Systems, is a National Infrastructure Model which is easily accessible to IMs and RUs. Each of the systems are reliant on consistent spatial and geographic information and as deployments of the systems draws closer, there is a pressing need for this model to be available in the short-term.

5.4 Incident Management Systems (IMS):

Network Rail have highlighted that the Incident Management Systems (IMS) they are procuring nationally has the following elements:

- Integrates functions currently performed by disparate / isolated existing systems into a single efficient interface.
- Provides much richer data to improve quality of decision and workflow support for Incident Controllers and response staff on the ground. Includes the use of GPS data and visualisation.
- Automates logging and communication processes, removing duplication, non-value adding admin tasks and speeding up initial stages of responding to an incident.
- Provides a more accurate 'Common Operational Picture' to all stakeholders, both in real-time and post-incident for analysis and learning. Provides estimates on incident durations based on previous similar situations.
- Delivers a strategic platform that can be rolled out nationally.

Whilst the system would mostly interface with other Network Rail systems (including Traffic Management), the group considered whether there is information that the system could usefully provide to Crew and Stock Systems.

IMS could provide information around positions/extent of line blocks, possessions etc. as well as predicted timescales for blockages/incidents, however, the consensus of the Task and Finish Group is that the Crew and Stock System should take this information from the Traffic Management system. It is planned for Traffic Management to publish LINX messages regarding:

- Emergency and Temporary Speed Restrictions
- Asset Status
- Emergency Possessions
- Possessions (Actuals)

Should the Crew and Stock System subscribe to these messages from Traffic Management, the RU can plan to the same spatial and temporal extent as the IM – whilst also being further aware of forthcoming possessions when planning trains (e.g. VSTPs around possessions). For areas which are not covered by Traffic Management systems, the RU could decide to subscribe to the IMS LINX messages directly – however, the national position would be to receive the information via Traffic Management.

It is noted that at the time of writing, only one area of Network Rail's infrastructure is trialling an IMS system developed by one specific supplier – any national rollout of IMSs is still to be defined. Similarly, the content above only considers interactions with Network Rail systems – other infrastructure managers may choose to develop and manage IMSs in a different manner.

6 Legacy File and Data Formats:

6.1 Format Changes:

The Concept of Operations highlights the following regarding legacy file and data formats:

9.1.12 Current industry procedures and data transfers between the RU and IM are reliant on legacy file formats – for instance, the transfer of timetable and schedule data. Allowances need to be made for new file formats or the current standard modernised. This may require defining a new, industry agreed file format based on what the RU can provide and the IM requires. Support must also be given to new or impending standards or information, such as ETCS compliant driver and service IDs.

From the conclusions drawn in this report, work may be required to understand if current file formats can accommodate what we may require of them in the future – if the changes are small, it may be cost effective to utilise an adapted legacy format.

However, it is the opinion of the group that the industry needs to focus on moving to new formats rather than trying to improve old ones. The new formats should be extensible and self-describing (e.g. XML [Extensible Markup Language], JSON [JavaScript Object Notation] or APIs [Application Programming Interfaces]), allowing maximum flexibility and the possibility to add additional information to the format at a later date. LINX itself uses XML, including for messages between itself and systems such as TRUST, and has become a widely used format in many IT applications and other industries beyond rail.

The group agreed that there should be a standard set of formats set out at a national level for the data transfer between Crew and Stock Systems and Traffic Management with:

- an appropriate change control process that is not overly bureaucratic and not expensive or time consuming to make changes / additions – to encourage innovation.
- a definition of minimum information to be shared between IMs and RUs – this report helps define the initial stages of this.
- a definition of minimum data to be included within each message(s).

This benefits the industry as each RU and IM are working to the same set of standards and each have the same expectation of each other. Any costs for the development of new messages can be shared and reduced via economies of scale.

These findings also align with the Joint Rail Data Action Plan published by Government in 2018 for a "data enabled transport system" focussed around subjects such as "data transparency, data use and access, data standards and quality". As part of this, it is intended to:

- Agree a definition of commercially sensitive data which will not be made available via open data sources.
- Define which systems hold which data (Data Catalogue) including a list of all rail datasets and information assets and systems as well as owners and licencing information. To support this, "Network Rail, RDG and the RSSB will create a 'single point of entry' for Rail Delivery Group's and Network Rail's Open Data Portals".
- Develop a common data model and architecture for the UK railway. This is to address the lack of clarity in the industry around which data publishing standards should be adopted, particularly around standards that support multi-modal journey planning.

The action plan also notes several of the constraints highlighted within this report – for instance, "the industry is littered with legacy rail systems which are locked down, due to the age, functionality or costs associated with suppliers updating systems to export data files".

The Task and Finish Group recommends that RDG and group members further engage with the Joint Rail Data Action Plan Taskforce and the RSSB's Data and Information System Interface Committee (DISIC) to:

- highlight the work undertaken on Crew and Stock Systems to date,
- consider where there is cross-over and alignment,
- contribute to the Taskforce outputs, where appropriate, including supporting the migration to more modern file and data formats.

From a LINX perspective, whilst the findings in this report describe the kinds of LINX messages that may be required, a more detailed analysis is required to determine, for example, message 'payloads' and the amount of information to be passed across. The Concept of Operations can be used to determine what information is held by the Crew and Stock System and it may be a simple initial exercise to highlight which information it would be useful for the RU to publish to LINX (and similarly what Traffic Management would need to subscribe to). This could form the basis of potential messages. Fundamentally, information most useful to Traffic Management concerns: associations, restrictions/delays and RU requests to alter a service. Information needed around crew and stock is limited, although this may change in the longer term.

Until new formats are introduced, legacy file and data formats will still need to be supported, maintained and available until a point when the industry no longer requires them. As an interim solution, it may be possible to continue using the legacy format(s) but also provide a secondary file/data packet to enrich the original information. For instance, the Common Interface File (CIF) containing the agreed timetable could be enriched with another file when imported into the Crew and Stock system to add information that is currently not supported in the CIF itself. In the medium to long term, a national strategy for migration away from legacy formats will likely be required – a first stage of this activity would be to determine which specific formats to target. Ownership of this may fall to the Data and Information Systems Interface Committee (DI-SIC) or Joint Rail Data Action Plan Taskforce, although this has not been fully studied at time of writing. This will be discussed during engagement with the groups (noted above).

6.2 Crew and Stock System Uptake:

To be able to utilise newer formats and provide information that LINX / Traffic Management requires to enable wider benefits to the industry, there must first be uptake of Crew and Stock Systems amongst RUs. Whilst the Department for Transport (DfT) specifying "Crew and Stock Systems that can interact with Traffic Management" in franchise specifications has helped, there are no guarantee that this will be included in every future specification. Similarly, current franchises may already be tied to an existing system until the end of the current franchise which may be several years away – it is unlikely that a new system would be deployed for these franchises until they are renewed. (It is noted that deployment of a system across an Owning Group, which runs several franchises, may mitigate this). These challenges are compounded by the current stall in franchise renewals which await the outcome of the Williams Review. In the absence of additional funding, the wider roll-out of Crew and Stock Systems appears challenging at this time.

