IMPC - Topic 3

Space 4.0 and the Evolution of the (Aero) Space Sector

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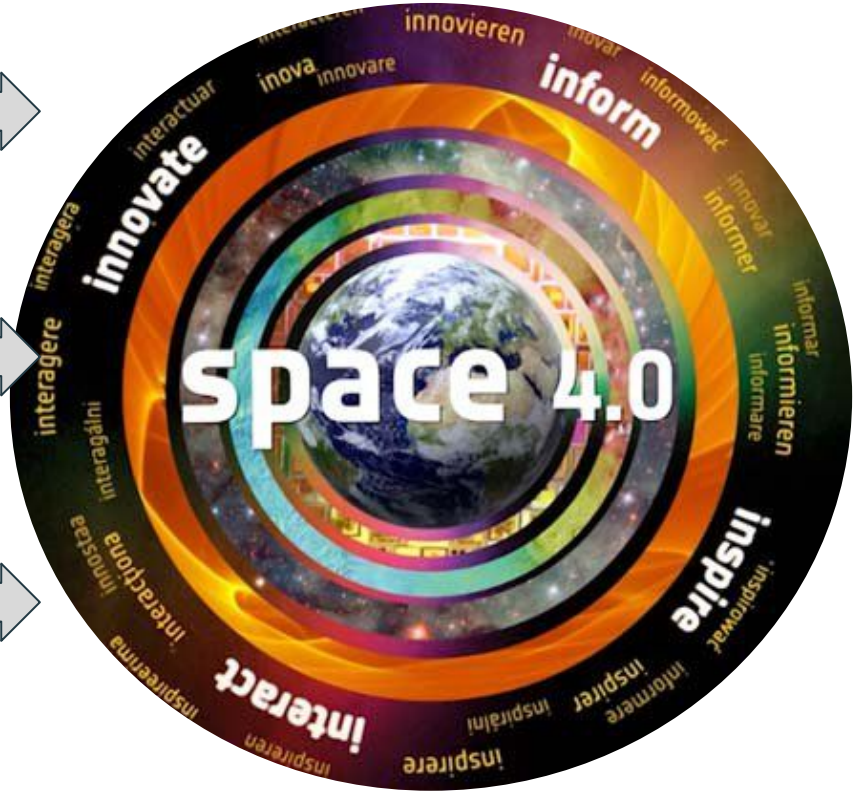
Space 4.0

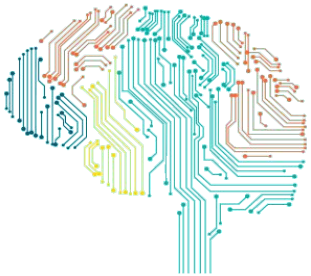


Global Connectivity

Launch Capability

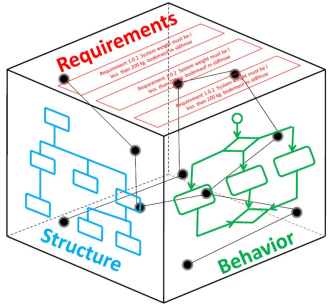
Spacecraft Miniaturization

Space 4.0



Artificial Intelligence

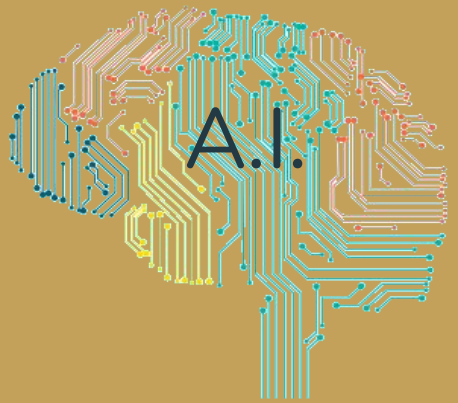
Demographics & Inspiration



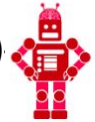
Model Based Systems Engineering

Disruptive Technologies

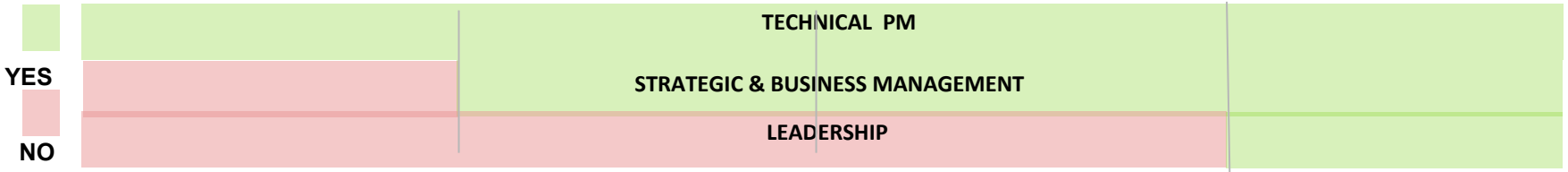
Artificial Intelligence



Prospect of evolution of AI in PM (LAHMANN, 2018)

