

TRain: The Railway Domain

A “Grand Challenge” for Computing Science & Transportation Engineering

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Abstract We present the rationale for the TRain Grand Challenge.

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1. What is the TRain Effort ?

The TRain Effort is a proposal put forward for the formation, worldwide, of an *Open, Free Consortium* of railway people and institutions (companies, industries), of academics (ie., people, researchers, scientists), and of research centres — within computer & computing science, software engineering, transportation science & engineering, reliability & safety engineering, and operations research, on the subject of exploring, creating, ie., researching, and freely propagating (publishing, on the net, etc.) *A Domain Theory for the Railway Infrastructure*.

Key points are research into the domain, not requirements, not algorithms, not software, of “all things” railways (see below). Building up a public repository of railway system models.

Of course it is unavoidable that research into domains, result also from research into and development of requirements and the design of algorithms and software. Hence the TRain effort will, obviously, see research results, ie., reports, papers, etc., that contain material on domains and requirements, or domains, requirements and algorithms, or domains, requirements and software design.

TRain is more a group of people “gathered” around joint research, reports, workshops, conferences, a railway formalisations repository, a web-based TRain newsletter, and possibly a web journal, than it is an organisation.

The organisation, ie., the *TRain Consortium*, is needed as a “mid-wife”, to help secure and to help “magnify”, a focused collaboration. The TRain

Working Groups are expected, in a sense, to be where “the real” work is being done (by its members) and co-ordinated (by its committee cum working group members). It is through working groups that the TRain effort will be “kick-started”.

The idea is *that railways: that rail nets, their static (ie., topological) and dynamic (ie., signaling and switching) properties, net development and maintenance, etc.; that rolling stock, its maintenance, deployment, etc.; that trains, their movement along the rails, that is: Train traffic, etc.; that passenger ticketing, inquiries, ticket cancellation, etc.; that freight handling: Reception, transfer, tracing, delivery, etc.; that scheduling & allocation of timetables, rolling stock, staff, etc.: that net planning & development (construction); that entirely new forms of train service; etc.; that is, that all aspects of railways: Strategic, tactical and operational management as well as operations can all be both informally and formally fully adequately described* — but that such models need be developed individually, and, formally, in rather different formal specification languages, and harmonised (ie., “integration of formal methods”), as well as communicated to all stake-holders.

The idea is to call for a “human genome”-like, worldwide R&D, open and free effort among university and railway industry R&D centres to achieve the above.

2. Why the TRain Effort ?

The Railway Industry Justification, the Whys. Because IT, ie., computing systems, for all aspects of railways, and especially for integrated, cross-related tactical and operational management, monitoring and control, etc. applications, become more and more important.

Because the design of these computing systems is hard, to very hard: Often fraught with cost overruns, late deliveries, and erroneous software, etc.

Because requirements for such systems are usually badly formulated. It is claimed that a proper, widely accepted *Domain Theory for Railways* can help ameliorate the above situation.

The Software Engineering Justification, the Why. Before computing systems can be designed one must understand the requirements. Before requirements can be formulated one must understand the domain. Today's computing systems for the railway infrastructure are not developed on the basis of anywhere near a reasonable understanding of the railway domain.

The Computing Science Justification, the Why. Because we need a grand challenge project in order to gather enough momentum to make progress along the road to industrially scalable and useful, integrated formal techniques.

The Science Justification, the Whys. Because there is no domain theory for such an important domain as that of railways. The natural sciences, so reveals “their name”, has domain theories: Physics (mechanics, thermodynamics, electricity, ...), biology, etc. *Is it not time for man-made structures to have their domain theories ?*

Towards a Science of Man-made Infrastructure Components, the Whys. We deploy the name 'infrastructure' - really without knowing its deeper, possible meanings. Transportation is one such infrastructure component. There are other infrastructure components: Financial service industry, health-care, public administration, etc. We must try understand the term 'infrastructure' — mathematically ! It seems high time someone started !

Sociologically and Psychologically, the Whys. Because it can be done; and because it is fun !

3. Who should Participate in the TRain Effort ?

Rail infrastructure owners, train operators, rail and train technology industries, mathematicians, operations researchers, computing scientists.

4. How to Participate in the TRain Effort ?

Individuals, interested in the TRain Effort, should either join an existing *Working Group*, or create one themselves! Working group individuals should study the railway domain, and describe parts of it, informally (but precisely) and formally, using any number of one or more formal techniques.

For characterisations of what is meant by *formal techniques* (cum 'Formal Methods') we refer to www.imm.dtu.dk/~db/colognet/train/index.php?page=faq&subpage=fm. For a survey of *formal techniques* we refer to www.imm.dtu.dk/~db/colognet/train/index.php?page=faq&subpage=fm-list.

