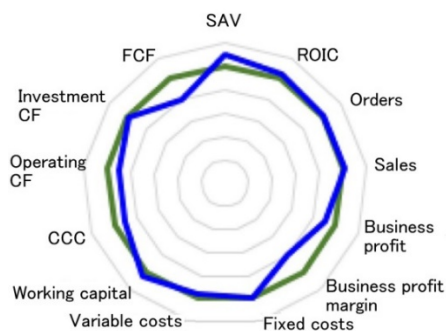# Decision making Support System for Data-driven Management

KAZUHISA TAMURA[1]   **SHUN KAWACHI**[4]

MANABU KASANO[2]   **SHUJI TAKIGUCHI**[4]

HIROKAZU EDA[3]   **ATSUSHI KATO**[5]

Mitsubishi Heavy Industries, Ltd. (MHI) Group has set "recovering and strengthening of competitiveness" as one of the key points of its 2021 Medium-Term Business Plan. To steadily carry out that and achieve, data-driven management, i.e., the timely and rational measure selection (decision making) based on data, is effective at the top, middle, and lower management levels. With the aim of the accelerating data-driven management in MHI Group, we have recently developed a system that aggregates and visualizes planned and result data pertaining to financial and production activities and that also conducts case studies based on Key Performance Indicator (KPI) trees and simulations, in order to support decision at any management level.

By combining these systems, we will promote data utilization using digital technologies and innovation beyond that, and contribute to the management of MHI group, a conglomerate.

1. Introduction

The results of management are quantified and evaluated in financial indicators that appear in the three financial tables (i.e., balance sheet, income statement, and cash flow statement) and in the stock price. For this reason, it is natural to utilize data for management, and efforts to utilize data are being made at all management levels. In order for rational decision making, it is useful to further promote real-time data utilization by digital technology and to select the best measures using case studies through simulations to examine specific and elaborate measures

Therefore, aiming at the utilization of decision making data by digital technology, we have developed a management decision making support system, which aggregates result data from different practical operation departments to visualize measures and targets at the field level as well as conducts simulations, in order for rational decision making.

This system consists of three parts: "Management Dashboard", which is designed to be used by top management and visualizes targets, results, and forecasts; "Business Plan Simulation", which examines and validates measures to achieve the Business Plan targets; and "Production Activity Simulation", which examines and validates measures to achieve departmental targets. In order to speed up the collection of result data, We solved through utilizing a company-wide data utilization platform that accumulates data from in-house systems on a daily basis.

This report explains the reason why the developed system consists of these three subsystems, the functions of each subsystem, and their assumed utilization.

The terms used in this report are defined as follows:
- CCC: Cash Conversion Cycle, days between accounts payable and accounts receivable collection
- KGI: Key Goal Indicator, the highest-level KPIs among the financial KPIs, including 13 items such as SAV, orders, sales, fixed costs, variable costs, CCC, etc., shown as the Business Plan targets (see **Table 1**).

*1   Chief Staff Researcher, Service Engineering Department, Research & Innovation Center, Mitsubishi Heavy Industries, Ltd.

*2   Manager, EPI Department, Digital Innovation Headquarters, Mitsubishi Heavy Industries, Ltd.

*3   Chief Staff Manager, EPI Department, Digital Innovation Headquarters, Mitsubishi Heavy Industries, Ltd.

*4   EPI Department, Digital Innovation Headquarters, Mitsubishi Heavy Industries, Ltd.

*5   BPI Department, Digital Innovation Headquarters, Mitsubishi Heavy Industries, Ltd.

- KPI: Key Performance Indicator, an indicator for performance evaluation.
- Financial KPI: KPI of cost of capital, invested capital, operating margin, selling and administrative expenses, gross profit, etc., including KGI.
- SAV: Strategic Added Value, Net income + Interest expense after tax - Cost of capital
- SBU: Strategic business unit, a business unit in the strategic business evaluation system.
- Measure: A measure to achieve a target. For top and middle management, a measure is an instruction to subordinate organizations. For lower management in practical operation departments, assumed measures may include overtime work, capital investment for efficiency improvement, and switching between internal and external manufacturing.
- Validity of measure: When a measure is effective for the achievement of a target, the measure is "valid."
- Activity KPI: KPI used in practical operation departments.
- Practical operation department: A department that implements design, engineering, procurement, or the like.

