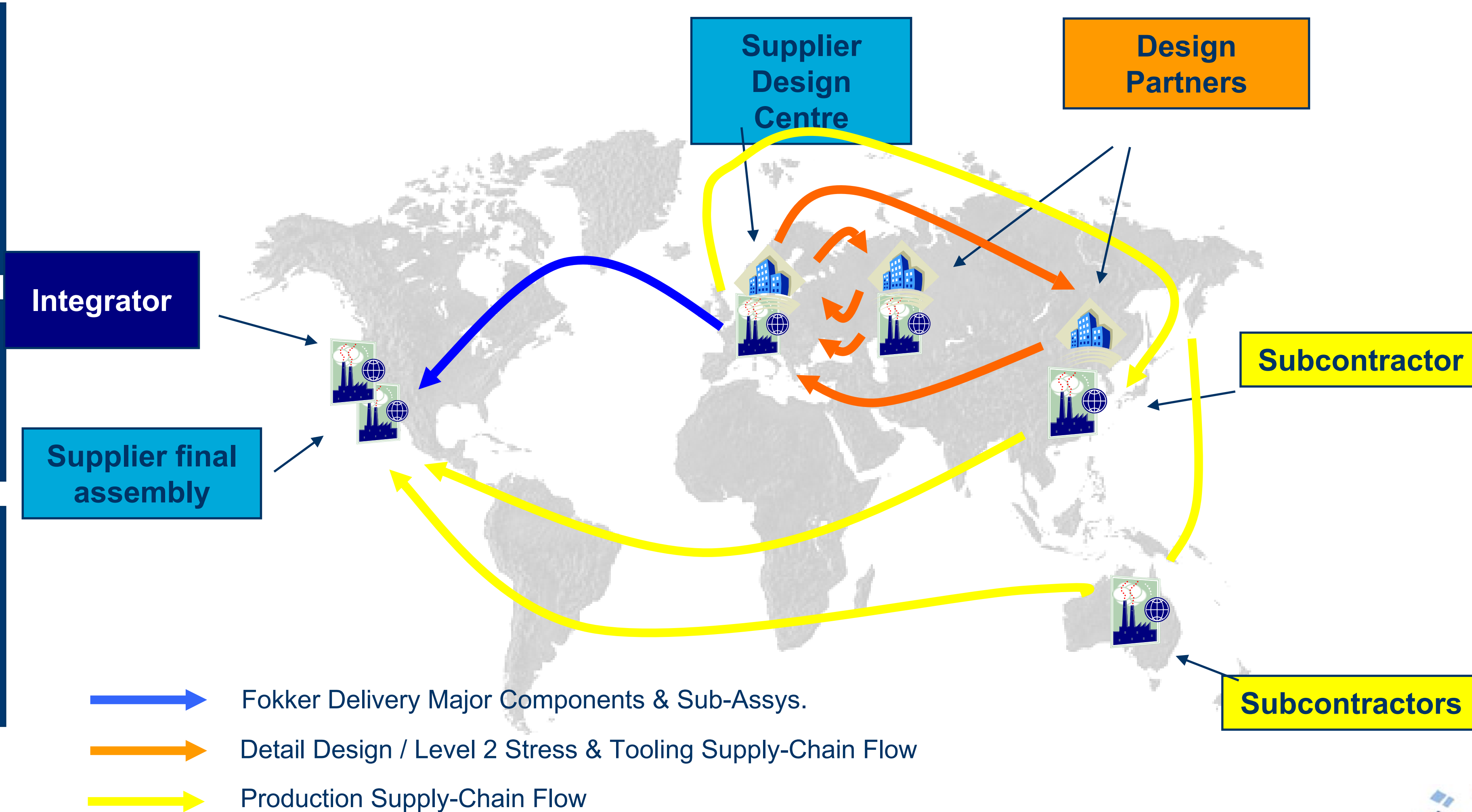
Time for a 100 visions and revisions:
A system dynamics study of the impact of concurrent engineering on supply chain performance

International System Dynamics Society Conference

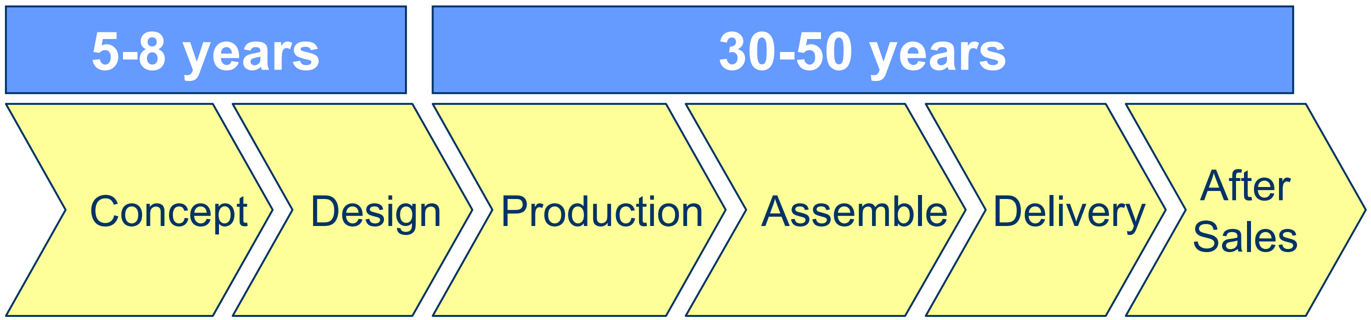
Oxford University, July 28, 2004

Henk Akkermans and Kim van Oorschot, Minase

Where is this coming from?
A high-tech supply chain from the aerospace sector



What is the problem?
How to sequence and organise product development and production ramp-up to mimimise time-to-volume



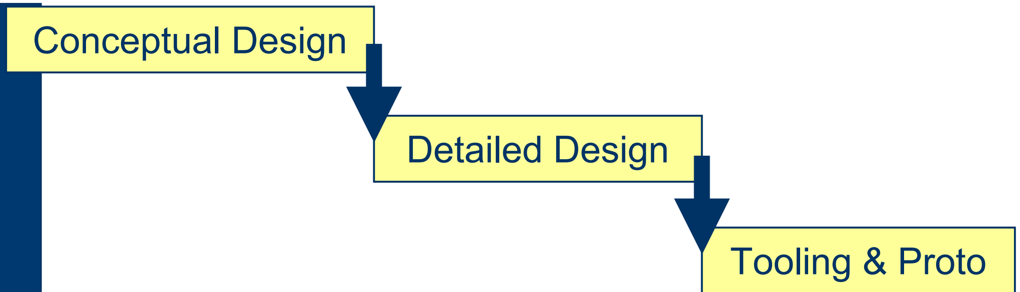
In Aerospace, new aircraft programmes are characterised by

•long, long life cycles *and*

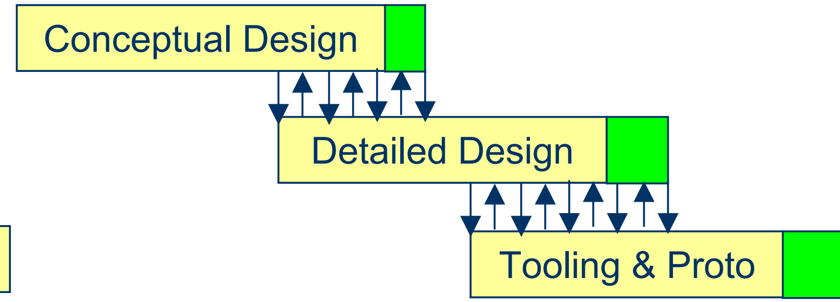
•a rush to ramp up production fast and hard

