Space Programs in Emerging Nations

Launching Hungary into Space

Dan Erkel
Dr Brian Weeden

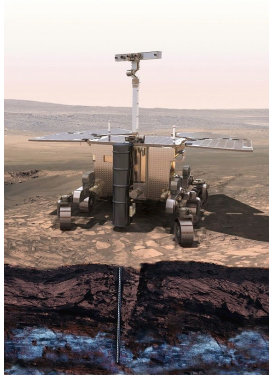
Dan Erkel

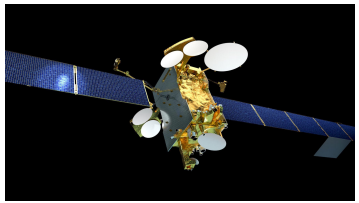
Systems Engineer, PhD Candidate

Experience
MIT AeroAstro ESL Research Assistant
Airbus Spacecraft Thermal Engineer
Turbomachinery Design Engineer

Education
2020- Technology and Policy SM - MIT
2019- AeroAstro PhD - MIT
2015 Space Eng MSc - Cranfield, UK
2013 BEng Mech Eng - UCL, UK

Research + Interests:
Small satellite thermal and systems engineering;
Modular satellites and platform optimsation;
Multidisciplinary optimisation for space systems;
Policies for proliferated LEO;
Space Situational Awareness;
Technology and policy in the small satellite ecosystem;





Brian Weeden

Director of Program Planning, Secure World Foundation

Experience
Secure World Foundation
U.S. Air Force Space and Missile Operations

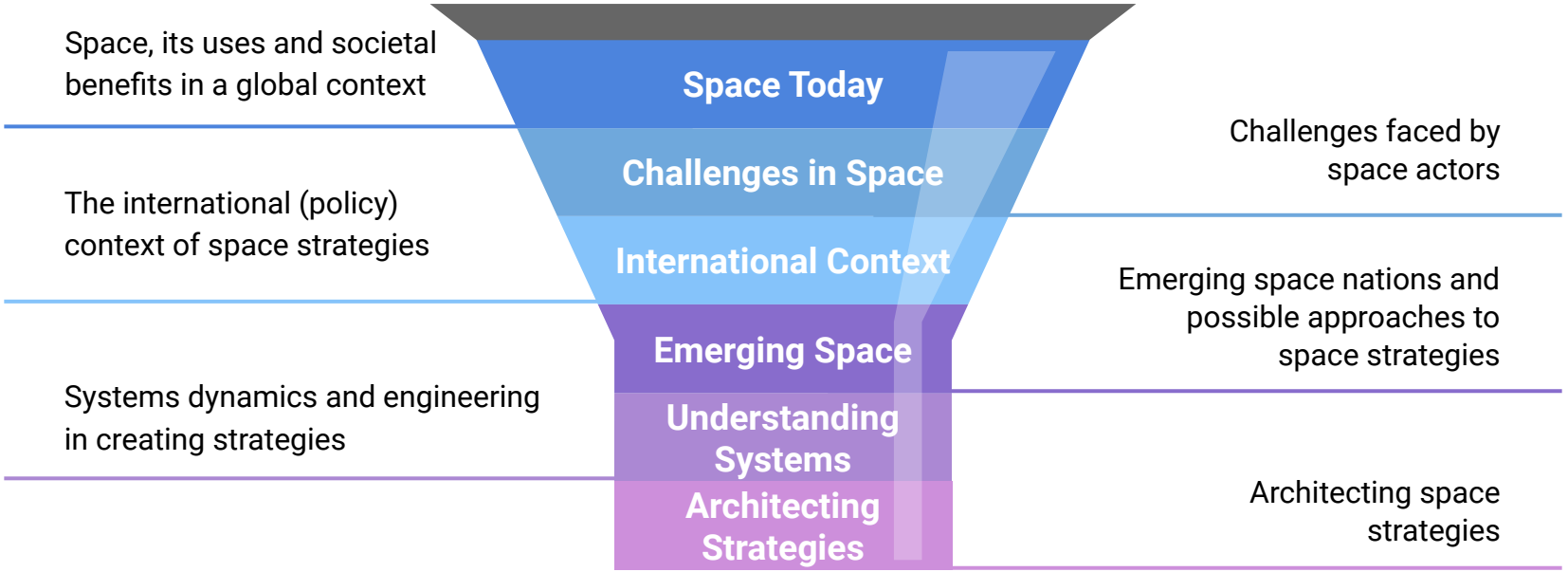
Education
20017 PhD Public Policy and Public Administration, George Washington U.
2007 International Space University SSP07 (Beijing)
2006 MS Space Studies. U. North Dakota
1998 BS Electrical Engineering, Clarkson

Research areas:
Space debris
Space situational awareness
Space traffic management
Space sustainability
Space security
Space governance

Emerging Space Programmes - Opening Thoughts

1. *Fundamental questions*:
   - **Why and how do countries with comparatively limited resources spend on developing a space programme?**
   - **What were the key elements of the space strategy of Hungary, an emerging space actor (EMSA) and how did it define these?**
   - **Is there a structured approach that could be used to define a space strategy for an EMSA?**
2. What defines **today's space ecosystem** from economic and policy aspects?
3. What are some key **dynamics** of this global **space ecosystem**?
4. How can **strategies** be intepreted as **systems problems**?
5. What elements of **systems architecting** can be used in strategy writing?
6. Does the "NewSpace-era" imply a **fifth industrial revolution** and what does this mean for EMSAs?
7. Why should we look at parts of space (LEO) as a **common pool resource** and what does this and other aspects of the space policy context mean for EMSAs?