Table 1 Thirteen targets of Business Plan (KGIs)

No.	Classification	KGI name
1	Indicators related to profit-and-loss statement (PL)	SAV
2		ROIC (return on invested capital)
3		Orders
4		Sales
5		Business profit
6		Business profit margin
7		Fixed costs
8		Variable costs
9	Indicators related to balance sheet (BS)	Working capital
10		CCC (cash conversion cycle)
11	Indicators related to cash flow statement (CF)	Operating CF
12		Investment CF
13		FCF (free cash flow)

2. Structure of decision making support technology

2.1 Decision framework for business planning and execution and structure of decision making support system

In order to enable top, middle, and lower management to select appropriate measures according to the targets linked to the Business Plan targets, a "visualization function" to grasp the current state and a "case study function" to examine measures and validate them for achieving the targets are considered necessary. In order to gain synergy in MHI group, a conglomerate, we offer these functions as a common system that can be used by the entire company.

(1) Visualization function: Visualize targets, results, and forecasts to understand the current state and identify KPIs that should be focused on to achieve the Business Plan targets and departmental targets.

(2) Case study function: Examine measures to achieve the Business Plan targets or departmental targets, validate the measures, and concretize the measures to be taken at the departmental activity level.

Among the "visualization function" and "case study function", the latter was divided into two categories because the management cycle differs depending on the management level: one for top and middle management, which has few differences among SBUs, and the other for lower management, which has large differences by SBU business characteristics.

Based on this concept, the system to support data-driven management decision making was composed of the "Management Dashboard", a visualization function for top management, the "Business Plan Simulation", a case study function for middle management, and the "Production Activity Simulation", a case study function for lower management (**Figure 1**).
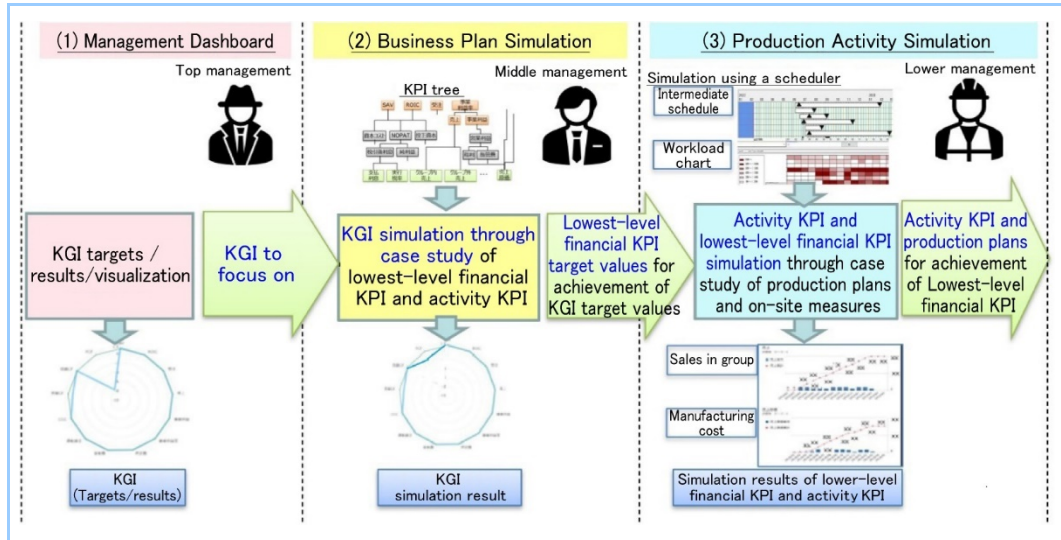
Figure 1   Three systems that support data-driven management

2.2   KPI structural model

When breaking down KGIs, the Business Plan targets, into the targets of practical operation departments, top management instructs middle management, middle management instructs lower management, and lower management instructs practical operation departments about the target KPIs and the target values at each level. The key tool in doing that is the KPI tree (**Figure 2**). The KPI tree represents the relationship between KGIs, financial KPIs and activity KPIs as a tree. KGIs can be calculated based on financial KPIs. For example, it is possible to simulate how FCF and CCC would change if the target selling prices and order quantities were improved and the manufacturing lead times were reduced.