MINASE
creating beauty together

A clash of ideas:
Sequential Engineering versus Concurrent Engineering



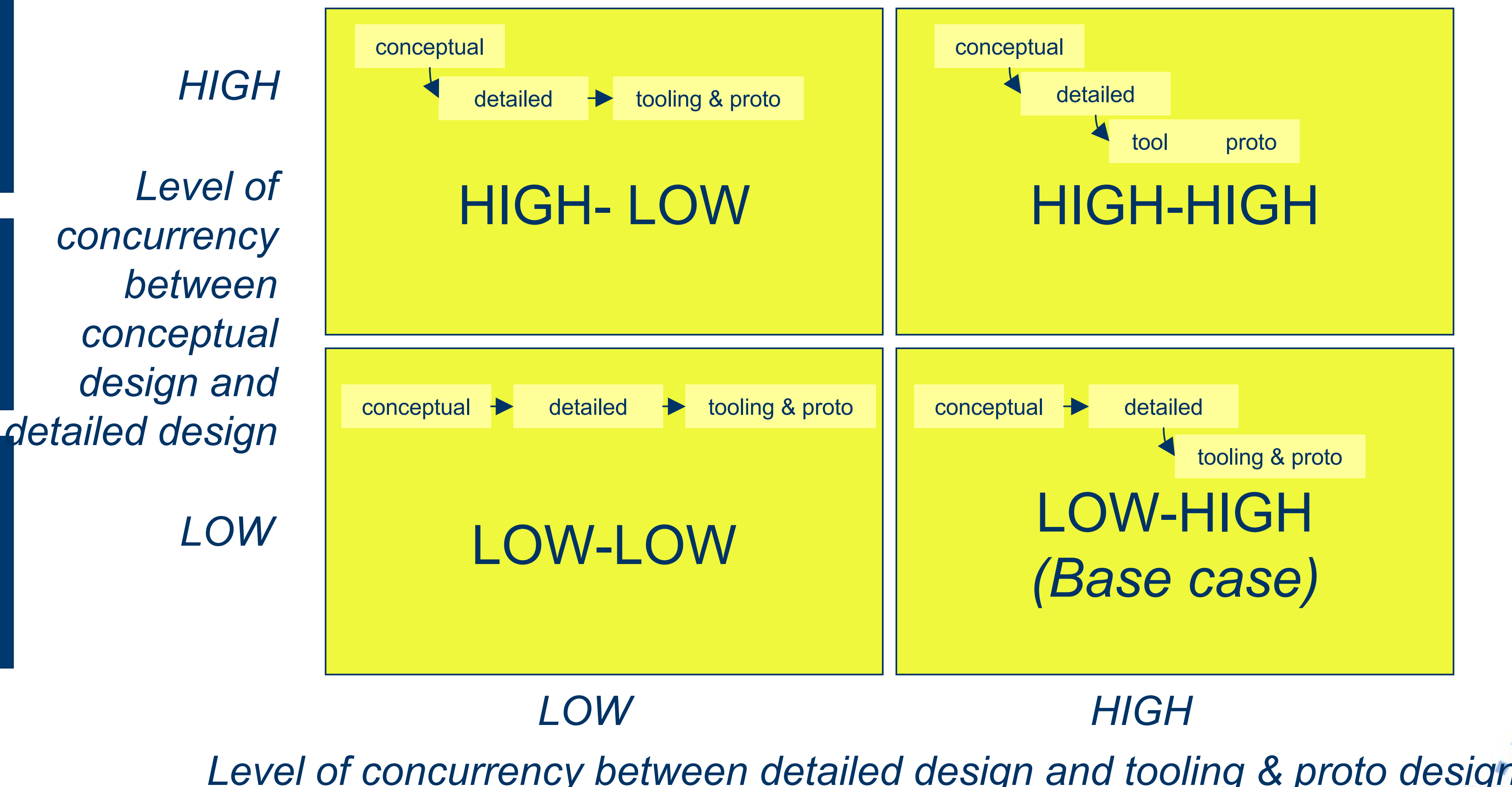
- **Activities in sequence**
- **Downstream phase begins with finished, frozen information from upstream phase**
- **One-way information transfer, one-way learning, risk of low design quality**
- **Low risk of iterations**
- **Low risk of rework**
- **Long leadtimes**
- **High risk of “idle time” of engineers (who are usually the bottleneck in product development)**
- **Hardly no communcation/feedback required between engineers of up- and downstream phases**



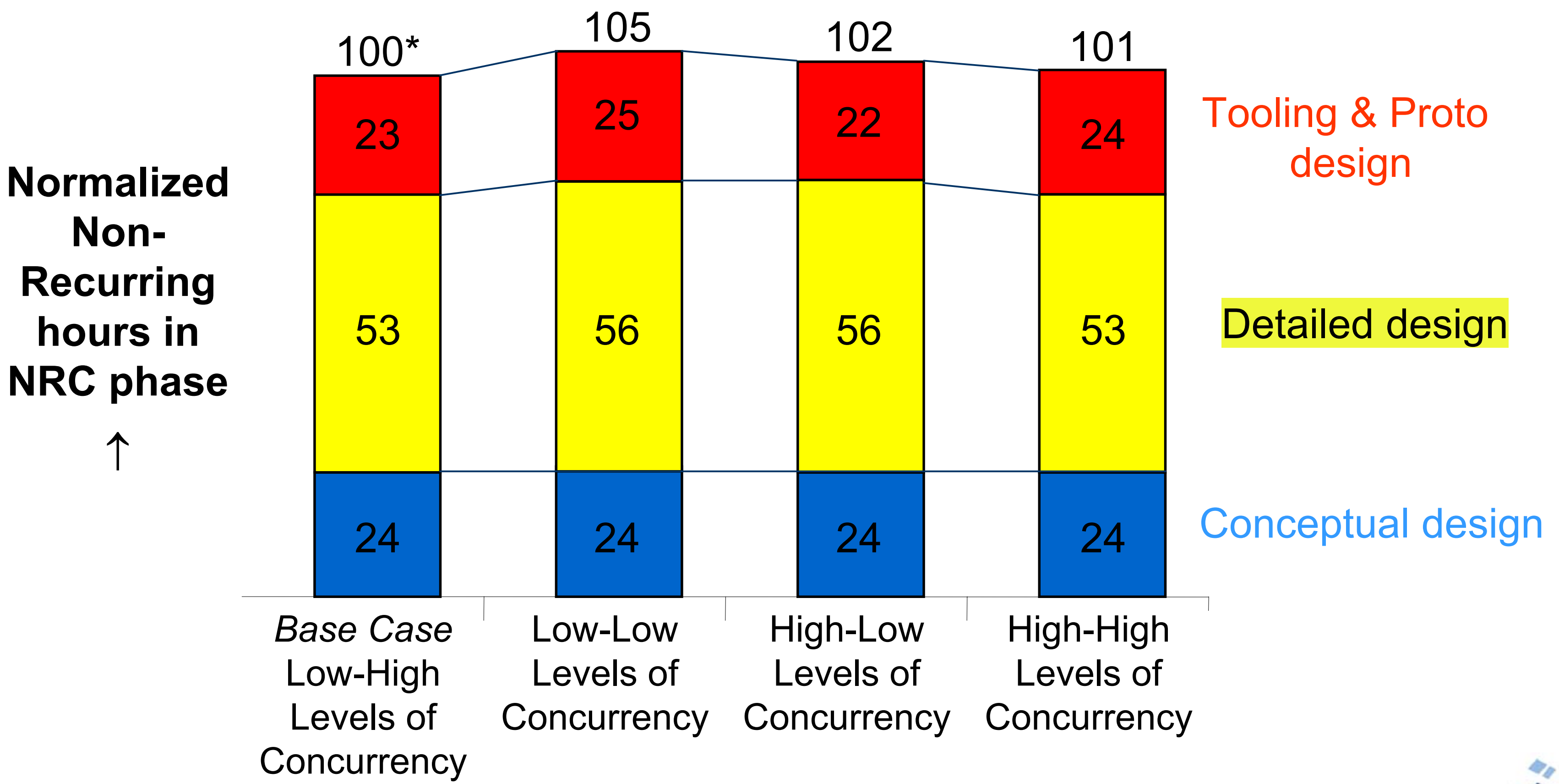
- **Activities in parallel**
- **Downstream phase begins with preliminary information from upstream phase**
- **Two-way information transfer, two-way learning stimulates high design quality**
- **High risk of iterations**
- **High risk of rework**
- **Possible short leadtimes (if required time for rework is not longer that time gained from early start)**
- **Low risk of “idle time” of engineers**
- **Communication/feedback (Knowledge Management) required between engineers of up- and downstream phases**