Researchers of the *TRain Open Consortium* should co-ordinate their efforts across the TRain open consortium - at least by announcing: We are researching “such and such” a TRain area. Researchers of the TRain open consortium should endeavour to report, at least yearly, with one or more documents (reports or publications). Researchers of the TRain Open Consortium are expected to put their research results, that is formal models of respective aspects of the railway domain, in the open, for free consumption.

The TRain Secretariat shall endeavour to maintain a TRain Repository of as many already existing and all future such “modelisations” - free for anyone to use. Such research results are then expected to serve as “patterns” that can be used freely by anyone, in particular by the rail technology industry, when developing new technologies for the railway domain.

Possibly the TRain open consortium should, preferably in collaboration with one or more railway institutions organise special research events (seminars, workshops, symposia, conferences, congresses) where results are presented and where “open problem” challenges are identified. The TRain open consortium should encourage publication, training, education events (summer schools, courses, etc.), etc. The TRain open consortium could influence national and international rail organisations toward deployment of published domain formalisation in national and international development projects.

The TRain Open Consortium shall not advocate special technical approaches - but, and this is, of course, important: Advocate the use of carefully (informal language) narrated (annotated) formalisations.

5. What is meant by “An Open, Free Consortium”?

By an *Open Consortium* is meant a loosely knit collection of individuals: Researchers, software engineers, railway technologists, etc., and of their host institutions: Universities, railway companies, research centres, etc. The “loose knit” is the TRain consortium. At any time individuals and institutions may enter (or leave) the open consortium. Each individual (person) or institution acts individually.

There are to be no legal or financial, contractual relationship between any two distinct institutions nor individuals from distinct institutions, binding them in any other by way than their offering one another the fruits of their individual research on TRain related matters. By “acting” together, as the TRain open, free consortium“, it is expected that each individual, each institution will be spurred on to a more concerted effort, including even joint efforts, towards “modelisation” of “all things” railways. By an open and free consortium of the kind proposed here is also meant that there is no central funding source, no shared or common capital from which TRain research and other TRain activities may be funded.

TRain individuals and institutions are themselves to secure any needed funding.

Although the TRain consortium will and shall not act as a funding agency, it may well decide to support identified national or international railway domain research projects. This support is not financial. Rather it could be support, say in the form of written recommendations to national or international funding agencies, of proposed research efforts.

The TRain Consortium shall be pro-active in encouraging and in helping to arrange joint research efforts. Whether the TRain Consortium can otherwise issue “blue seals” of approval of individual or joint research efforts remains to be seen. Our current “thinking” is: Rather not. We would rather like to see research efforts emerge and survive, ie., attract attention, on their own scientific

merits. We would like to believe that subscribing to the TRain Consortium Charter suffices as a qualifier.

6. What is Meant by a “Grand Challenge” ?

From Tony Hoare, *Journal of the ACM*, Vol.50, No.1, January 2003, pp 63-69, we quote that which characterises a Grand Challenge — where the ‘it’s refer to the Grand Challenge being discussed:

(1) Fundamental: It relates strongly to foundations, and the nature and limits of a discipline. (2) Astonishing: It implies constructing something ambitious, heretofore not imagined. (3) Testable: It must be objectively decidable whether a grand challenge project endeavour is succeeding or failing, (4) Revolutionary: It must imply radical paradigm shifts. (5) Research-oriented: It can be achieved by methods of academic research – and is not likely to be met solely by commercial interests. (6) Inspiring: Almost the entire research community must support it, enthusiastically – even while not all may be engaged in the endeavour. (7) Understandable: Comprehensible by - and captures the imagination of- the general public. (8) Challenging: Goes beyond what is initially possible and requires insight, techniques and tools not available at the start of the project. (9) Useful: Results in scientific or other rewards - even if the project as a whole may fail. (10) International: It has international scope: Participation would increase the research profile of a nation. (11) Historical: It will eventually be said: It was formulated years ago, and will stand for years to come. (12) Feasible: Reasons for previous failures are now understood and can now be overcome. (13) Incremental: Decomposes into identified individual research goals. (14) Co-operative: Calls for loosely planned co-operation between research teams. (15) Competitive: Encourages and benefits from competition among individuals and teams - with clear criteria on who is winning, or who has won. (16) Effective: General awareness and spread of results changes attitudes and activities of scientists and engineers. (17) Risk-managed: Risks of failure are identified and means to meet will be applied.

7. Conclusion

We invite the reader to study the TRain home page: www.imm.dtu.dk/~db/-colognet/train, to consider joining TRain, and to contribute to the TRain effort. We expect to formalise the foundation of the TRain consortium by the end of 2004.