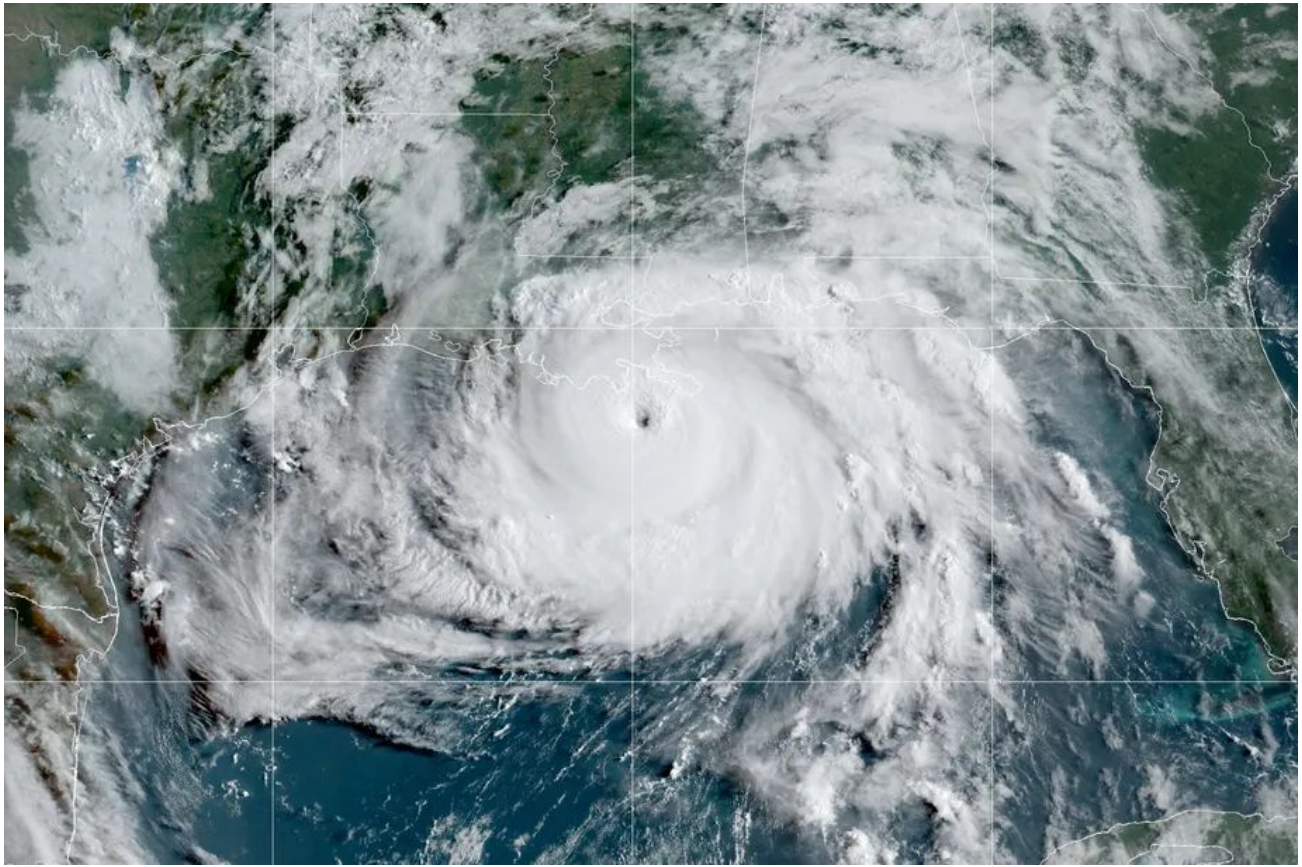
Structure of Today's Talk



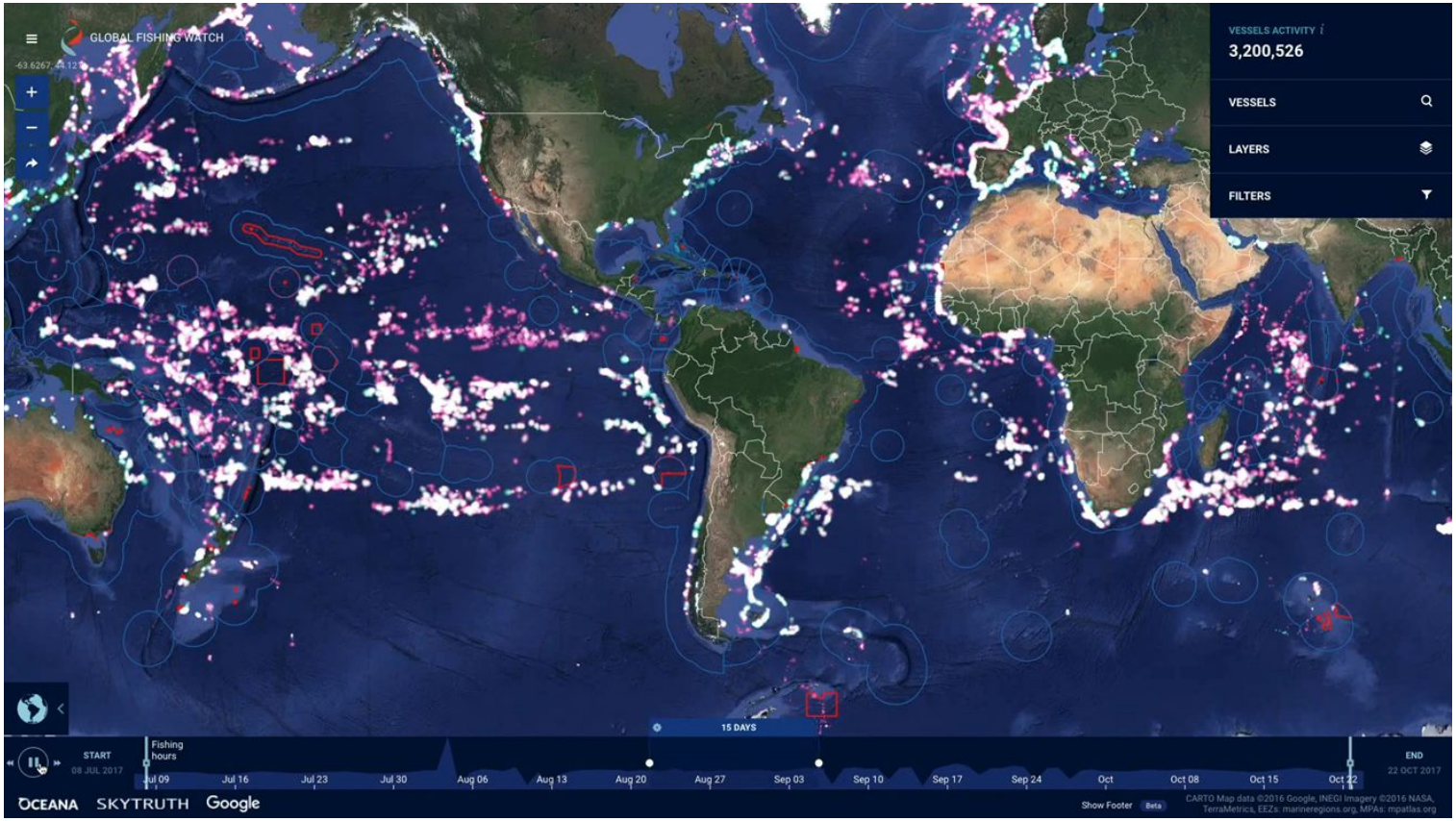
Space is a Ubiquitous, if sometimes Invisible Part of Our Daily Lives

Dr Brian Weeden