	Integration & Automation	Chatbots assistants (CA)	Machine learning (ML) (PM)	Autonomous PM
KEY ELEMENT	 Streamlining and automating tasks through integration and process automation	 Integration and automation with additional human-computer interaction	 Enabling predictive analytics and giving advice to the project manager based on what worked in past projects	 Combining the previous elements
PROSPECT	>enhance the quality of PM processes >reduce the effort and labour costs *Project managers can be focused on complex project activities*	>take over basic PM tasks >relieve project teams of repetitive tasks *Project manager will be increasingly replaced by project assistants*	>give the increased visibility into the projects >enhance the quality of decision-making *ML will give intelligent advice on project scheduling and tasks*	>enhance the quality of smaller, standardized projects >reduce the quantity of human interaction *Autonomous project managers seem unlikely within the next 10-20 years*

Where we expect AI to support project management skills?



Infusing AI algorithms into PM tasks (LAHMANN, 2018)

PROJECT PLANNING	COST ESTIMATION	RISK MANAGEMENT	PERFORMANCE MANAGEMENT
	Knowledge Based Expert System (KBSE)		
Provide estimates of the duration and resource requirements for project activities	Estimate the suitable markup to increase the possibility of winning tenders	Estimate the probability of occurrence for project risks	Assess claims and provide expert decisions
	Artificial Neural Network (ANN)		
Automate the sequencing of project activities based on functional requirements	Predict the possible cost overruns based on the project parameters	Mimic the human procedure of risk evaluation and adaptation	Predict the performance of future projects based on the project parameters
	Genetic Algorithm (GA)		
Optimize the schedule of construction project activities	Get accurate forecast of project cost from past data	Supports simulation of risk factors	Analyze past projects and resources to produce an optimal performance management
	Fuzzy Logic (FL)		
Determine project priorities in the portfolio management process	Optimize the cost-time trade-offs in construction projects	Assess risks in construction projects to model probability distributions	Improve project management efficiency in construction projects

AI SWOT analysis

INTERNAL

STRENGTHS

- Reduce costs and mistakes, time to treat project/clients requests
- Facilitates routine operations
- Analyze risks
- Improves the analysis method
- Keep projects on time and on budget

WEAKNESSES

- No human creativity
- Not able to balance the capabilities and emotions of diverse set of humans (empathy) and lead them toward success
- Require special training for the team (online courses, corporate training)
- Require continuous monitoring/adaptation
- Additional research needed into ethical, legal, and social aspects

EXTERNAL

OPPORTUNITIES

- Integration with Apps not used in PM field (e.g., Even.com predictive budgeting tool)
- Incorporate AI into PM portfolio as a way of facilitating predictive steering of complex transformation projects
- Global cloud services

THREATS

- Significant disruption to business models
- Requires a large investment
- Over-reliance on AI as a sole source of truth
- Security, reliability and confidence in the AI system
- Development of standards and platforms for testing

Conclusions & recommendations

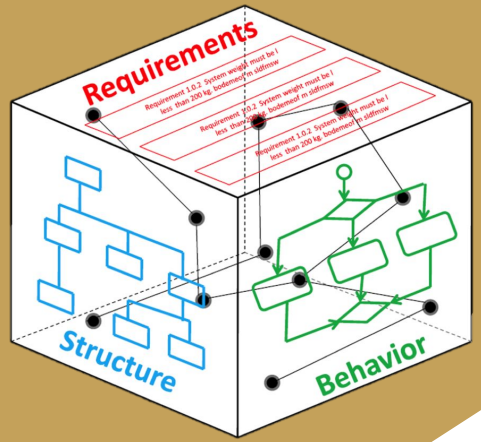
Conclusions

- AI will assist, not replace, project managers
- AI can help increase project success rates
- AI can add real strategic value and drive positive change in PM and business transformations
- Scaling AI is a company-wide transformation
- AI implementation in PM requires a large company investments