To help alleviate some funding concerns, the group suggests that increasing competition in, and introducing new companies to, the Crew and Stock System market can help bring costs down. Over the last 2 years and since the publication of the Concept of Operations, new suppliers have been entering the GB market and competition has increased – the industry needs to continue encouraging this.

6.3 Enablers and Wider Industry Changes:

The roll-out of Traffic Management has highlighted that current timetable and information from train planning does not provide enough granular detail to fully describe services / train paths – e.g. use of split platforms. Furthermore, there is a need to define, as an industry, truly unique service identifiers so that systems can always identify a specific service – it is believed that this should be defined at the train planning stage. The level of detail required by Traffic Management and unique IDs would also be of benefit to the 'Control' aspects of a Crew and Stock System, particularly where the systems are supporting each other to assess a service/path change requests. Modern Crew and Stock Systems with train planning elements may well be able to provide this level of detail, however, without changes to the Train Planning Rules mandating that this, there is no impetus / facility to provide this information.

Key Finding:

To support the roll-out of Traffic Management, C-DAS and Crew and Stock Systems, it is critical that the outputs of the timetabling process deliver the granularity that these systems require. Any changes required to the Train Planning Rules should be identified in earnest considering the timescales it would take to implement any alterations (and also have these reflected in any systems).

RUs already deploying Crew and Stock Systems highlight that it is difficult to release resources to test and develop systems / new processes, particularly in Control. This highlights the leanness of today's current operations and touches on a wider issue around the number of highly skilled Controllers – in some cases, it has meant that system testing has been hindered. There may be a case for a pool of Controllers / Subject Matter Experts / Super Users that are shared between operators and centrally funded (similar to RDG/RSSB). This would help move systems forward and operators that are using the same supplier can benefit that the testing only needs to be done once, rather than two companies trying to work on the same problem in parallel.

At the point of system deployment, RUs also highlight that Crew and Stock Systems cannot just be added to Business as Usual operations– training and development is required which will entail extra resources (time, money and people). As highlighted in the Concept of Operations:

> *…a loss of users' trust or faith in the system can undermine its efficacy and the benefits. This can result in, for example, staff returning to older systems/methodologies or using pen and paper. For the system to be successful, it needs to maintain trust from the initial outset, and increase convenience, whether through an increase in efficiency or quickening of current tasks, lessening the chance of staff not using it. [Clause 9.1.3]*

As such, the transition from current methods to the Crew and Stock System is a critically important time. The group highlights that the size of this task should not be underestimated and that organisations need to be willing to add extra resources to the deployment project if the system is to be successful – this lesson is equally true for the deployment of Traffic Management. As an example, one of the critical aspects of the Crew and Stock System is that data should always be up-to-date – if current practices see, for instance, stock allocations updated hours or days after the fact, changing the mindset of users to update information in real-time can be a substantial task. This also emphasises another of the key aspects of Crew and Stock Systems – it must be intuitive, and the user should be able to update information quickly, easily and efficiently.

7 Findings:

- The catalogue of messages that can be exchanged between systems is not mature at this stage and requires more development and detailed work. The Group has helped define what messages need attention from a Crew and Stock System perspective. There should be a consistent approach in relation to what data goes to which system to ensure a level to consistency for RUs.
- Rather than developing legacy file and data formats, the industry needs to move to more modern, extensible and self-describing formats (e.g. XML, JSON) and APIs (Application Programming Interfaces). This aligns with Joint Rail Data Action Plan. In the medium to long term, a national strategy for migration away from legacy file formats will likely be required – a first stage of this activity would be to determine which specific formats to target.
- Standard message formats are of benefit to the industry. It helps for all RUs to be coordinated, particularly if new messages have development cost associated – economies of scale.
- Planning coordination between Traffic Management systems is not mature – this is a particular concern for operators crossing multiple Traffic Management (TM) boundaries where the TM functionalities can be different. A National Planning Layer may be required.
- The need for a National Geography Model, which is common across IM and RU systems, is becoming more pressing.
- To support the roll-out of Traffic Management, C-DAS and Crew and Stock Systems, it is critical that the outputs of the timetabling process deliver the granularity that these systems require.
- It is difficult to release resources to test systems / new processes, particularly in Control. There may be a case for a pool of Controllers / SMEs that are shared between operators.
- Developing direct links from ETCS to Crew and Stock Systems is not recommended for future work at this time. There may be a case for a connection between Automatic Train Operation systems and Crew and Stock systems, but this will require further detailed investigation.
- C-DAS systems should be procured 'LINX message ready' so that it may take information inputs from multiple systems including Traffic Management and Crew and Stock Systems. The RU can design which system it wants the C-DAS trackside to subscribe to.
- Incident Management Systems (IMS) could provide information around positions/extent of line blocks, possessions etc. as well as predicted timescales for blockages/incidents, however, the consensus of the Task and Finish Group is that the Crew and Stock System should take this information from Traffic Management.

8 Proposed Actions and Future Risks:

Each of the Findings above have linked Proposed Action(s) or Future Risk(s) summarised in the tables below. These have been organised into 4 separate groupings: 'group finalisation', 'LINX message development', 'wider enablers' and 'other'. Each row is highlighted as either an 'action' or 'risk' and have assigned owners where applicable.

Group Finalisation:

Comment	Action or Risk	Owner (if applicable)
Update Crew and Stock Concept of Operations with findings from the group and Process Maps.	Action	RDG
Run industry consultation to endorse changes made to the Crew and Stock Concept of Operations.	Action	RDG
Reissue Crew and Stock Concept of Operations on RDG website.	Action	RDG

Raise awareness of group's findings and proposed actions at wider governance groups and organisations. It has been identified that further engagement may be required with: other Infrastructure Managers, Freight Operators, suppliers and the Department for Transport. Engagement is also required with the RSSB's Data and Information System Interface Committee (DISIC).	Action	RDG and Group Members

LINX Message Development:

