A New Approach Based on SFI Concept for Shortening the Plant Construction Period

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Conventionally, plant construction work involves two major constraints. One is that designing the I/O part of a production control system incorporating users' specifications and implementing its control and monitoring functions are dependent on each other and thus these specifications must be determined at the same time. The other is that tuning field devices, which are installed in plant sites and connected to the I/O interface of the DCS, and can be checked for wiring integrity only after the DCS is installed.

This paper introduces a new project execution method based on a system-free instrumentation concept (SFI concept), which resolves these two constraints and reduces the period and cost required for plant construction. New products for CENTUM VP R6 for implementing the SFI concept are also described.

CONSTRAINTS IN PLANT CONSTRUCTION

In continuous production plants, raw materials and intermediate products in the form of fluids are transported among units such as distillation columns and boilers units, and then energy is supplied to process them through media such as steam. In production plants, control systems monitor flow rates, pressures, temperatures, and other parameters of raw materials and intermediate products running through units, and then control them by operating valves, motors and others.

In this paper, construction related work such as designing, installation and construction work for production equipment, buildings, facilities, piping, wiring and the like are collectively referred to as a construction project. DCS related work such as defining the specifications of control and monitoring functions of a DCS, designing in accordance with the specifications, implementing the design, performing factory acceptance test (FAT) of the system, and shipping the system are referred to as a DCS project. Here, a safety instrumented system (SIS) [i] is categorized as a DCS. In the early stages, the construction project and the DCS project are carried out separately but they are eventually merged. Although it is desirable that each project be executed according to its own schedule, they are mutually dependent and this causes two critical constraints creating a critical chain in plant construction.

Constraint A: Constraint on Determining the I/O Specifications of the DCS

A DCS inputs and outputs signals from and to field devices such as sensors and actuators. Changes in the types and number of input and output (I/O) signals significantly affect the schedule of the procurement and arrangement in a construction project. In the conventional system layout with I/O cabinets centralized in control rooms, I/O related hardware specifications, such as the number of I/O cabinets, the number of signals, I/O unit layout, cabling, and power supply capacity designing, and the communication specifications for control and monitoring functions of DCS must be mutually adjusted after reviewing respective specifications that are determined through investigations. Thus, it is crucial to synchronously determine the I/O-related hardware specifications and the DCS specifications as shown in Figure 1.

Constraint B: Constraint on Adjusting and Confirming Work for Devices and Wiring

Adjusting field devices and checking the integrity of wiring require the control and monitoring functions of the DCS. Therefore, device adjustment work can be done only after the DCS is installed, wired with devices, and has started

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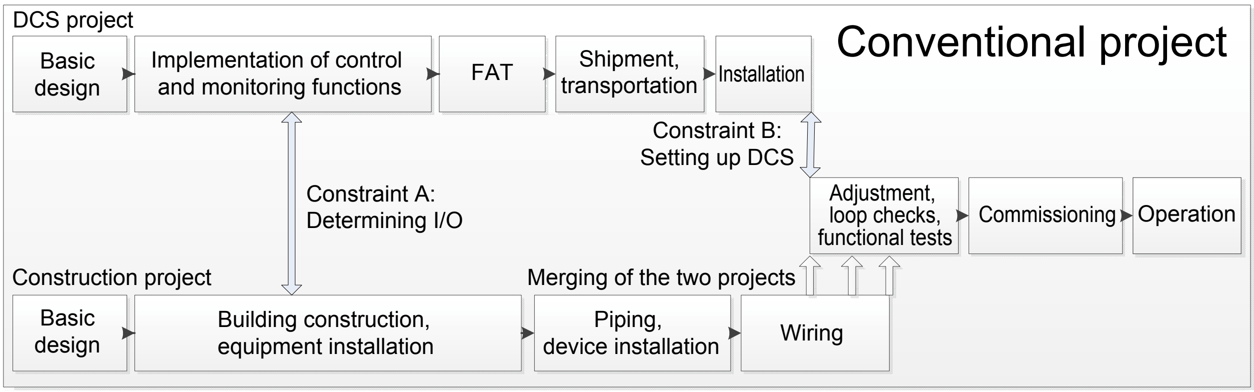


Figure 1 Constraints A and B in plant construction

operation on site. A delay in device adjustment after the merging of the construction and DCS projects often leads to a delay in the whole project schedule as shown in Figure 1.