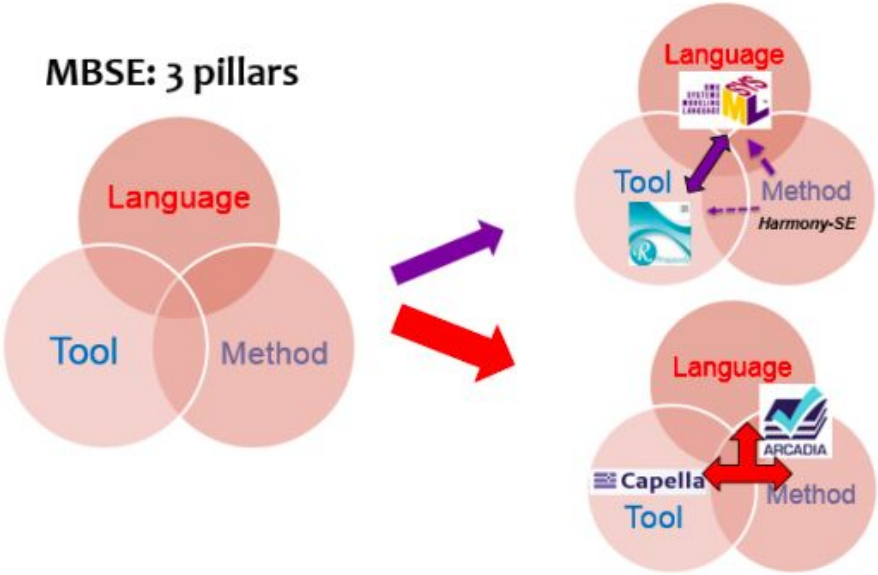
Recommendations

- Company must invest in highly qualified data scientists, systems engineers, solution architects when integrate AI
- The project managers needs to master AI based tools to be successful
- Company should conduct the trainings and seminars for a team prior the implementation of AI
- Respect clever distribution of the roles between AI assistant tools and project managers