Comment	Action or Risk	Owner (if applicable)
The industry risks spending a significant amount of money developing and deploying new systems (e.g. Traffic Management, Crew and Stock Systems, Driver Advisory Systems etc.) that do not communicate with each other and undermines overall benefits.	Risk	N/A
The group have identified the LINX messaging "gap" at a strategic level from an "interactions between Traffic Management and Crew and Stock System" perspective. Further work is required to add definition to the messages; adding detail to the strategic plan.	Risk	N/A
Proposed mitigations to risks – Steps 1 to 5		
Step 1: A group of experts to consider the 'next level of detail', determining message payloads (i.e. decisions around what data to include in each message - this does not include message creation) This requires: • Determination of costs (i.e. group facilitation) • Determination of timescales • Determination of resources required (e.g. level of expertise, supplier involvement) A group of experts to also consider: • "Size of the prize" (delay minutes, costs etc.). Determine delay attribution codes that may be applicable • Potential savings with a Crew and Stock System linked with Traffic Management (not just Crew and Stock System on its own). May be based on percentage of "size of the prize". • Worked example(s) for previous incident(s)	Action	RDG
Step 2: A group of experts to determine <u>indicative</u> costs for the creation of the new LINX messages and alteration of others. Dependent on Step 1. This requires: • Determination of costs (based on previous message development costs, similarity to current LINX messages / European Standards). • Determine timescales for creation and development. • Determine resources required. Who should develop the messages? (e.g. Network Rail (NR), Supplier etc.)	Action	RDG/NR/DR
Step 3: A group of experts to create Business Case for LINX message creation (i.e. is the cost of developing the messages worth it?). This could include: • Savings vs costs (BCR) – as determine in Step 1.	Action	RDG/NR/DR

• Indicative forward timescales for deployment. • Potential end users / trial deployments. This could determine a sponsor / recipient. • Possible funding streams. • Suggested Ownership / Governance. • Who develops the messages.		
Step 4: Funder and developer (as determined in Step 3) create messages	Action	Funder & Developer
Step 5: RSSB create Rail Industry Standard (RIS) to document the message and how they are used – ensuring that all RUs and IMs follow the same standard. This requires: • Determining the sponsor – this could be RDG. • Determine accountable governance group. An RDG Approved Code of Practice could be produced as more immediate, interim standard to help coordination in the short term	Action	RSSB/RDG

Wider Enablers:

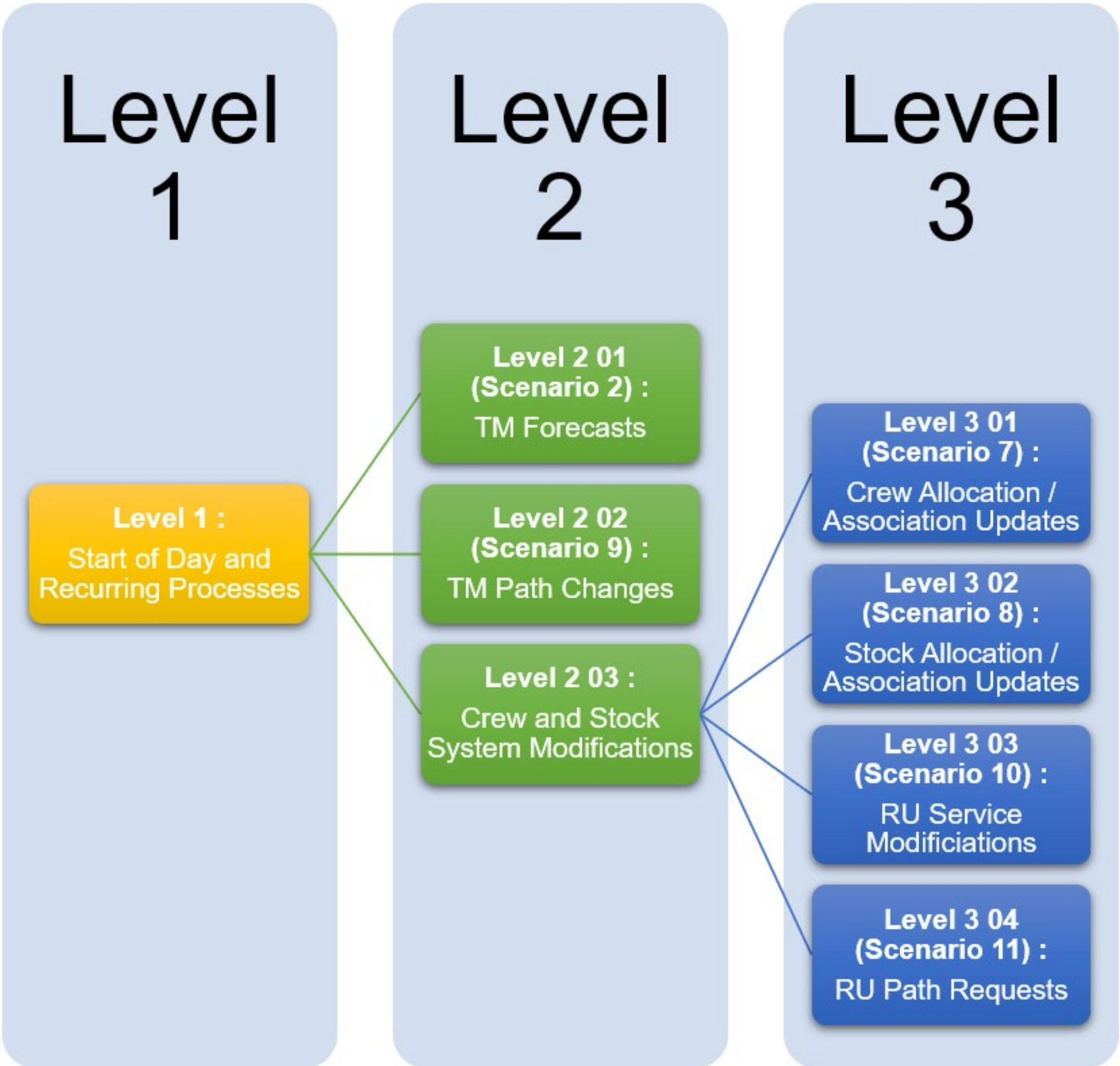
Comment	Action or Risk	Owner (if applicable)
Planning coordination between Traffic Management systems is not mature – this is a particular concern for operators crossing multiple Traffic Management (TM) boundaries where the TM functionalities can be different. A National Planning Layer may be required.	Risk	N/A
The need for a National Geography Model, which is common across IM and RU systems, is becoming more pressing.	Risk	N/A
To support the roll-out of Traffic Management, C-DAS and Crew and Stock Systems, it is critical that the outputs of the timetabling process deliver the granularity that these systems require.	Risk	N/A
In the medium to long term, a national strategy for migration away from legacy file formats will likely be required – a first stage of this activity would be to determine which specific formats to target.	Risk	N/A

Other:

Comment	Action or Risk	Owner (if applicable)
There may be a case for a connection between Automatic Train Operation systems and Crew and Stock systems, but this will require further detailed investigation. This may fall into the scope for the proposed Digital Railway System Authority 'Guiding Mind' groups which specifically look at system interfaces. RDG to raise at the group with actions assigned to group as appropriate.	Action	RDG/NR/DR
It is difficult to release resources to test systems / new processes, particularly in Control.	Risk	N/A