UNRESOLVABLE CONSTRAINTS WITH EXISTING DCS CONFIGURATION

As a measure to resolve constraint A, many spare I/O units or slots are prepared for risk mitigation. However, this increases the footprint of the system and power supply capacity. Eventually, the cost of the entire project often increases.

Conventionally, there is no way to resolve constraint B other than to increase the manpower just after installing the DCS for executing various works in parallel to shorten the work period. This method mitigates to a certain extent but does not eliminate constraint B.

RENOVATION IN PROJECT EXECUTION

Yokogawa aims to resolve the two constraints by renovating project execution methods and integrating functions in new products. The details are described below.

Resolving Constraint A by Free Wiring between Field Devices and I/O Units of a DCS

Constraint A can be resolved by determining the DCS design and its I/O configuration in accordance with the results of installing field devices and wiring for them on site, instead of defining the I/O part depending on the DCS design. This becomes possible if signal lines from field devices and equipment can be freely connected to nearby I/O units of the DCS. Yokogawa satisfied the following four requirements necessary for eliminating this constraint.

(1) I/O units and modules of a DCS can be separately installed at locations close to field devices and equipment at a site.
(2) Any wires for analog/digital input/output (AI/AO/ DI/DO) signal can be connected to any terminals of an I/O unit of a DCS in an arbitrary order.
(3) 2-wired and 4-wired analog inputs also can be connected to terminals at any positions.
(4) Even if field devices are connected to I/O units of a DCS, the DCS can easily identify them when the DCS starts up.

Resolving Constraint B by Time-independent Device Adjustment

Conventionally, field devices are adjusted just after the DCS is installed. However, enabling the wiring of field devices to be freely connected to the I/O units of a DCS as described in the previous section, without using the monitoring and control functions of a DCS, can resolve constraint B. Yokogawa satisfied the following four requirements necessary for eliminating this constraint.

(1) Yokogawa provides a lineup of I/O units and modules for its DCS, each of which can be mounted on panels as a component, brought into the field and installed there just like commercial off-the-shelf (COTS) I/O units or modules.
(2) Settings of field devices on site can be defined via a certain I/O unit near its site. For example, a user can identify the existence of a valve with the device name FV101 beyond a terminal of the unit and define its device information.
(3) Field devices can be adjusted via the unit described above by using EDDL [ii] and DTM [iii] provided by device vendors.
(4) At the start of DCS operation, the DCS can obtain the device connection information from the unit described above, and the settings of the devices defined via the unit. They can be used as maintenance information for the devices.

NEW SFI MODEL ACHIEVED BY N-IO AND FieldMate

System-free instrumentation (SFI) is Yokogawa's new concept to fulfill the eight requirements described above and resolve constraints A and B at the same time. The SFI model is a project execution model based on the SFI concept. New products are used in combination for the project execution.

New Approach for Achieving the SFI Model

The approach for achieving the SFI model comprises six steps (1) through (6) as follows, as shown in Figure 2.

(1) Providing a new I/O (N-IO) where any of AI (2-wire and 4-wire), AO, DI and DO signals can be connected to any terminals in an arbitrary order, and signal types and assignment to monitoring logics can be determined later.

(2) Making common panels allowing distributed installation with N-IO mounted available as standard products (COTS).

(3) Making it possible on site without using a DCS to define and use information, such as connecting I/O channels (terminals), corresponding signal types and field devices connected to corresponding channels. For this purpose, a PC in which Yokogawa's FieldMate versatile device management wizard and its optional function FieldMate Validator are installed, is connected to the N-IO, and I/O configuration and device adjustment can be performed at the same time [1].

(4) Making use of EDDL and DTM provided by device vendors for device tuning. By using all functions of the EDDL and DTM through FieldMate, devices can be adjusted via the N-IO.

(5) Making it possible to construct a total system without considering physical I/O channels during the entire system construction period from designing the control and monitoring functions of a DCS to their implementation and inspection. For this purpose, CENTUM VP R6 allows I/O channels to be defined by generic names. Thus, applications can be designed and engineered before physical I/O connection positions are determined. Furthermore, the information on physical I/O connection positions obtained in (3) can be automatically imported into applications.

(6) Making it possible to use the results of adjusting field devices obtained in (4) as the initial parameters for their lifecycle maintenance. For this purpose, FieldMate can be used and transmits its information on each device to the plant resource manager (PRM), a centralized asset management software package that operates after installation of the DCS, to synchronize the information with the PRM.