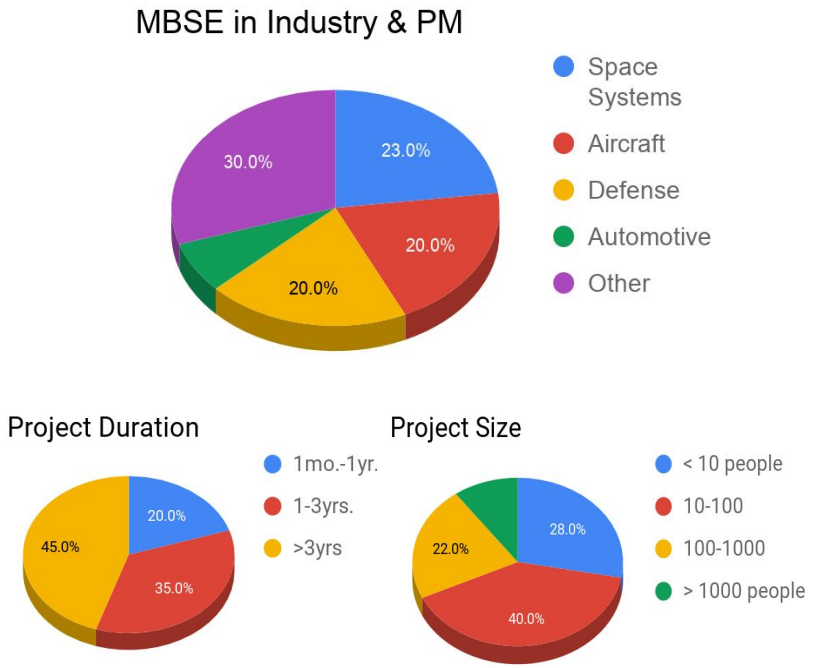
Model Based Systems Engineering



MBSE introduction

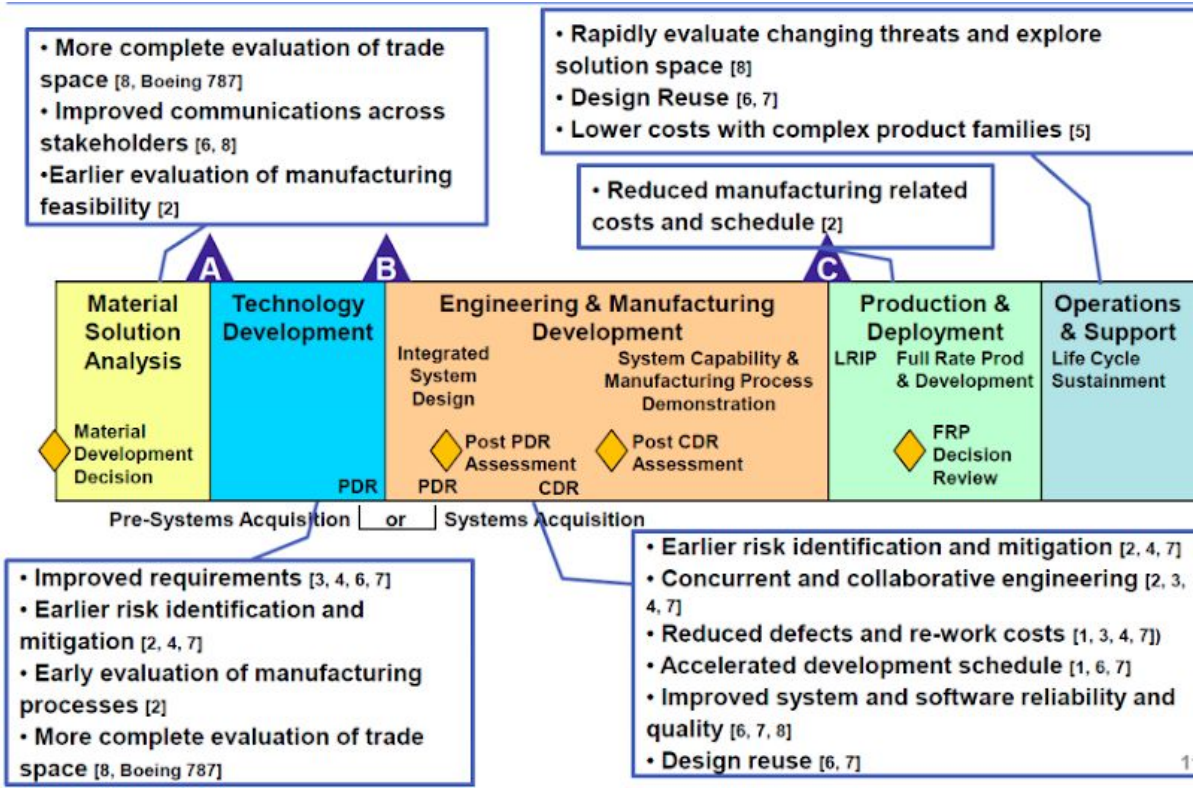


MBSE 3 pillars implementation (Badache N. & Roques P., 2018).



NASA presentation, Daniel L Dvorak, Model-Centric Engineering, part I: An introduction to model-based System Engineering, 2013

MBSE benefits for PM across the project life cycle

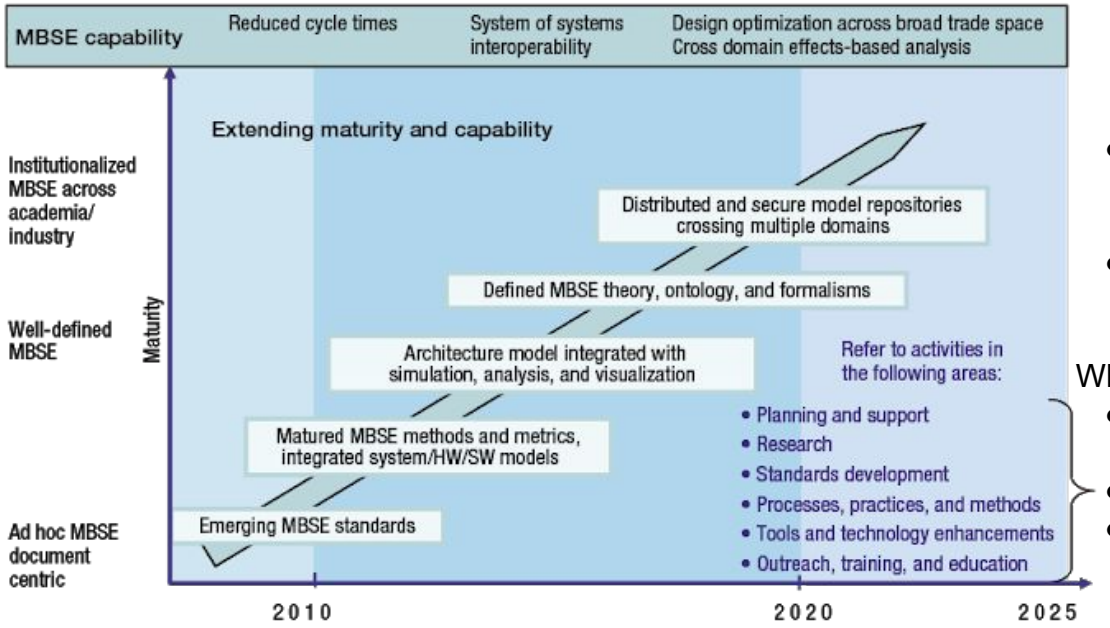


[Hause, 2013]

Key benefits for PM:

- Consistency
- Traceability
- Reuse
- Information sharing
- Knowledge capture

MBSE maturity status and prospects



MBSE Maturity Road Map, INCOSE IW (Chakraborty, 2016)

- MBSE is still at early stage of maturation
- Forecast: MBSE transition needs another 10 - 15 years

What needs to be done in the meantime:

- **Encourage** team and project managers!
- **Improve** interoperability!
- **Support** by INCOSE and OMG!

MBSE interoperability issues

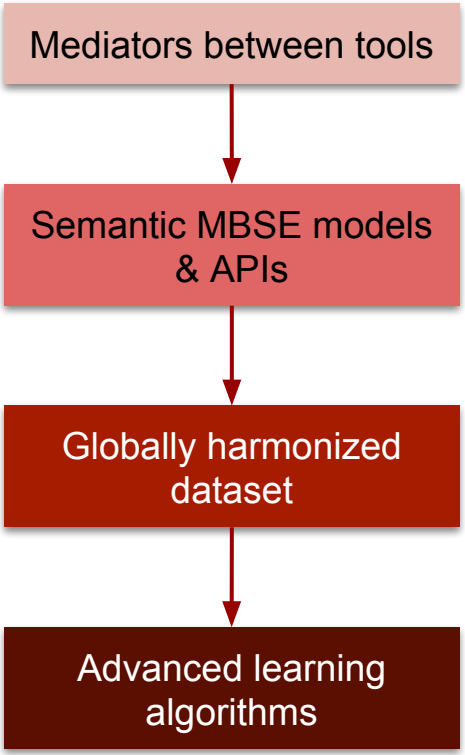
Interoperability issues between MBSE tools concern:

