Terminal Automation System

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***Abstract*— Terminal Automation System (TAS) provided by renowned automation vendors is installed to automate the field operations and is interfaced with its commercial ERP systems like SAP. Prior to SAP, IndianOil used TDM for commercial billing and stock accounting. The earlier interface with TAS was a socket-based interface. This entailed setting up of a middleware server which used to act as an interface / gateway between SAP and TAS.**

***Index Terms*— Terminal Automation System (TAS)**

I. INTRODUCTION

The current document outlines the procedure for a direct interface between TAS and SAP.
Vendors have to provide a 'Direct Interface' between SAP and their Terminal Automation System (TAS). Henceforth, there will not be any middleware server. The functionality of the middleware / interface server has to be incorporated by the LRC software itself. There will be a direct connectivity between SAP and TAS / LRC using RFC.
However, socket-based interface should also exist to take of disaster scenario, when SAP would not be available. In case of a disaster, SAP-enabled TDM will be used for sending information for filling of tank-truck, tank-wagon etc. This interface will be called 'TDM Interface'.
Hence, it is necessary that LRC software should have provision to take care of both Direct as well as TDM interface.

Terminal Automation System (TAS)
TAS consists of Loading Rack Computer systems (LRCS), Operator Interface Computers (OIC), Programmable Logic Controllers (PLC), Batch Controller Units (BUC), and Access Control Devices (ACD).
Automation vendors provide interface solution as part of TAS covering the following areas.

a) Tank Truck automation. Truck filling is volumetric as well as gravimetric. It is thru Loading Rack Computer Systems (LRCS). Control room houses the LRC computers, TTES (Tank Truck Entry System), Swipe / Proximity card readers, OIC (Operator Interface Consoles). Communication is through RFC. It is an online interface.

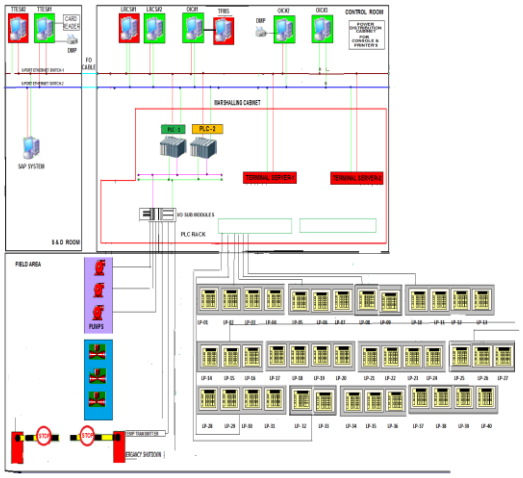
b) Tank Farm automation. Online tank farm inventory data is obtained through the TFMS (Tank Farm Management System) system. Product levels and alarms are seen on the screen. It is an online interface.

c) Tank Wagon automation. TWES (Tank Wagon Entry System) is used to prepare the loading memo, forwarding note file and rake information. Masters of rake are maintained in the system. TankWagon automation is online interface based on RFC / BSD sockets.

d) Weigh-bridge. The weighbridge is used to take the weight of empty truck (Unladen-weight / Tareweight) and the gross weight of the truck after product has been loaded (Registered Laden Weight). Online data after truck is weighed is obtained on a workstation. It is an online interface.

The above automation systems should be integrated together, with the LRC computer being the main system, where all the information is available. These should not operate in isolation. Rather, these should be tightly interfaced with LRCS System.
LRC computer will be single point of communication with commercial systems like SAP for getting data pertaining to Tank-Truck, Tank-Farm, Tank-Wagon and Weigh-Bridge.

II. SYSTEM ARCHITECTURE



Whole Plant Is Controlled By PLC PANELS and This SYSTEM ARCHTECH. Explains the whole Controlling System.

III. MAJOR PARTS OF AN AUTOMATION SYSTEM

- Lrcs-load rack computer system
- Plc-programmable logic controller
- Ttes- tank truck entry system
- Oic-operator interface console
- Ts-terminal server
- Field equipments(accuload, proximity card reader, barrier gate, bqd, flow metering system)

IV. LRCS(LOAD RACK COMPUTER SYSTEM)

- Heart of automation system
- Serving to all client PC
- backend database(Oracle 10g) for truck event recording
- SCADA (Indusoft) for auto operation of pump, RIT, barrier gates
- Front end Visual C++ programming for smooth operation
- Windows Server 2003R2-Operating system Designed with redundant purpose.