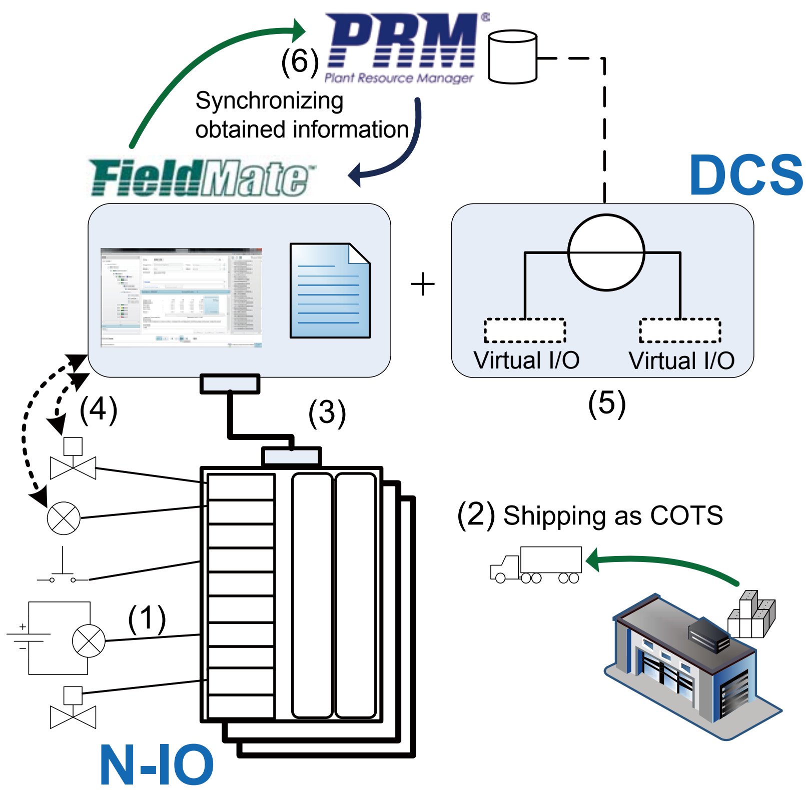


Figure 2 Six approaches for achieving the SFI model

NEW PRODUCTS FOR ACHIEVING THE SFI MODEL

This chapter explains new products for achieving the SFI model.

CENTUM VP and ProSafe-RS

The N-IO for CENTUM VP and ProSafe-RS accepts various types of signals with simple parameter settings. With an optional adaptor, it can also handle pulse signals (CENTUM VP only). The N-IO has a broader environmental tolerance than the previous I/O systems for the CENTUM series and can be mounted on panels in the field by using only N-IO.

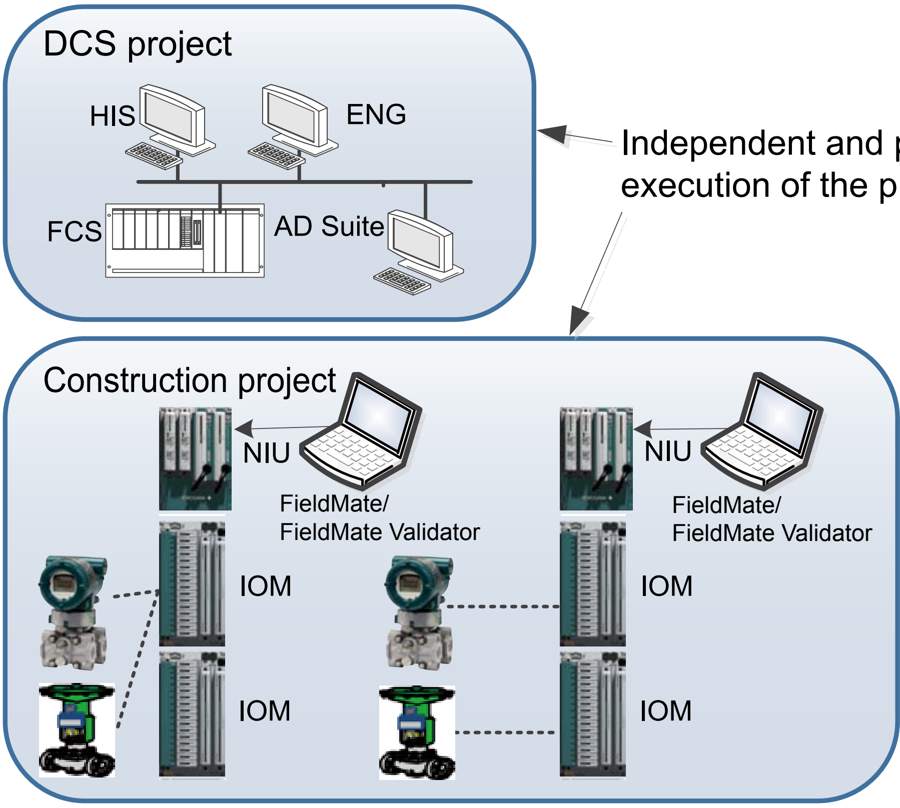
The logic design function for control and monitoring functions, provided by AD Suite [2] for CENTUM VP and ProSafe-RS, allows virtual assignment of I/O channels and holds the information on the virtual channel assignment and physical I/O terminal positions as an IO list. During synchronous data exchange, AD Suite takes in the latest I/O adjustment results from FieldMate Validator and updates the I/O list with reference to the results. Then, by combining the updated I/O list and the logic design of the control and monitoring functions, AD Suite completes the system implementation.