MINASE
creating beauty together

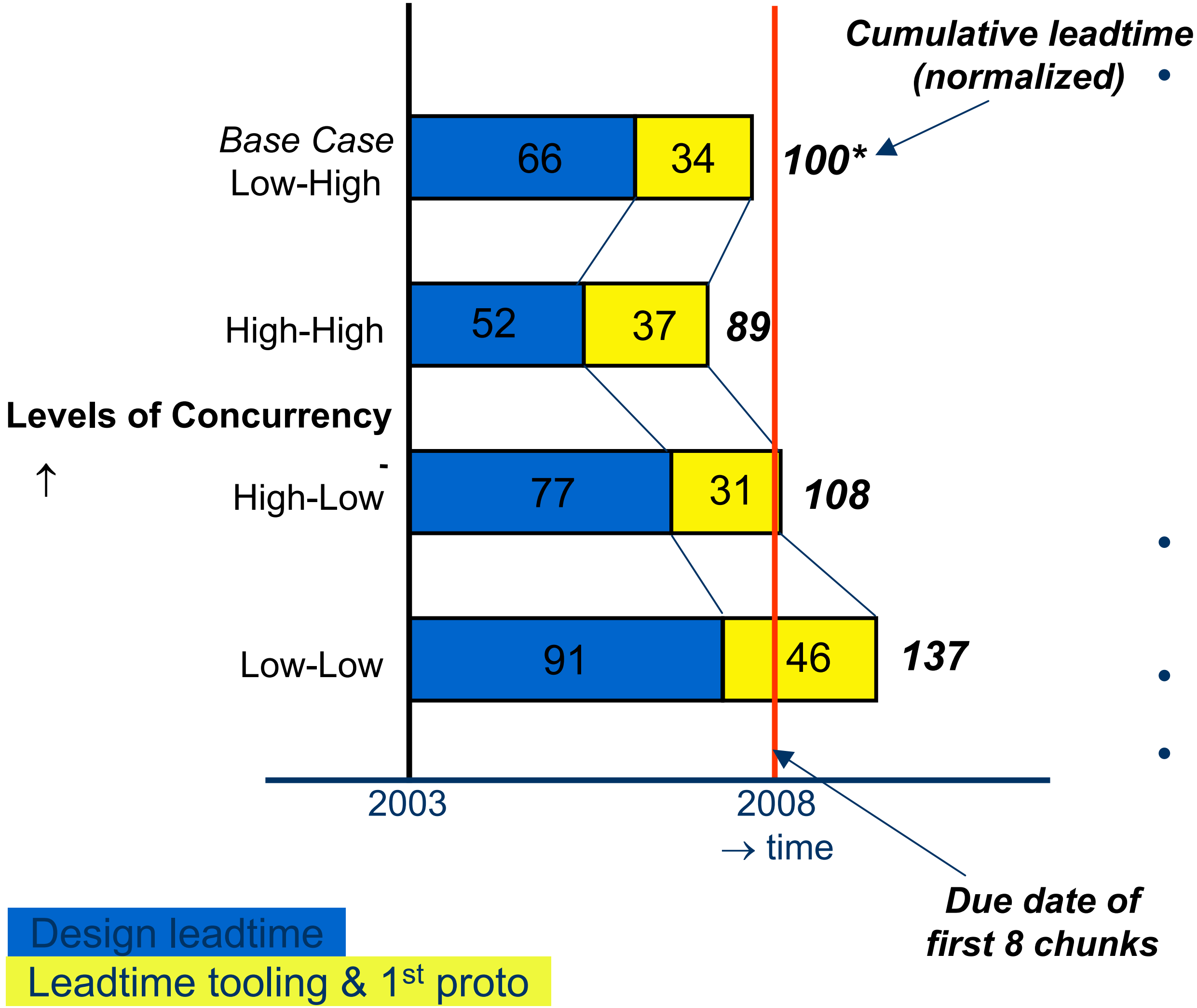
In a 3-stage design process, there are four different degrees of concurrency to be considered:



In terms of cumulative design hours required, none of these scenarios really stands out - although the Low-Low strategy appears most expensive



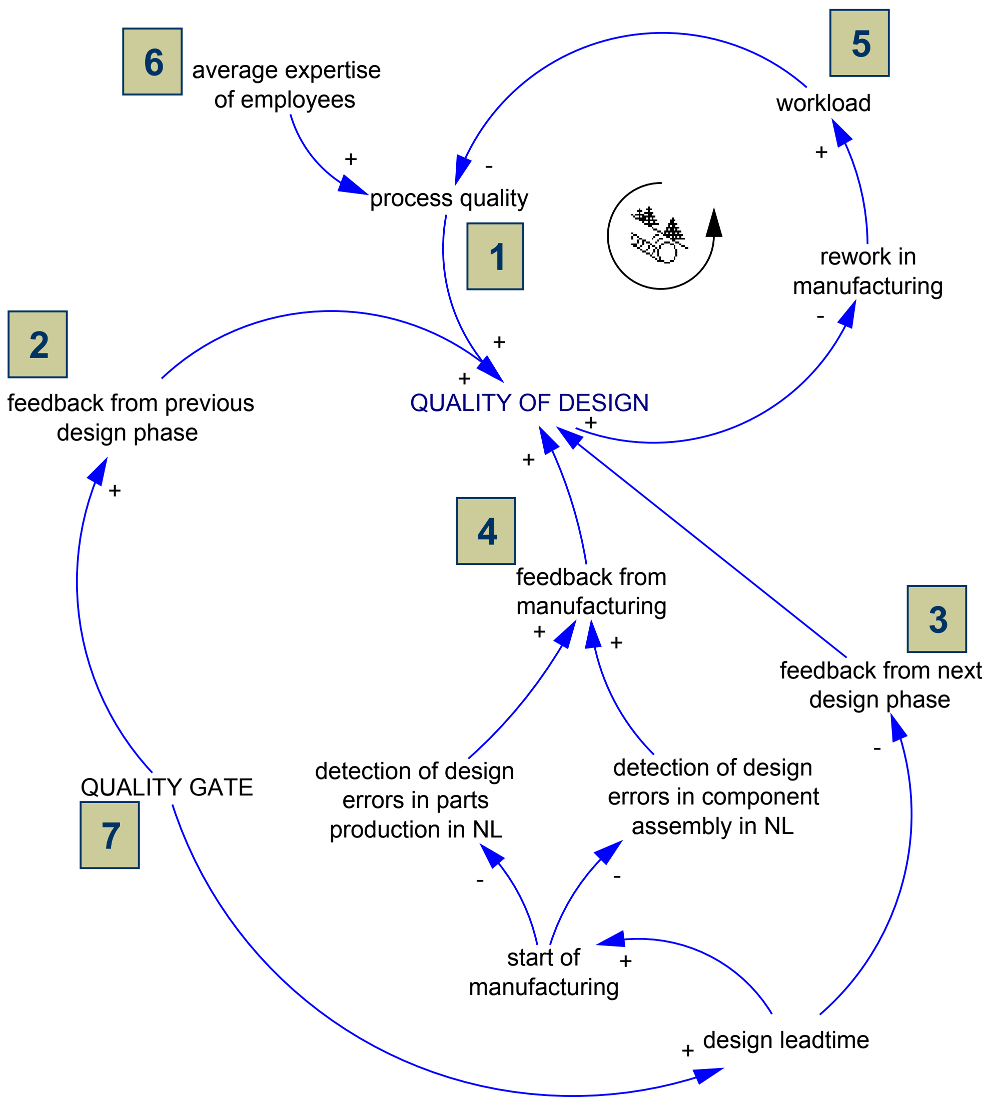
But, design *lead times* are very different for the four strategies



- The start of the Recurring phase can be much sooner with high levels of concurrency (NRC leadtime is reduced by 11% compared to the base case
- Leading to earlier customer interaction
- And better IRR's
- High-Low & Low-Low scenarios will not be able to meet customer due dates

