

EXPLORING SD&PM USAGE FOR Work-in-Process

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With thanks to:
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Jim Martin / Jotne EPM Technology
Joe Walsh / intrinSIM

Simulation Data & Process Management

- Technology to support SD&PM has been available for several years
- Deployment of SD&PM has been limited to a relatively small number of companies for **focused** activities
- Wide ranging deployment of SD&PM for the full spectrum of simulation usage continues to be an elusive goal
- Can SD&PM technology support Work-in-Process?

Terminology Used

- Tool Categories

- Computer Assisted Engineering (CAE)
- Simulation Data Management (SDM)
- Simulation Process Management (SPM)
- Simulation Process & Data Management (SPDM)
- Product Data Management (PDM)
- Product Lifecycle Management (PLM)

- User Objectives

- Simulation Data & Process Management (SD&PM)
 - Management of simulation data and simulation processes for all modes of activity and tools for simulation
- Work-in-Process
 - Management of PRODUCT data, particularly SIMULATION data, during the development of the product (prior to release of a design)

SD&PM Background

- Simulation data comes from multiple sources and work flows (ad-hoc work needs to be considered)
- Legacy data must be accommodated
- Context related information required for meaningful use of data
- Data access requirements
 - Project and process context
 - Consumer of data
 - IP issues
- Comprehensive information sharing
- Long term archival of data and processes
 - THIS presentation!



The obligatory V diagram



SD&PM Usage Tiers

LOTAR (Long Term Archival and Retrieval)

Multi-Enterprise Access

Enterprise Access

Engineering Review

Work-in-Process

Legacy Data

- See presentation “Multi-Tiered Simulation and Data Management” presentation to NAFEMS 11/21/2013 for details

SD&PM Usage Tiers

Work-in-Process

- Multiple sources of how data can be created each with their own set of requirements and issues
- Used by: work groups that create the data

Work-in-Process Options

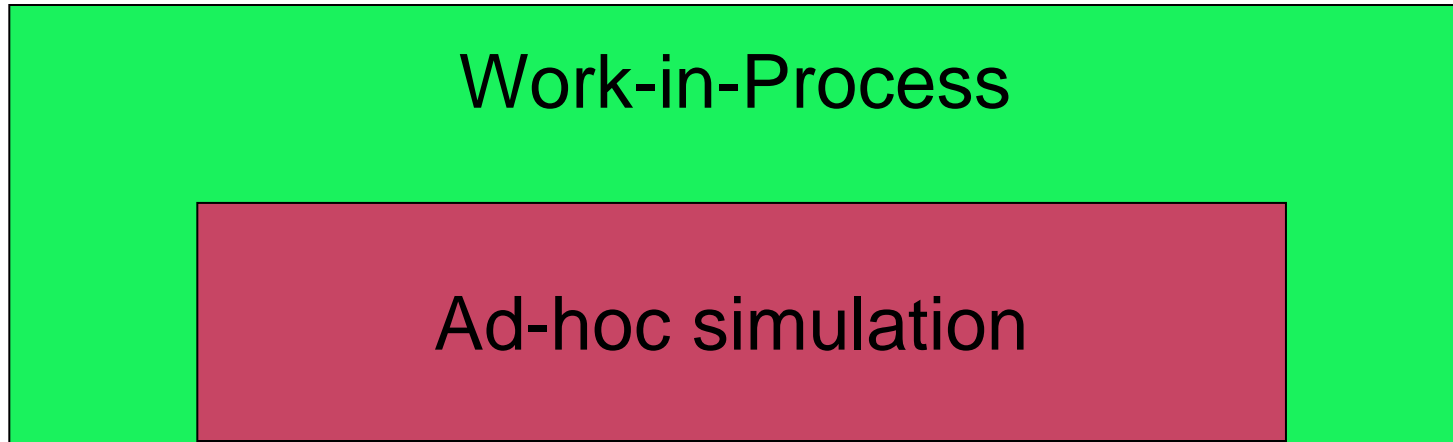
Ad-hoc
Simulation

Independent
Process
Automation
Tools

Integrated
Process & Data
Automation

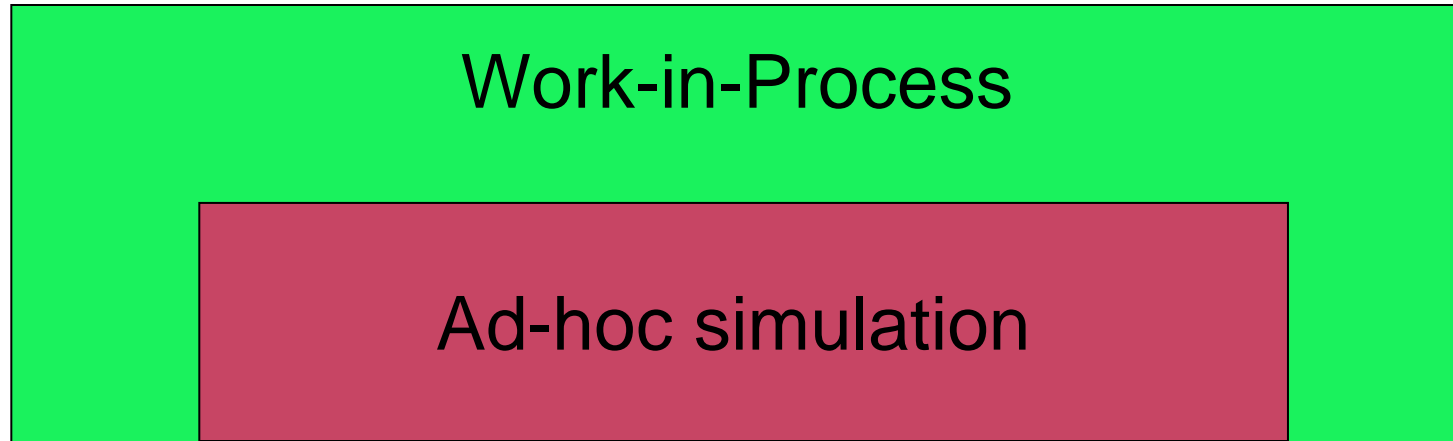
High Level
Drivers

SD&PM Usage Tiers – Work-in-Process



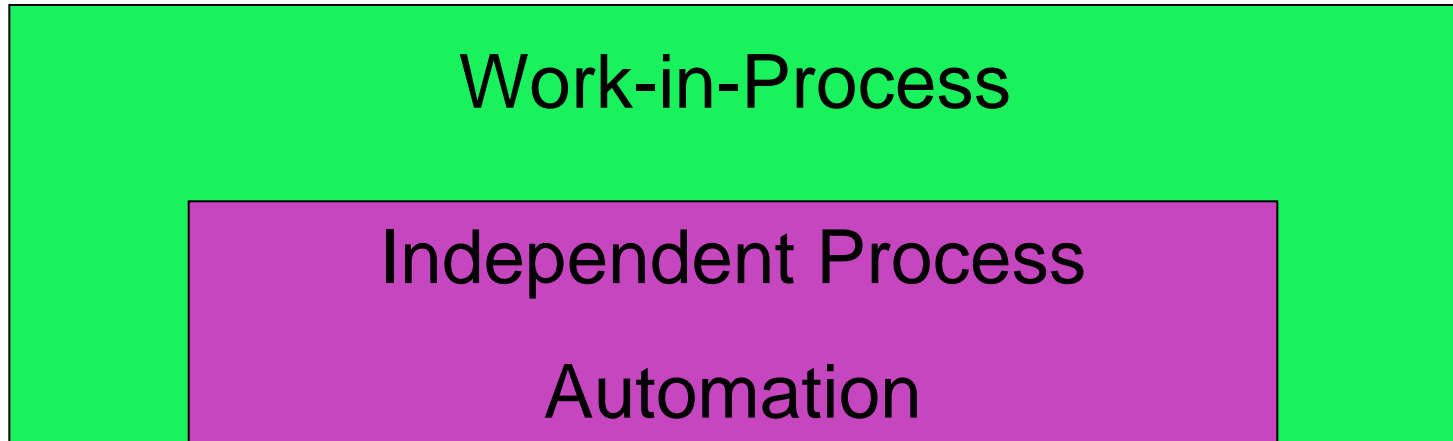
- Non-automatic execution of solvers
 - Accounts for significant % of simulation runs (50-100%)
- SDM environment needs to be
 - Simple and straightforward
 - User-specific access rights desirable
 - Easy (automatic) metadata capture
- Needs lightweight visualization with ability to explore data