SUN DIRECT
SUN DIRECT
SUN DIRECT
VIDEOCON



GOES satellite image of Hurricane Ida, August 2021.
Credit: NOAA



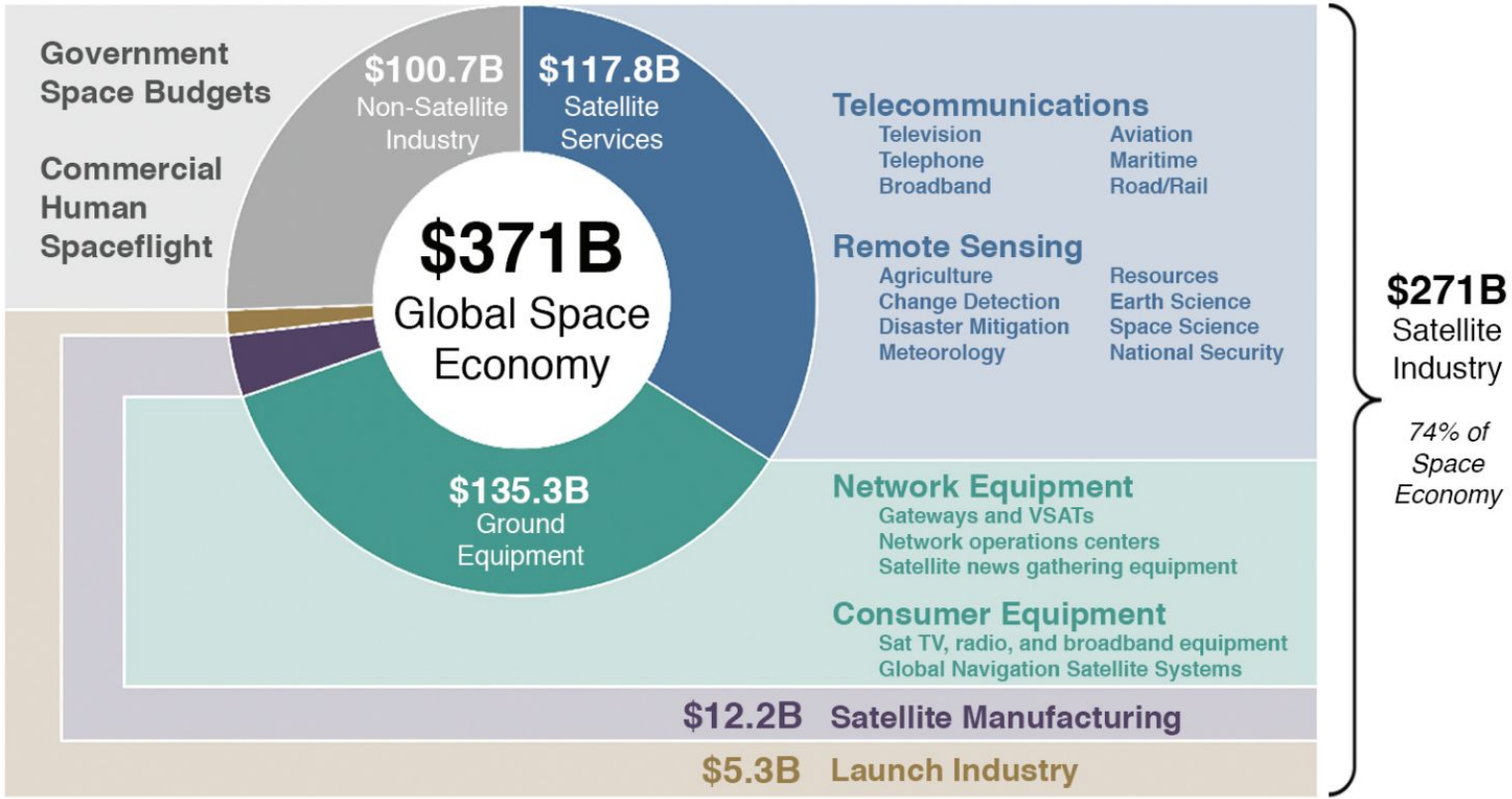
Source: [Global Fishing Watch]