*100=4.6 yrs

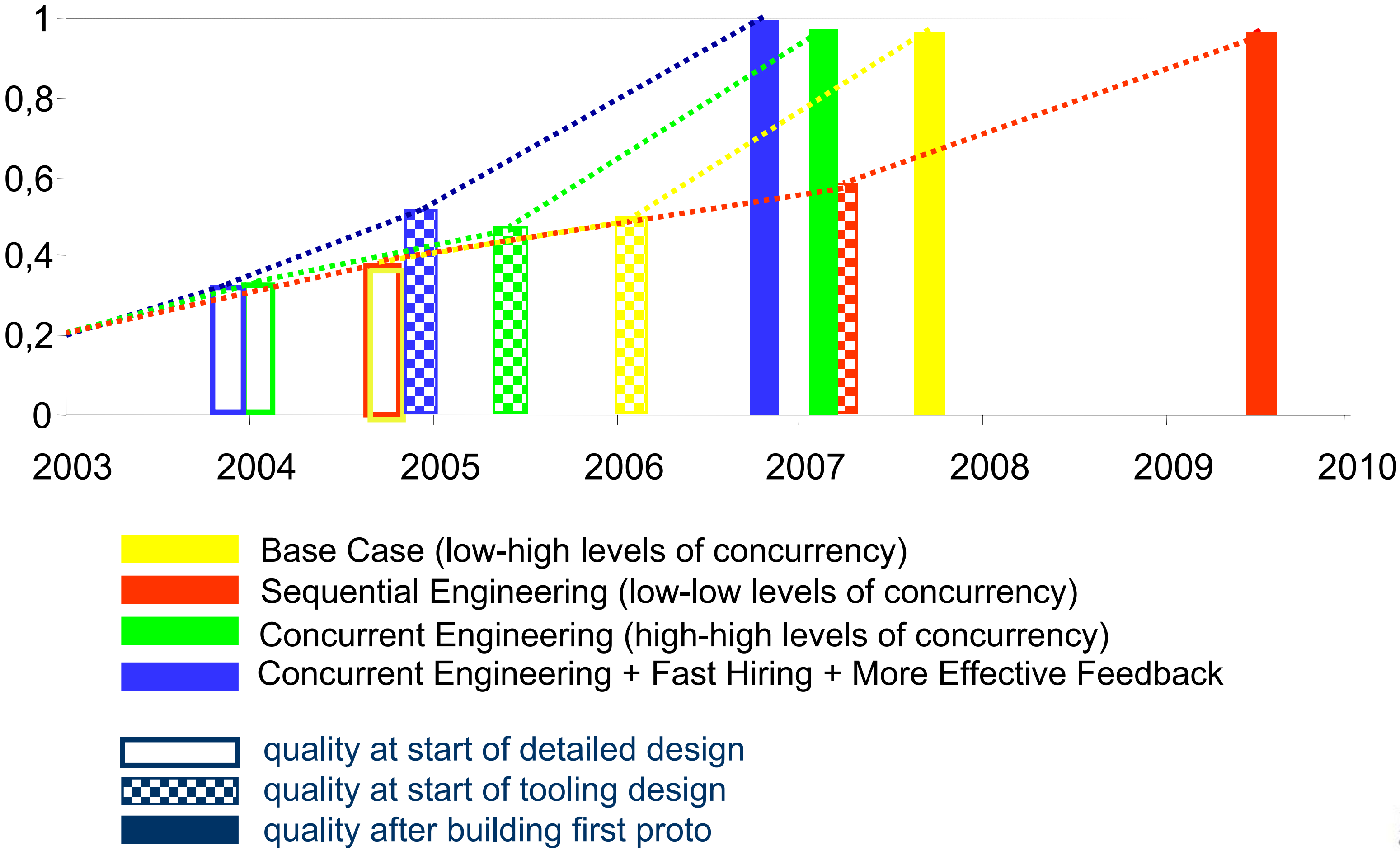
Why is it, that setting high "quality gates" does not lead to a high quality outcome?



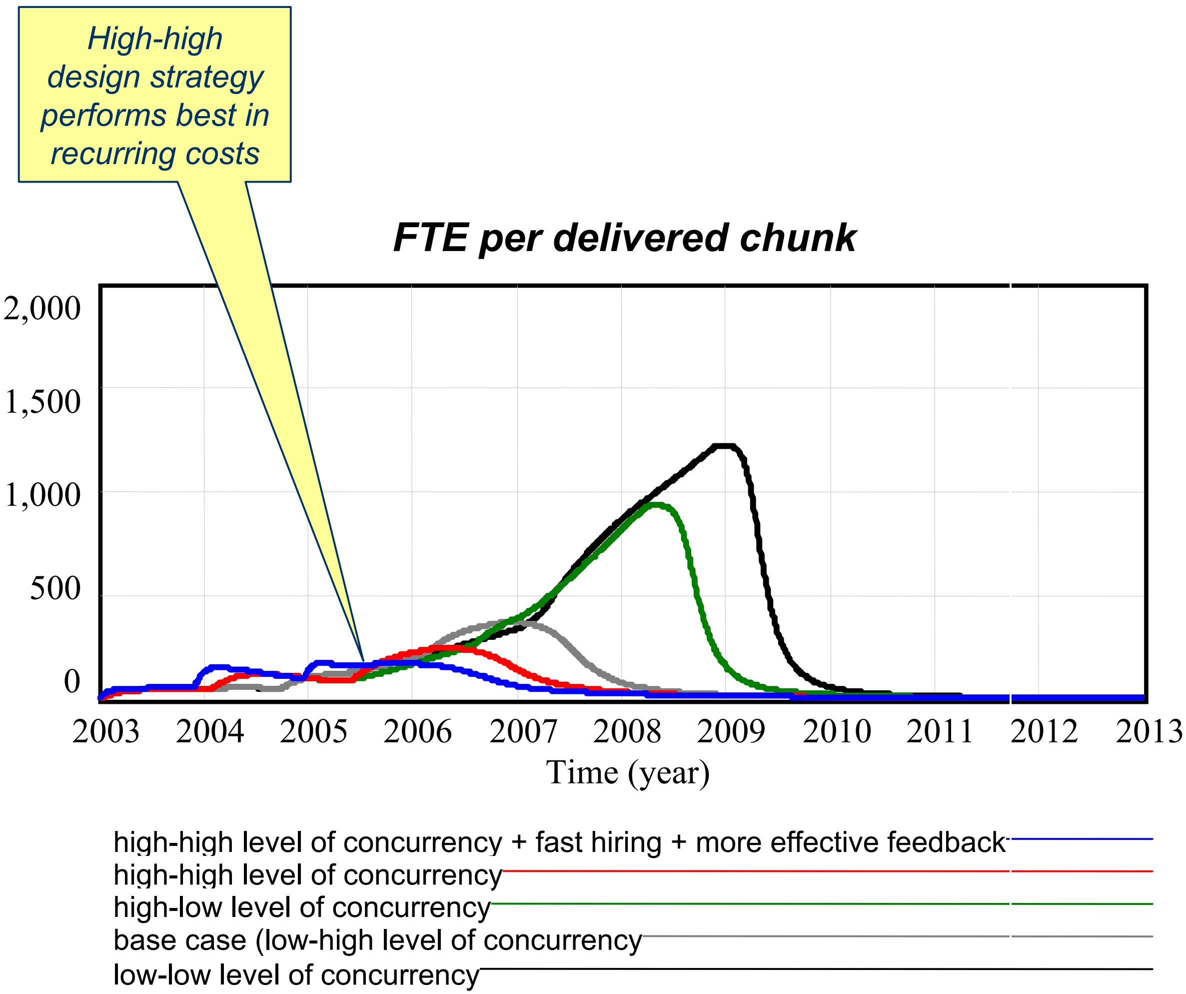
- **Quality of Design is influenced** directly **by:**
  1. Process quality (quality of engineers)
  2. Feedback from previous design phase
  3. Feedback from next design phase
  4. Feedback from manufacturing phases
- **Quality of Design is influenced** indirectly **by:**
  5. Workload of engineers
  6. Expertise of engineers
  7. Quality gates

A high quality gate has a positive effect on the feedback from the previous design phase, however, high quality gates increase design leadtimes. As a consequence, feedback from the next design phase and from manufacturing is delayed, which has a negative effect on the quality of a design.

High quality gates (sequential engineering) increase leadtimes, delay feedback from next design phase and from manufacturing, and result in lower quality of the first protos



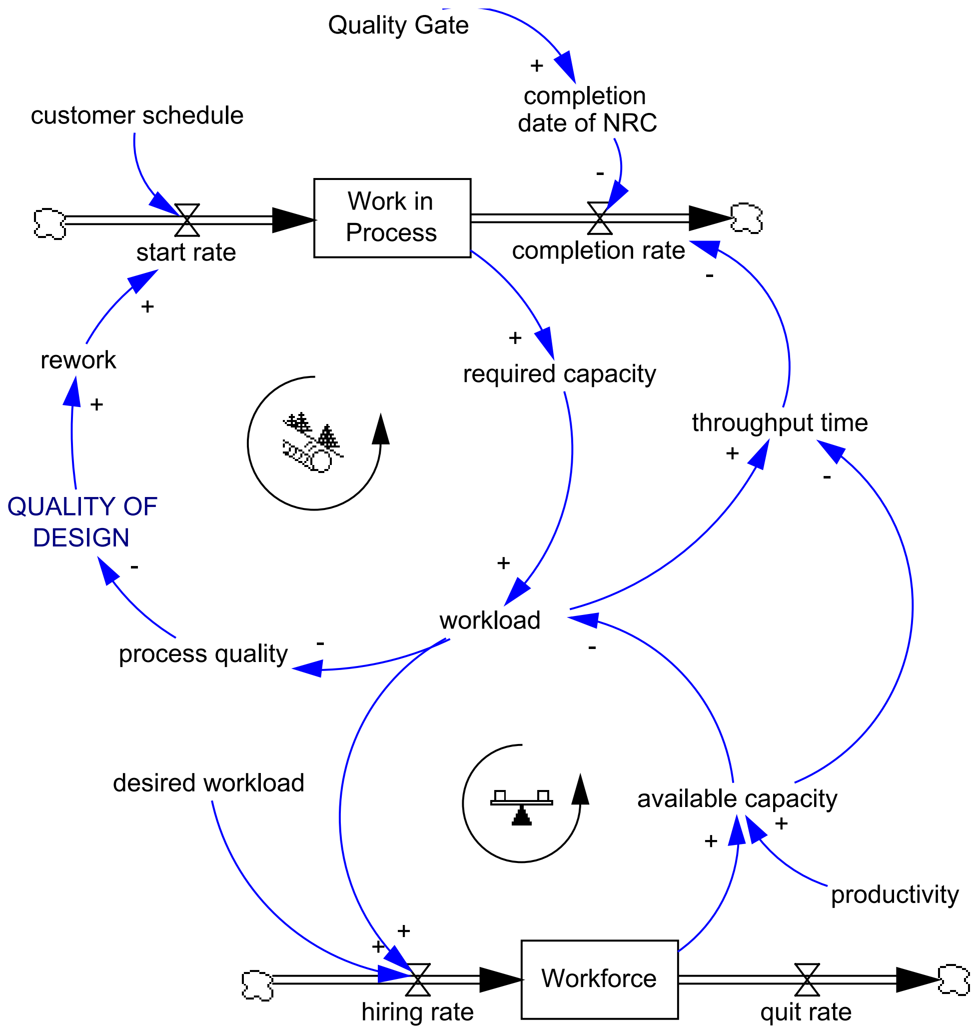
Importantly, the recurring prodution costs under the four Non-Recurring scenarios are completely different