- Modeling
- Simulation
- Collaboration activities

Current solutions for resolving the model exchange issue (Lu, 2018):

- Linked data → add semantic meaning
- Meta-model integration → create common flexible templates
- Tool-based integration via Application Programming Interfaces (APIs) → common standard / protocol

Proposed implementation roadmap

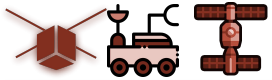


Recommendations for PM

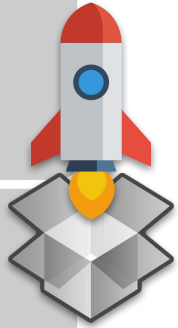
Support	• Create Guidelines to help implement MBSE in organisations • Provide comprehensive training for future users • Provide assistance during implementation
Standardisation	• Include MBSE in existing standards (e.g. ECSS / NASA PM Handbook) • Define standards for the three main elements of MBSE specifically for PM (--> MBPM)
Collaboration	• Intensify collaboration (e.g. with INCOSE, OMG or IPMA) to increase efficiency & learn best practices
Testing / Communication	• Support step-wise introduction of MBSE & MBPM • Verify and communicate the benefits!

Disruptive Technologies and PM in Space 4.0

Traditional Space vs. Space 4.0

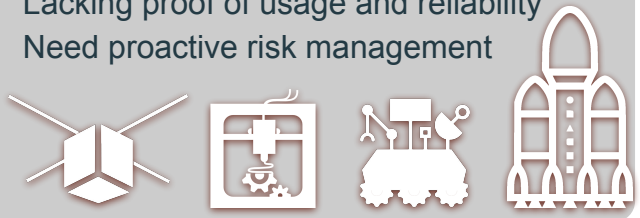


	Traditional Space	Space 4.0
Key Drivers	• High reputation agencies • Large projects • Human missions	• Venture capital • Market needs • **Disruptive technologies**
Characteristics	• Very risk averse • Limited adoption of new technology • Dependent on political environment • Mostly scientific oriented	• Acceptance of risks • Fast / iterative development • Lower costs • Open-market oriented



Disruptive technologies & impacts on PM

Driven By	Technologies / Methods	Impacts
Aerospace Applications	• Reusable spacecraft • Additive manufacturing (3D printing) • In-situ resource utilization (ISRU) • Nanosatellites	• Lacking proof of usage and reliability • Need proactive risk management
Other Industries	• Internet of Things (IoT) • Blockchain • Cloud solutions • Agile PM with Scrum • Virtual reality/ augmented reality (VR/AR)	• Less reporting effort • Documents verification • Concurrent development • Minimal prototypes, rapid iteration • Facilitating collaboration

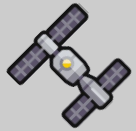


Disruptive business models

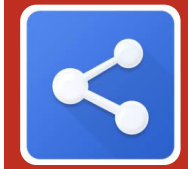
Direct Sales	Specific service / product (e.g., launch)	SPACEX, BLUE ORIGIN, ULA United Launch Alliance
	Built-to-client-specification	BOEING, LOCKHEED MARTIN
	Subscription-based	iridium, OneWeb
Data Provider	Collected / analyzed data	spire, planet., Google Maps
Marketplace	Platforms where customers compare options	CubeSatShop, SPACEFLIGHT, NTL NASA

Supply chain management

"Right quality for the right cost"

Segment	Strategies & Methods
Small Satellites	 • Use Commercial-Off-The-Shelf (COTS) to reduce costs • Reliability is a key factor • NASA's COTS database with flight heritage with their description and documentation.
Launchers	 • Falcon 9's parts mostly built in-house ➔ Control over the design and building process. • Use COTS when at least two providers exist 
Space Logistics	 • Supply humans missions with life-sustaining resources. • Harvesting materials from ISRU • MIT's Interplanetary Supply Chain Management and Logistics Architectures (IPSCM&LA) and Planetary Resources 

Recommendations



Knowledge Sharing

- Cloud services
- Successes / failures of disruptive technologies
- Space-sector conference for lessons learned

Promote Standardization

- Address complexity as function of interfaces
- Improved documentation of COTS performance
- Expand on examples from CubeSat sector

Leverage Decentralization

- Seed spectrum of entrepreneurial start-ups
- Flat organizational structures
- Data providers support scientific researches
- Crowd-sourcing & “gig economy”

Demographics & Inspiration

Current situation in space sector

Perception of the traditional space industry:

- Outpaced as most technologically advanced
- Inherently slow moving
- Success limited to the existing players

