Data-driven Simulation of the Extended Enterprise

Bing Cao, Richard Farr, Mike Byrne and James Tannock

Nottingham University Business School,
United Kingdom

Simulation of the Extended Enterprise

- Supply chain design is a key focus of modern manufacturing in the Extended Enterprise (EE)
- With the ever increasing complexity and dynamics of supply chains, simulation is a powerful tool to assess EE performance
- In traditional simulation approaches, the model is constructed by a user, who defines a model step-by-step using the user interface of the simulation tool
- If model configuration must be changed, this must be carried out by a simulation expert, thus greatly limiting the usefulness of simulation to non-expert users

Data Driven EE Simulation

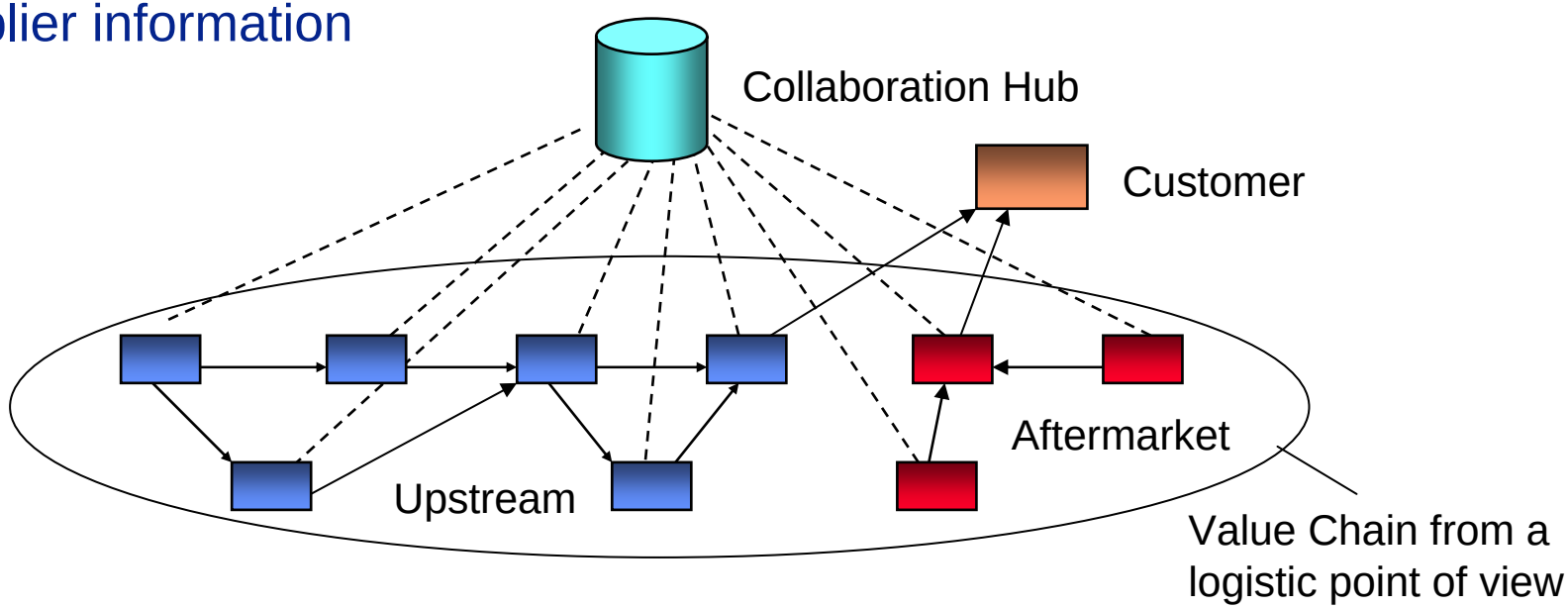
- The concept of data-driven modelling and simulation of the supply chain/EE has been adopted.
- Enabled by the relatively limited domain nature of a supply chain/EE
- The model is constructed automatically by a the Supply Chain Model Builder application, based on data existing in company IT systems
- Model development time is greatly reduced
- A model created this way can be reconfigured rapidly, by changing the external data.
- User can explore the implications of radical changes to a simulated EE, with little knowledge of the simulation software itself

Aerospace Engine Industry Supply Chain

- Some characteristics of the aerospace engine industry:
  - Complexity of the product/service offering (inc. bundled service and build kits, etc.)
  - Importance of aftermarket supply chain (inc. MRO, component repair, etc.)
  - Global nature of supply chain, increasing importance of Far East (esp. China, Japan, etc)
  - Suppliers often chosen for high-level business reasons (e.g. R&R sharing) with little consideration of logistics issues
  - Component value and therefore high cost of holding inventories
  - Complex relationships between businesses that can operate at several levels in the supply network

The VIVACE Extended Enterprise Concept

- Partners in the aerospace Extended Enterprise are connected via a collaboration hub
- Each enterprise partner provides information about its capabilities to the collaboration hub
- Supply Chain simulation techniques can access the hub to obtain supplier information