- The earlier learning that results from the earlier start of each phase leads to earlier learning and hence to better design quality in the recurring phase to start with
- Especially the doing-it-right-the-first-time strategy of sequential engineering (low levels of concurrency) proves to be much slower and costlier as a result of this

MINASE creating beauty together

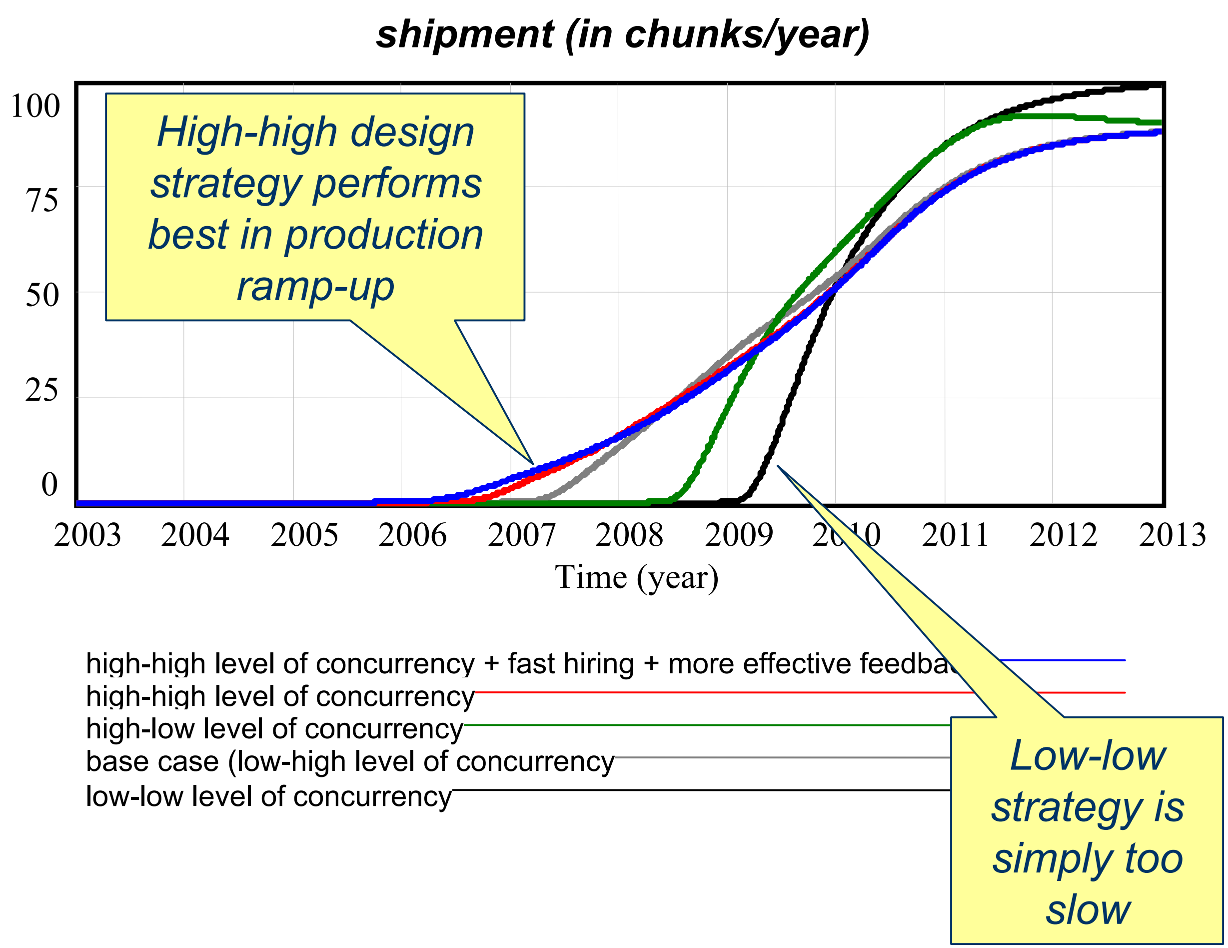
These cost differences can be explained by the “factory physics” of workload



- **Workload has three effects:**
  1. It influences quality of design and thus the amount of rework
  2. It influences the hiring rate of new employees and thus the available capacity
  3. It influences the throughput time and thus the completion rate
- **High quality gates (sequential engineering) delay the completion date of the NRC phase and therefore also delay the completion of the RC phase. Because the customer schedule is fixed, work in process increases. As a result, the workload increases. Consequently, more employees are hired. Therefore,** sequential engineering requires a larger workforce…

MINASE
creating beauty together

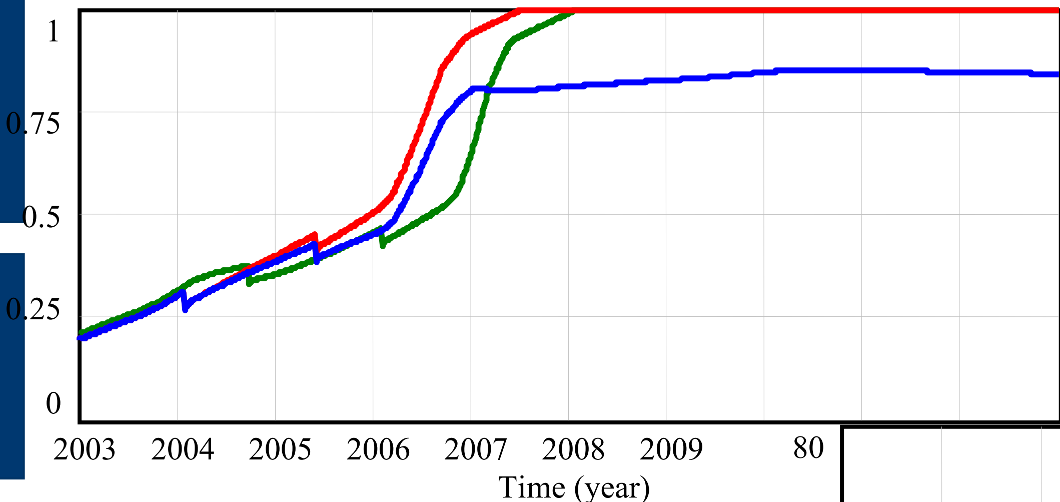
Also, the differences in production ramp-up speed as a result of these different Non-Recurring scenarios are considerable



- **The earlier learning that results from the earlier start of each phase generates earlier production output that meets the production schedule**
- **Especially the doing-it-right-the-first-time strategy of low levels of concurrency proves to be too slow due to its late start of the RC phase**