SD&PM Usage Tiers – Work-in-Process



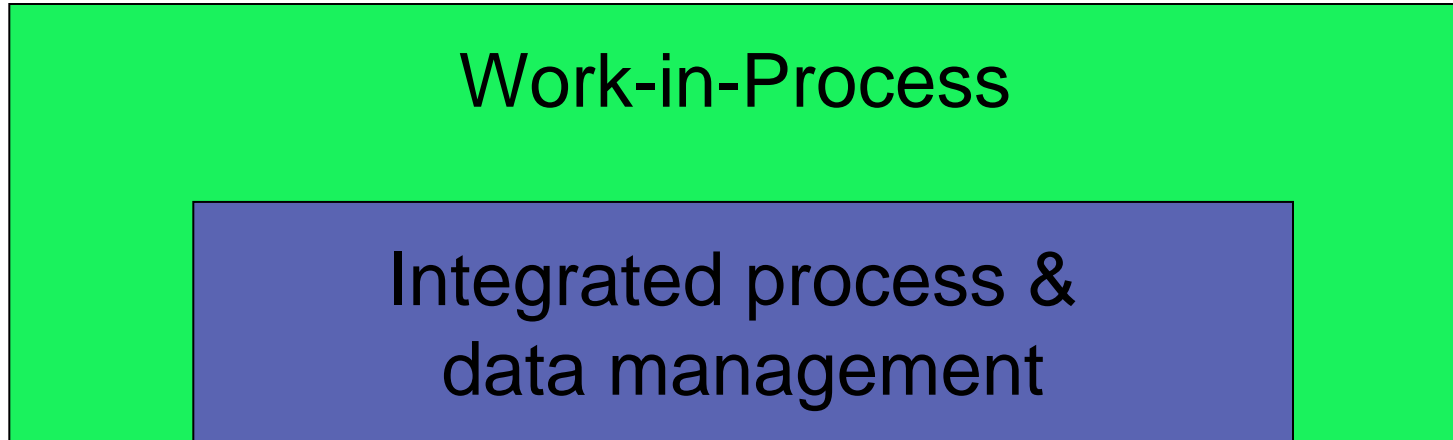
- Need SMEs
- Need an SPM solution
 - Capture HOW
 - Capture WHAT
 - Repeatability

Work-in-Process



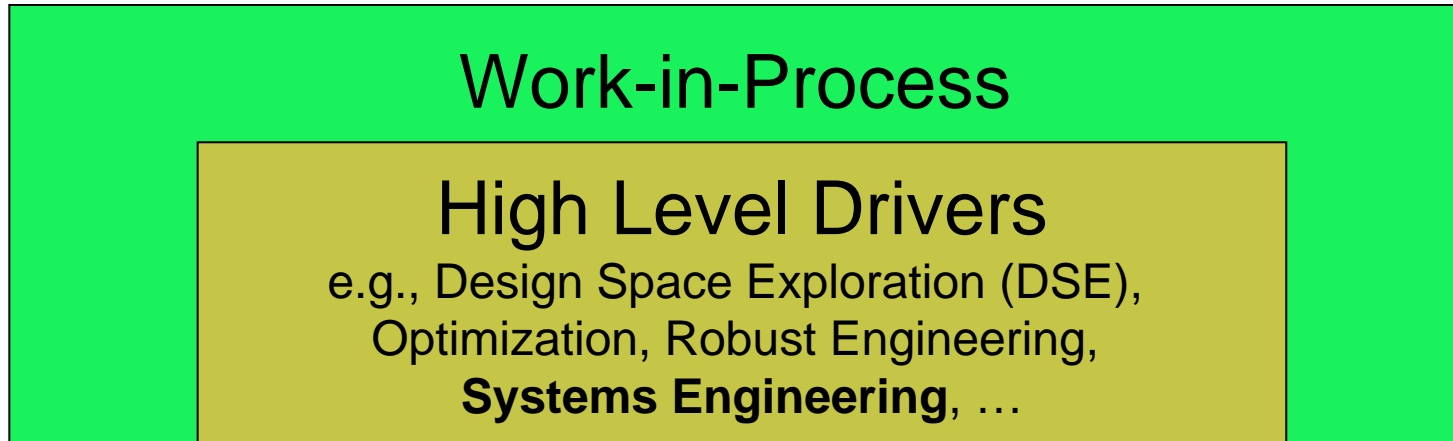
- Automated
- Execute all S&A tools
- Integrate process automation tools and SDM
 - **Rewriting all processes is not viable**
- Other needs similar to ad-hoc simulations (previous)

Work-in-Process



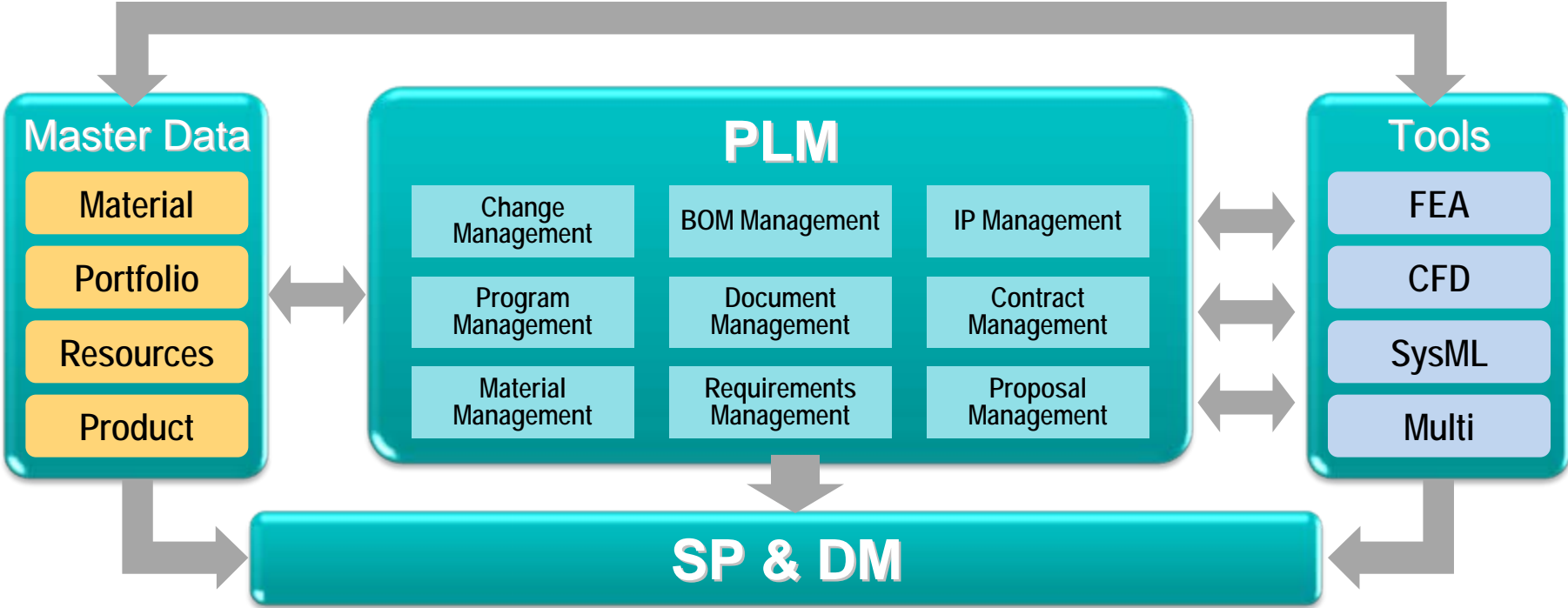
- Automatic comprehensive capture of metadata, context, and environment
 - Capture of PROCESS also preferred
- Lightweight visualization required with ability to explore data
- Process creation through capture of ad-hoc simulations
- Requires tight integration with PLM system
 - If separate SDM and PLM systems are in use

Work-in-Process



- Complex systems and processes that spawn simulations
- MUST integrate with SDM environment
 - Automatically exchange data, context and metadata with SDM
 - SDM and PLM may work better as one solution