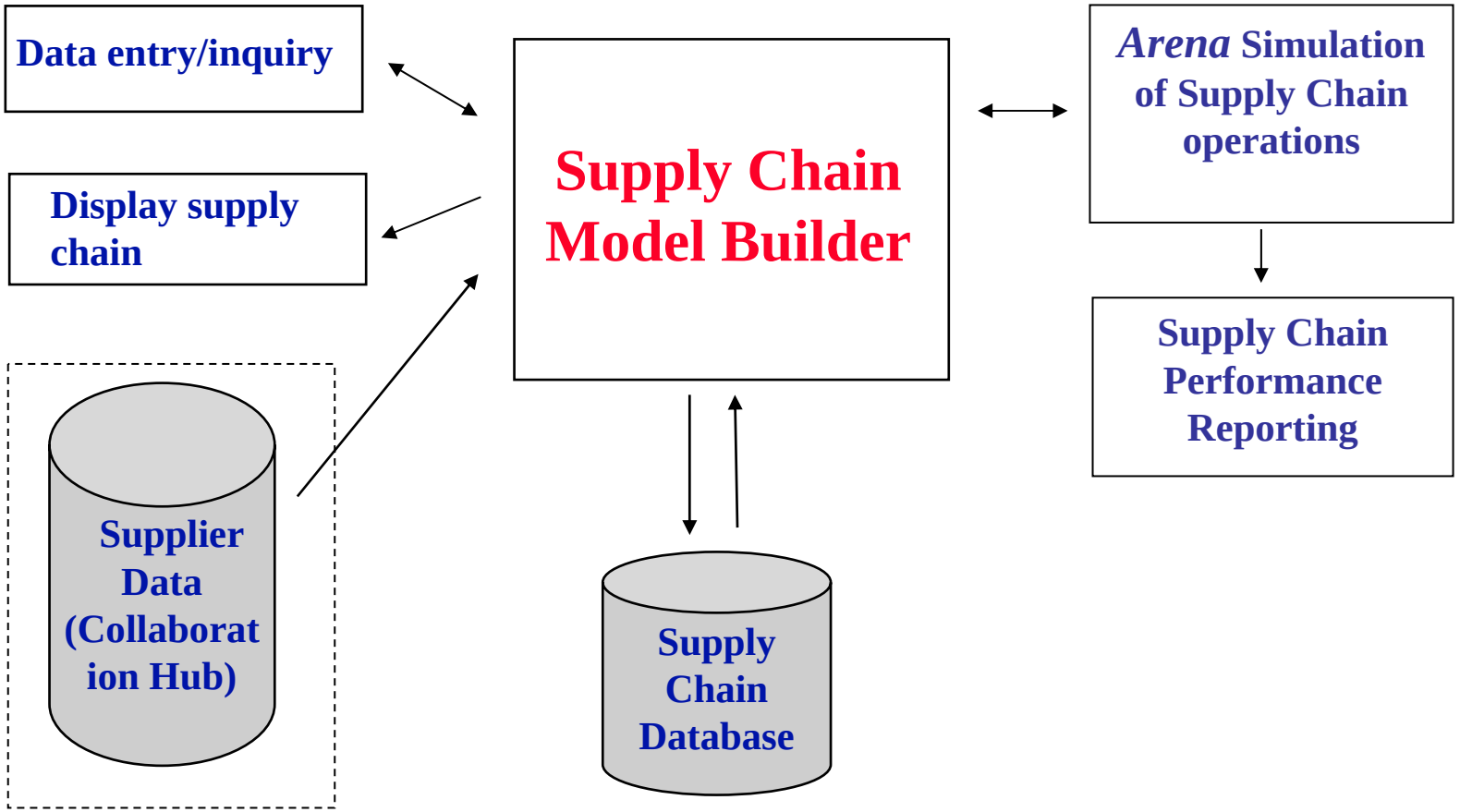
Data Driven Modelling of the EE

- In VIVACE, a data-driven simulation would mean that a database of supplier information (ultimately in the Extended Enterprise Collaboration Hub) would be interrogated, and a corresponding set of nodes created within a network model, each node with appropriate properties representing the relevant capabilities of the supplier which it represents
- The network model can then be transferred to discrete-event simulation system to explore its performance and dynamics
- At present, the VIVACE Collaboration Hub is not yet available and the system uses information from SAP, such as extended BoM data for model creation