Source: The Telegraph

UN Sustainable Development Goals

The Satellite Industry in Context

(2020 revenues worldwide, in billions of U.S. dollars)



Source: [BryceTech]

Emerging Challenges from Growing Uses of Space

Dr Brian Weeden

Increasing congestion in space

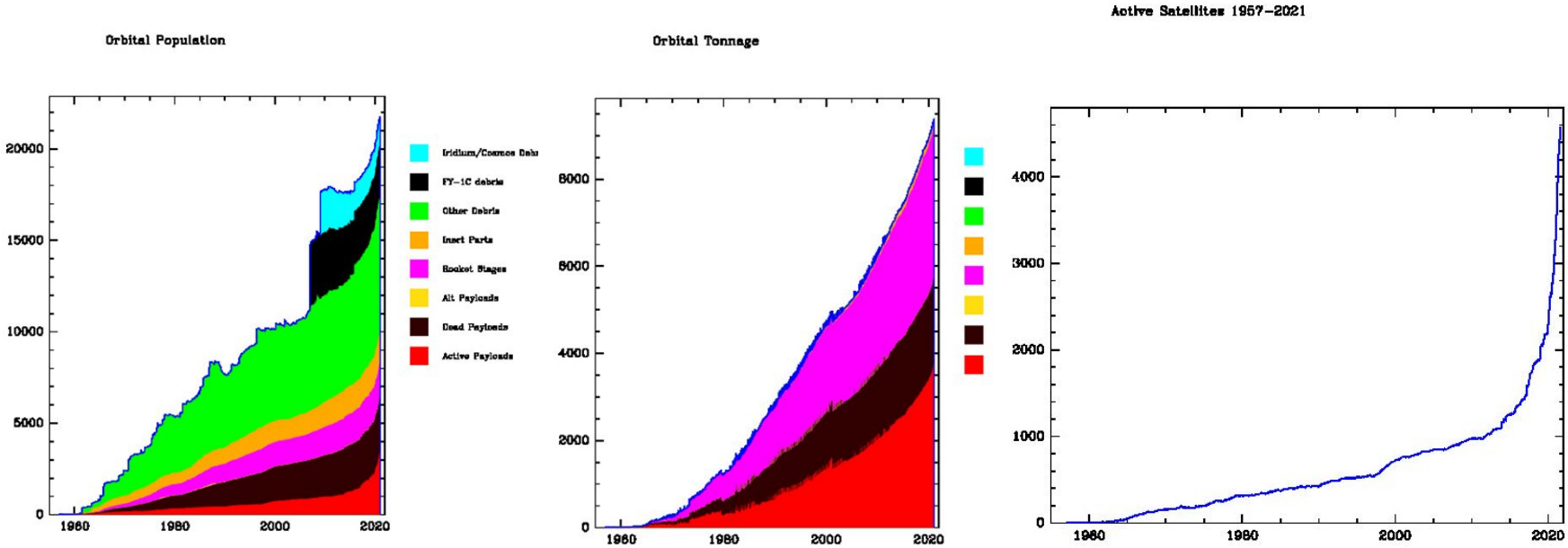
Total Active Satellites:			
United States	Russia	China	Others
2,778	167	431	1,164

Total Space Debris:		
Larger than 10 cm	~36,500	Can cause catastrophic collisions; sources of new debris
Between 1 and 10 cm	~1,000,000	Can cause major damage
Smaller than 1 cm	many millions	Can cause minor damage