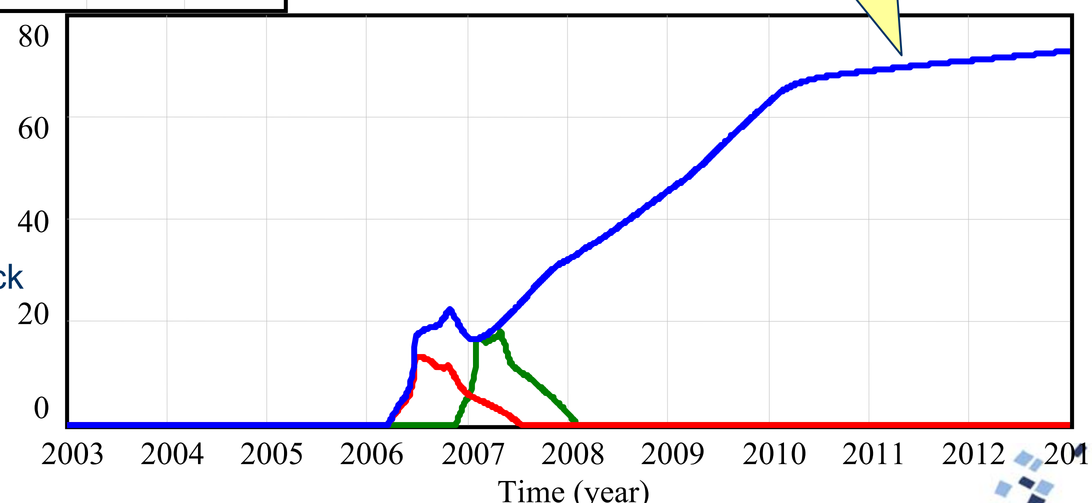
On the importance of information feedback from one design phase to its preceding phase

average quality of design phases



No feedback from downstream phases results in a lower design quality and consequently in far more rework in manufacturing

rework on components



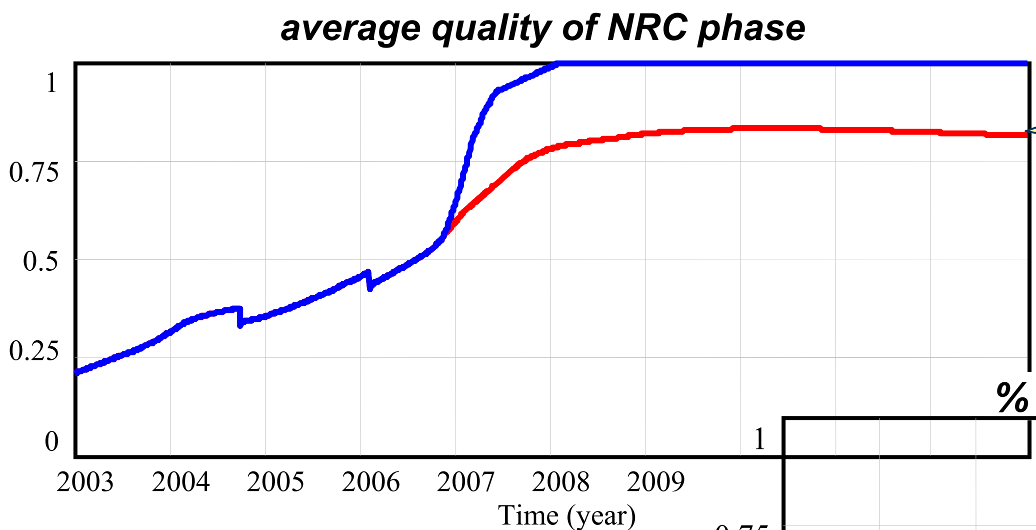
Base Case

High-High level of concurrency with feedback

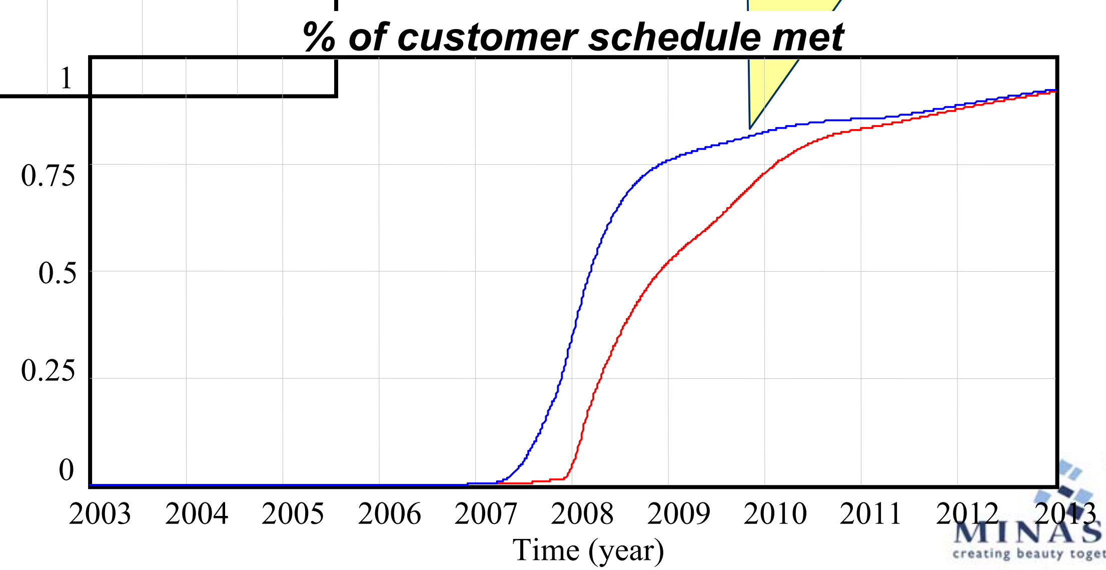
High-High level of concurrency and NO feedback from downstream phase to upstream phase

On the importance of a Test Factory close by

(1): For a high-quality output of the Non-Recurring processes, it is essential that a close link is maintained with Recurring processes for feedback on the manufacturability of the first 10,000 parts



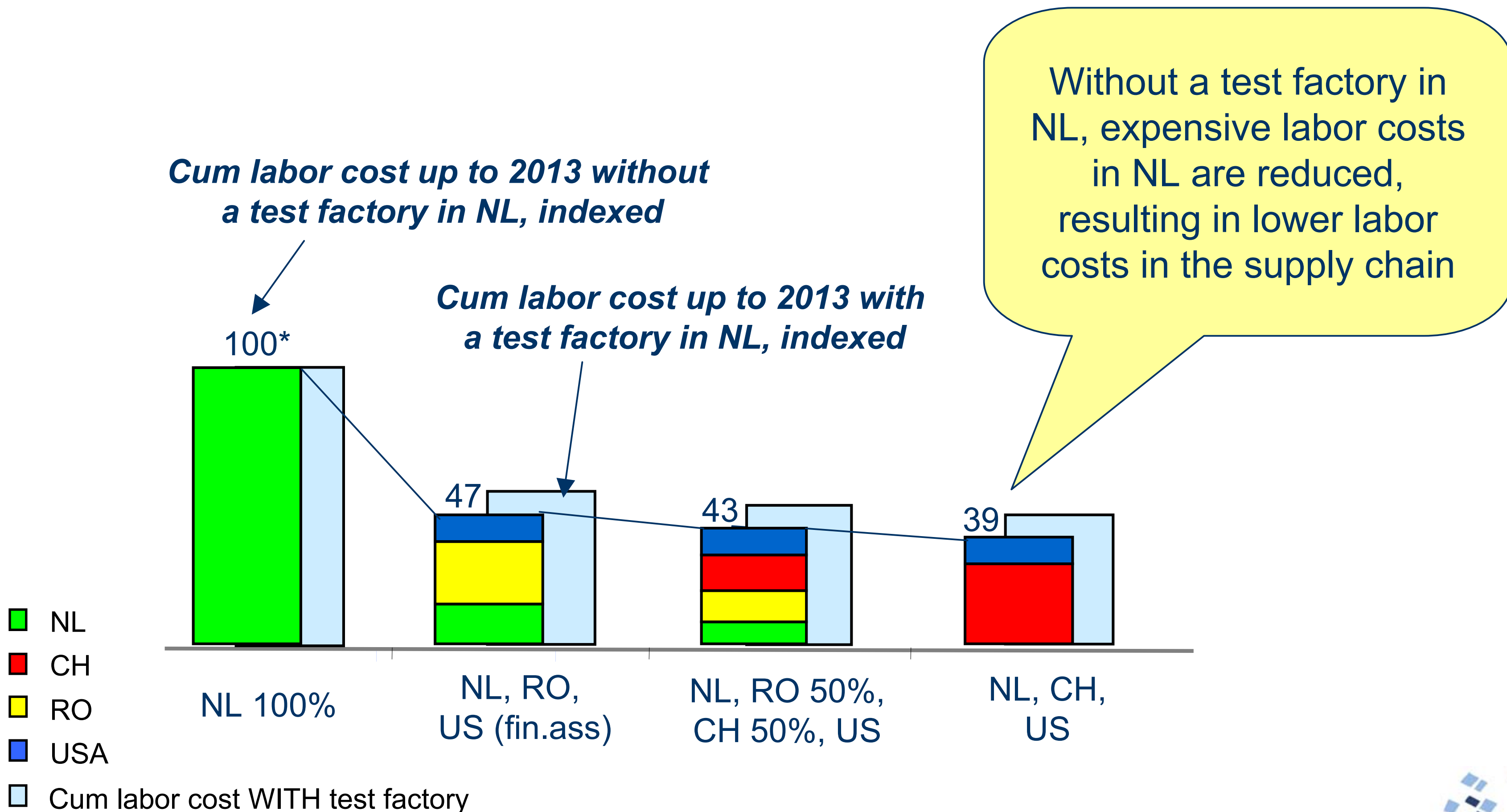
Without feedback from manufacturing, design quality is low, leading to more rework in manufacturing and a longer leadtime.
As a consequence, customer orders will not be met