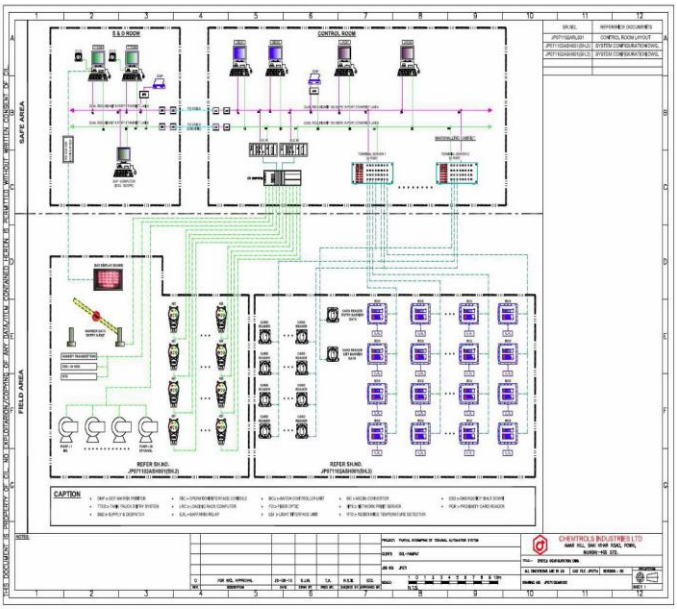
V. PLC-PROGRAMMABLE LOGIC CONTROLLER

- Manufactured by GE Fanuc
- Dual redundant Processor
- Easley accessible from LAN network
- User friendly programming for any modification
- Simple logic to understand & operation
- Easy to replacement of any hardware failure
- Lots of spares parts available for future extensions

VI. PLC SPECIFICATION :-

- Programmable logic controller (PLC) shall be dual redundant hot standby PLC with dual processors and single I/O for all process DI & DO as specified.
- The CPU for PLC shall have minimum of 32-bit processor to enhance the processor speed.
- Programmable logic controller (PLC) system shall be programmable, modular microprocessor based safety system, which shall be used for implementation of safety shutdown / interlocks and terminal operation monitoring.
- The system shall be designed "fault avoidant'', as a minimum by selecting high-grade components of proven quality and proper design of system electronics. The system shall be highly reliable, highintegrity safety system on both qualitative and quantitative technologies. Redundancy shall be provided as a minimum, as per this specification to improve system availability, reliability and safety. Due consideration shall be given to the environmental conditions particularly for field mounted subsystems.
- The system shall be modular in construction and expandable in future by adding additional modules, which shall be easily accessible for maintenance and repair. The modules shall be suitable for inserting in 19'' rack / DIN rail mounting. The types of modules shall be kept to minimum possible in order to have interchangeability and low spares inventory.
- The PLC shall have very high noise immunity in order to ensure safe and reliable operation when subjected to electrical radio frequency interference and electro magnetic disturbances expected in a plant. The design of system electronics shall be in compliance with the electromagnetic compatibility requirements as per 'IEC-801-Electromagnetic compatibility for Industrial Process Measurement and Control Equipment'.

VII. SYSTEM CONFIGURATION



Communication Sub system :-

Redundancy in communication subsystem shall be as follows unless otherwise specified.

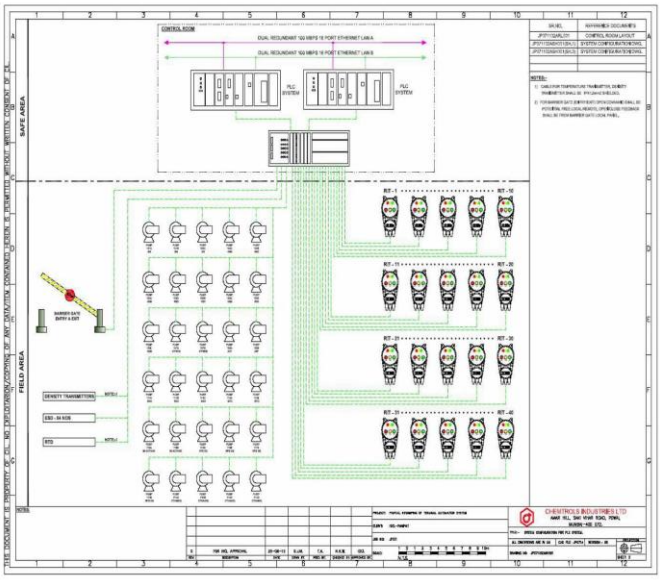
- The communication subsystem shall be a digital communication bus that provides reliable and highspeed data transfer between the processor subsystem & I/O subsystem.