Data Architecture

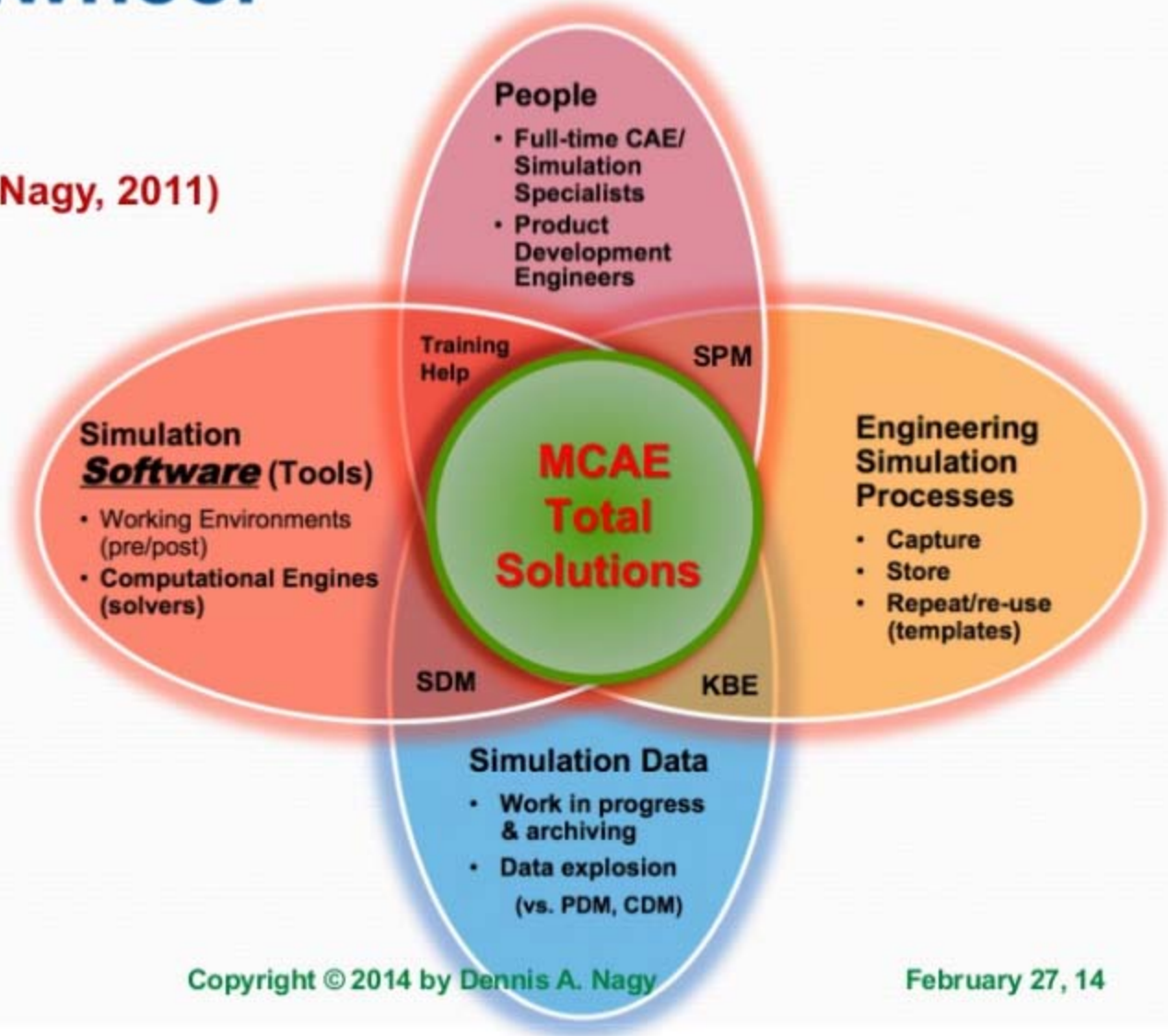




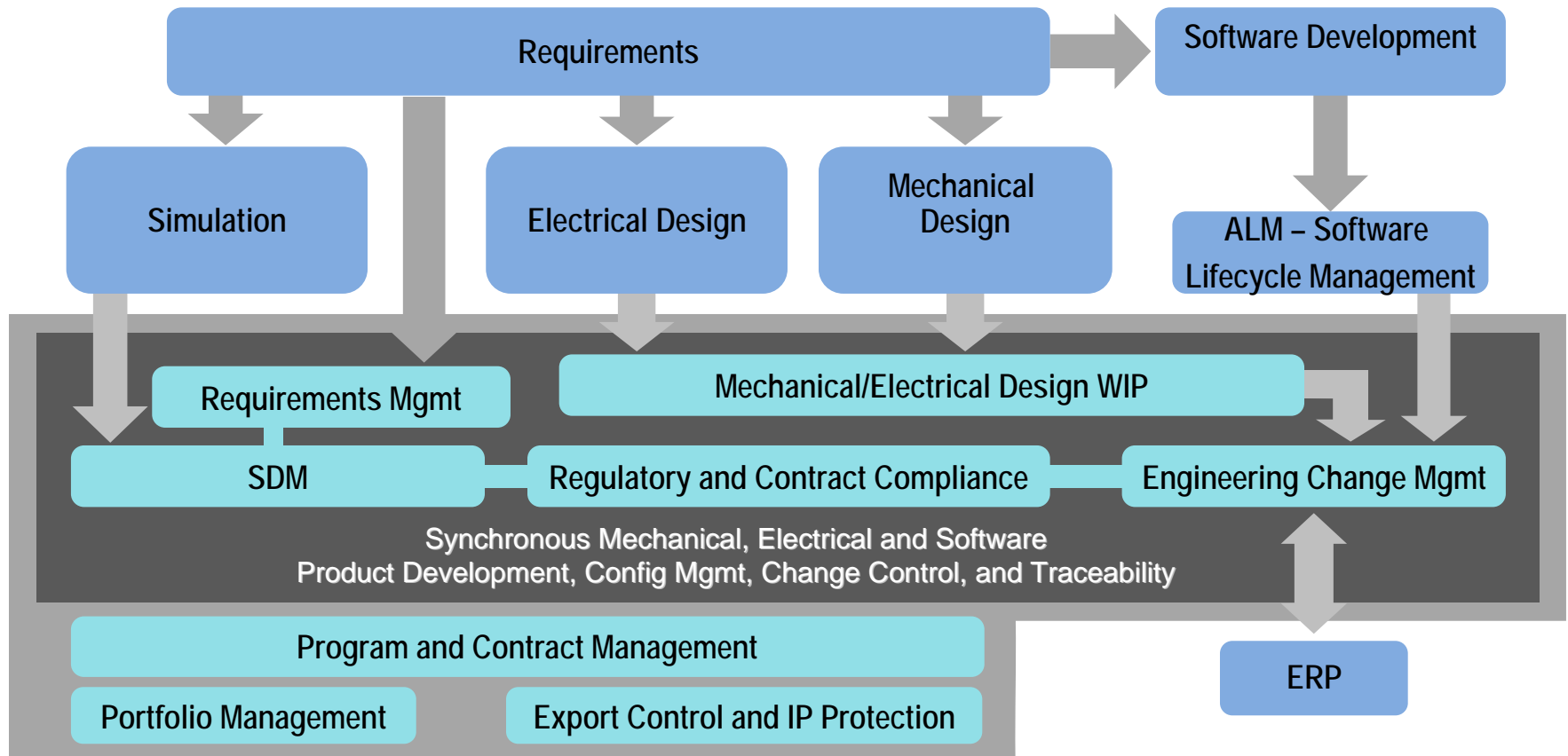
The MCAE Total Solutions

“Pinwheel”