A1 Appendix 1: Interactions with Traffic Management - Process Maps:

8 process maps follow and correspond as such:



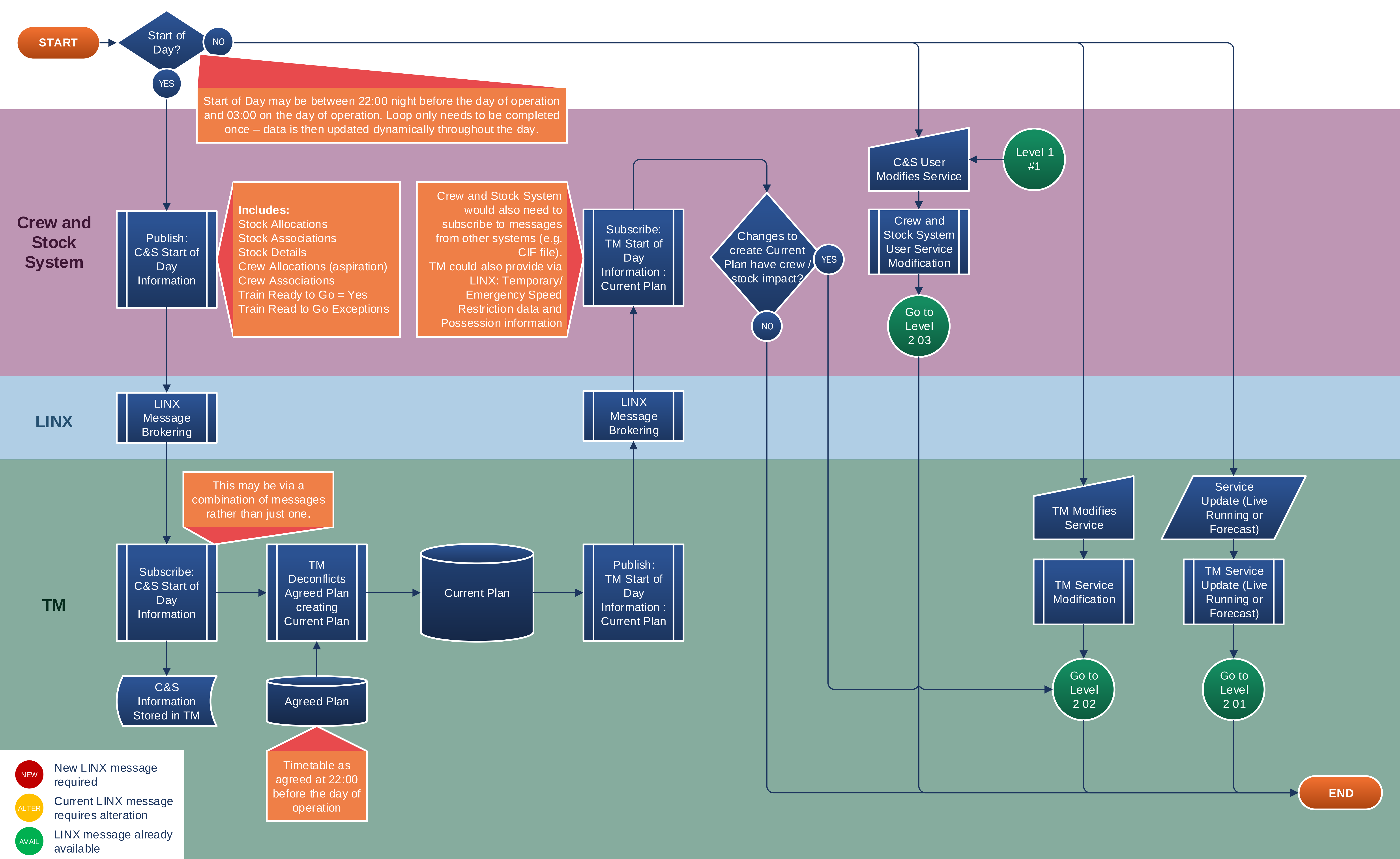
Crew and Stock Systems: Task and Finish Group

Traffic Management Interactions: Process Mapping

Level 1: Start of Day and Reoccurring Processes

Inbound Map(s): 2 02 | 2 03 | 3 04

Outbound Map(s): 2 01 | 2 02 | 2 03



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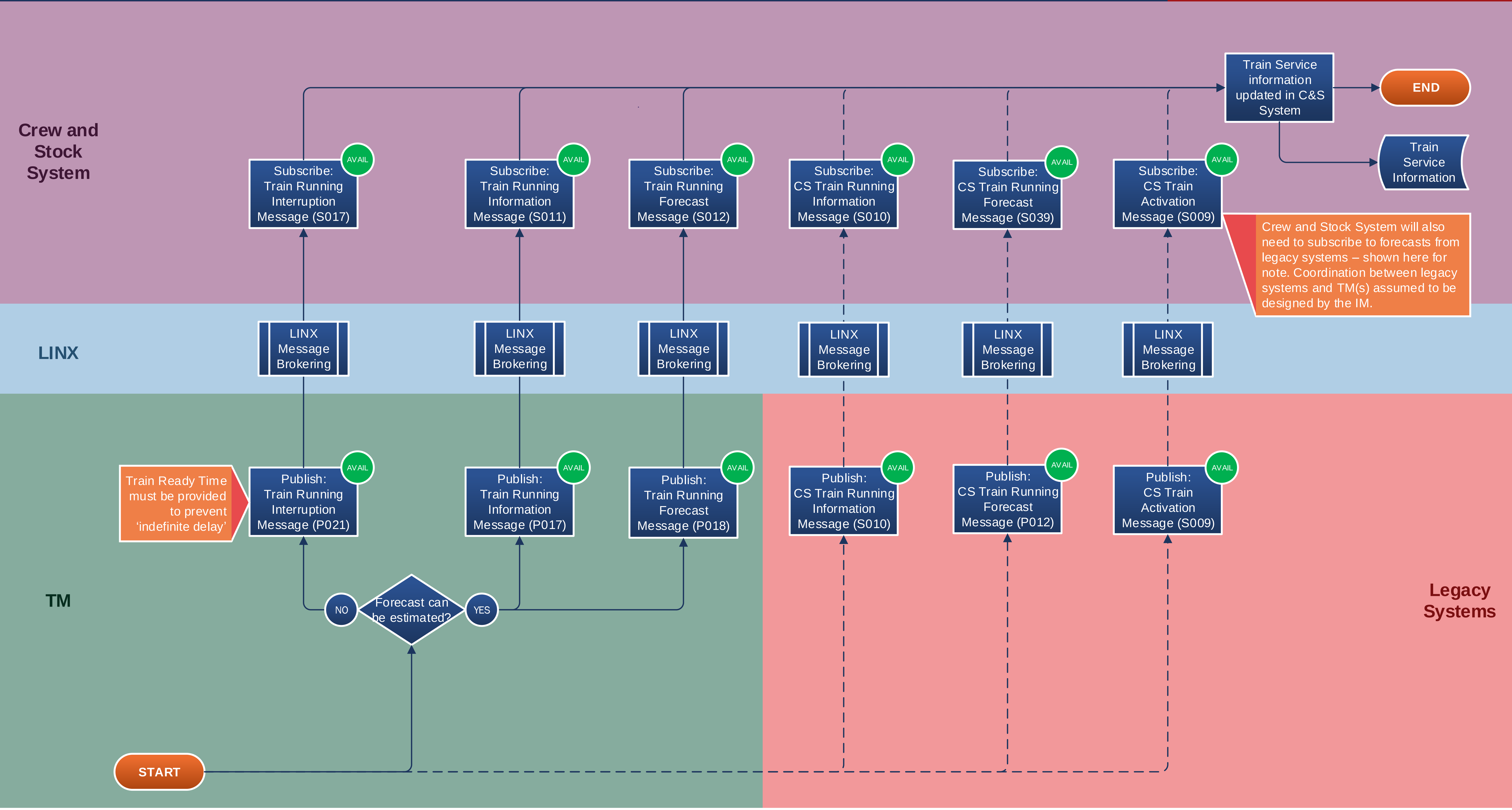
Crew and Stock Systems: Task and Finish Group