Current through Sept 1, 2021

Source: Union of Concerned Scientists, European Space Agency

…make that *accelerating* congestion

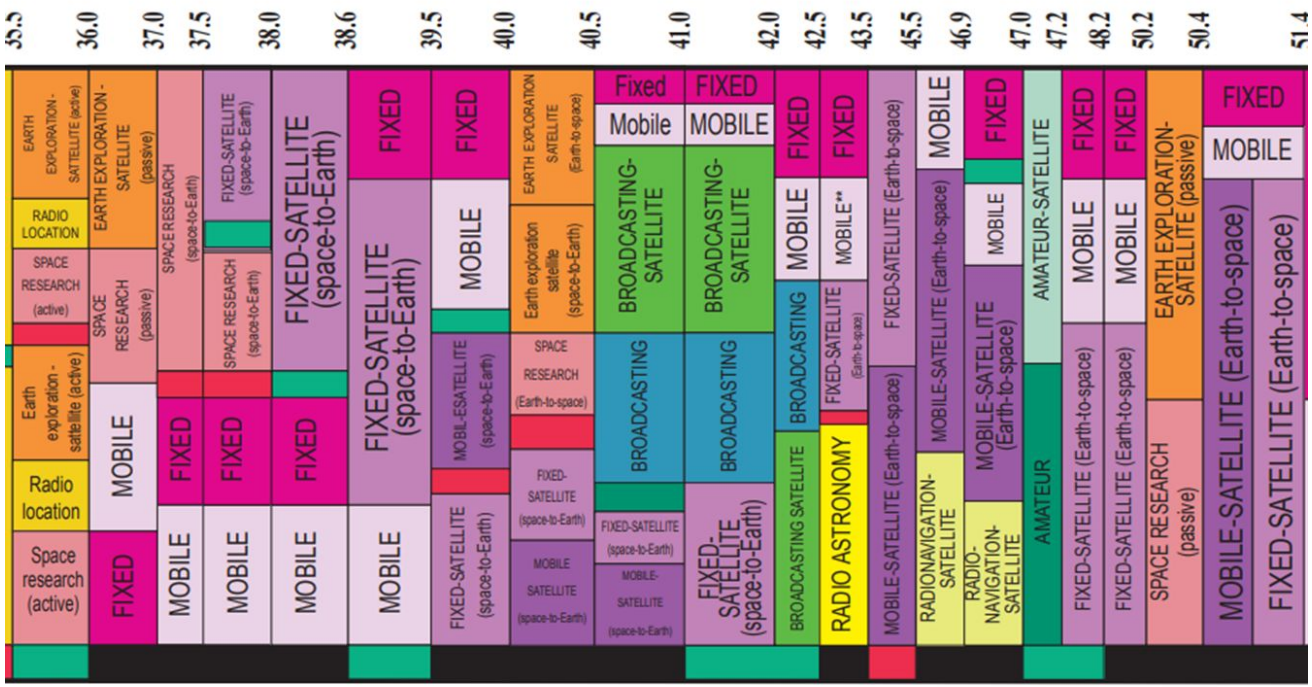


Source: [Jonathan's Space Page]

With more coming

Constellation	Total Satellites	Altitude	Country	Status
OneWeb Gen1	6,372	1,200 km	UK	394 launched
OneWeb Gen2	47,800	1,200 km	UK	Planning
Starlink Gen1	4,408	540 – 570 km	US	2,041 launched (1,495 operational)
Starlink Gen2	30,000	328 – 614 km	US	Planning
Kuiper	3,326	590 – 630 km	US	First launch 2022
Lightspeed	298	1,015 – 1,325 km	Canada	First launch late 2023
GW	12,992	590 – 1145 km	China	Planning

Radiofrequency spectrum congestion



Proliferation of counterspace threats

	China	Russia	U.S.	France	India	Iran	Japan	North Korea
LEO Co-Orbital	Y	G	Y	R	R	R	R	R
MEO/GEO Co-Orbital	Y	Y	Y	R	R	R	R	R
LEO Direct Ascent	G	Y	Y	R	Y	R	R	R
MEO/GEO Direct Ascent	Y	Y	Y	R	R	R	R	R
Directed Energy	Y	Y	Y	Y	R	R	R	R
Electronic Warfare	G	G	G	Y	Y	Y	R	Y
Space Situational Awareness	G	G	G	Y	Y	Y	Y	R

Legend: none R some Y significant G

Source: SWF Global Counterspace Capabilities Report

Projected Exploration Missions (2020-2030)

Data include announced missions, with dates as announced, and projected missions (likely missions such as typical supply missions to space stations), with estimated dates.

BRYCE space and technology

International Space Station

Mission	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
SpaceX Cargo	3	3	1								
Northrop Grumman Cargo	2	1	2								
Sierra Nevada Corp.		1	1								
Cargo TBD			1	4	4	4	4	4	4	4	4
Demo-2 *Endeavour*	1										
Boe-OFT 2	1										
Boe-CFT		1									
Commercial Crew	1	2	2	2	2	2	2	2	2	2	2
Soyuz Crew	4	2	2	2	2						
Orel Crew						2	2	2	2	2	2
Progress	2	2	2	2	2	2	2	2	2	2	2
HTV	1		1		1		1		1		1
Axiom 1					1		1		1		

152 Crew and cargo missions to LEO

Chinese Space Station

Mission	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Shenzhou		1	1	1	1						
NG Shenzhou	1		1			1	1	1	1	1	1
Tianhe 1		1									
Wentian			1								
Mengtian			1								
Xuntian				1							
Tianzhou		1	1	1	1	1	1	1	1	1	1

First crewed landing since 1972

Mission	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Artemis		1		1	1	1	1	1	1	1	1
Human Landing System (HLS)					4	4	4	4	4	4	4
Lunar Gateway PPE and HALO				1							
Lunar Gateway Hab						1					
Lunar Gateway JAXA Logistics Habitat									1		
Lunar Gateway JAXA Pressurized Rover											1
Gateway Logistics Services (GLS)					1	1	1	1	1	1	1
Artemis Base Camp Foundation Habitat									1		
Artemis Base Camp Mobility Habitat										1	
Artemis Base Camp Logistics Mission											1
Commercial Lunar Payload Services (CLPS)		2	2	2	2	2	2	2	2	2	2
CAPSTONE		1									

95 Missions to the Moon

Mission	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Chang'e 5	1										
Chang'e 6				1							
Chang'e 7					1						
Chang'e 8							1				

Mission	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Luna 25		1									
Luna 26					1						
Luna 27						1					
Luna 28 (sample return)							1				
Luna 29								1			
Orel (uncrewed circumnavigation)					1						
Orel (crewed circumnavigation)							1				
Orel (crewed landing)										1	

Mission	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
HERACLES EL3 (ESA, JAXA, CSA)								1			
Moon Cruiser 1 Logistics Mission (with ESPRIT)						1					
PTScientists ALINA		1									
Spacebit Mission 1		1									
Chandrayaan 3				1							
Hakuto-R Mission 1			1								
Hakuto-R Mission 2				1							
JAXA SLIM			1								
KARI Pathfinder Lunar Orbiter			1								
Lunar Surface Access Service (LSAS)			1								
SpaceX dearMoon Project						1					