FieldMate, FieldMate Validator and PRM

FieldMate, a tool for setting and adjusting field digital devices, can adjust devices by using DTM and save device parameters.

FieldMate Validator is an optional function of FieldMate. When connected to the N-IO directly, FieldMate Validator operates the N-IO without using the control and monitoring functions of a DCS, configures the N-IO and confirms its connection with field devices. FieldMate can adjust devices using the functions of FieldMate Validator via the N-IO. The results can be transmitted to the PRM and saved as the initial data for later maintenance.

A PC with FieldMate and FieldMate Validator installed in it is connected to a USB port of the N-IO unit, and accesses the N-IO unit and field devices with the HART communication function via the N-IO unit. Figure 3 shows an example of an I/O system configuration using FieldMate and FieldMate Validator.



HIS: Human Interface Station
ENG: Engineering Station
FCS: Field Control Station
AD Suite: Automation Design Suite
NIU: Node Interface Unit
IOM: I/O Module
FieldMate Validator: N-IO loop check/setting software

Figure 3 Example of I/O system configuration using FieldMate and FieldMate Validator

RENOVATION IN PROJECT EXECUTION BY THE SFI MODEL

As described above, the SFI model resolves the two constraints A and B at the same time. Resolving these constraints will drastically change the procedure of project execution. The advantages of the SFI model in the whole project execution and in each phase of a project are described below.

Shorter Project Period

As shown in Figure 4, the SFI model enables the construction project, including the procurement of local panels with the N-IO mounted and other devices, and their installation, wiring and adjustment, to be independently scheduled and carried out in parallel in each area of the field, regardless of the DCS project. Standardized local panels can be procured easily and quickly. Furthermore, in terms of the amount of implementation work for control and monitoring functions of a DCS, the SFI model reduces the required implementation work relating to I/O hardware, and shortens the time up to shipment. Eventually, the DCS and construction projects can merge earlier than conventional projects. Upon the merging, the N-IO and field devices have already been connected, and so the functional tests can be started immediately after the installation of the DCS, thus reducing the period of the entire project.

Simplified Wiring

Wires from field devices can be connected to any terminals of the N-IO unit, which simplifies the wiring work. Furthermore, N-IO components, which are required for changing or adding signals on site, can be ordered quickly and individually just like COTS, thereby mitigating the risk of delays in the project.

Renovation in I/O Component Procurement

Signal types do not need to be specified when ordering N-IO components. The only items that must be specified are the number of panels (points) and optional modules (adapters) to convert non-conventional signals. Thus, I/O component procurement is easier and quicker, and the costs for design changes are lower than before.

Shortened DCS Implementation Period by Virtual I/O Channel Assignment

By using logical I/Os, engineers can focus on implementing the control and monitoring functions of a DCS without considering their physical information. This helps shorten the implementation work period.