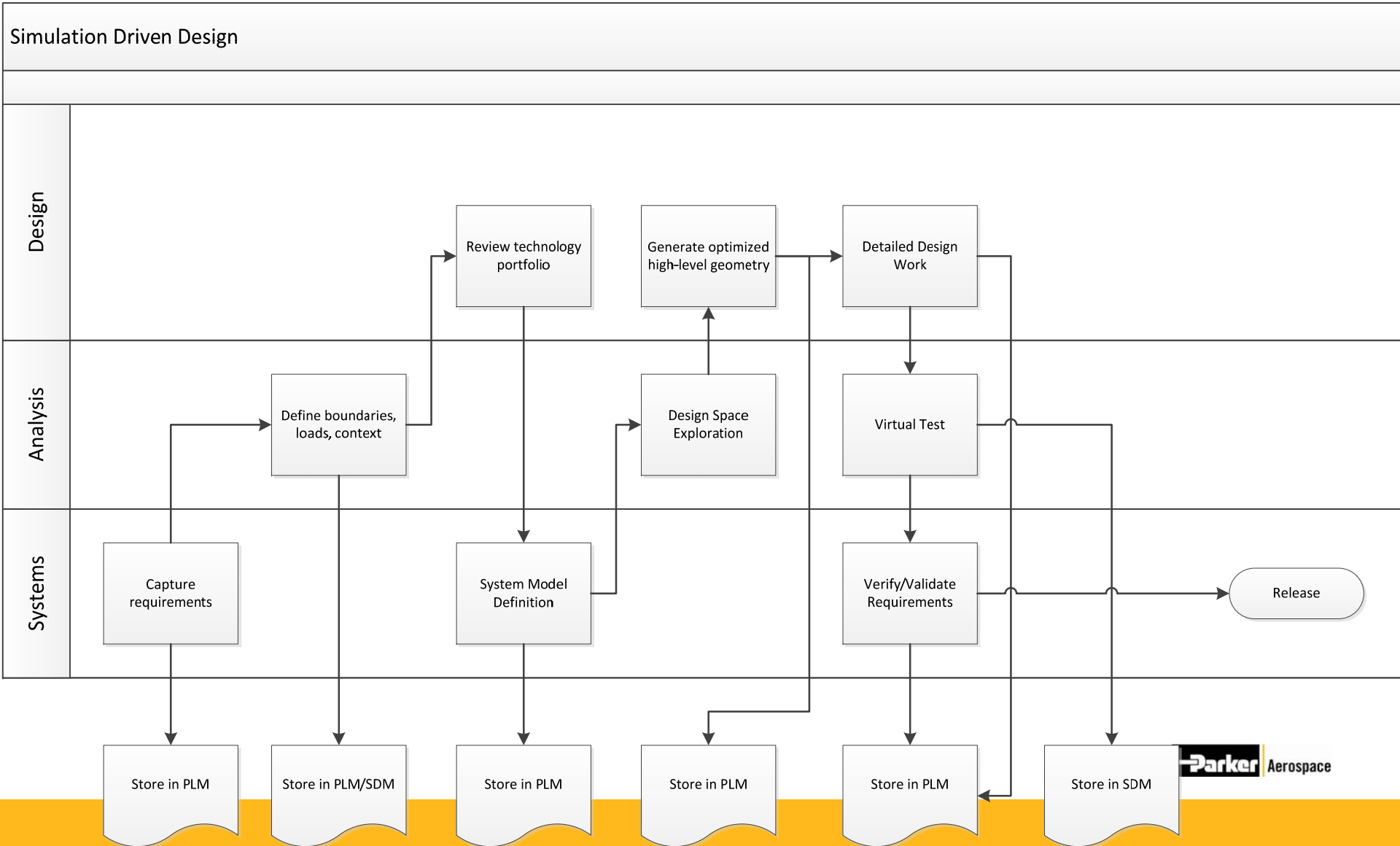
(© D. Nagy, 2011)



Managing Systems Design



WIP logical flow



Deploying Broad Scale SD&PM

- A multi-tiered SD&PM deployment
 - Even WIP itself is multi-tiered
 - Target automation early
 - Review options based on your needs
 - **Be wary of any supplier that claims to meet requirements for all tiers**
 - Implement your preferred options
 - Automate at every juncture
 - DO NOT DUPLICATE data – capture once, reuse

Deployment Recommendations

- Different SD&PM solutions offer dissimilar approaches
 - Varying advantages and disadvantages
- SD&PM offerings are usually developed for a specific application *and usage tier*
 - Even when the supplier does not say they did
 - **No single SD&PM technology covers all usage tiers well**



Questions?

I may have answers, or at least know who to ask!



For More Information

- LOTAR: <http://www.long-term-archiving-and-retrieval.org/>
- NAFEMS: SDMWG: <http://www.nafems.org/about/tech/sdmwg/>
- AP209: <http://www.ap209.org/>

Backup slides

SD&PM Usage Tiers

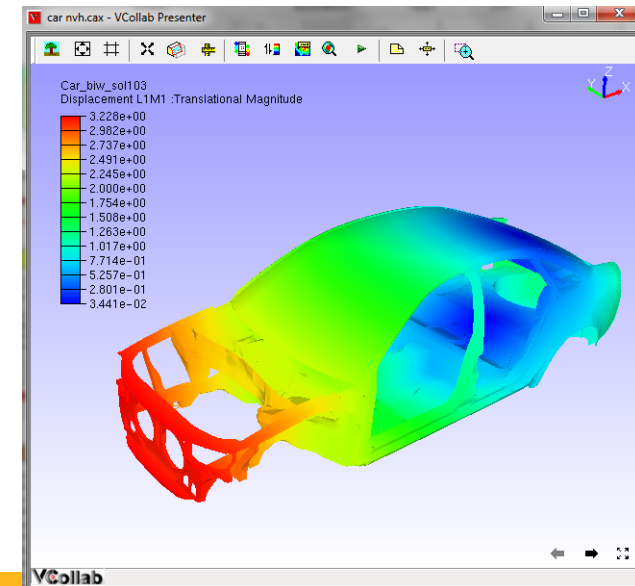
Legacy Data

- Simple approach (e.g., smart shared drives)
- Re-running solutions to capture data is not (usually) a viable approach
 - Would have to be planned in advance
- Metadata extraction
- Capabilities to add context data
- Automatic visualization of data
- Used by:
 - Selected data (decreasing amounts) used by all potential participants including LOTAR
 - All data used by work groups that created the data

SD&PM Usage Tiers

Engineering Review

- Access to data and pedigree to support communication and decision making
- May be summary of different aspects at product development stages
- *Typically* a subset of the data from the Work-in-Process tier
- Lightweight visualization
- Simple access and multiple views into data
- Approvals & issues management
- Used by:
 - Project/product teams
 - Engineering departments
 - Program organization



SD&PM Usage Tiers

Enterprise Access

- Access to data and pedigree to document decisions
- Only a subset of the data required at Engineering Review tier
- Reduced data set for integration into product lifecycle management solution
- Simple access and multiple views into data
- Lightweight visualization
- Used by: **Enterprise beyond Design Engineering**