11 Missions to Mars

Mission	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Mars 2020	1										
NASA MNG Sample Return Mission							1				
NASA MNG Mission TBD 1									1		
NASA MNG Mission TBD 2											1

Mission	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Tianwen 1 Rover	1										

Mission	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
ExoMars 2022			1								
Mangalyaan-2					1						
JAXA TEREX 1				1							
JAXA TEREX 2					1						
JAXA MMX					1						
UAE Hope	1										

As of August 31, 2020

UN COPUOS Membership

Albania, Algeria, **Angola**, Argentina, Armenia, Australia, Austria, Azerbaijan, Bahrain, **Bangladesh**, Belarus, Belgium, Benin, Bolivia, Brazil, Bulgaria, Burkina Faso, Cameroon, Canada, Chad, Chile, China, Colombia, Costa Rica, Cuba, Cyprus, Czech Republic, Denmark, Dominican Republic, Ecuador, Egypt, El Salvador, Ethiopia, Finland, France, Germany, Ghana, Greece, Hungary, India, Indonesia, Iran, Iraq, Israel, Italy, Japan, Jordan, Kazakhstan, Kenya, **Kuwait,** Lebanon, Libya, Luxembourg, Malaysia, Mauritius, Mexico, Mongolia, Morocco, Netherlands, New Zealand, Nicaragua, Niger, Nigeria, Norway, Oman, Pakistan, **Panama**, Paraguay, Peru, Philippines, Poland, Portugal, Qatar, Republic of Korea, Romania, Russian Federation, Rwanda, Saudi Arabia, Senegal, Sierra Leone, Singapore, Slovakia, **Slovenia**, South Africa, Spain, Sri Lanka, Sudan, Sweden, Switzerland, Syrian Arab Republic, Thailand, Tunisia, Turkey, Ukraine, United Arab Emirates, United Kingdom of Great Britain and Northern Ireland, United States of America, Uruguay, Venezuela & Vietnam

Sustainability questions

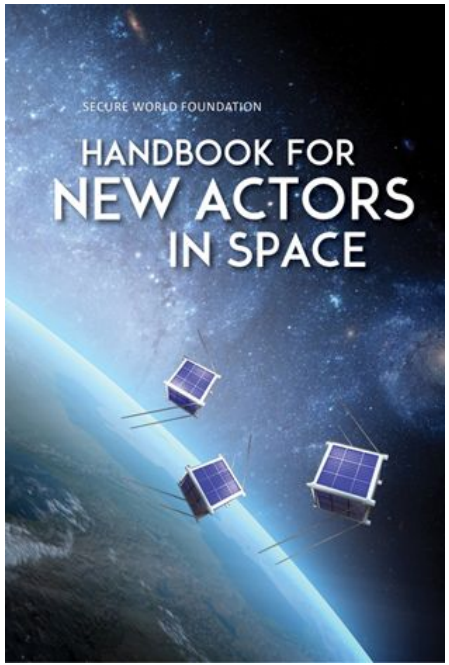
- Will all these new actors experience the same “learning curve” as the legacy actors?
  - Will they make the same mistakes, or just new ones?
- How do new spacefaring countries develop national space policy and law?
- How do we help maximize the benefits from new actors entering the space domain while minimizing potential sustainability challenges?

SWF Handbook for New Actors in Space

Goal: Create a publication that provides an overview fundamental principles, laws, norms, and best practices for safe, predictable, and responsible activities in space

Two specific audiences:

- Countries developing space programs and/or having to oversee and regulate their first satellites
- Universities and start-up companies that are developing/operating satellites

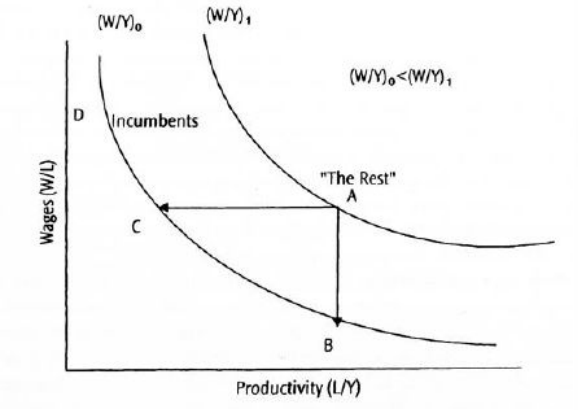


www.swfound.org/handbook

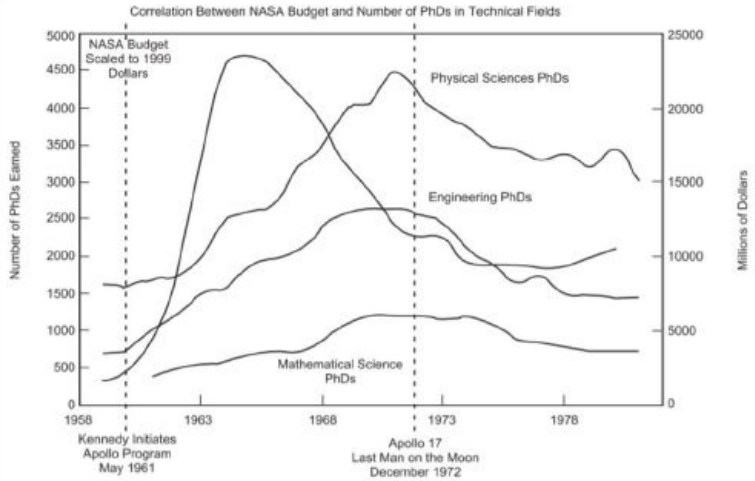
Emerging Space Nations
Hungary in Space

Dan Erkel

Guns or Butter? A false dichotomy



Source: Amsden - The Rise of the "Rest" [2001]