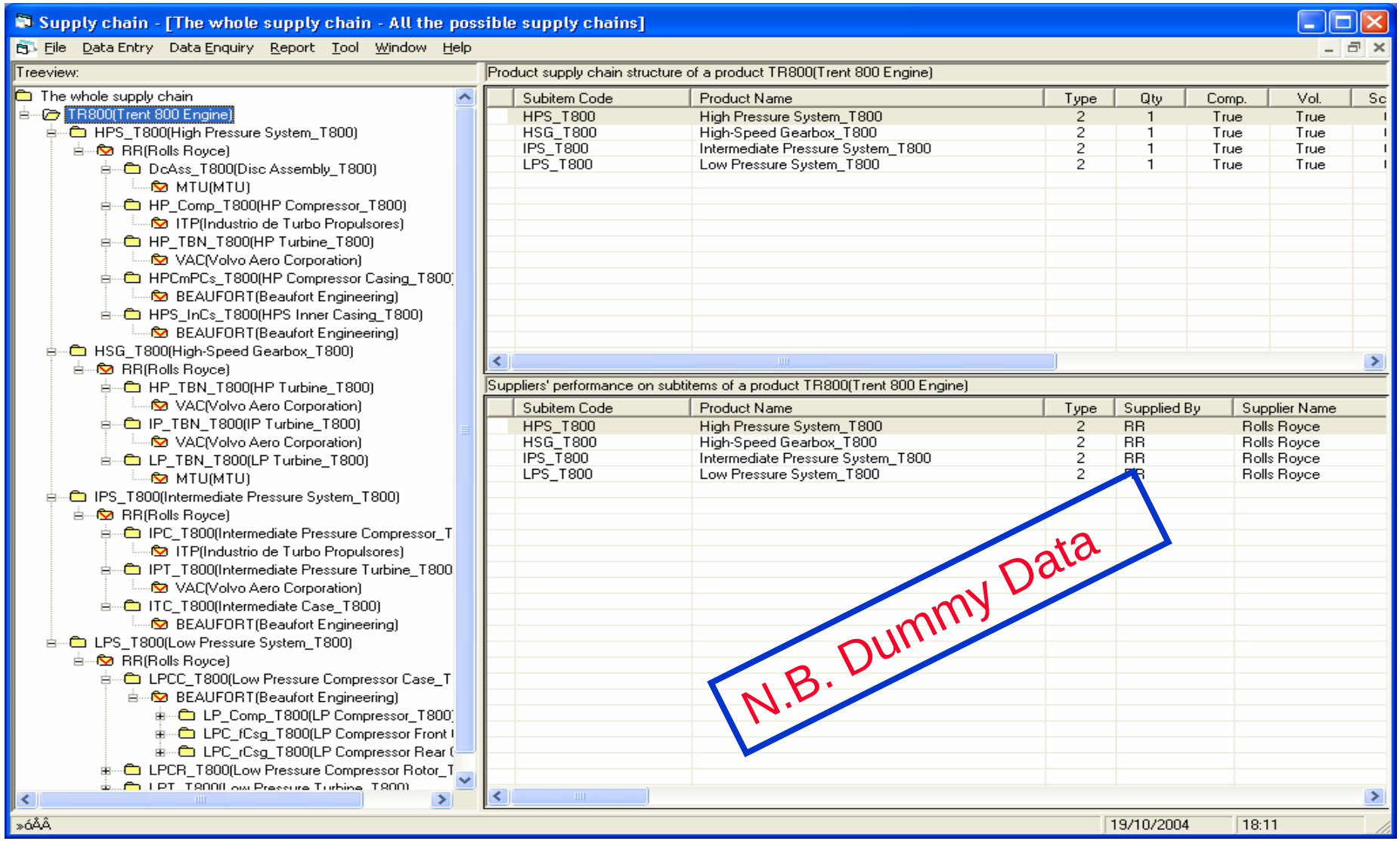
Why Data-driven Simulation in Vivace?

- Evaluating supply chain implications for different extended enterprise and supplier options
- ‘What-if’ questions to understand complex supply chain behaviour, e.g.
- Up-front evidence Demand variability and other uncertainties
  - Information distortion
  - Evaluating supply chain implications for new product designs
  - of logistics issues associated with suppliers
- Assistance with the ‘7-day proposal’ (WP 2.1) for new products

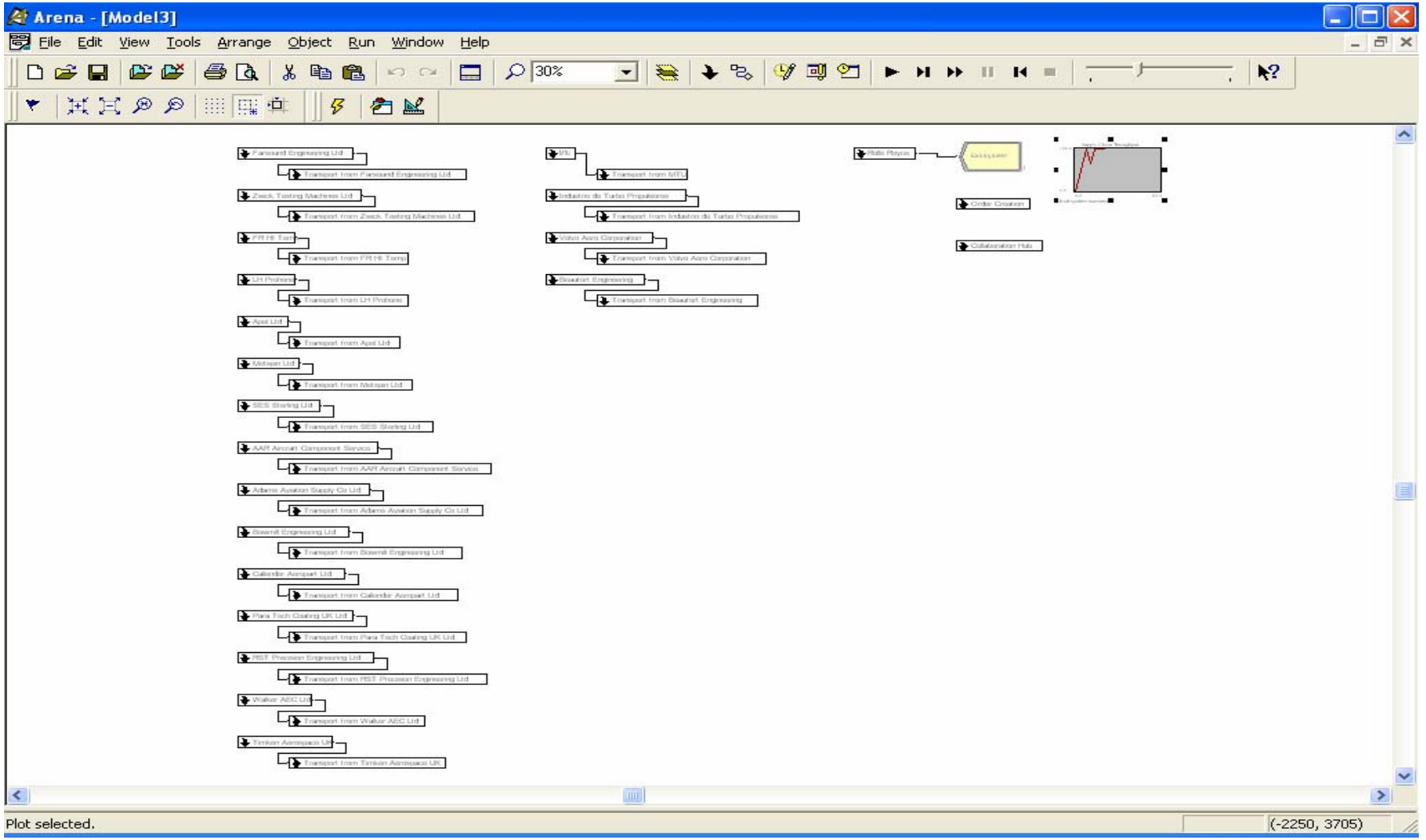
Data-driven Modelling/Simulation Architecture