Traffic Management Interactions: Process Mapping

Level 2 01 : Forecasts from TM to C&S System

Inbound Map(s): 1, 2 02, 3 03, 3 04

Outbound Map(s): None



NEW — New LINX message required

ALTER — Current LINX message requires alteration

AVAIL — LINX message already available

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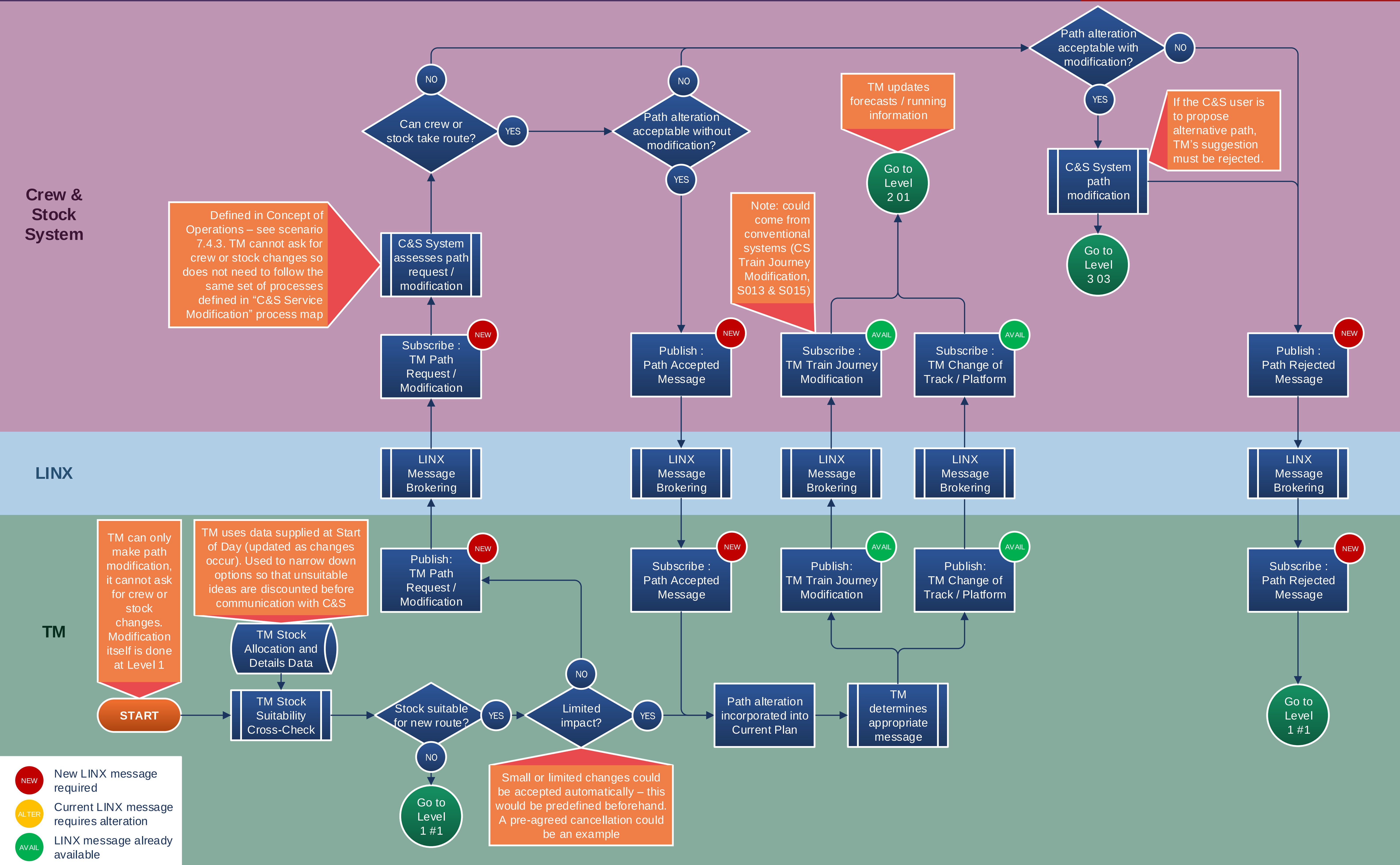
Crew and Stock Systems: Task and Finish Group