a) Communication Interface between each I/O rack & the dual processor system shall be via separate dedicated dual

redundant communication link in multi-drop mode as a preferred choice

b) The communication interface between each processor subsystem and host LRC system shall be dual redundant TCP/IP communication, consisting of separate communication interface modules located in / from each individual processor rack and two individual communication links, with each one configured in redundant mode.

c) In case of redundant communication subsystem on the failure of the active device the redundant device shall take-over automatically without interrupting the system operation. Information about the failed device shall be displayed locally as well as on the console. It shall be possible to manually switchover the communication from main bus/device to redundant bus/device without interrupting the PLC functions. The mechanism used by the system for error checks and control shall be transparent to the application information/program. Error checking shall be done on all data transfers by suitable codes. All communication interfaces shall be galvanic ally or optically isolated.



Process of Integration

The first step in the process is that of user will be creating a shipment in SAP for filling of truck. SAP will then send data for filling of truck by making a direct call to the TAS vendor's program. Data is passed to TAS through Remote Function Calls (RFC). Vendor's system shall then post this data in LRC.

Complete information for filling of truck – material, quantity, customer, truck capacity and compartment details are passed to the Load Rack Computer System (LRCS), which in turn communicates with the Tank Truck Entry System (TTES), Tank Farm Management System (TFMS), batch-controllers, Programmable Logic Circuits (PLCs) and other field equipment.

After getting the truck information, TTES computer is used to authorize the truck. To authorize, Proximity card reader / Touch Key / Swipe Card is used to attach a unique key / card to the FAN. LRCS allocates bay for filling the truck depending on which product is to be filled.

Thereafter, Filling Advisory Notes (FANs) are printed thru TTES.

The truck driver takes the FAN and the card / touch-key to proceed to the loading gantry where actual loading is done. The card / touch-key is shown at the entry gate and then at the designated bay.

Filling bays are equipped with Remote Interaction Terminals (RITs) for controlling filling operations at the bay.

Electrical connections are made and hosepipe is connected to the truck compartment. The batch controller shows the quantity to be loaded for the compartment. Pressing 'start' button on the RIT starts filling the truck.

The status of truck changes to 'Loading' on the TTES screen.

Once loading is over for all compartments, sealing / weighing of truck is done. Thereafter, the status of the truck changes to 'Loaded & Sealed'.

Once the status is 'Loaded & Sealed', filled truck details are posted in SAP by TAS making a direct RFC call to SAP. LRC will post the data in SAP only when the truck status is 'Filled and sealed' instead of the existing polling mechanism. This will be done by function module given by IOC.

After invoice is printed for the truck in SAP, the 'gateopen' call is made to LRC and the exit-gate opens. Thereafter, the truck can exit the location's premises.

TFMS computer monitors the product stocks in location's tanks. Data regarding levels of products in tanks and alarms are obtained from LRC using the 'Reconcile-Inventory' function call, which is described in the next section.

Remote Function Call (RFC)

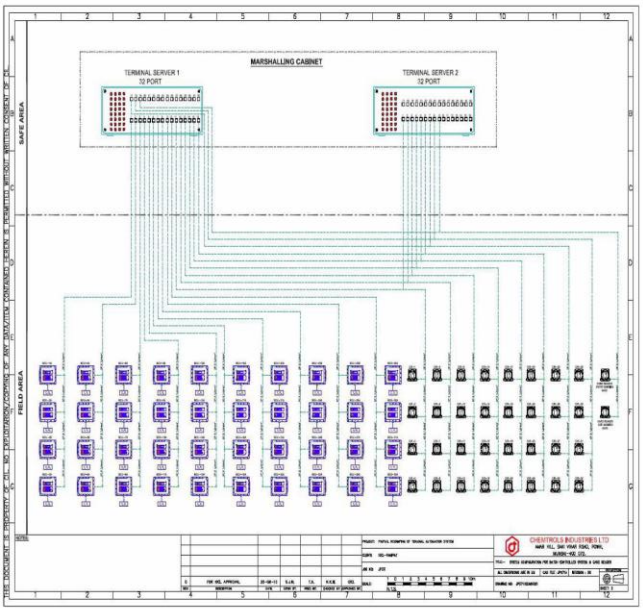
It is a SAP interface protocol that simplifies the programming of communication processes between systems and manages the communication process, parameter transfer and error handling. Remote Function Call(RFC) calls and executes predefined functions in a remote system.

