DHARMA – DEVELOPMENT OF SOFTWARE FOR THE EFFECTIVE MANAGEMENT OF DAM ASSET AND HEALTH DATA

P.N. SINGH AND Y.N. BHISE
Dam Rehabilitation and Improvement Project, Central Water Commission, New Delhi, India

T. KENDALL, P.K. MAJUMDAR, D.K. CHAUBEY, D. L OLLIVIER, AND C. BAILLET
Dam Rehabilitation and Improvement Project, Egis Eau, Montpellier, France

ABSTRACT

India occupies the third position in the world with over 5,330 large dams in operation and around 410 large dams under construction (CWC, 2019). Important information relating to the design, construction, operation, periodic inspection, maintenance, and rehabilitation of these dams is often available at the dam sites. However, this information is usually not arranged and disseminated in a form amenable for analysis by dam-owners and policymakers at the State and Central levels, thereby hindering the effective planning and implementation of dam safety initiatives across the country.

DHARMA (Dam Health and Rehabilitation Monitoring Application) is a web-based software, designed to support the effective collection and management of dam safety-related information in India. The software was conceived by the Central Water Commission (CWC) – the apex technical organisation attached to the Ministry of Water Resources, River Development & Ganga Rejuvenation, Ministry of Jal Shakti – with responsibility for promoting dam safety in the country and is being developed as part of the Dam Rehabilitation and Improvement Project (DRIP), with technical assistance from Egis, the Engineering and Management Consultant for the project.

This paper documents the DHARMA initiative to date since the nationwide launch of the software at the International Dam Safety Conference in January 2018 and considers its prospects over the coming months and years.

1. INTRODUCTION

The Sanskrit word 'Dharma' has many meanings, including 'intrinsic nature', 'moral duty' and 'what is established or firm'. For the purposes of this paper, 'DHARMA' is the Dam Health and Rehabilitation Monitoring Application: a web-based asset management software conceptualised and pioneered by the Central Water Commission (CWC) of India to support the effective collection and management of dam safety-related information in the country.

The DHARMA software (Figure 1) is currently being further developed and implemented as part of the 'Dam Rehabilitation and Improvement Project' (DRIP), with technical assistance from Egis, the Engineering and Management Consultant for the project. DRIP is being undertaken by the CWC with loan assistance from the World Bank at a total cost of approximately 450 million USD, to address two main objectives: i) improve the safety and performance of 223 existing dams in a sustainable manner and ii) strengthen the dam safety institutional setup in nine participating implementing agencies across seven States as well as in the CWC.