100% Outsourcing in USA & China, **with** test factory in NL

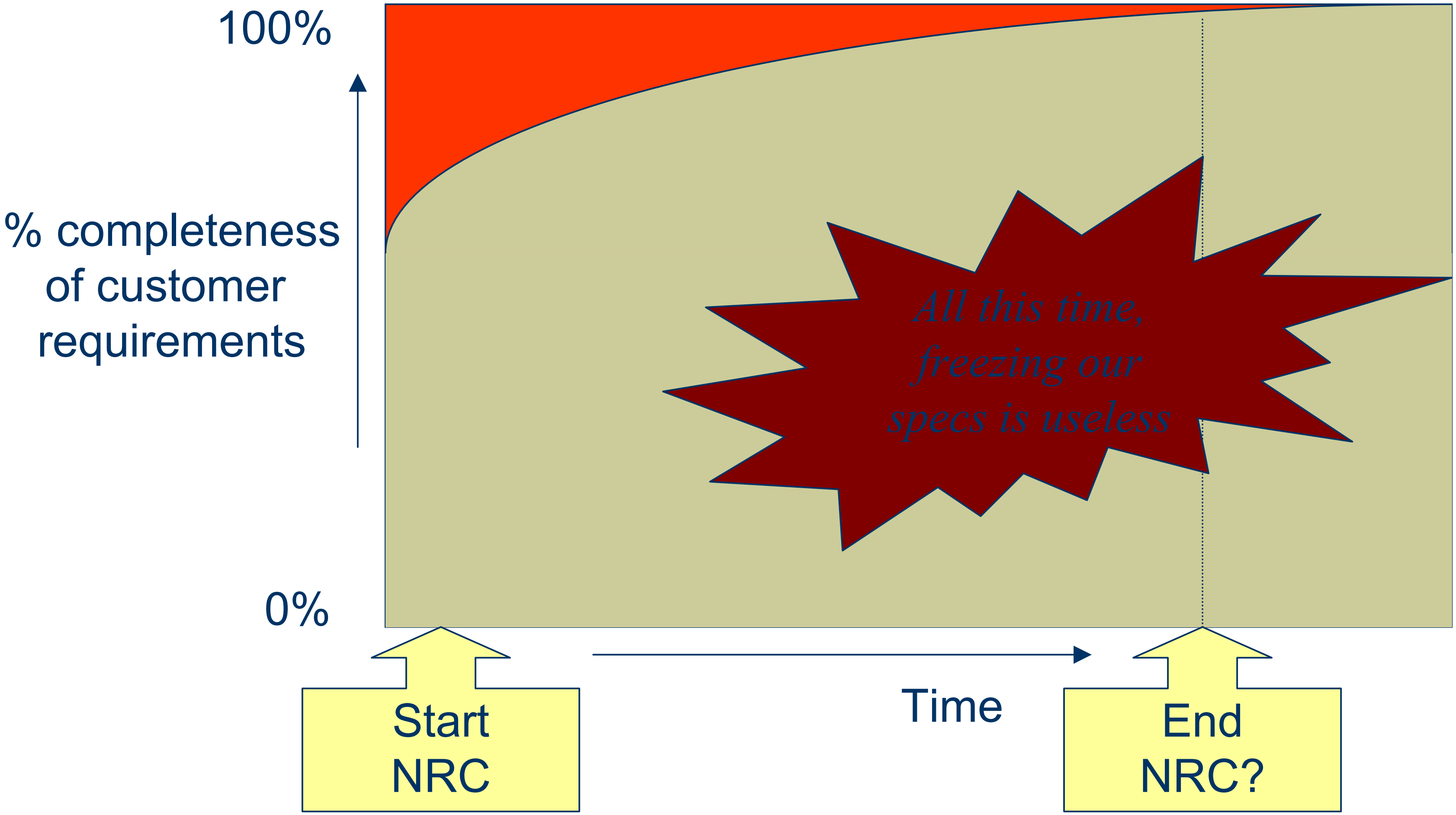
100% Outsourcing in USA & China, **without** test factory in NL

The cost effects of a Test Factory nearby on the production costs in the supply chain are marginal