RFC is an application program interface (API) to SAP R/3 applications from SAP. To write applications that communicate with R/3 applications and databases, RFC interface is used.

RFC and C-program executables will be used for communication between SAP and LRC systems.

While primarily RFC would be used to communicate between the servers, the technology of the same would differ from the normal RFC methodology as described below.

• While document saving, the output type in SAP triggers an ABAP program.
• This ABAP program in turn generates the structure to be passed to the C program residing on the TAS server.
• RFC pings the TAS servers to check if the connectivity is there. If the connectivity is not there, an error message is sent to the user saving the shipment. The shipment can be sent again by repeating the output procedure. • After the ping is successful, SAP document creation process is released and the data in TAS structure is passed to the C subroutine written at the OS level on SAP server.
• This subroutine would be a very small routine whose job would be to simply push the data structure to another function module in TAS server. It would get a confirmation of document correct posting in TAS and accordingly update the document. In case of error, an express mail would be sent to the user working on the document.
• The reverse communication would also work in the same way and the actual connection between the two servers would be made at OS level (C scripts).
• LRC should respond with proper response codes as mentioned in this document.
• Vendor has to invoke the relevant function module (Y_TASCANCEL) along with error code in case of any error – truck database error, fan database error etc.



Programs for communication with SAP:-

The some of following sample programs will be provided by the vendor. Vendor has to develop and incorporate these programs in their LRC software. Vendor's technical representative will meet the Corporate Information System Technical team of IOC to discuss the functionality.

a) RFCEXEC.EXE
Standard program provided by SAP which is the Listener for RFC. This executable has to be incorporated in LRC server by the vendor.

b) SAPLISTN.C
Program which receives data from SAP and sends it to LRC. Vendor has to develop this program to send data to LRC . There should not be any transformation of data received from SAP. Data received from SAP should be available in LRC tables. It should also have the functionality of sending appropriate error code in case truck is rejected in LRC due to invalid product, allocation failed, truck database error, FAN database error etc. back to SAP in form of a SAP Mail Message. The logon credentials in encrypted form, SAP client no and IP addresses of the SAP Server will have to be maintained in LRCS database.

c) TASCRON.C
Vendor has to develop this program to post data to SAP using the functionality of confirming and posting in SAP whenever truck gets filled and sealed in SAP. Function modules which are required to be invoked will be provided by IOC . It should also have the functionality of sending appropriate message in case truck also if a TT is cancelled manually in LRCS along with user-id in form of a SAP Mail Message . The logon credentials in encrypted form, SAP client no and IP addresses of the SAP Server will have to be maintained in LRCS database.

d) GATEOPEN.C
Sample program for opening the exit barrier after truck has been invoiced.

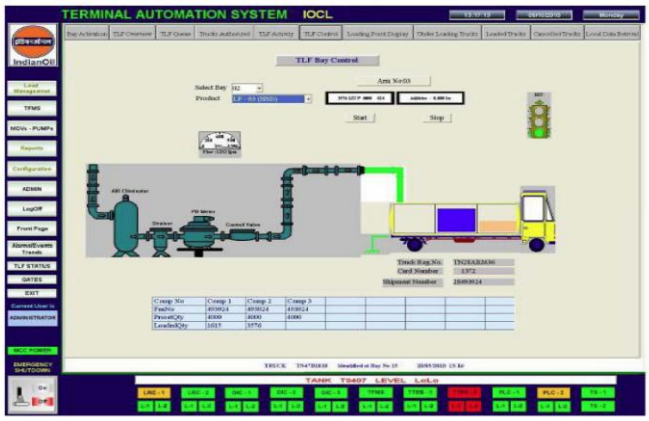
e) TASINVENT.C
Sample Program to get tank inventory data wherever Tank Farm Management System has been implemented.

f) TASMSG.C
Sample program for sending appropriate error code in case truck is rejected in LRC due to invalid product, allocation failed, truck database error, FAN database error etc. back to SAP in form of SAPMail Message and also if a TT is cancelled manually in LRCS along with userid .

g) TASCONFIRM.C
Sample Program for confirming in SAP whenever a truck gets loaded and sealed in LRCS.