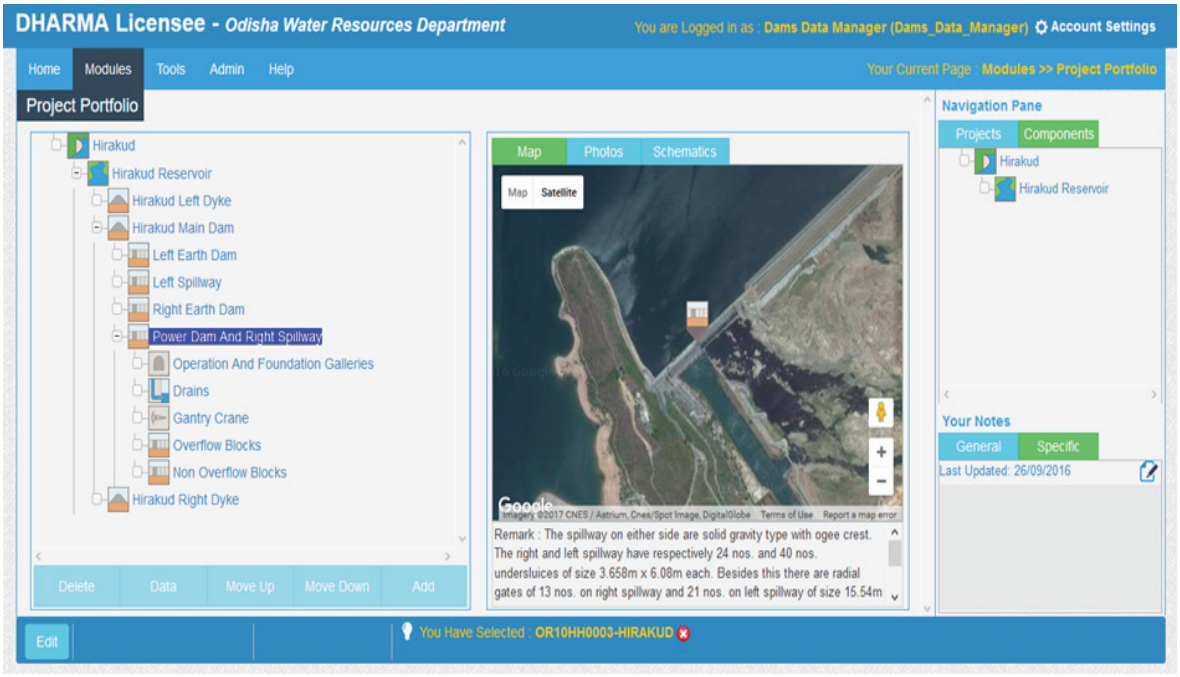

Figure 1 : Screenshot of DHARMA software (Project Portfolio Module for Hirakud Dam, Odisha)

2. INSTITUTIONAL CONTEXT

2.1 India's Dam Safety Challenge

India occupies the third position in the world with over 5,330 large dams in operation and around 410 large dams under construction. Although these dams have a large range of ages – the oldest, 24m high Thonnur Tank in Karnataka, dates back to 1000 AD – over half were constructed during the 1970s and 1980s. Today, half of the large dams in India are over 25 years old, 80 are over 115 years old and by 2020, more than 20% of all large dams in India will be at least 50 years of age (CWC, 2019).

Many of India's dams have been poorly maintained since their construction and are now showing signs of increasing distress. Typical structural issues include swelling and shrinkage and deterioration of joints and water stops in concrete and masonry dams and excessive or inadequate vegetation and slope instability in embankment dams. Malfunctioning hydro-mechanical and instrumentation equipment and high reservoir sedimentation rates present further operational problems.

2.2 DRIP as a Catalyst towards a Strong Dam Safety Culture

As summarised by Figure 2, one of the key barriers to a stronger dam safety culture in India is inadequate investment in dam maintenance both in terms of physical assets and staff leading to a persistent situation of a complacent workforce and deteriorating infrastructure (Mathur et al, 2017). The DRIP project was launched as a catalyst towards a more virtuous cycle of increased, targeted investment and proactive asset management by addressing both the 'hard', physical and 'soft', institutional aspects of dam safety.

For the hard 'Rehabilitation and Improvement' component of the project, around 223 existing large dams (less than 4% of India's portfolio) have been inspected, 'diagnosed' and are now undergoing structural and non-structural rehabilitation measures. In parallel, the soft 'Institutional Strengthening' component is delivering a range of initiatives to strengthen capacity at the dam, State and Central levels. These include training and capacity building, ISO 9001 certification of CWC as Central Dam Safety Organisation, founding of an annual dam safety conference, academic partnerships, publication of Guidelines and Manuals as well as development and implementation of the DHARMA software.