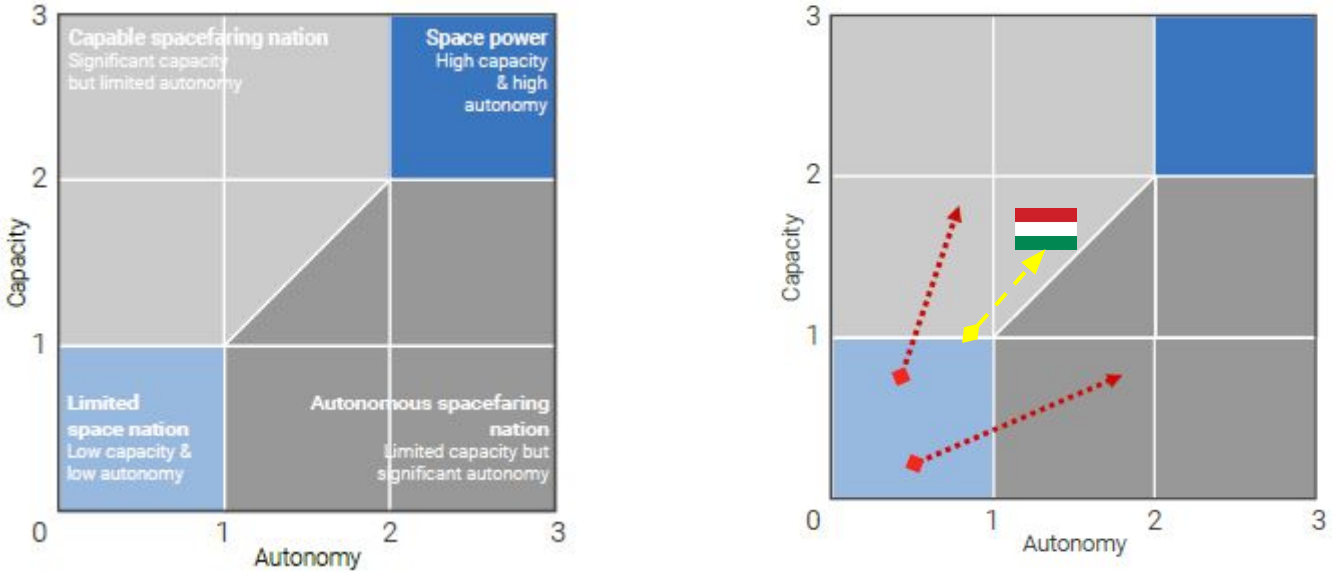
Source: Siegfried - Benefits for the World [2003]

Credit: Tesat-Spacecom

But really, why? Carl Sagan's survival tips

- Surviving… lessons of the Bogota convention and common pool resources
- Seizing the opportunities - the 5th industrial revolution?
- Range of reasons in the context of power
  - Military power
    - National security
    - Cooperation
    - Sovereignity
  - Economic power
    - Clear socio-economic benefits
    - Long-term sustainability and development (brain drain)
  - Soft power
    - Prestige - external and internal
- What's good for "the Rest" is good for the West - external effects

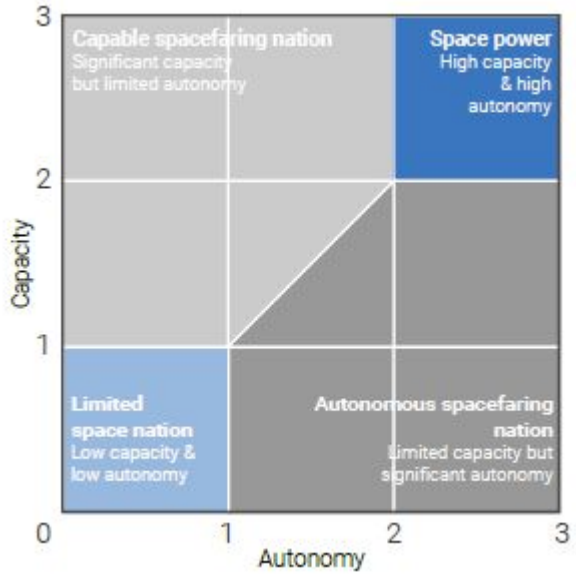
What is Emerging and from Where?



[Source: ESPI- Space Power Matrix]

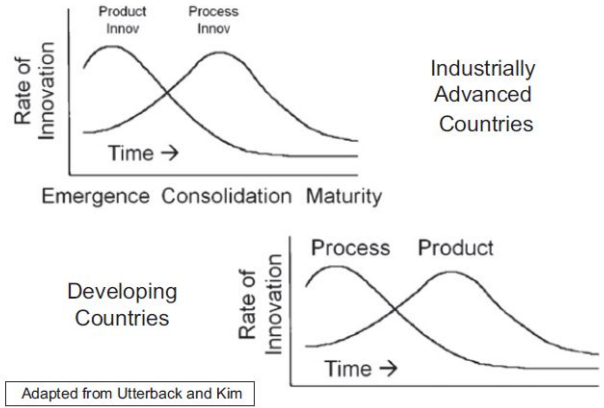
What is Emerging and from Where?

- Distinguishing emerging space *markets* and emerging space *nations* or *actors*
  - Is there a connection? *NewSpace and small sats*
- Emerging Space Actors (EMSA)
  - “Developing” and “emerging nations”
- Comparisons with other spacefaring nations
  - Resource scarcity and different motivations
- Classifying EMSA-s (based on Harding, 2012)
  - Tier 1: China, Brazil, India
  - Tier 2: MENA, South Africa, CEE (?)
  - Tier 3: Latin Americas, Post Soviet states, CEE (?)