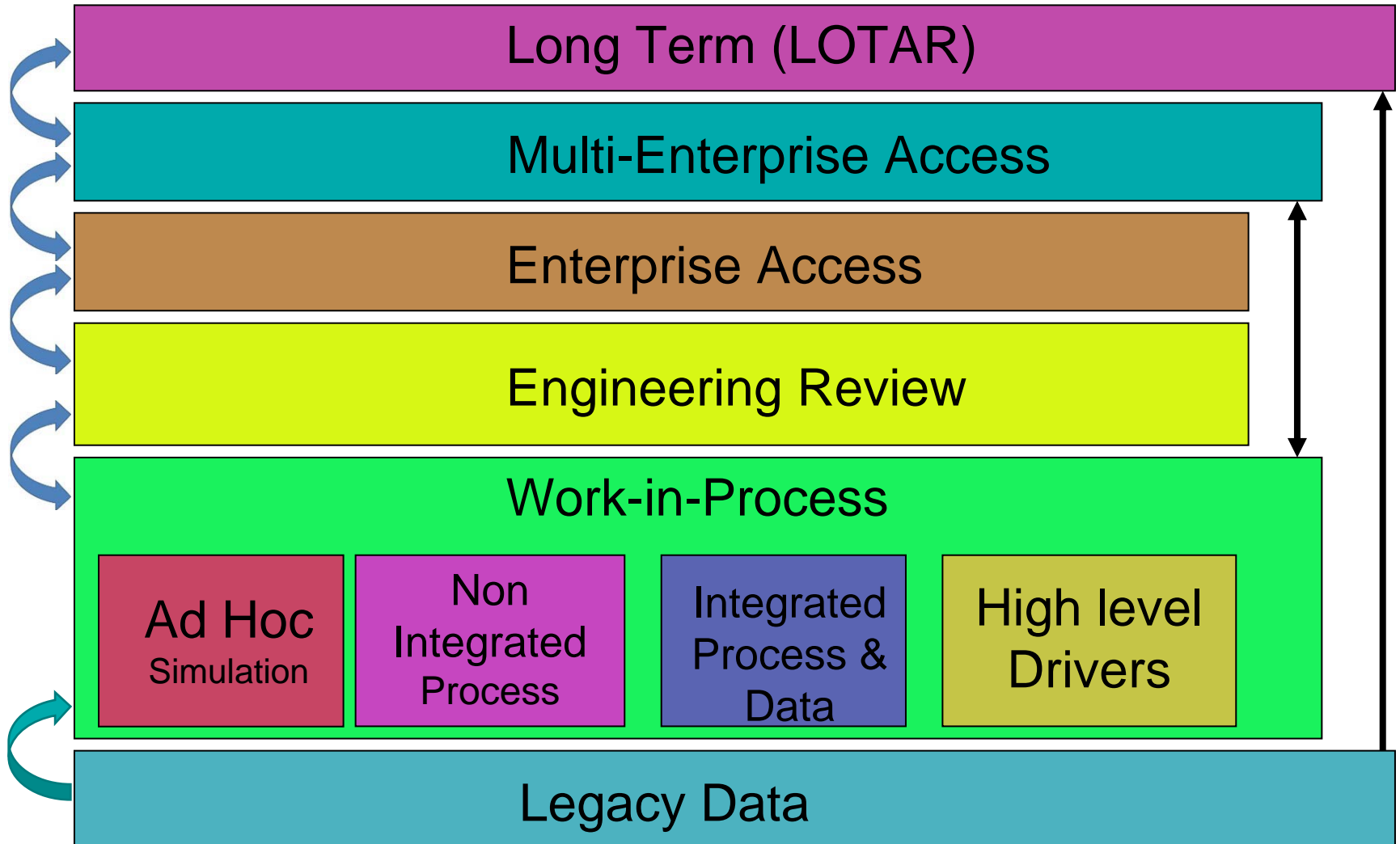
SD&PM Usage Tiers

Multi-Enterprise Access

- Data representation and access controls for IP protection
- Supports supply chain and multi-enterprise collaboration
- May need access to “Work-in-Process tier”
 - Only a subset of the data from the Engineering Review & Work-in-Process tiers
- Lightweight visualization
- Used by: Organizations sharing design and simulation data