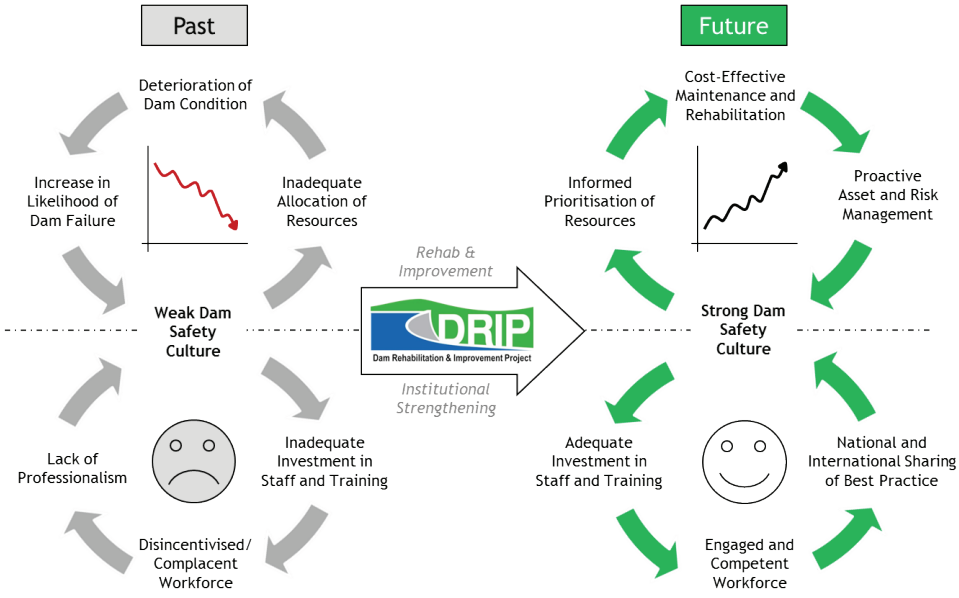

Figure 2 : Institutional Context of Dam Safety in India (adapted from Blockley and Godfrey, 2000)

3. DHARMA SOFTWARE

3.1 DHARMA Objectives

The DHARMA software was originally conceived to address four main objectives: i) bring stakeholders together, ii) ensure completeness of information, iii) assess soundness of dam health and iv) effectively manage asset inventory (Pillai et al, 2014).

Whereas the first two objectives concern data collection, objective three and particularly objective four require effective processing and reporting of this data to ensure that the right decisions can be taken by the right individuals at the right time. In other words, as has been the case for the 223 dams undergoing rehabilitation on DRIP, there is a three-step process of: i) where are the dams, ii) what condition are they in and iii) what should be done about them.

The key role of DHARMA in relation to Figure 2 is to help answer this third question and thereby enable a transition from a weak and reactive to a strong and proactive dam safety culture. In this scenario, rehabilitation works would be anticipated long in advance, informed by effective operation and maintenance practices and prioritised on a sound, scientific basis.

As well as lowering risk and costs, DHARMA should assist dam owning organisations to "realise value" whether economic, social and environmental from their dam assets.

3.2 DHARMA as an Asset Management Software

The ISO 55000 standard defines asset management as *"the coordinated activity of an organisation to realise value from assets"* where an asset is an *"item, thing or entity that has potential or actual value to an organisation"* and realisation of value *"will normally involve a balancing of costs, risks, opportunities and performance benefits"*.

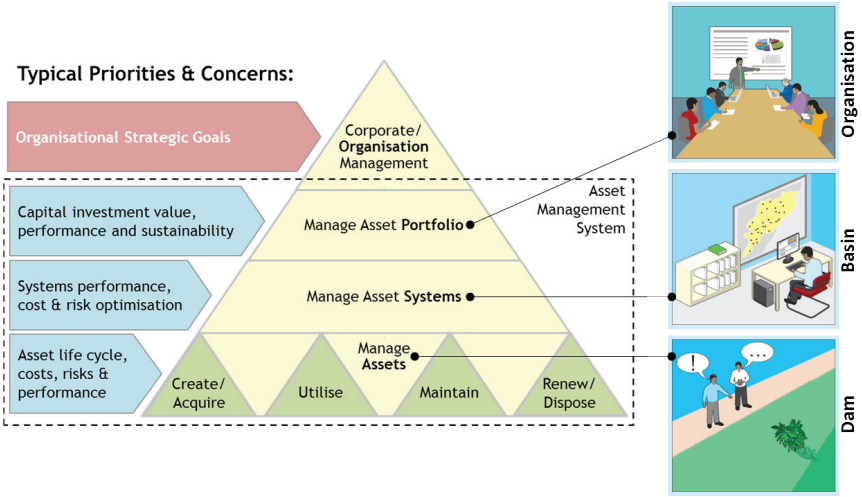

Figure 3 : Levels of Asset Management (adapted from Institute of Asset Management, 2012)