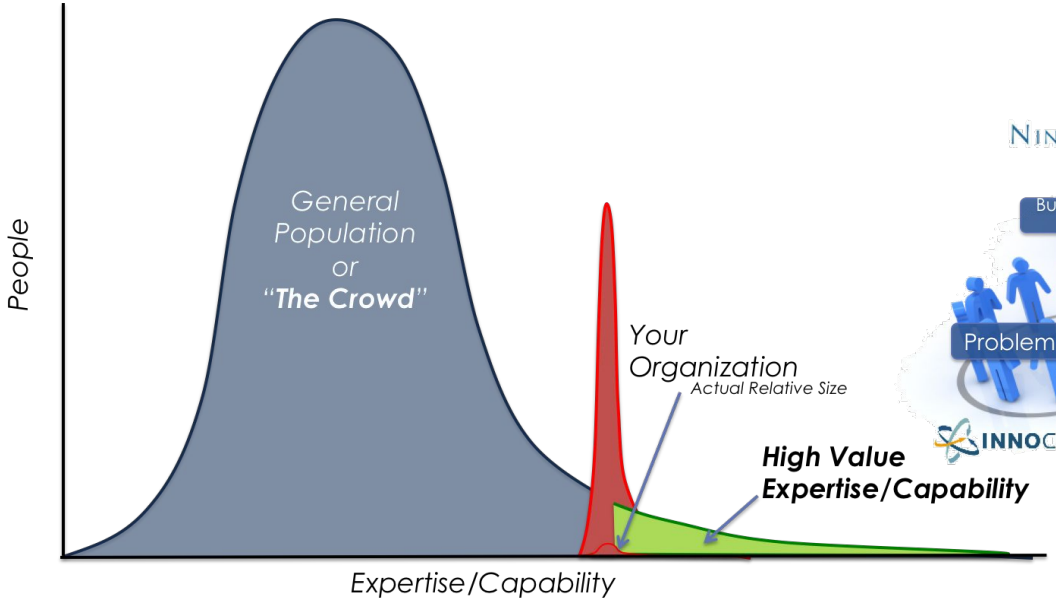
Moreover: large population **near retirement** and a larger population **just entering** the field, but with comparatively fewer in mid-career.

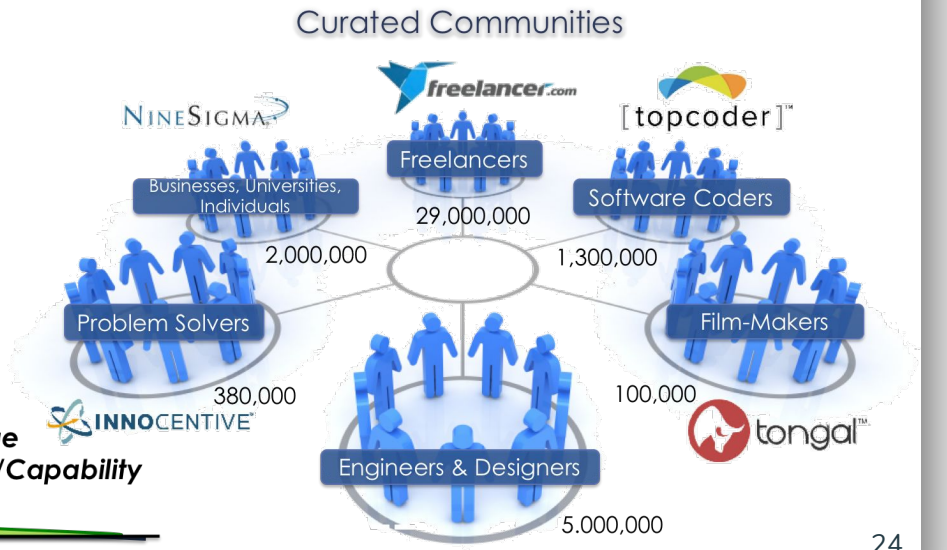
→ **Space 4.0 as an initiative to attract and inspire young generation**

Recommendations

Engagement and Inspiration via Crowdsourcing

PM practices can **incorporate crowd-sourced initiatives**, especially as they open opportunities to **work with, train, and hire** highly capable people with little prior space experience.





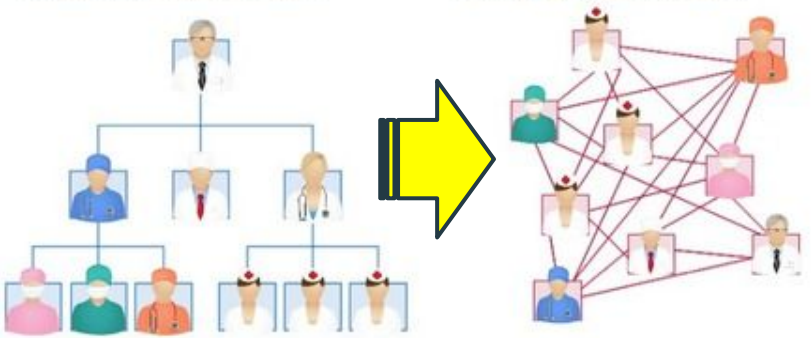
Recommendations

Infusion of Best Practices from Other Industries

Modern PM processes can **make aerospace companies more attractive** to a younger generation, e.g., going paperless, remote work, working time to “experiment” with new processes/technologies.