SD&PM Usage Tiers

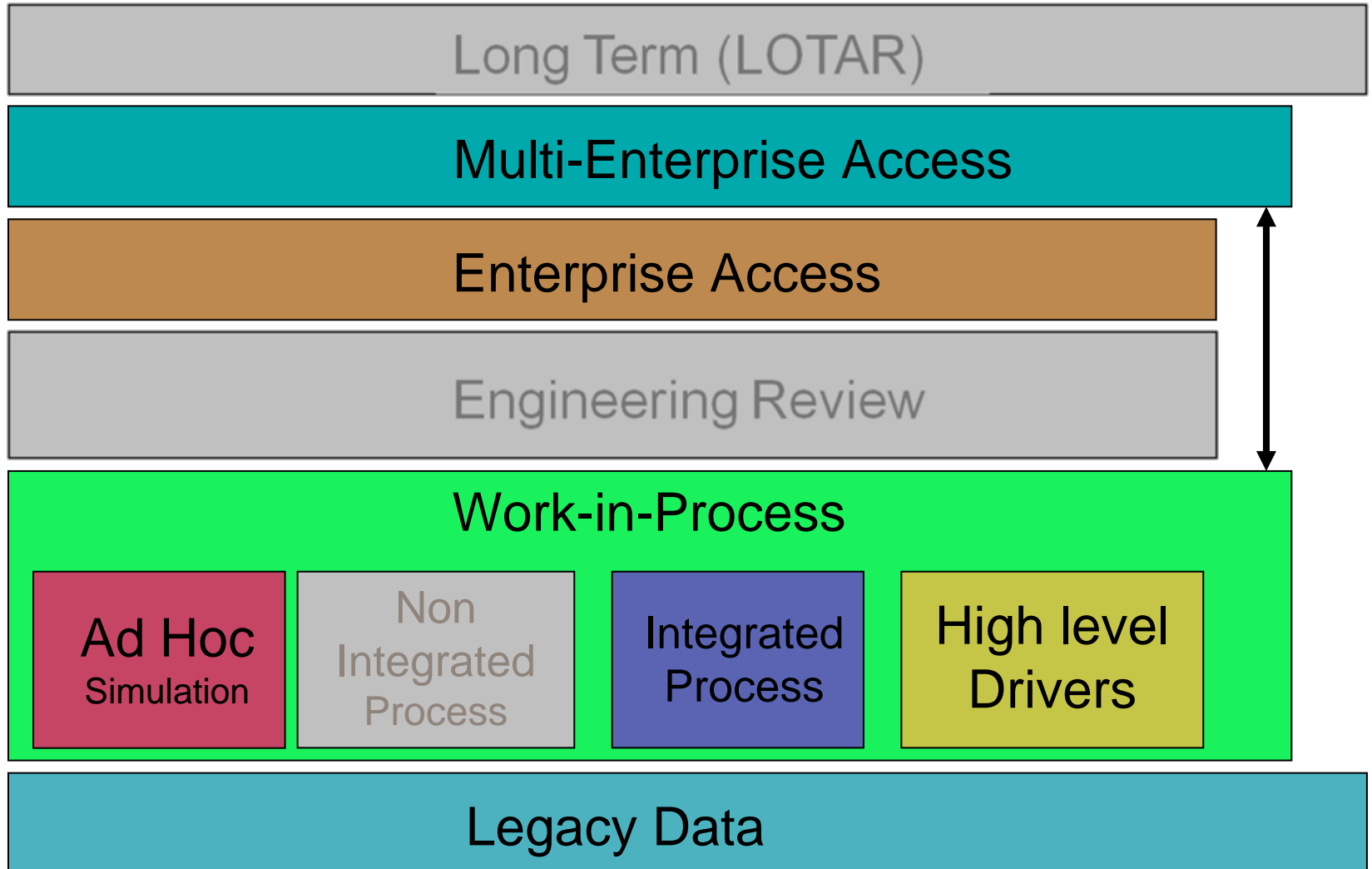
Communication Between Tiers



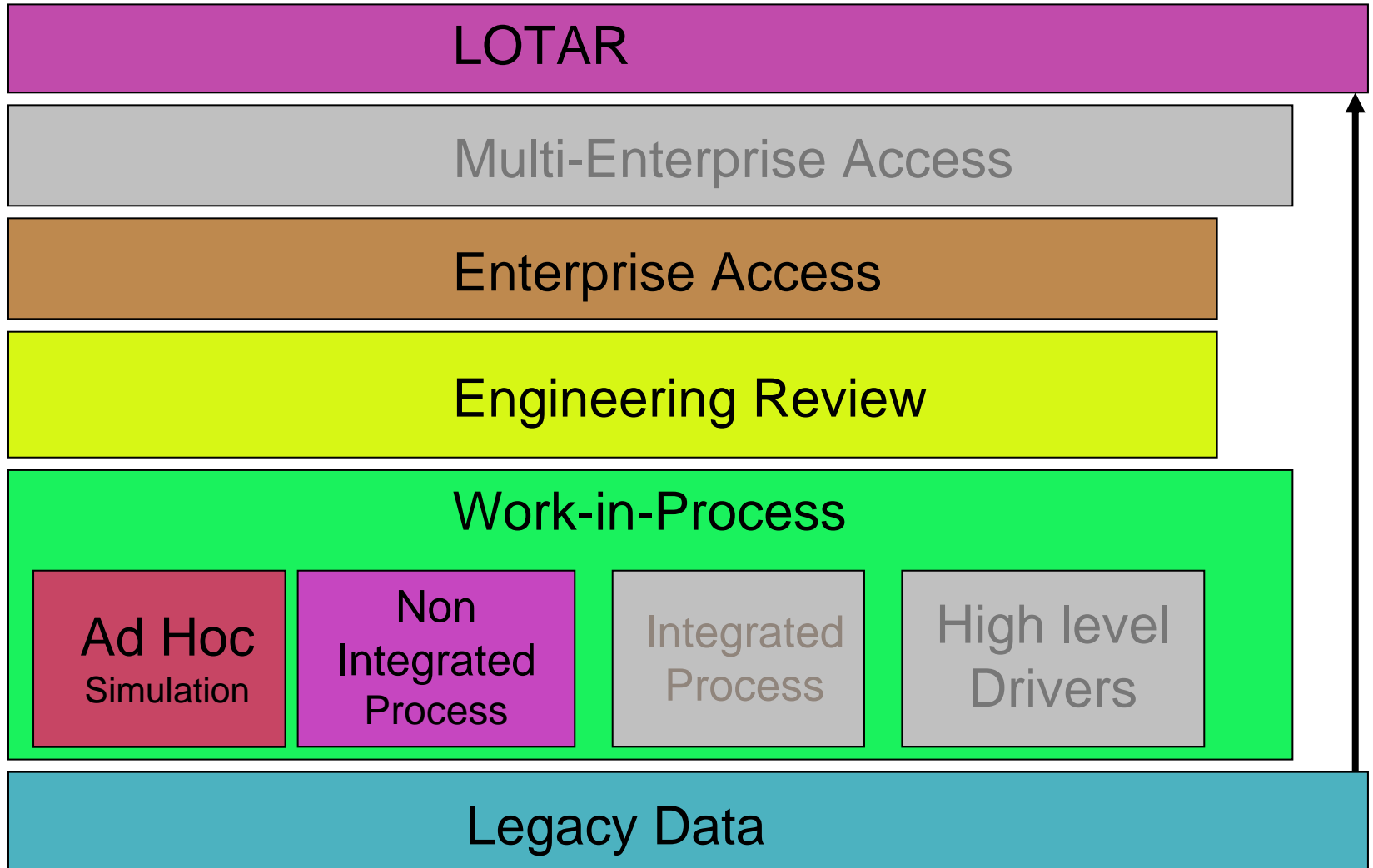
Deploying Broad Scale SD&PM

- A multi-tiered approach allows a pragmatic methodology for wide scale SD&PM deployment
 - Define what aspects are important for your organization
 - Define a phased approach
 - Review options based on your needs
 - **Be wary of any option that claims to meet requirements for all tiers**
 - Implement your preferred options

Which Aspects Are Important Company “1” Example

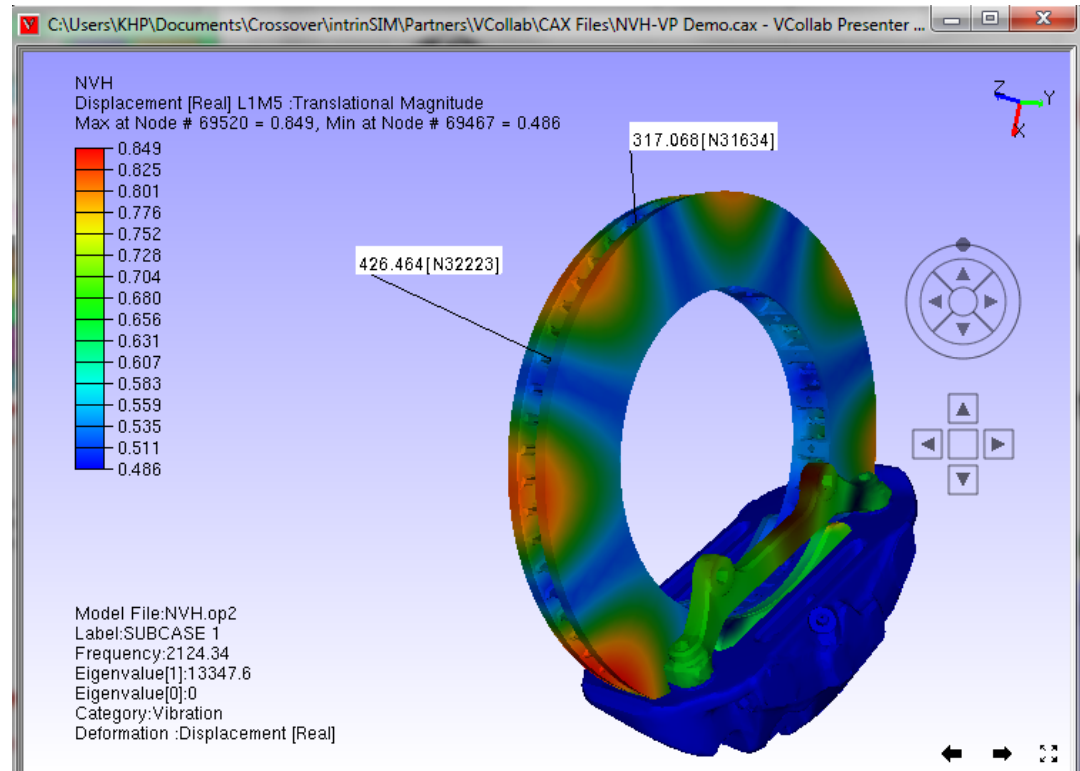


Which Aspects Are Important Company “2” Example



Priorities and Phases

- Let's take a look at Company 2 in a 2 phase approach
 - Realistic implementations may need more than 2 phases