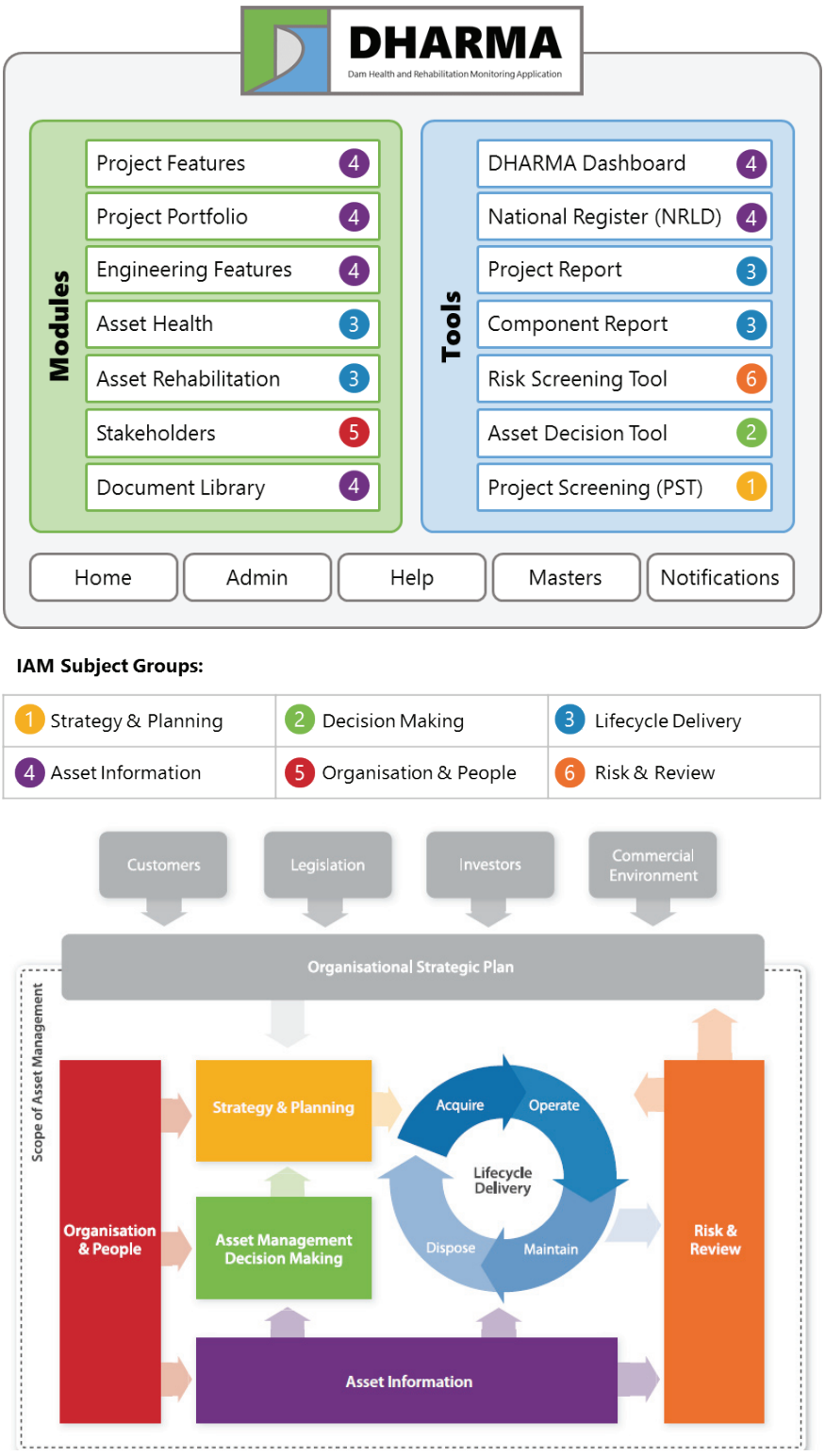

Figure 4 : DHARMA and the Subjects of Asset Management (adapted from Institute of Asset Management, 2014)

Figures 3 and 4, adapted from literature of the Institute of Asset Management, demonstrate the relevance of the asset management field to DHARMA and the wider Indian dam safety context. Figure 3 encourages the reader to understand individual assets as being part of a system and the system as part of a portfolio with different types of decisions to be taken at the different levels, all informed by and aligned with the organisational strategic goals.

DHARMA has three levels of user: Application Users (Dam Data Manager and Dam Health Engineer), Licensees (Licensee Admin and Licensee Super Admin) and Licensor (Central Admin and Central Super Admin). A typical State Water Resource Department's portfolio may consist of four river basins (systems) with fifty large dams (assets) in each.