git

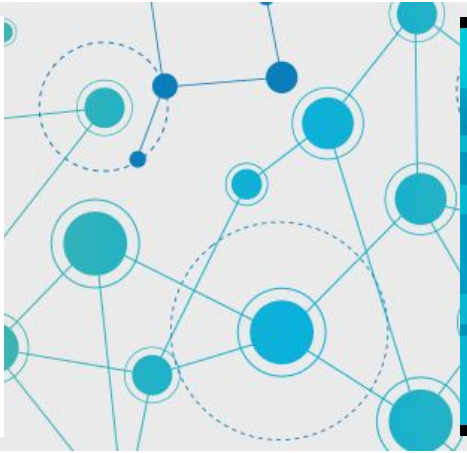
slack



Recommendations

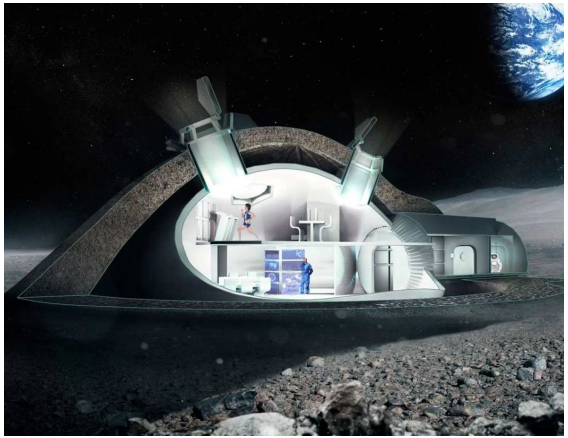
Mentoring and Peer-Networking

PM should promote **cross-generational partnering & peer networking** within projects & across institutions to **capitalize on the relative strengths** and experiences of different age groups.



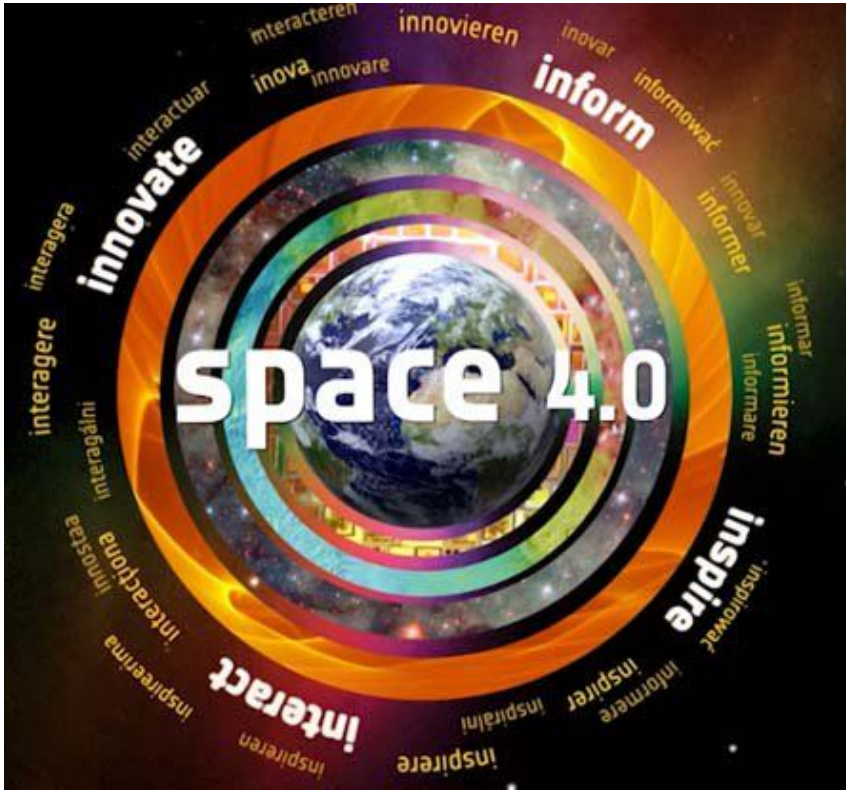
Conclusion

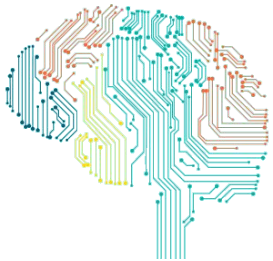
Adopting the recommended practices within PM would change the image of traditional space companies/organizations and help them be seen as **attractive, forward-thinking career opportunities** for young professionals.