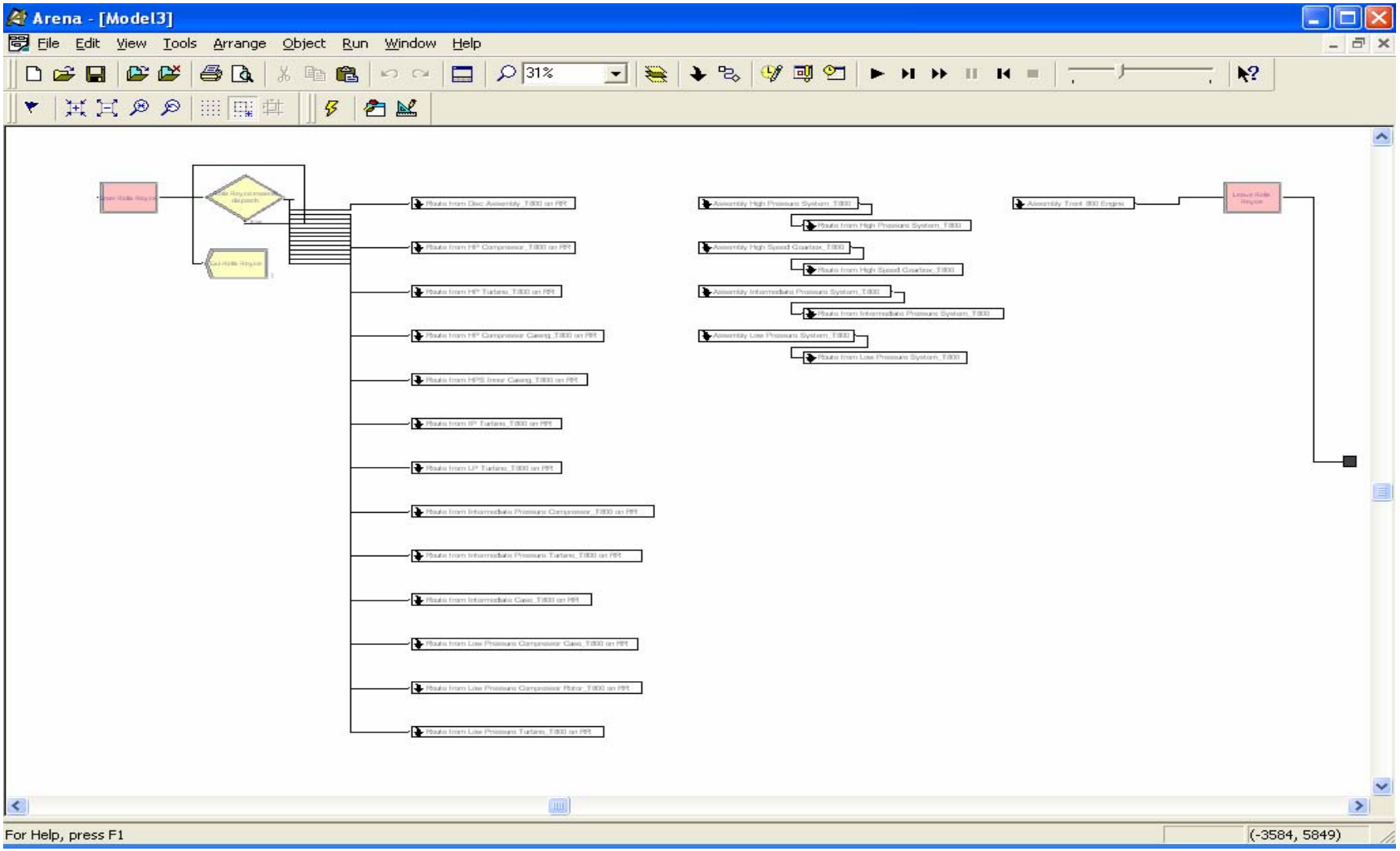
Screenshot of the Supply Chain Model Builder