This dam owning organisation can be supported by DHARMA to "realise value" by taking a systems approach. More specifically, interventions at individual dams can be planned in the physical context of each of the four basins (consequences up and downstream) and institutional and financial context of their portfolio (could limited funds be better spent on any of the other 199 dams). At the national level, DHARMA can support policymaking and implementation of legislation and highlight to organisations such as the Central Water Commission in which States and dam owning organisations efforts can be prioritised.

Figure 4 proposes a mapping of the six subject groups of asset management onto the seven modules and seven tools of DHARMA. The modules are primarily for data collection whereas the tools are for data processing, reporting and analysis.

A distinction is made between the static and dynamic modules of DHARMA. Static modules, such as Project Features, Project Portfolio and Engineering Features store information which rarely changes (eg. purpose of the project, height of dam, type of radial gate). Dynamic modules, such as Asset Health and Asset Rehabilitation track the latest status of the dam asset and components throughout their lifecycle and therefore require regular updating (eg. inspection and instrumentation data, details or recent maintenance and rehabilitation works).

The 'DHARMA Dashboard' tool allows all users to compare their completion status of the seven modules of the software at dam, Licensee and Central level, introducing an element of healthy competition. The 'National Register of Large Dams' replaces the previous annual compilation of MS Excel files and PDF documents to provide the latest available information on the salient features of all 5,700+ large dams across the country.

Just as the 'NRLD' tool allows the user to generate a report of all or selected dams in the country, the 'Project Report' and 'Component Report' tools allow the user to generate reports for his/her selected dam project or dam component. For example, instead of going through ten years of pre and post-inspection reports to understand the condition history of a stilling basin, the component report can be generated to isolate only this information.

This type of report generation is made possible through careful structuring of the data. The Project Portfolio module allows users to describe their dam asset using sixteen components and associated pre-defined component types. Once approved, this structure is used for further data collection, processing and reporting throughout the software.

Whereas the seven modules serve as the database of DHARMA, the Risk Screening, Asset Decision and Project Screening tools serve as the decision support system, enabling users to answer the question raised earlier of "what should be done about the dams".

4. DHARMA IMPLEMENTATION

4.1 DHARMA Progress

The current version of DHARMA has been under development since late 2015. The first two modules (Project Features and Project Portfolio) were made live in May 2016 at the 14th World Bank Review Mission. A complete first version with seven modules and two tools (DHARMA Dashboard and National Register of Large Dams) was launched by the Minister of Water Resources as part of the International Dam Safety Conference held in Kerala in January 2018.

The Central Project Management Unit (CPMU) of DRIP continues to progress the design, development and implementation of the software in close collaboration with the Central Water Commission and India's dam owning organisations. To date, over 30 trainings have been held in 12 States for over 1,000 participants. The evolution of number of users and overall completion status of the software for the first three modules is provided in Figure 5.

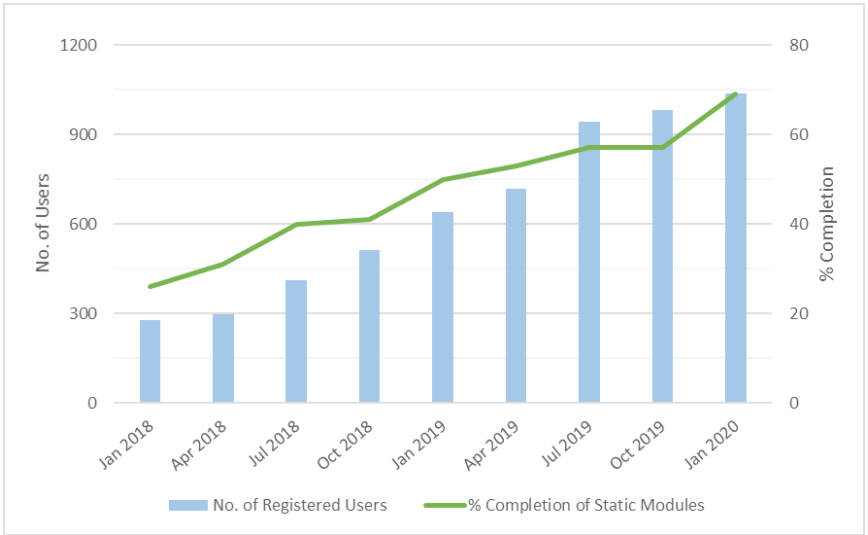

Figure 5 : No. of registered users and dams and completion status since National launch