Traffic Management Interactions: Process Mapping

Level 2 02 : TM Path Changes

Inbound Map(s): 1

Outbound Map(s): 1, 2 01, 3 03



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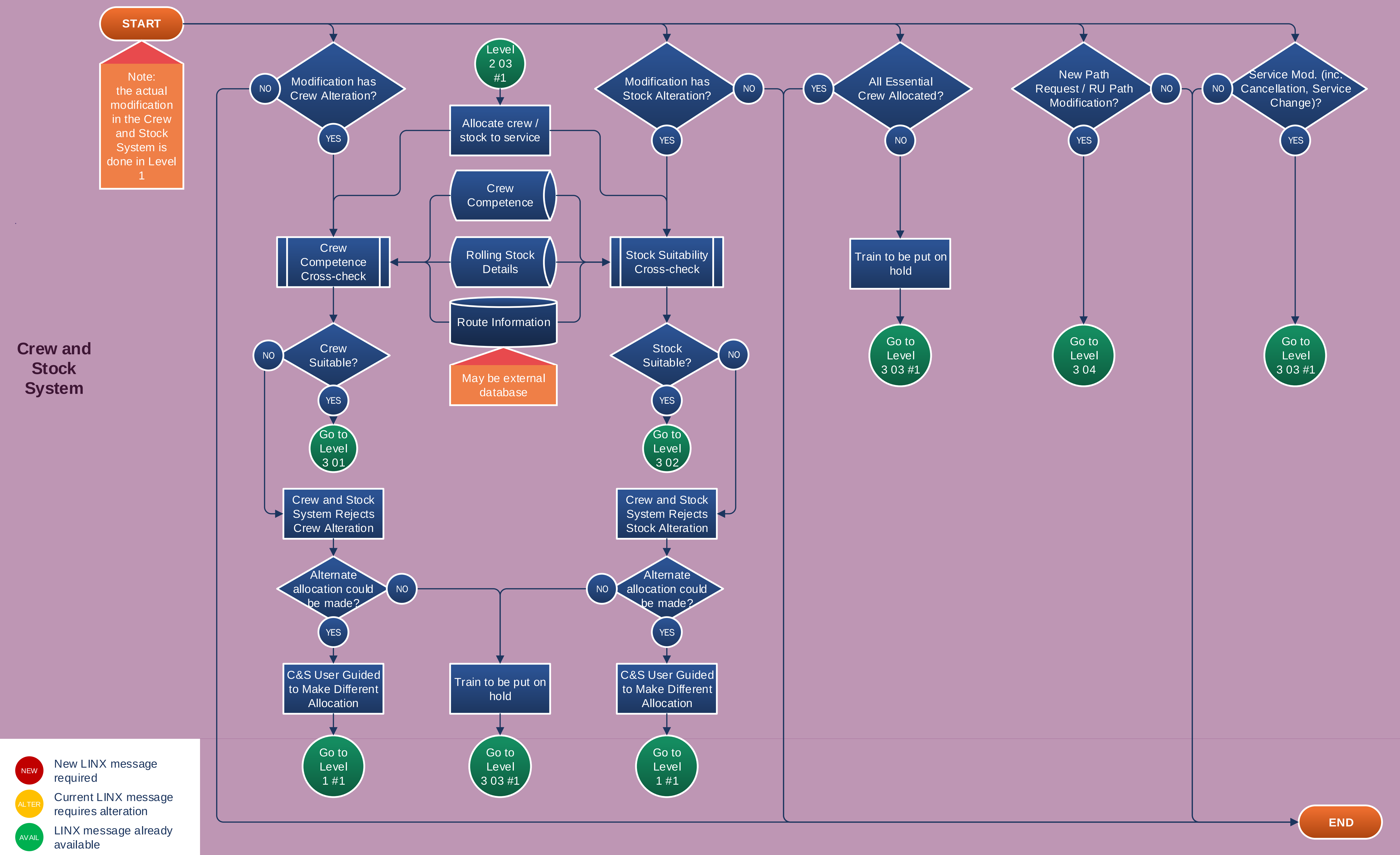
Crew and Stock Systems: Task and Finish Group

Traffic Management Interactions: Process Mapping

Level 2 03: Crew and Stock System Modification

Inbound Map(s): 1, 3 04

Outbound Map(s): 1, 3 01, 3 02, 3 03, 3 04



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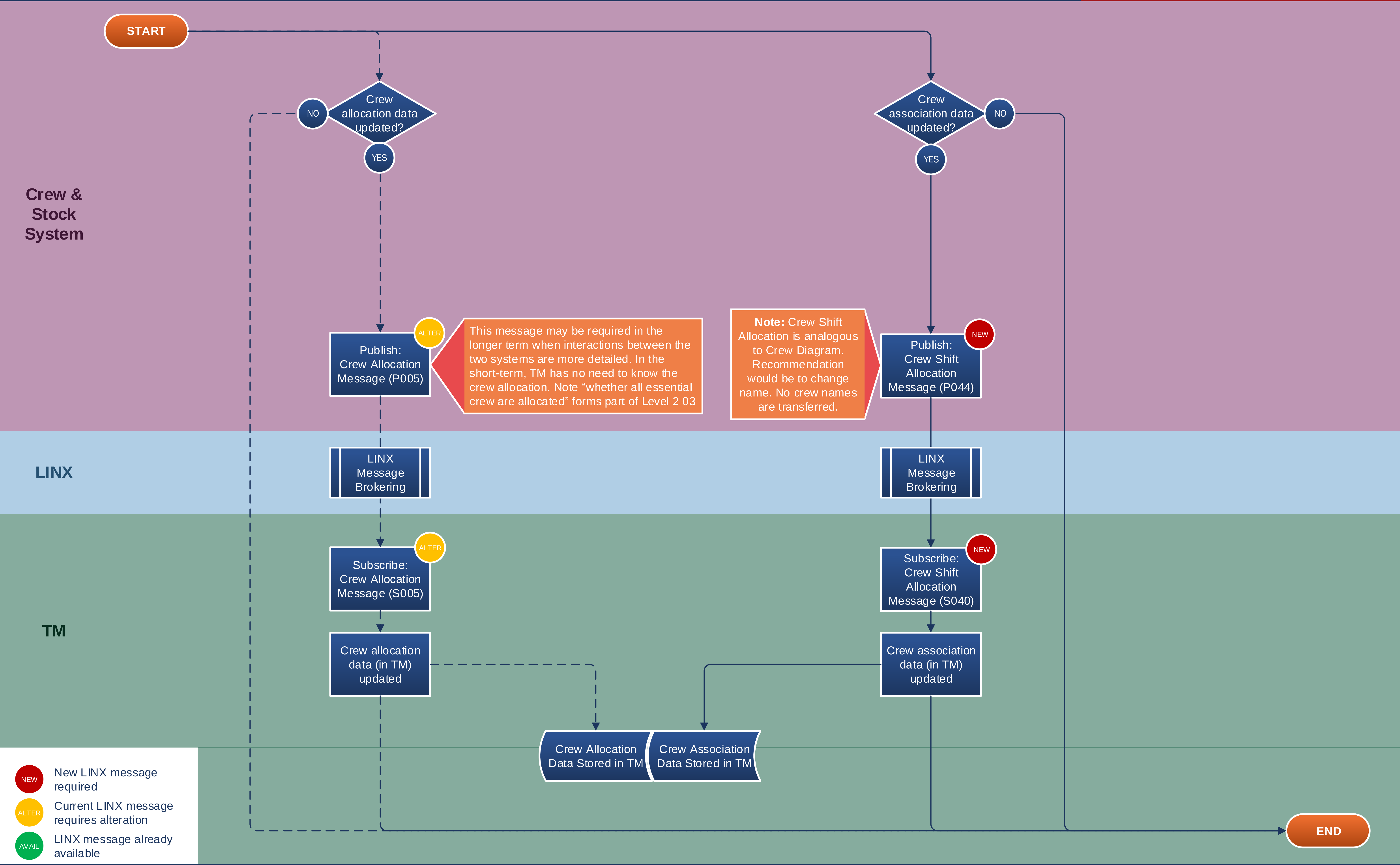
Crew and Stock Systems: Task and Finish Group