In "the Business Plan Simulation", correlation values between financial KPIs and activity KPIs are set as parameters in the master data in advance, which enables financial KPIs to be calculated using activity KPIs as input.
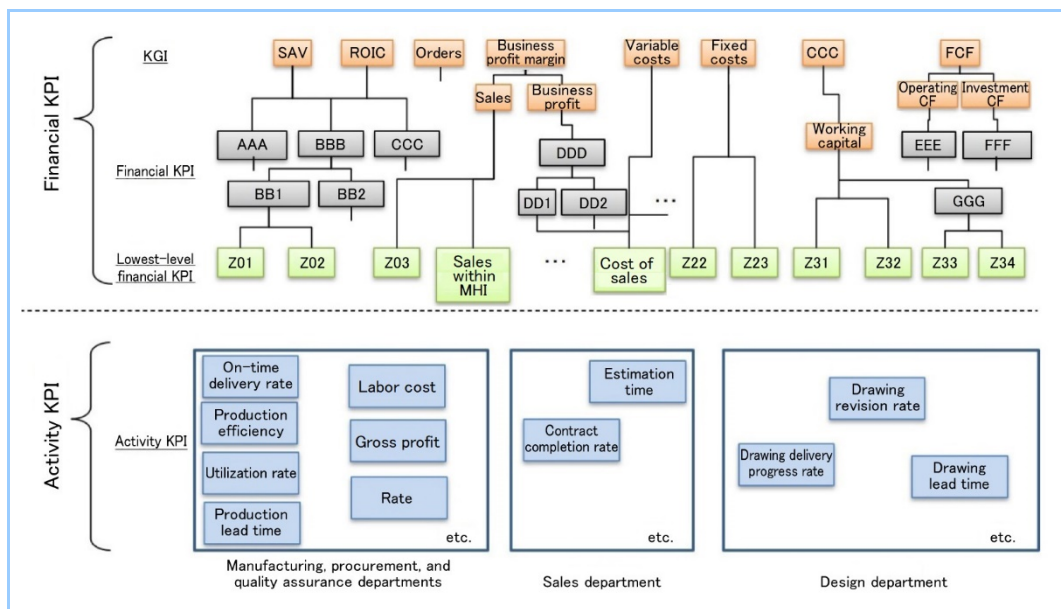

Figure 2   KPI tree

3. "Management Dashboard"

"The Management Dashboard" is used by top management, and its purpose is to identify KPIs (KGIs or financial KPIs) that should be focused on by the organization at the upper level of the SBU. For this reason, based on the idea that it is necessary to understand results and trends of the KPI in question, we visualized the KPI in a graph format in consideration of larger-the-better and smaller-the-better characteristics. Specifically, we prepared a radar chart that enables

visualization of the difference between the KPI target and the KPI result at a glance and a trend chart for each KGI to grasp the trend of the KPI in question in order to make the achievement or non-achievement of each KGI visible (**Figure 3**).


Figure 3   Screen image excerpt from Management Dashboard (all values shown are samples)

4. "Business Plan Simulation"

The aim of "the Business Plan Simulation" is to concretize the measures to be taken by practical operation departments to achieve the targets of KPIs (KGIs or financial KPIs) identified by "the Management Dashboard" as what should be focused on (i.e., to set the target values of activity KPIs). The Business Plan Simulation consists of a case study function that shows the results (KGI, financial KPI) of implementing the examined measures, and a visualization function to validate the case study results. the Business Plan Simulation is used by middle management, but assumed users are parties in charge of SBU management and planning among them.