Which Aspects Are Important Company 2 - Phase 1

LOTAR

Multi-Enterprise Access

Enterprise Access

Engineering Review

Work-in-Process

Ad Hoc
Simulation

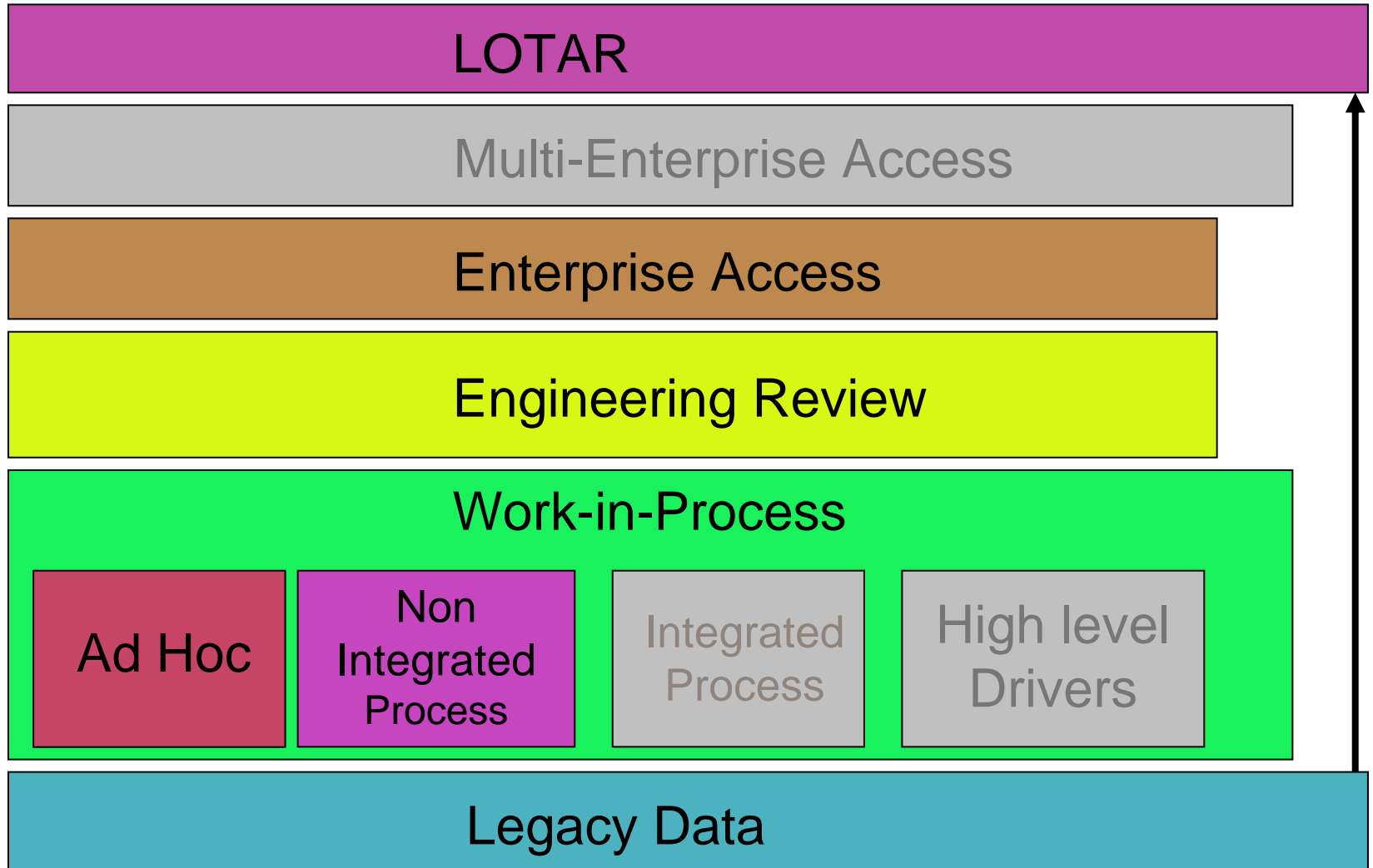
Non
Integrated
Process

Integrated
Process

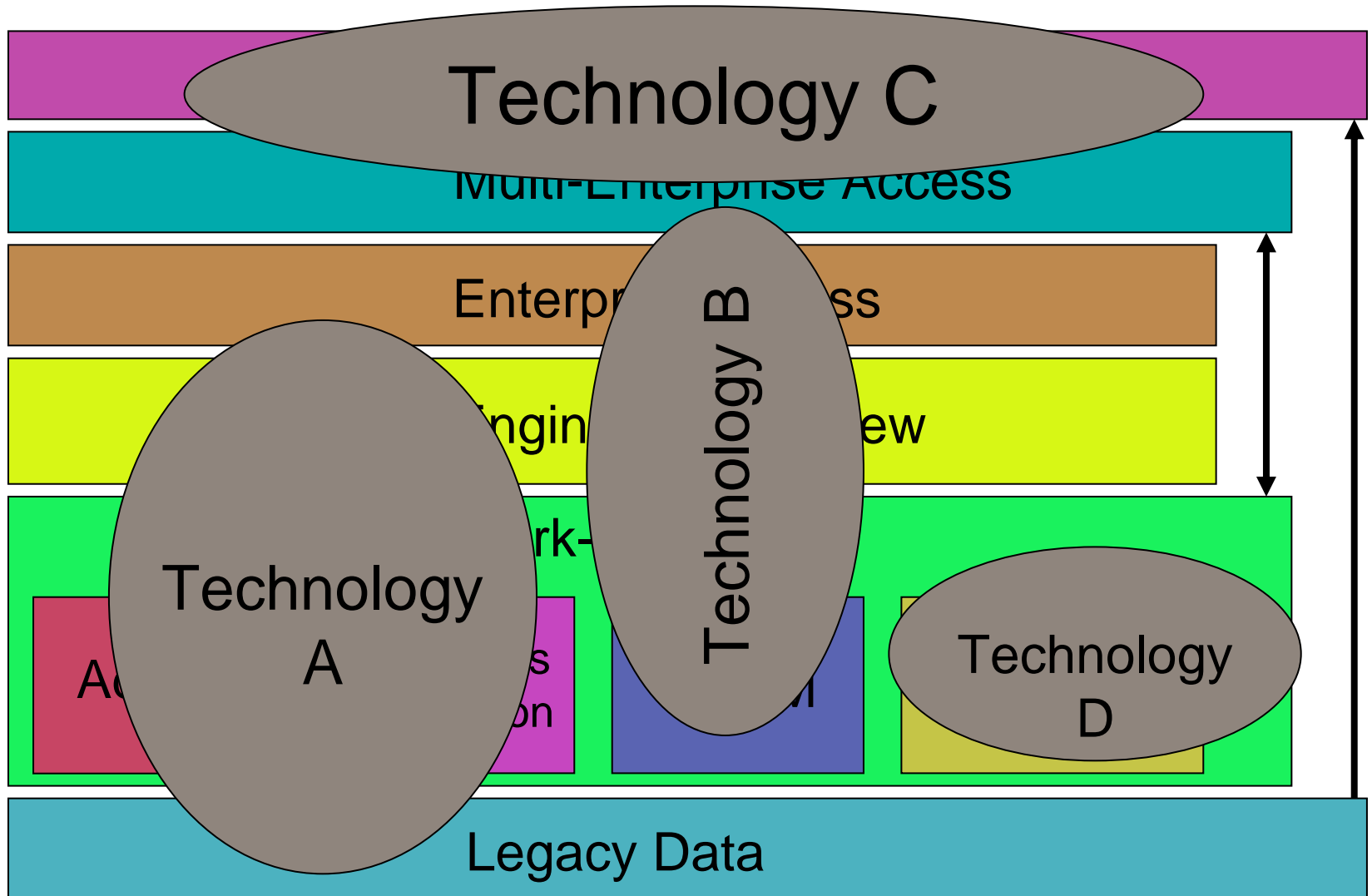
High level
Drivers

Legacy Data

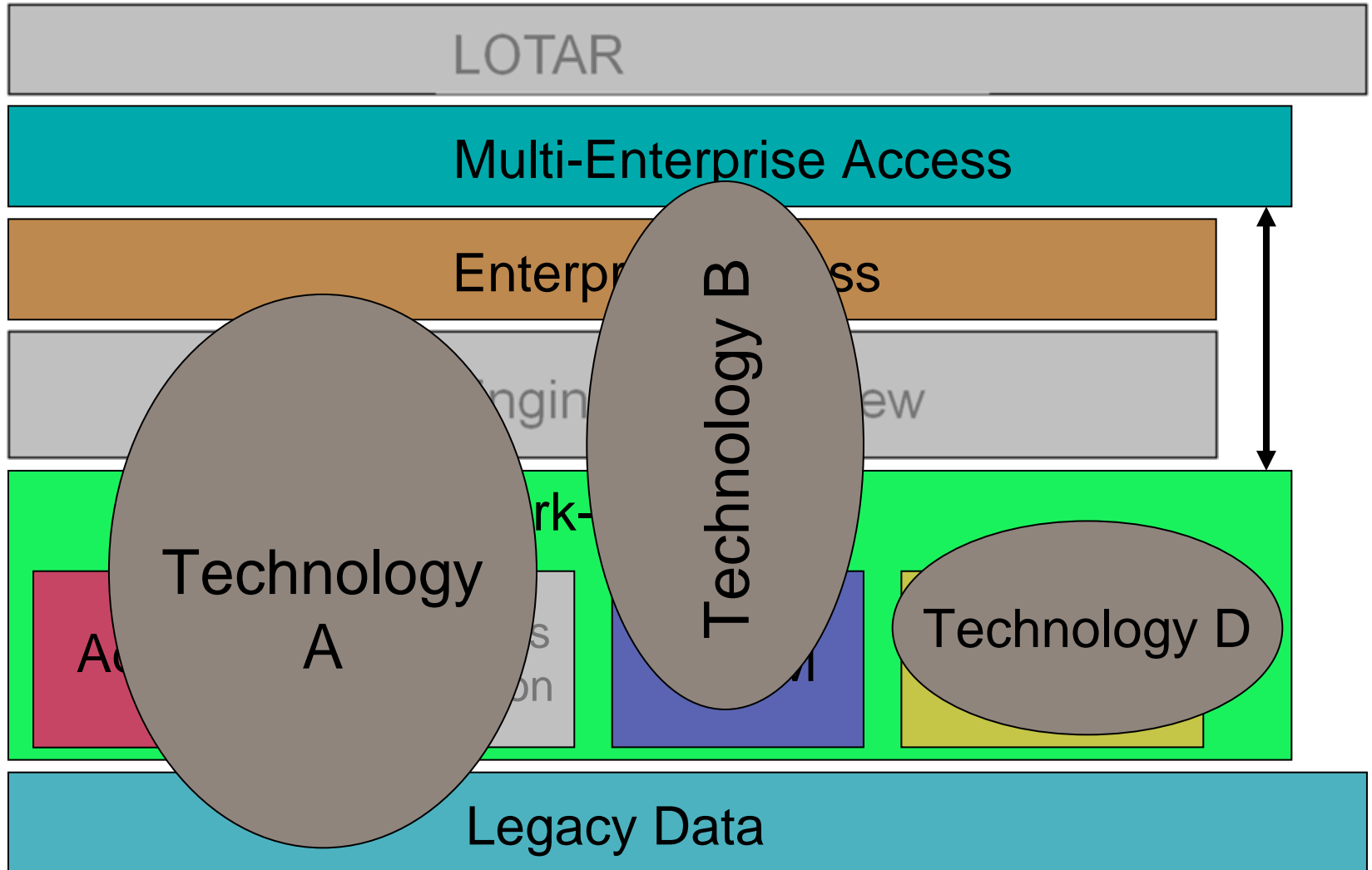
Which Aspects Are Important Company 2 - Phase 2