Traffic Management Interactions: Process Mapping

Level 3 01 : Crew Allocation / Association update from C&S to TM

Inbound Map(s): 2 03

Outbound Map(s): None



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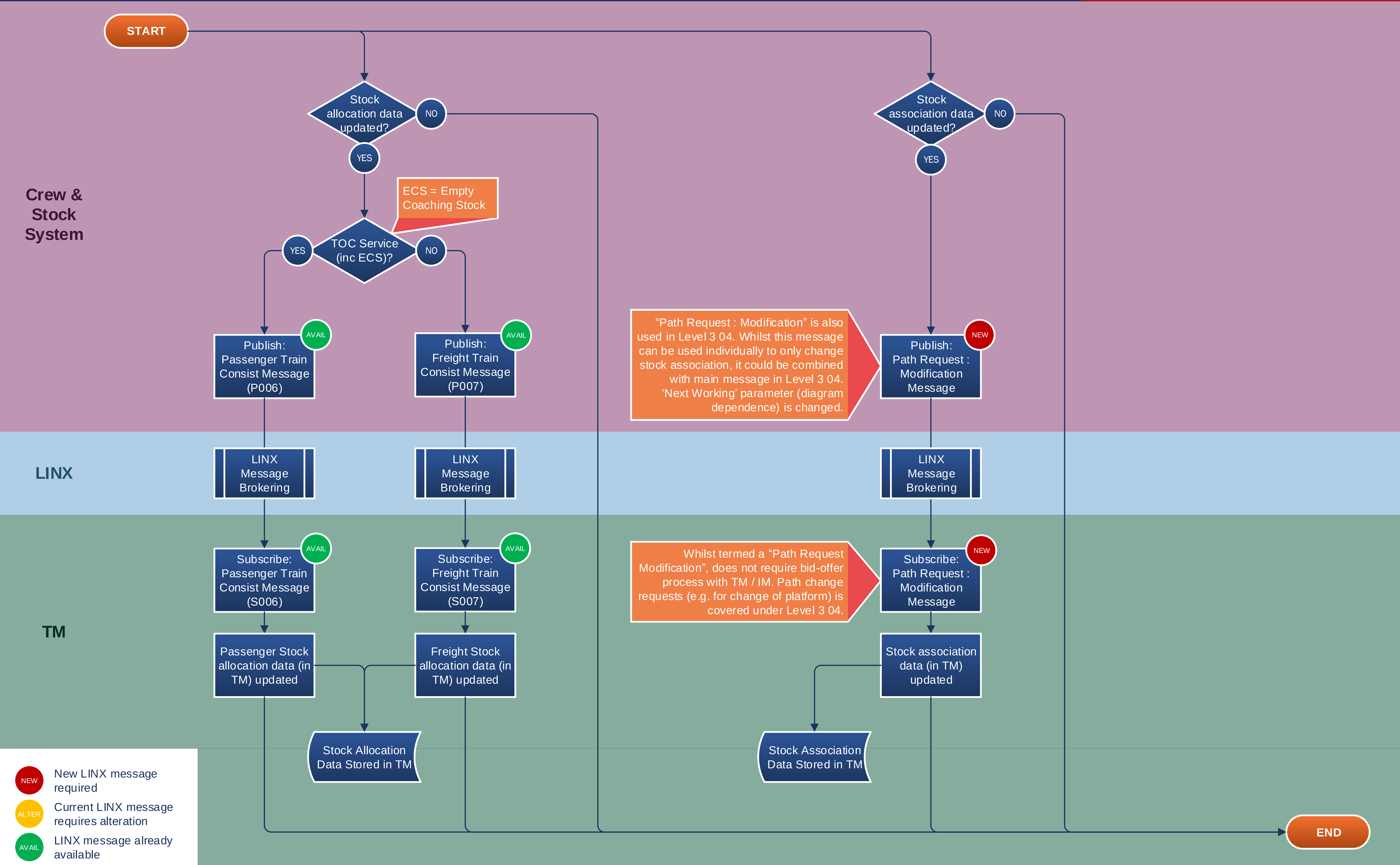
Crew and Stock Systems: Task and Finish Group

Traffic Management Interactions: Process Mapping

Level 3 02 : Stock Allocation / Association update from C&S to TM

Inbound Map(s): 2 03

Outbound Map(s): None



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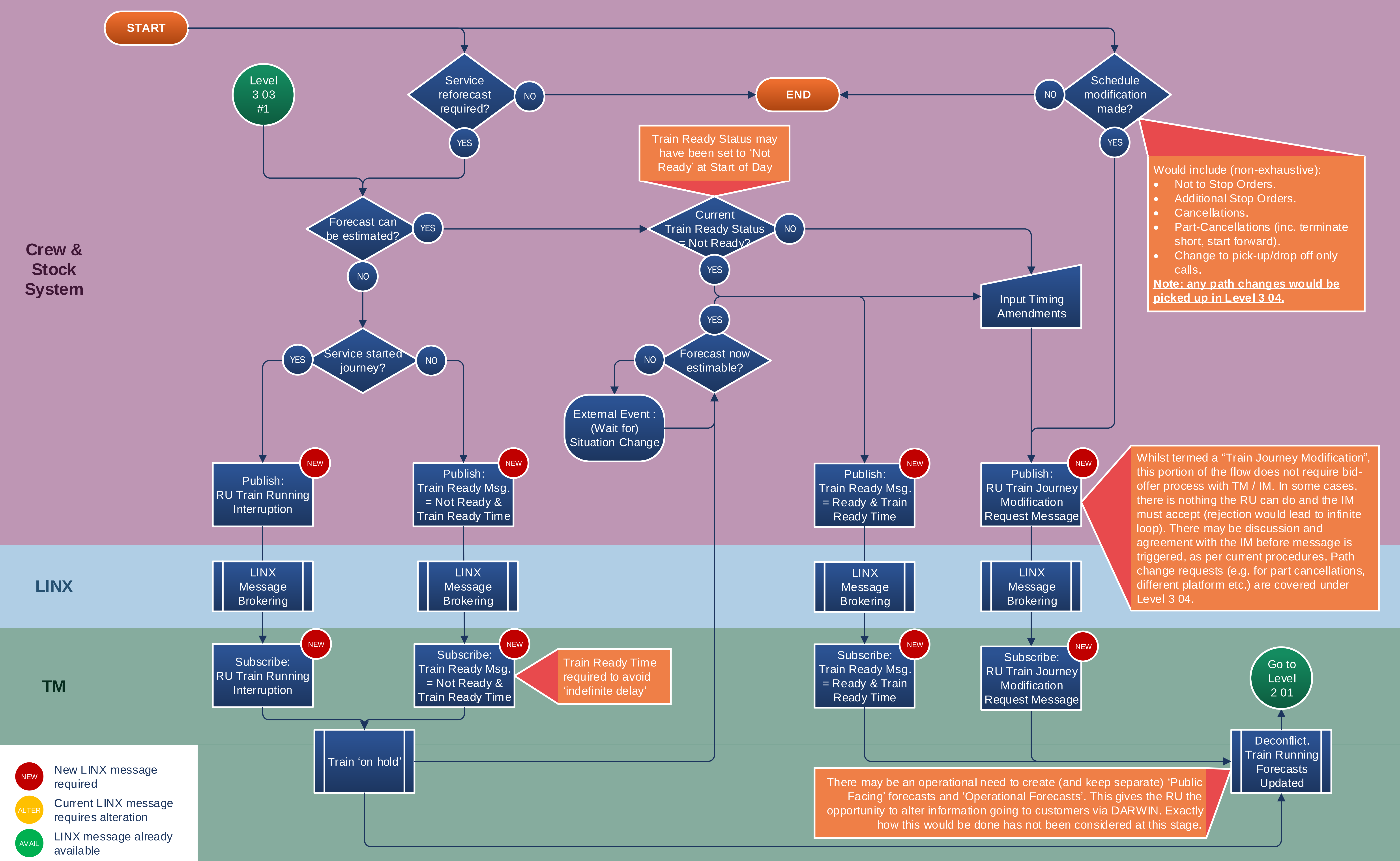
Crew and Stock Systems: Task and Finish Group