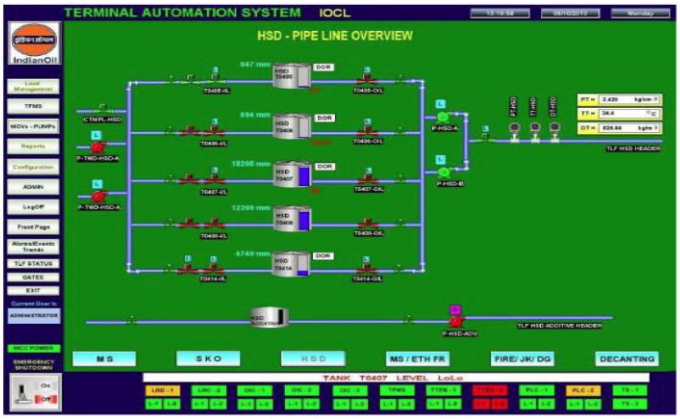
h) TASPOST.C
Sample Program for posting data in SAP.

i) CANCELTT.C
The vendor has to develop this program for cancelling TTs in LRCS in case the TTs is cancelled in SAP.



VIII. TTES (TANK TRUCK ENTRY SYSTEM)

- Using at S&D block to access the registed trucks
- To Generate the truck FAN-Slips
- User friendly client system
- Front-end Visual C++ Language programming
- Monitoring automation events in TLF
- Easy to search a truck & all controls monitoring the particular truck
- Workstation PC (hp Z400) with Windows 7.
- Connected with bay queuing display to show the Truck & bay no. in the TT parking area



IX. MAIN PRODUCT PUMPS FOR TLF:-

It is presumed that all existing Pumps Start, Stop, R/L, Run, Stop signals are already hard wired and connected to the PLC system directly from MCC Control circuit for remote operations & respective feedback are available in the existing TAS . CIL shall remove these terminations (Start, Stop, R/L, Run, Stop) in CCR Marshalling Cabinets going to existing PLC & connect the same to new PLC. Similarly Remote Interaction Terminal terminations presently done in existing PLC shall be modified & linked to new PLC being supplied by CIL. CIL shall integrate all 28 product Pumps related to TLF.provided all hardwiring between MCC & CCR is healthy.

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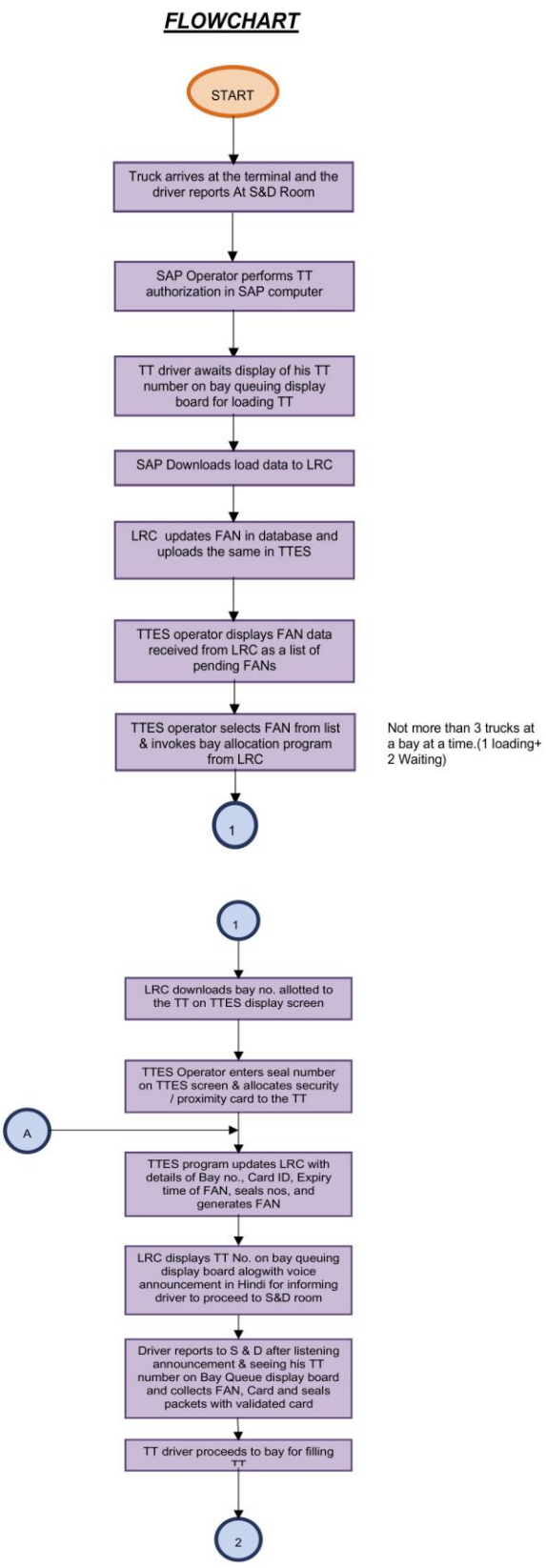