4.2 DHARMA Prospects

Following encouraging progress over the past two years on the collection of static data, the current focus is to promote the collection, processing and reporting of dynamic data and particularly for routine visual inspections. An expanded version of the Asset Health module to include sub-modules on inspections, instrumentation, operation & maintenance and dam break analysis & emergency action plans is scheduled for release at the ICOLD 2020 conference in Delhi.

The software is well aligned to the organisational strategic plan of the Central Water Commission and its mandate of promoting improved dam safety practices across India. DHARMA has been designed in compliance with the contents of the fourteen Guidelines and Manuals published under DRIP including the '*Guidelines for Safety Inspection of Large Dams*' and '*Guidelines for Assessing and Managing Risks Associated with Dams*'. Importantly, DHARMA must continue to be a user-friendly software, which is well adapted to its users.

In the years to come, as the uptake of the DHARMA gathers momentum among dam-owning organisations and as asset management practices are incorporated into the regulatory framework (such as the 2010 Dam Safety Bill, now under consideration of the Upper House of the Indian Parliament), further avenues for the useful expansion of the DHARMA software can be explored. These could include the domains of the 'Internet of Things' and 'Building Information Modelling' (BIM) at the dam level (Pocock et al, 2014) and the role of 'Big Data' and 'Machine Learning' at the Dam, State and Central levels.

In the meantime, the World Bank and Government of India are planning to build on the success of DRIP with a further two phases of the project which would cover around 700 dams in 18 States. DHARMA can be an important resource for the effective planning of these phases.

5. CONCLUSIONS

This paper has sought to offer an insight into the progress and challenges to date of developing and implementing a web-based asset management software for improved dam safety practices in India. The journey from a situation of complacent staff and deteriorating assets towards one of proactive, informed asset management and prioritisation of investment at the 'asset', 'system' and 'portfolio' levels has been set out with reference to international best practice.

Although DHARMA is still at an early stage in this journey, the example may be of interest to other countries and dam safety organisations facing similar challenges and exploring similar initiatives.

Figure 6 : DHARMA presentation and launch at Dam Safety Conferences (top) and DHARMA Application User trainings in Chennai and Bhubaneswar (bottom)

ACKNOWLEDGEMENTS

The authors would like to acknowledge the support of Central Water Commission for this exciting opportunity to be involved in the design, development and implementation of the DHARMA software.

For more information please visit www.damsafety.in/dharma

REFERENCES

Central Water Commission (2019), *National Register of Large Dams*

Pillai, Dr B.R.K., and Giraud, S. (2014) *Dam Rehabilitation and Improvement Project*

Kendall, T., Singh Chetan, M., Sharma, N., Reddy, M.B., Chaubey, D., Arora, A., (2017) *DHARMA – A New Tool for the Effective Management of Dam Asset and Health Data Across India*

Kendall, T., Singh Chetan, M., Sharma, N., Reddy, M.B., Arora, A., Chaubey, D. (2018) *DHARMA – An Integrated Approach for Asset Management of Large Dams*

Mathur, NK., Kendall, T., Chaubey, D., L'Ollivier, D., Joshi, H. (2019) *DHARMA – Progress and Prospects*

Mathur, N.K., Narayan P., and Reddy, M.B. (2017), *Institutional Strengthening for Sustainable Dam Safety*

Blockley D., Godfrey P., *Doing It Differently* (2000), Thomas Telford Publishing

The Institute of Asset Management (2014), *Asset Management – an Anatomy*, The IAM

ISO (International Organization for Standardization) (2014) *ISO 55000:2004 Asset management – Overview, principles and terminology*, ISO, Geneva, Switzerland

Pocock, D., Shetty, N., Hayes, A., Watts, J. (2014), *Leveraging the relationship between BIM and asset management*, Infrastructure Asset Management, Volume 1 Issue 1, ICE Publishing