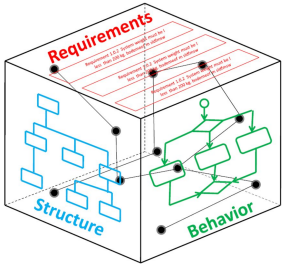
Overall Conclusions & Recommendations

Space 4.0 - 4.0 Areas of Opportunity





Artificial Intelligence

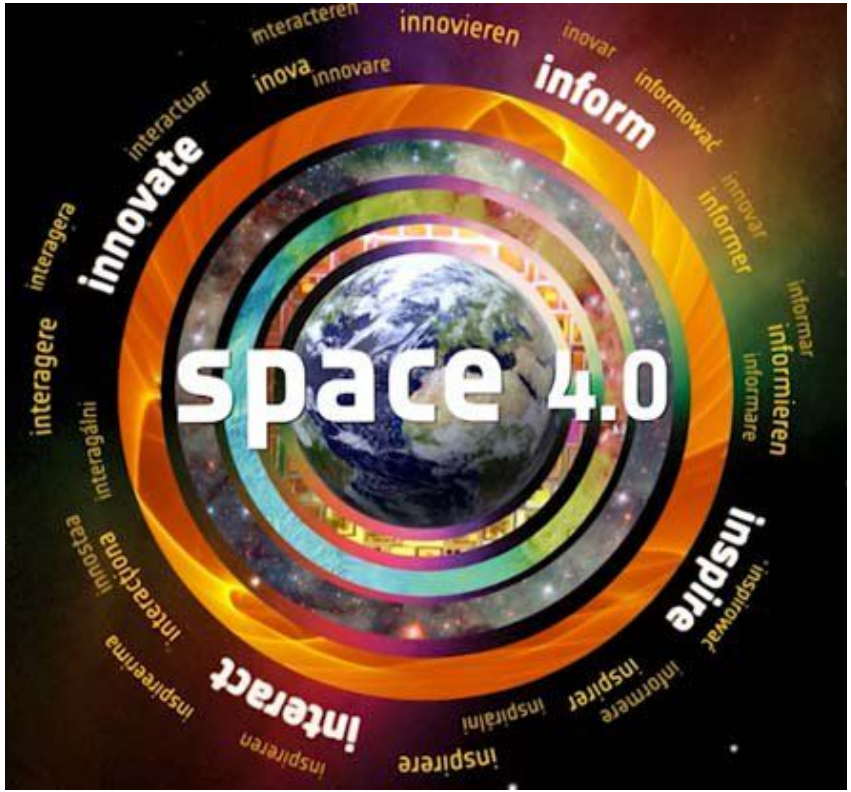


Model Based Systems Engineering

Demographics & Inspiration

Disruptive Technologies

Space 4.0 - 4.0 Cross-Cutting Themes



Capitalize on external trends & industries

Interfaces, standardization, interoperability

Importance of human factors within PM

Decentralized aerospace = expanded & inclusive

Questions?


space 4.0
inform
innovieren
informować
informer
informar
informare
informieren
inspire
inspirować
inspirer
inspirar
inspirare
inspirieren
interact
interactuar
interagera
interagir
interagere
interagálni
interactiona
interactiona
innovate
innovar
innovare
inova

Back-Ups

Recommendations

- Further promote standardization throughout the industry.
  - E.g. in Cubesat industry
- Improve the monitorization and documentation of the in-orbit performance of COTS parts.
- Evaluation study of successes and failures in disruptive technologies.
  - Space-sector conference for exchanging the experiences and lessons learned
- Take full advantage of cloud solutions for sharing data/services among stakeholders and incorporate decentralization at various scales.
- Seed a broad spectrum of technology start-ups (entrepreneurial / pre-revenue companies).
- Investigate data providers as supplemental sources of scientific information.
- Address complexity as a function of interfaces.
  - Develop missions based on standardized interfaces between sub-systems
  - Adopt a more flat organizational structure instead of a top-down authority

Recommendations

Engagement and Inspiration via Crowdsourcing

→ Crowdsourcing offers access to curated communities of expertise by issuing challenges to solve difficult and focused problems

→ Public challenges elicit responses from people of all disciplines and backgrounds

PM practices can incorporate these crowd-sourced initiatives, especially as they open opportunities to work with, train, and potentially hire highly capable people with little prior space experience.

Recommendations

- Infusion of Best Practices from Other Industries

→ PM should observe and adapt technologies from other industries and not reinvent solutions that already exist.

→ Environments like Git and Slack encourage agile development, flattened hierarchies, and the sense of a “digital commons” where all contributions are encouraged and recognized.

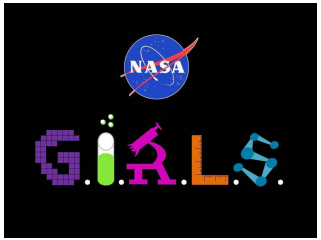
Modern PM processes can make aerospace companies more attractive to a younger generation, e.g., going paperless, remote work or dedicating part of the working time to “experiment” with new processes/technologies.

Recommendations

- Mentoring and Peer-Networking

→ Experienced staff can give guidance and motivation to young professionals while sharing best practices and important context for institutional processes.

→ Early career professionals are often more attuned to the newest advancements and are enthusiastic to experiment with evolving technology.



PM should promote cross-generational partnering within projects to capitalize on the relative strengths and experiences of different age groups.