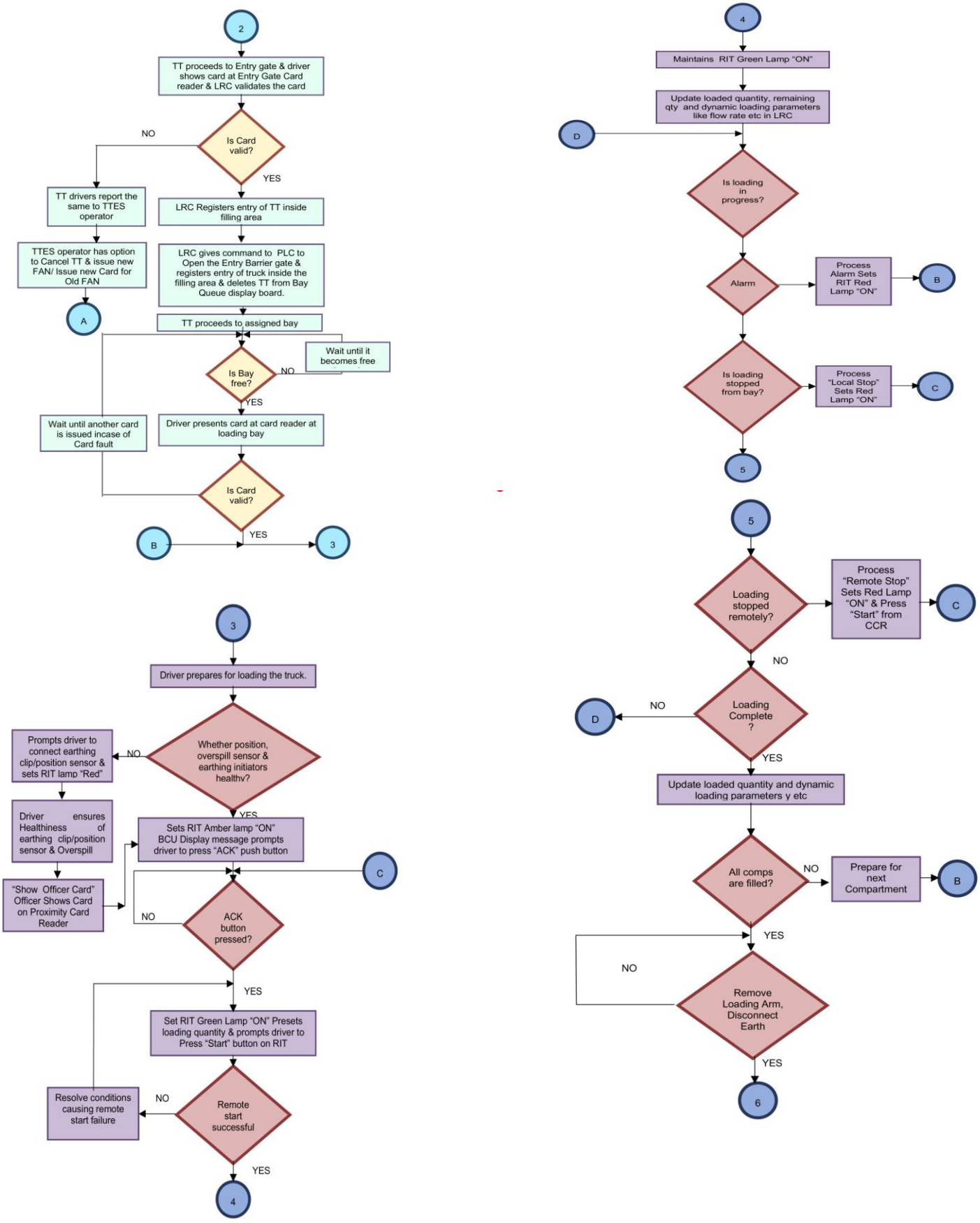
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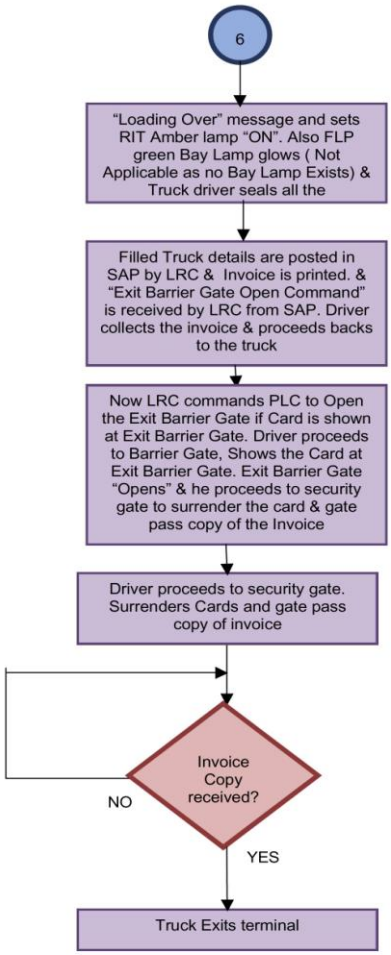
TT proceeds to Entry gate & driver shows card at Entry Gate Card reader & LRC validates the card
Is Card valid?
NO
YES
TT drivers report the same to TTES operator
TTES operator has option to Cancel TT & issue new FAN/ Issue new Card for Old FAN
A
LRC Registers entry of TT inside filling area
LRC gives command to PLC to Open the Entry Barrier gate & registers entry of truck inside the filling area & deletes TT from Bay Queue display board.
TT proceeds to assigned bay
Is Bay free?
NO
YES
Wait until it becomes free
Wait until another card is issued incase of Card fault
Driver presents card at card reader at loading bay
Is Card valid?
YES
B
3
3
Driver prepares for loading the truck.
Whether position, overspill sensor & earthing initiators healthy?
NO
YES
Prompts driver to connect earthing clip/position sensor & sets RIT lamp "Red"
Driver ensures Healthiness of earthing clip/position sensor & Overspill
"Show Officer Card" Officer Shows Card on Proximity Card Reader
Sets RIT Amber lamp "ON" BCU Display message prompts driver to press "ACK" push button
C
ACK button pressed?
NO
YES
Set RIT Green Lamp "ON" Presets loading quantity & prompts driver to Press "Start" button on RIT
Remote start successful
NO
Resolve conditions causing remote start failure
YES
4
4
Maintains RIT Green Lamp "ON"
Update loaded quantity, remaining qty and dynamic loading parameters like flow rate etc in LRC