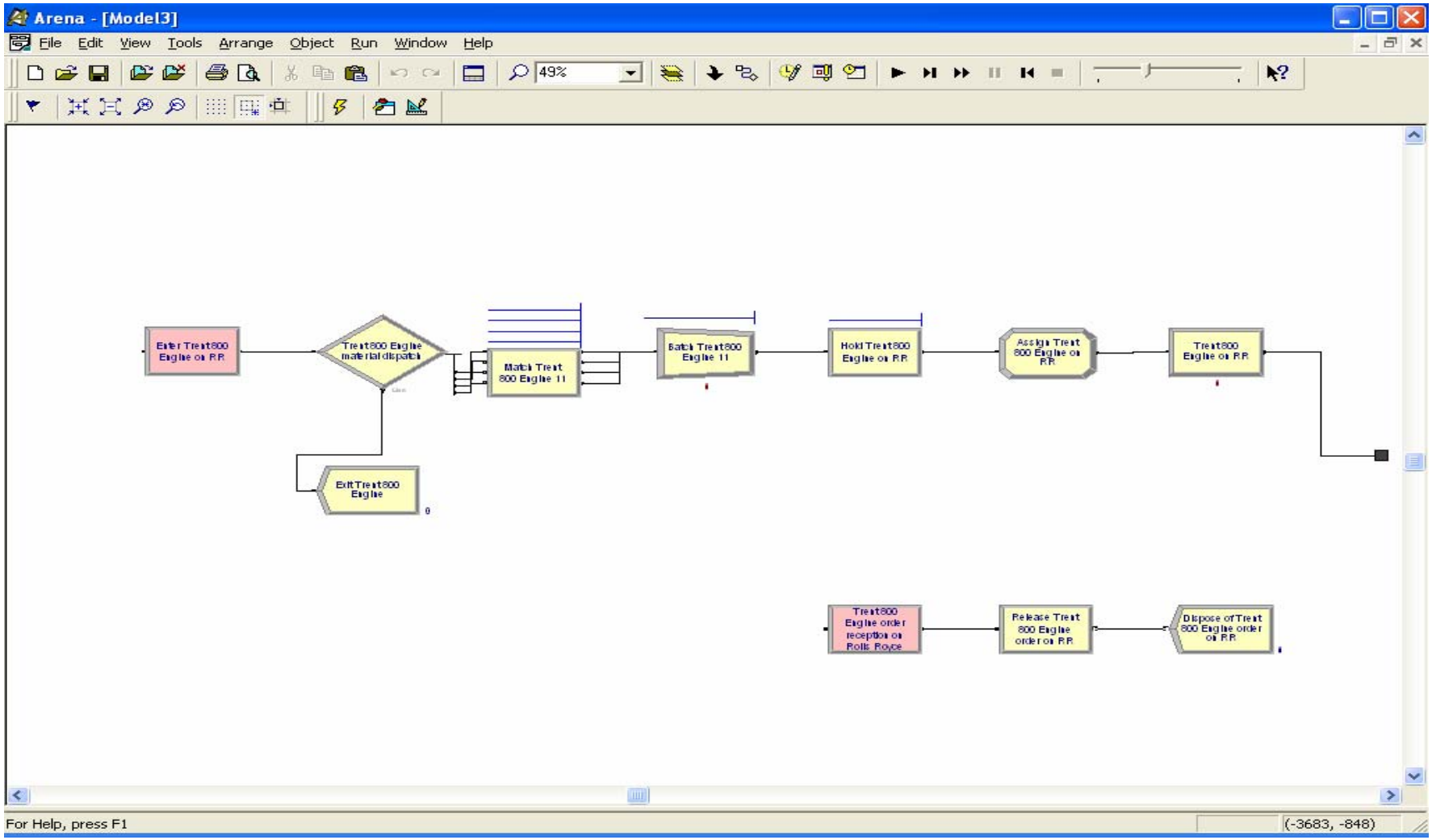
The Top Level Model of Data-driven Supply Chain in Arena