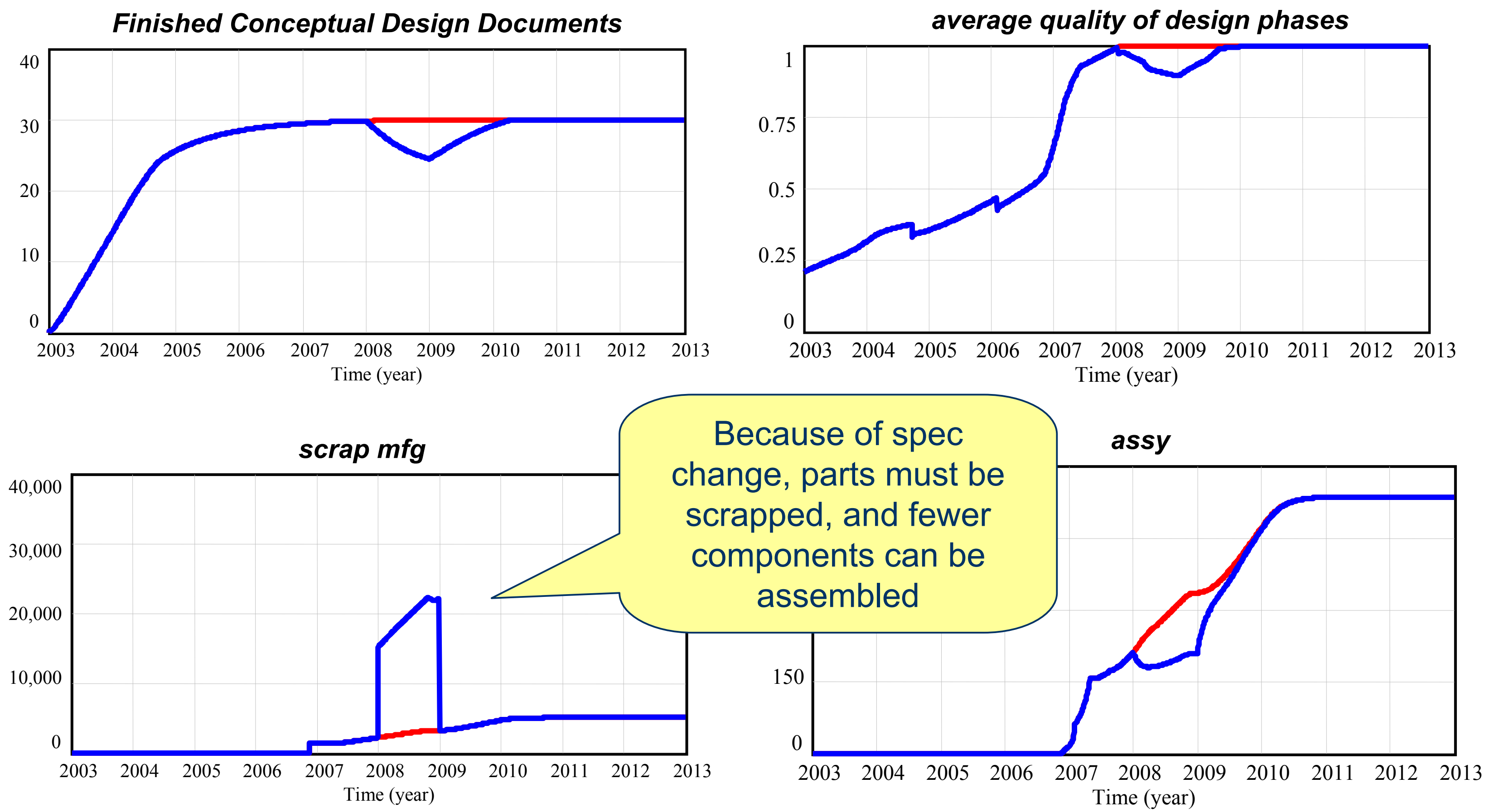


100* =164M Euro

Changing customer specifications are a fact of life during NRC processes

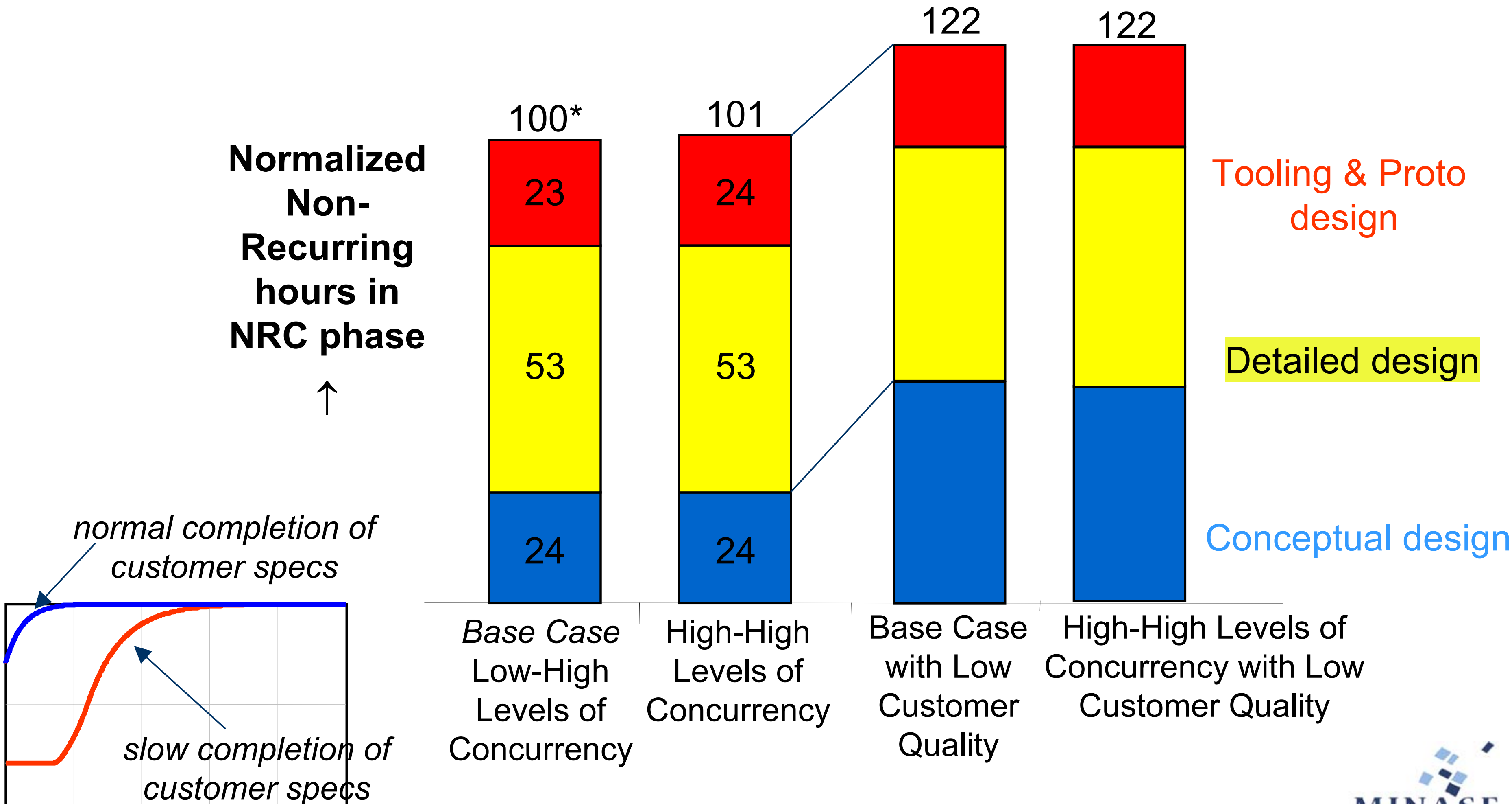


An unanticipated major change in customer requirements after the end of the NRC phase generates significant problems in manufacturing



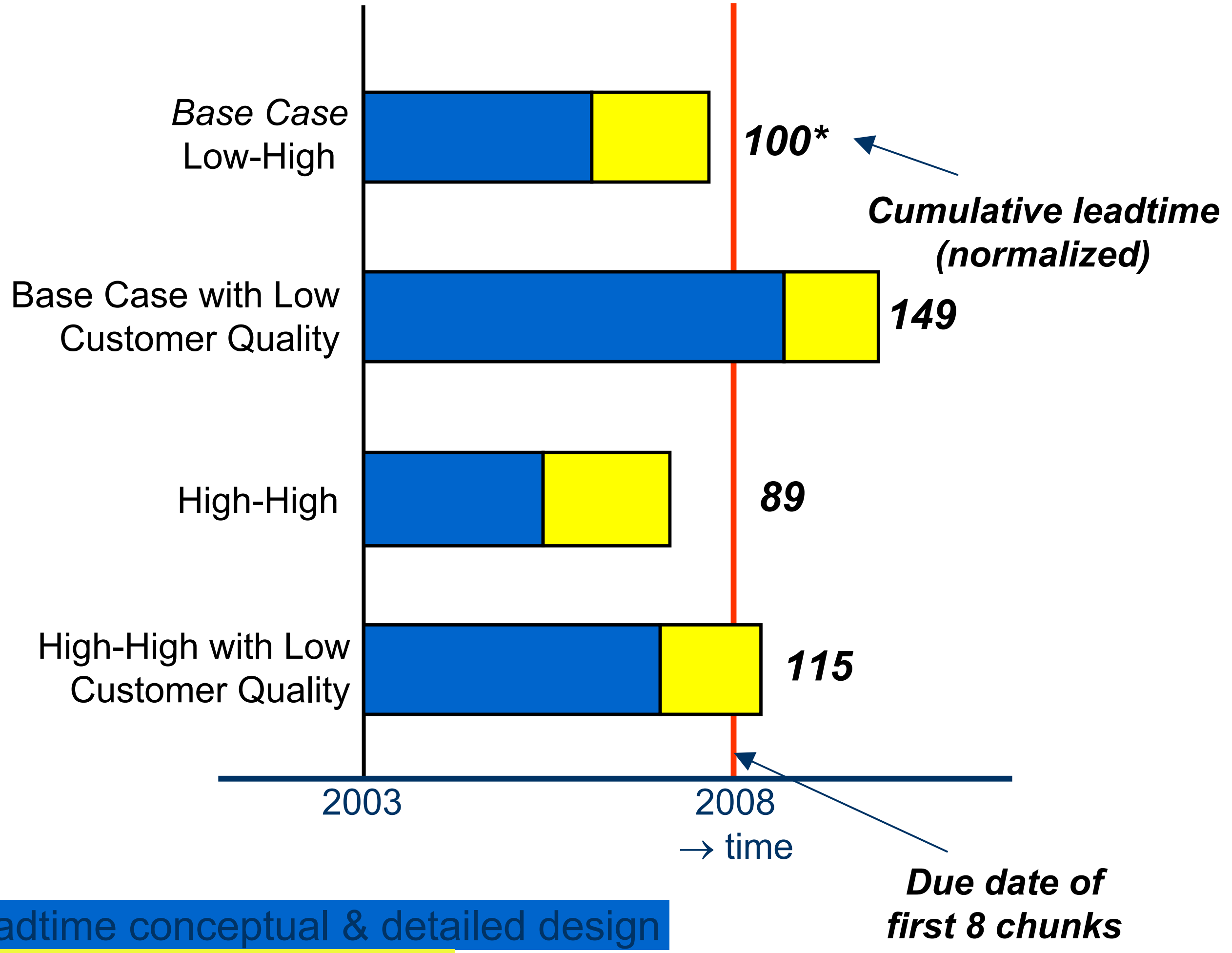
Base Case   Base Case with major customer specification change

Slow completion of customer specifications result in an increase of required Non-Recurring hours (especially in Conceptual Design), and



100* = 869k

Slow completion of customer specifications result in much rework and therefore a longer Non-Recurring leadtime



Leadtime conceptual & detailed design

Leadtime tooling & 1st proto

100* = 4.6 year

Management implications from this study

- Strive for maximum concurrency between design stages
- Strive for maximum communication and openness between stages
- Maintain a production test facility nearby the design centre
- Ensure optimal feedback from production to design during ramp-up
- Make the costs effects of late changes in customer specs explicit to the customer

MINASE
creating beauty together