D
Is loading in progress?
Alarm
Process Alarm Sets RIT Red Lamp "ON"
B
Is loading stopped from bay?
Process "Local Stop" Sets Red Lamp "ON"
C
5
5
Loading stopped remotely?
Process "Remote Stop" Sets Red Lamp "ON" & Press "Start" from CCR
C
NO
Loading Complete ?
NO
D
YES
Update loaded quantity and dynamic loading parameters y etc
All comps are filled?
NO
Prepare for next Compartment
B
YES
NO
Remove Loading Arm, Disconnect Earth
YES
6



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X. SUMMARY AND CONCLUSIONS

The following security guidelines should be implemented for a secure operation of the automated terminals:

The automated terminal control room operations should be manned by our staff / officer only and should not be manned by the vendor representative.

Batch controller should keep the operational data for the day and the same will be compared with the LRCS database for generating exception report.

The automation vendor has to provide security for the total operations with a view to have an audit trail of each and every operation at the automated location.

The security and authorizations should be implemented at the following areas:-

1. Operating system level
2. Database level
3. Application software level

REFERENCES

[1] Reconcile-inventory data.

[2] Data structure received from SAP should be available in tables in LRC. .

[3] User's guide: Indian Oil Corporation Limited SAPLRC Direct Interface Protocol ver 4_1.doc .

[4] Industrial Computer Hardware User's Manual