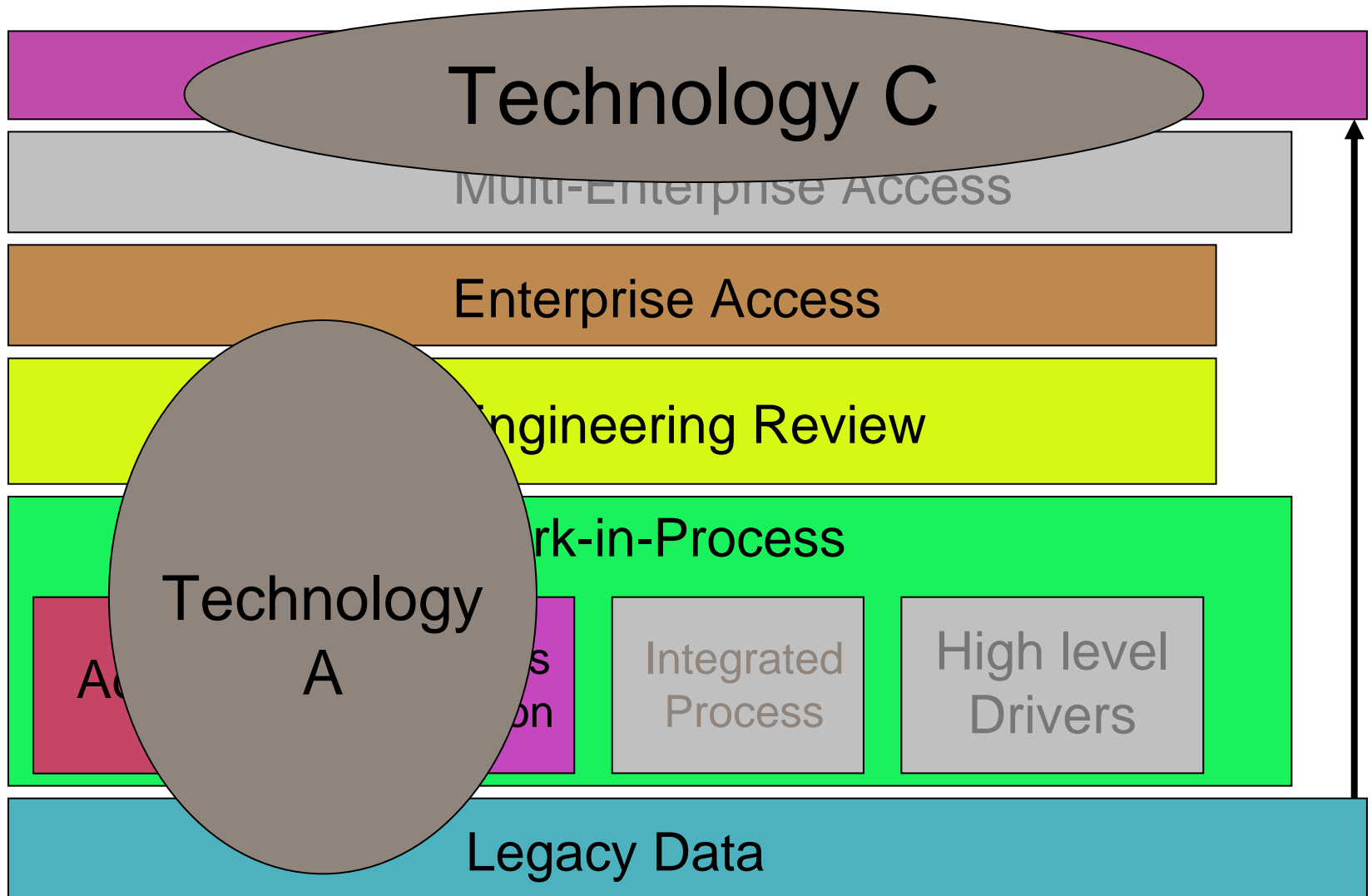
SD&PM Technology Map



Company 1 Example - Solution Map



Company 2 Example - Solution Map



Long Term Archive and Retrieval

LOTAR

- **Standards based** *representation* to ensure data retrieval throughout the full retention period
- Only a subset of the data from the Engineering Review & Work-in-Process tiers
- Verification and validation mandatory at both archival and retrieval
 - May be required at intervals when infrastructure upgrades occur
- Needs lightweight visualization
- Prefer lightweight, high-fidelity data storage
- Used by: Organizations with long term retention requirements

LOTAR

One customer – LOTAR means ALL DATA (input, raw results, post-processed results, reports) for program life

Program life – 30-50-70-100 years

But – what about infrastructure (hardware upgrades, OS upgrades and patches, DB upgrades or replacements, AV signature patches, application improvements, new versions, network changes...)?

LOTAR

For LOTAR to be effective, SD AND PM (Simulation Data AND Process Management) is critical

First, consider the DATA

Next, understand the ENVIRONMENT

Finally, study the PROCESS

And work to manage it all

DATA

Data – can be many different elements

Geometry (if “traditional” stress analysis, for example, or CFD simulation) – original and ‘simplified’

Models (products and systems) – 0D, 1D, 3D, 4D?

Product requirements

Mesh for FEA work

Solver execution parameters

DOE variables and settings at each execution

Test setup instructions (virtual, physical, or hybrid)

ENVIRONMENT

LOTAR – is also the **Environment**

Physical test (SW-in-the-Loop; HW-in-the-Loop) environment, including sensors used (with release and setup information)

Application release level(s)

Operating system (including patches, service packs, A/V signatures, other applications installed, etc.)

Analysis reports

And, most importantly to some (regulatory agencies) – the RAW output of the simulation or PHYSICAL TEST

PROCESS

And – it is not just the DATA, it is the **PROCESS**

How is the model created?

How is the geometry simplified? (Rules and process)

How is the test setup performed (ad-hoc, one time, repeatable, standard)?

Are the test cases defined before the product, or developed based upon the “finished” design?

How is the test/simulation output managed, controlled, and post-processed?

How is the test report produced?

Management

Most design data will already be managed in a PDM or PLM system

Adding Simulation and analysis data is not usually a major VOLUME issue:

- Geometry Models – MB to low GB

- Product requirements – KB to low MB

- Mesh for FEA work – typically KB to low MB

- Solver execution parameters – Bytes to low KB

- DOE variables and settings – Bytes to low KB

- Test setup instructions - Bytes

- Application release level(s) – Bytes to GB (if executable archived)

- Operating system – GB (if “gold image” retained)

- Analysis reports – KB to MB, typically

Management

Most design data will already be managed in a PDM or PLM system

Adding Simulation and analysis data is not usually a major VOLUME issue, EXCEPT:

DATA

Raw data – 5 (small) to 500 (large) TB per program

RAW Cost PER YEAR in 2013 dollars = \$3,879/TB ¹

Service = 1 FTE/180 TB (\$500/TB/year)²

Controllers, OS, software, backups, migrations =
\$13,275/TB/year ³

Per year storage = \$17,654/year

50 years at 3% inflation and constant cost =
\$1,981,164 (straightline calc)

1 – Gartner “IT Key metrics 2013”

2 – Gartner “IT Key metrics 2013” plus FTE salary + benefits of \$90,000/year

3 – “ITCalc.com” – Network Appliance storage calculation cost

DATA

Costs to rerun versus retain raw data:

Engineer = \$150,000

Server = \$150,000

Software licenses = \$250,000

Total = \$550,000 – **One time (per data production)**

DATA

Storage costs = \$2,000,000 (approximately) over life of program

Simulation costs = \$550,000 (approximately) at qualification, and if re-run in future

Current programs at tier-one – 150 (MY company)

Number of occurrences of re-analysis in last 33 years (my history at my company) – 10

Cost to store raw data = $\$2,000,000 * 150 = \300 million

Cost to rerun analysis = \$5,500,000 (over last 33 years)

Cost to MAINTAIN execution environment over **50** years = ???

Savings by managing only input, high precision reduced data (used for visualization and LOTAR), and reports = \$294,500,000

DATA

But – what if you can reduce the cost of maintaining RAW data, while still retaining the ability to post process with HIGH FIDELITY?

DATA

Raw data – 5 (small) to 500 (large) TB per program

RAW Cost PER YEAR in 2013 dollars = \$3,879/TB ¹

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Controllers, OS, software, backups, migrations =
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50 years at 3% inflation and constant cost =
\$1,981,164

Reduce storage consumption by 50% - \$990,582 PER
PROGRAM

1 – Gartner “IT Key metrics 2013”

2 – Gartner “IT Key metrics 2013” plus FTE salary + benefits of \$90,000/year

3 – “ITCalc.com” – Network Appliance storage calculation cost

DATA

Overall cost to retain the data would also drop by 50% - from \$294,500,000 (\$300MM) to “only” \$147MM

But... if raw data can be retained until the curve of cost exceeds the curve of recreation, the best of both worlds can be obtained.