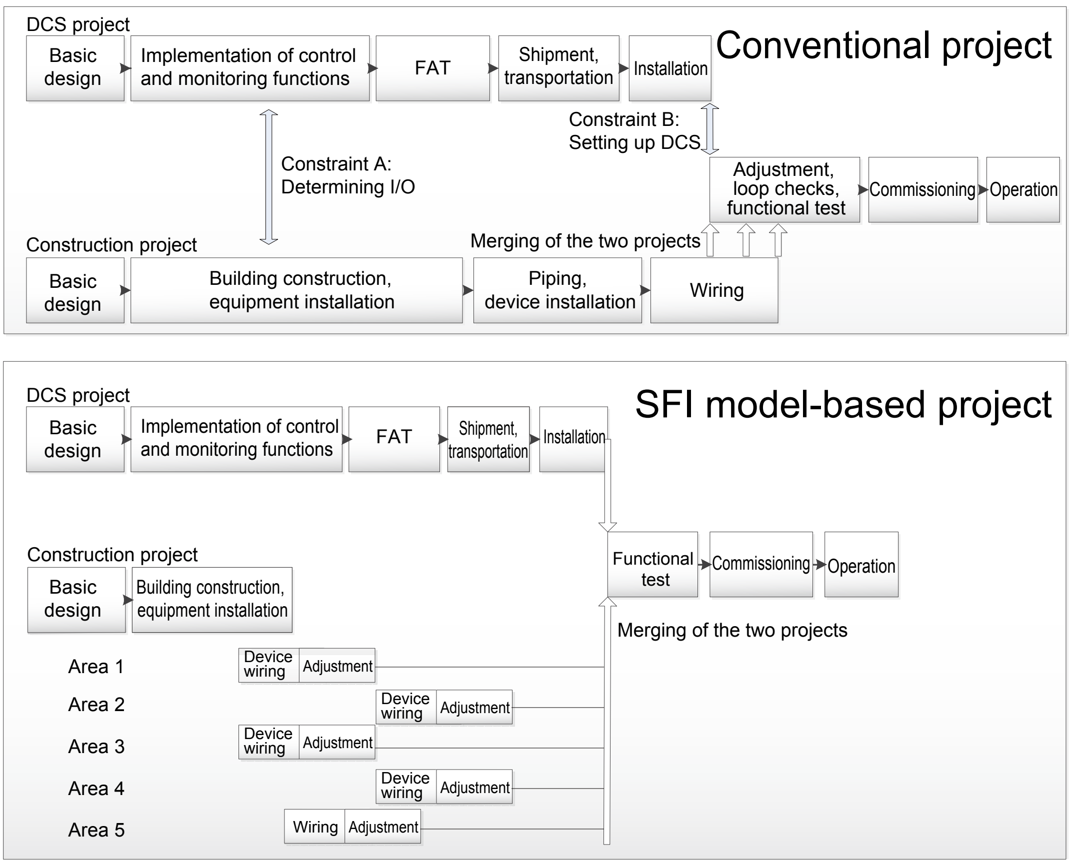


Figure 4 Project execution in accordance with the SFI model

Securing Time for Adjusting Intelligent Devices

As field devices become more intelligent and their functions become more sophisticated, the amount of information and parameters involved increases and their adjustment becomes more complicated. Therefore, the adjustment needs the help and advice of specialists, often from remote locations, and repeated operation tests, which takes more time and requires more information to be exchanged. Eliminating constraint B secures the time for adjusting such highly intelligent devices.

FURTHER RENOVATION OF THE SFI MODEL

This paper described the SFI model that can shorten the project period and mitigate risks in project execution by resolving the two major constraints in plant construction based on the SFI concept. It also reported that the model was implemented in new products for CENTUM VP. Applying the SFI model to actual plant construction projects is expected to shorten the project period and substantially reduce project costs.

Plant construction will become increasingly complex. However, by improving the SFI model and widening its application range, Yokogawa will respond to changes in the plant construction and deliver benefits to customers.

REFERENCES

(1) Keiichiro Kobuchi, Mizuo Kawahara, et al., “FieldMate: Versatile Device Management Wizard Evolving with Field Instruments,” Yokogawa Technical Report English Edition, Vol. 53, No. 2, 2010, pp. 27-30

(2) Mitsuhiro Yamamoto, “Innovating the Engineering Environment with Automation Design Suite,” Yokogawa Technical Report English Edition, Vol. 58, No. 2, 2015, pp. 21-26

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i A safety instrumentation system leads processes in a safer direction when the processes run out of the normal control ranges and reach dangerous conditions.

ii Electronic device description language (EDDL) defines device parameters of each device and describes how to access the device in text.

iii Device type manager (DTM) is an application that defines the graphical user interface (GUI) specific to each device.