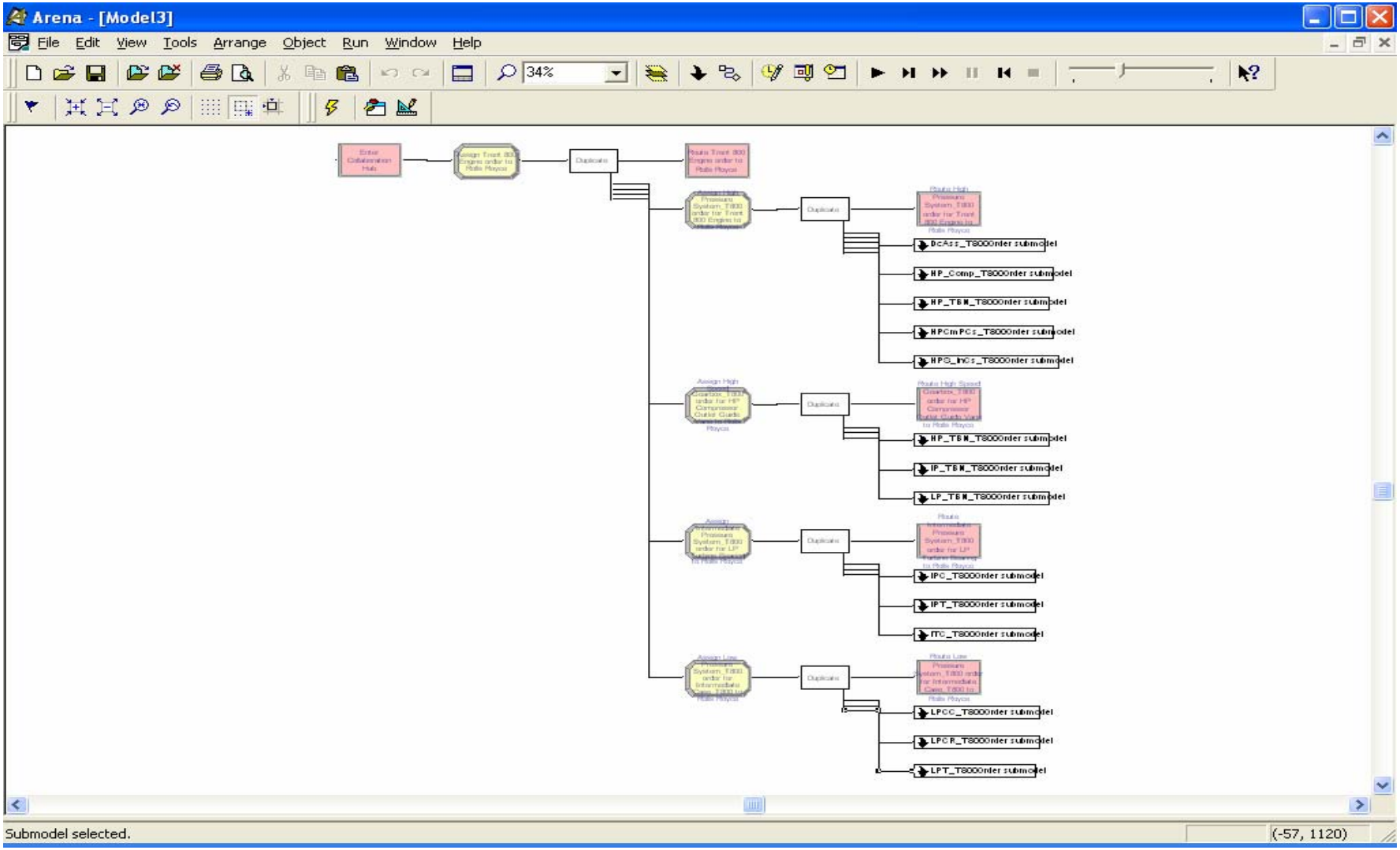
A Supplier Sub-model



An Assembly Sub-model



The Collaboration-hub Ordering Model



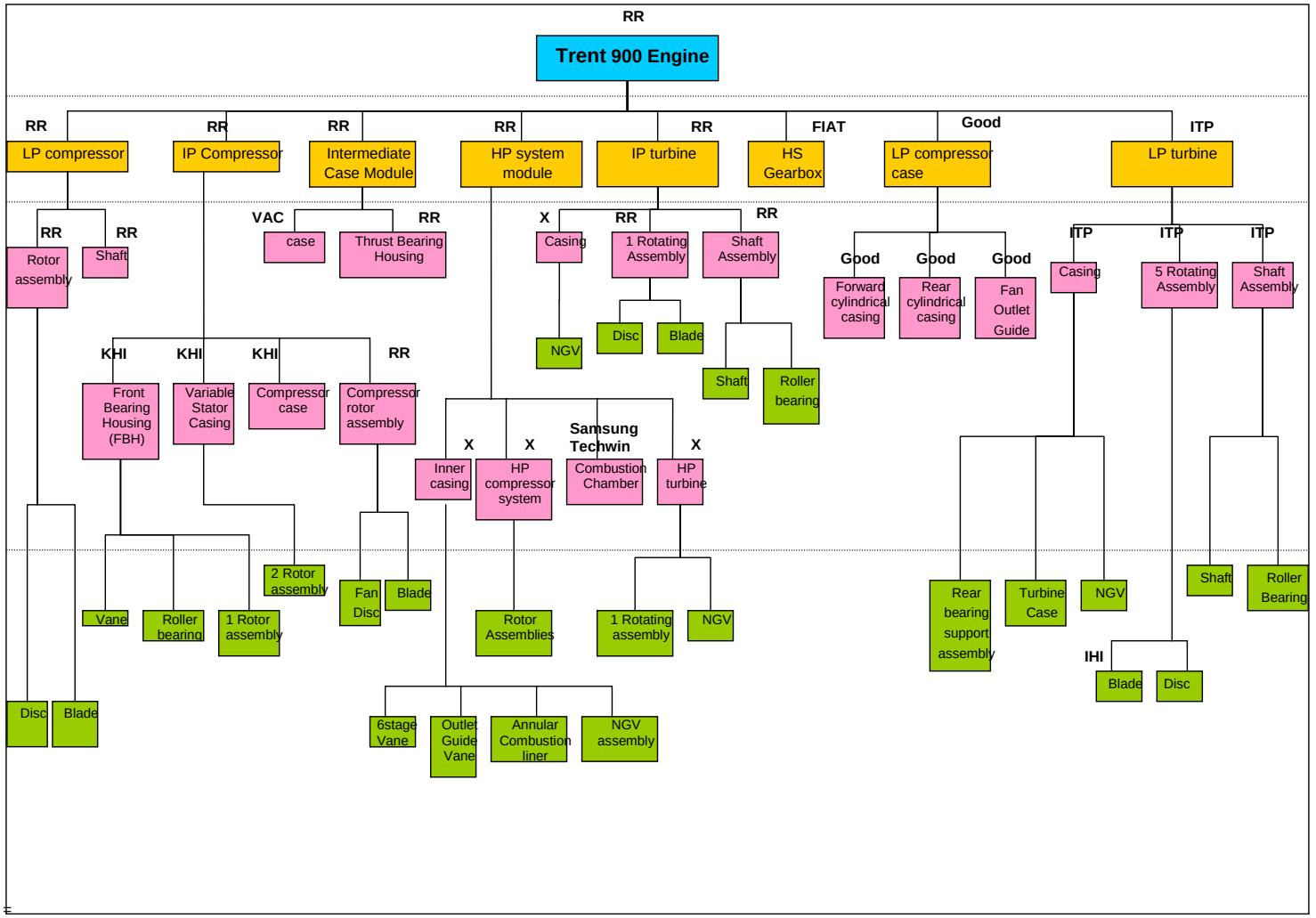
Supply Chain Performance Measurement

- Performance on the aggregated level
  - Calculate a single weighted and normalized multi-criterion metric, based on
  - performance metric categories, individual metrics, weightings, simulated metric values, weighted and normalized values for categories, absolute benchmarks, relative benchmarks
- Performance on the detailed level
  - The key performance indicators (KPI), e.g. delivery lead-time, WIP costs and manufacturing reliability, can be plotted on two-dimensional graphs