Traffic Management Interactions: Process Mapping

Level 3 03 : RU Service Modification

Inbound Map(s): 2 02 2 03

Outbound Map(s): 2 01



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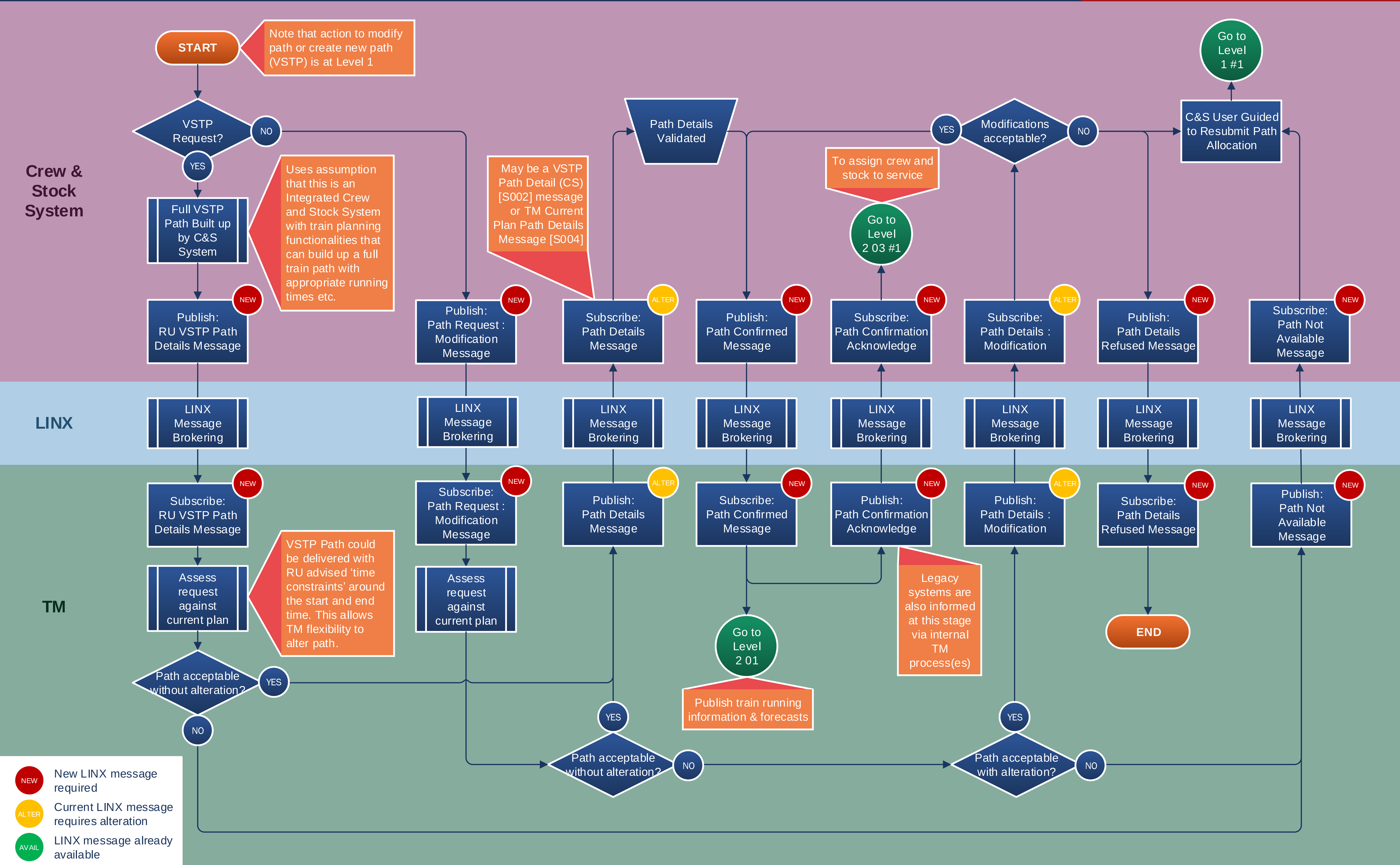
Crew and Stock Systems: Task and Finish Group

Traffic Management Interactions: Process Mapping

Level 3 04 : RU Path Request

Inbound Map(s): 2 03

Outbound Map(s): 1, 2 01, 2 03



Crew and Stock Systems: Task and Finish Group

Traffic Management Interactions: Process Mapping

Symbol Index

START / END	Terminators (START and END)
Off page reference	Off-page reference / link **or** Inbound link on map (defined by previous step)
Process	Process
Predefined Process	Predefined Process (although may not be defined as part of the Process Mapping exercise)
Decision (YES / NO)	Decision required (YES or NO)
Data Stored	Data is stored within system for later use
Stored Data Accessed	Data stored within system is accessed
Database	Large database of information (may be external to system)
Manual Input	Manual input by system user required
Data Input	Data input required by system
Manual Operation	Manual operation must be undertaken by system user
External Event	External Event not controlled by the system or user
NEW	New LINX message required
ALTER	Current LINX message requires alteration
AVAIL	LINX message already available