The case study function calculates the forecast values of financial KPIs and KGIs using the financial KPI tree when various values of activity KPIs (e.g., 85% of utilization rate, 0.5 hours of overtime, etc.) based on the proposed measures are input as case study conditions (**Figure 4** left).

The results of executing this function for multiple cases are compared, and the user selects the measure that is considered to be optimal. The function to evaluate case studies side by side enables display of multiple calculated cases for comparison as shown in Figure 4 right.
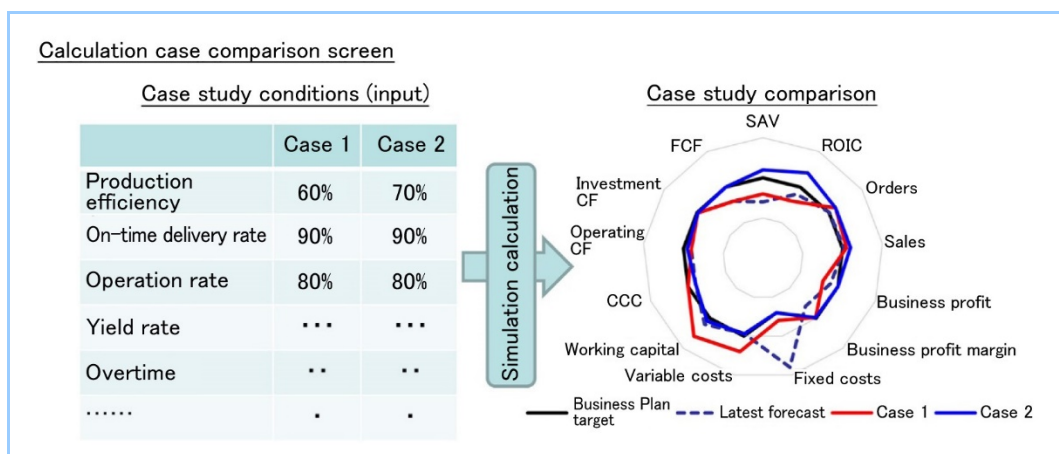
Figure 4   Image of comparison cases in business plan simulation
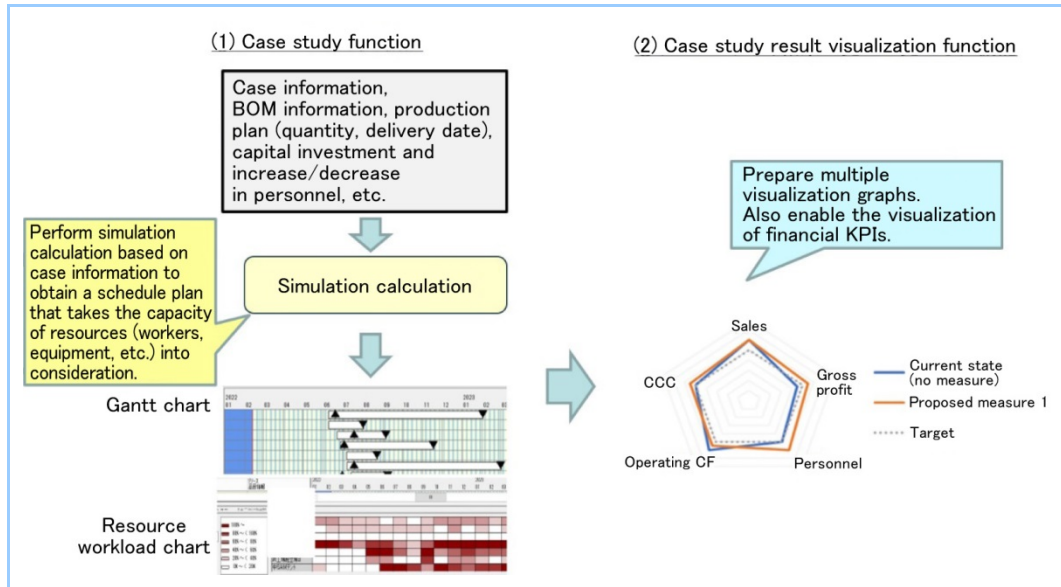
5. "Production Activity Simulation"