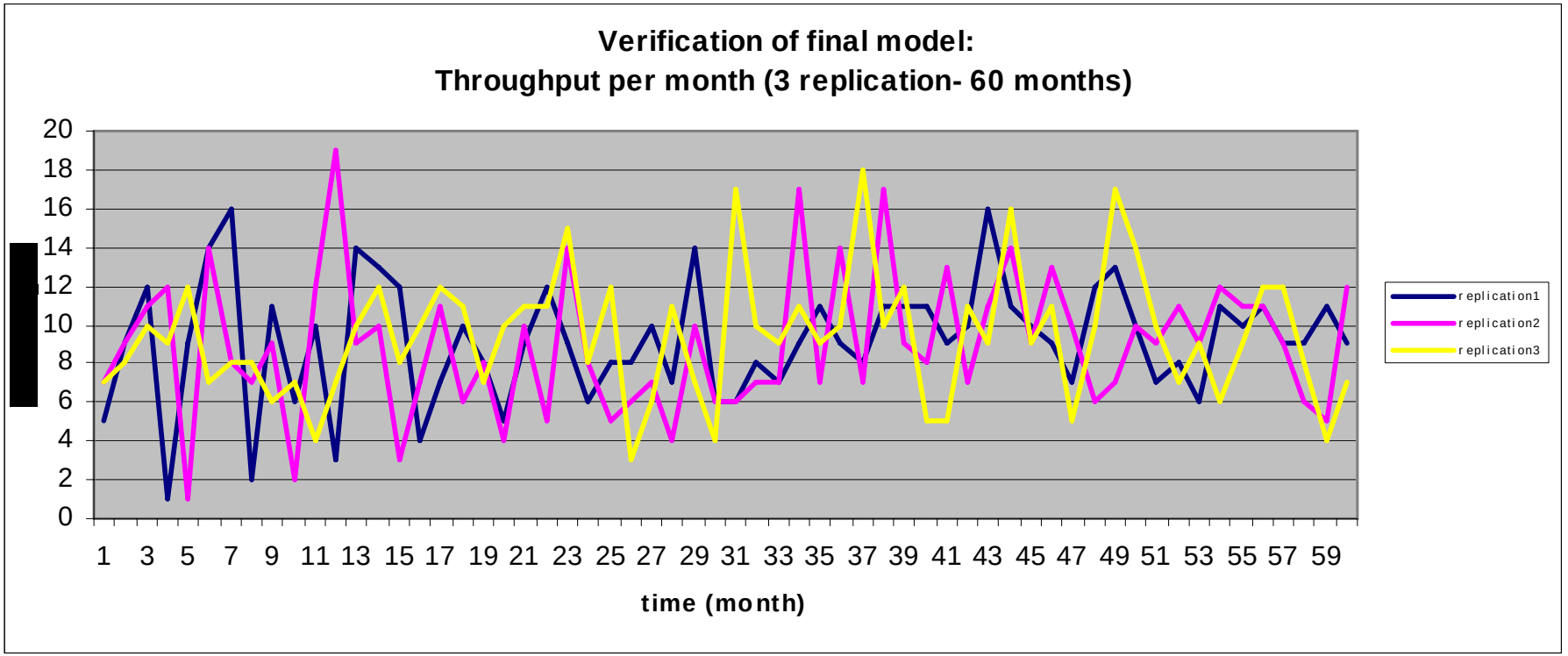
Status of DD Model Creation

- Methodology: starting from the main supplier the model is built ‘backwards’ down to the lowest level suppliers
- Model structure: a multi-layer structure potentially allowing for modelling realistic supply chains, e.g. any selection of supplier, product, network structure
- Model creation: an Arena model is automatically created from the database, using a Visual Basic application, the Supply Chain Model Builder (SCMB)
- The model currently runs with dummy data based on a Trent 800 BoM, using three-levels of supplier

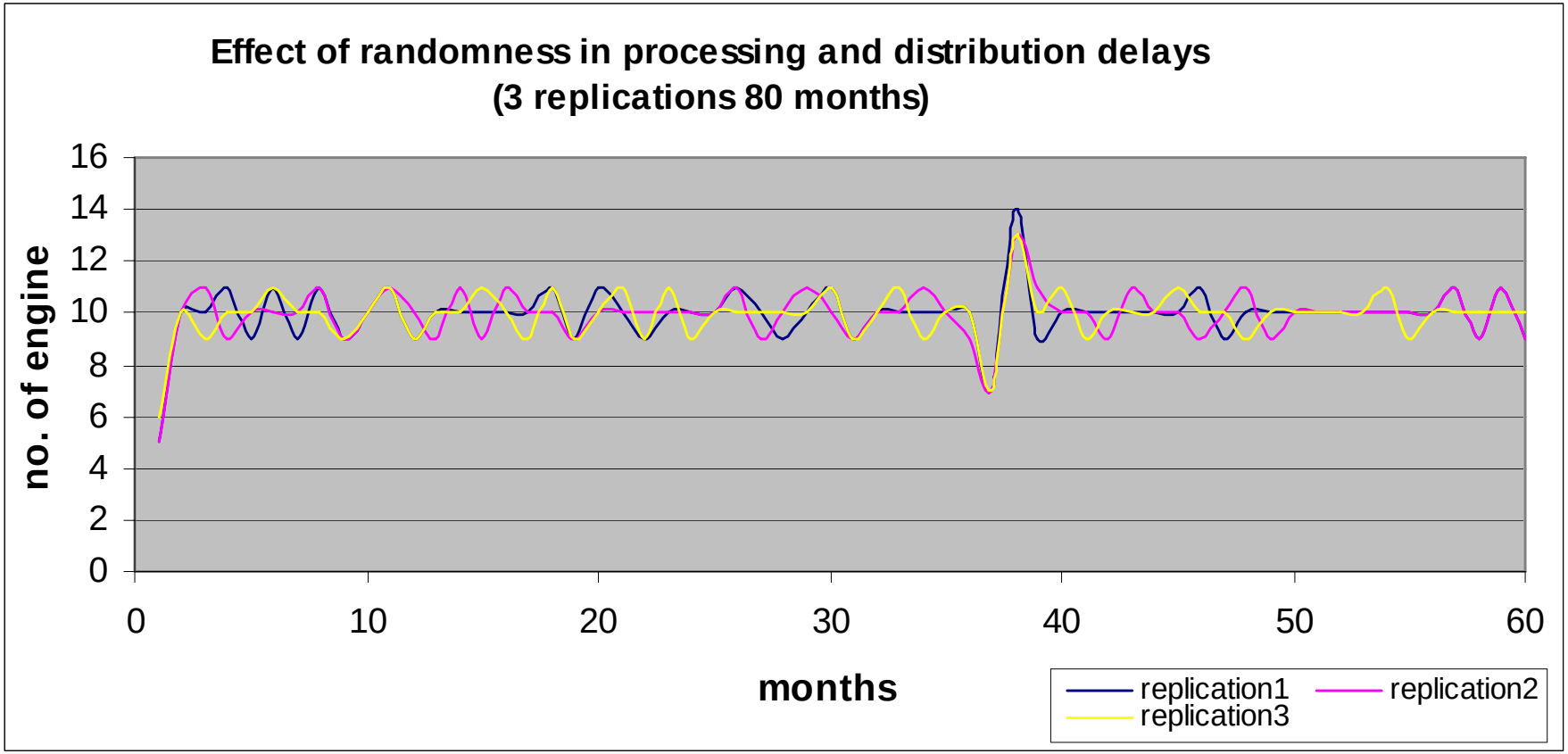
RR Trent 900 BOM



Trent 900 throughput rate



Effect of Randomness in material supply



Future Developments

- Further improve the prototype model for better efficiency and functionality. Adding
  - information flow and control
  - animation
  - reporting
- Model verification and testing programme
- Use case developments, requiring additional realistic supplier and logistics information (e.g. Trent 900) from industrial partners
- Experimenting with model and simulation settings, e.g. deciding steady-state requirements
- Validation and Experimentation with use cases
- Modifying the database and model to accommodate new functionality as required by users