The aim of "the Production Activity Simulation" is to examine specific measures to achieve targets in practical operation departments, to validate the measures, and to concretize the measures to be taken at the departmental activity level. The function of the Production Activity Simulation consists of a case study function and a case study result visualization function, similar to "the Business Plan Simulation". The Production Activity Simulation is used by the head of lower management, i.e., the head of a practical operation department, or the department in charge of management and planning.

The inputs to this case study function include case study conditions such as production plans (delivery date and quantity) and resource additions, as well as case information, process information, equipment information, customer information, payment conditions, calendar, and exchange rates, etc. The outputs are the production plan and activity KPI forecasts.

As the simulation calculation engine, a scheduler developed in-house is used. **Figure 5** shows the flow of simulation calculation based on the case study condition input and visualization of the results.


Figure 5　Utilization image of production activity simulation

6.　Conclusion

In order to support decision to realize data-driven management for achieving the Business Plan targets, we developed a management decision making support system consisting of three mechanisms: "Management Dashboard", "Business Plan Simulation", and "Production Activity Simulation". **Figure 6** shows its utilization image in data-driven management.

Moving forward, we will promote the utilization of the developed system in our businesses to support the steady realization of the Business Plan. At the same time, to achieve our goal of carbon neutrality, we will continue to identify related KPIs and improve case studies including CO_2 emissions.
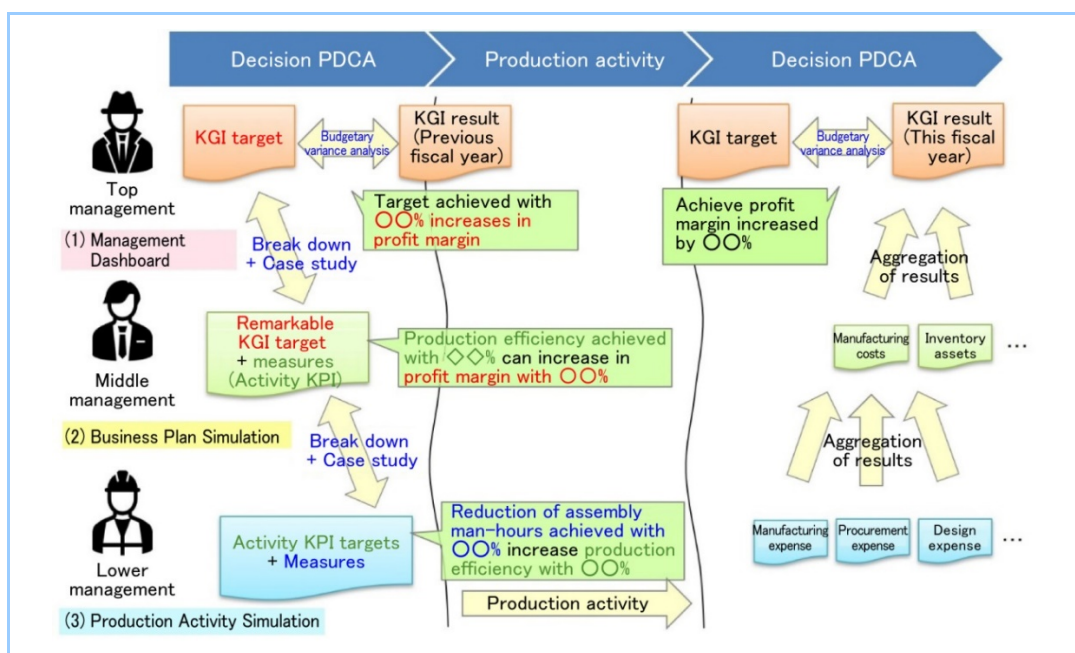
Figure 6　Utilization image of developed system for data-driven management