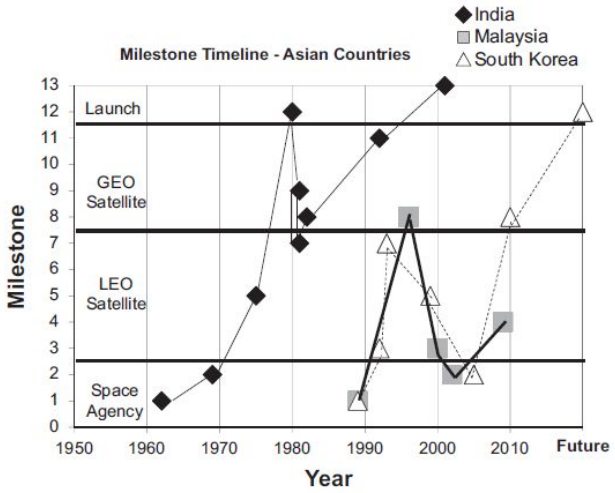


[Source: ESPI- Space Power Matrix]

How are things emerging? Frogs?



Source: Wood, Weigel [2011]



Source: Wood, Weigel [2012]

Photo by Balint Halpern

The Hungarian National Space Strategy

- Hungary - the country
- Understanding Hungary’s history in space
  - Rich history in some level of involvement in space research, first astronaut, Bertalan Farkas flown in 1980 as part of the Soviet Intercosmos programme (seventh in the world)
- Primary motivations and expectations for the space programme
  - Recognition of the opportunity present today
  - Opportunities and pressures offered by the ESA membership
- Approach for development through coordination - governmental involvement
  - Civilian focus

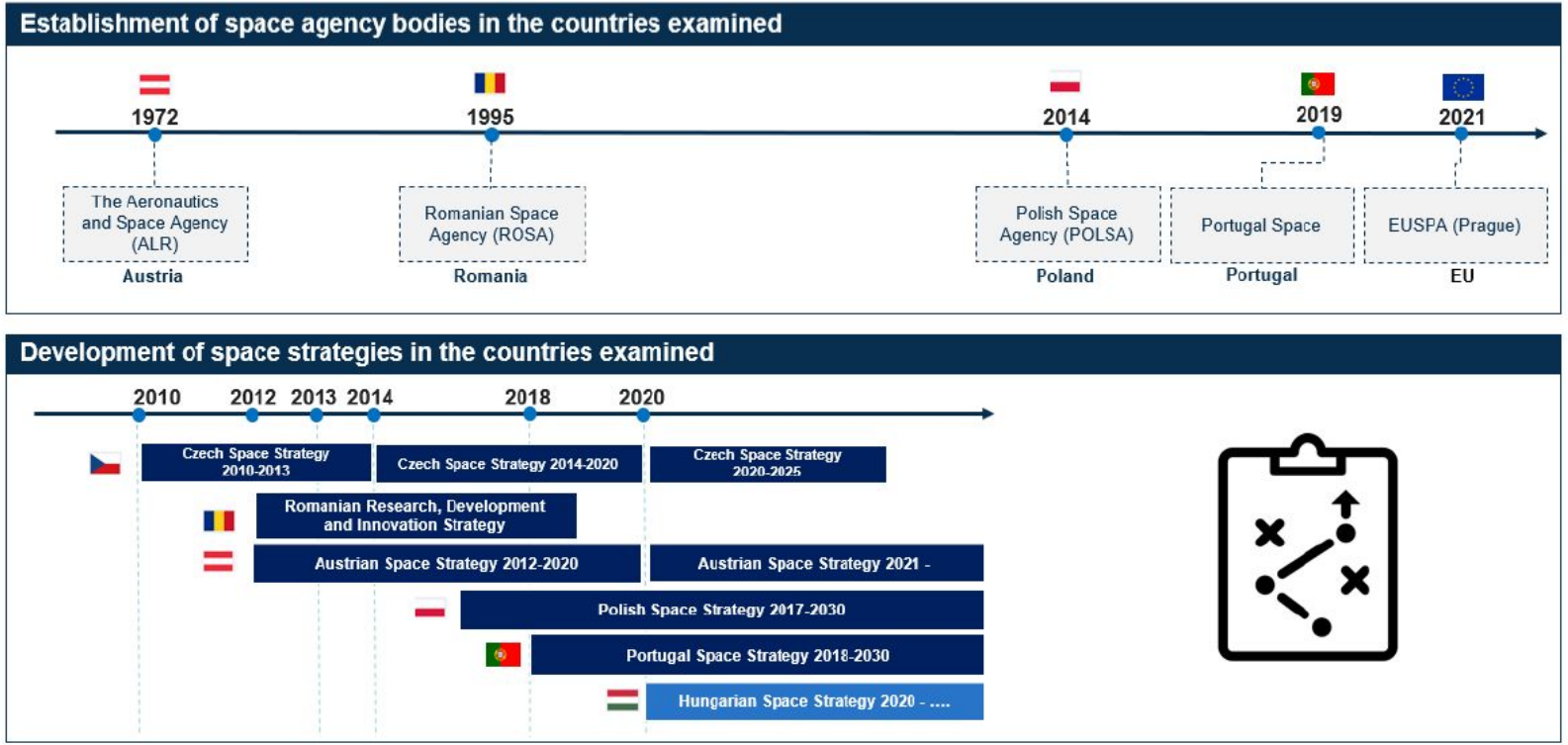
Source: Hungarian National Space Strategy [2021]

Hungarian history and space heritage

Credit: NASA

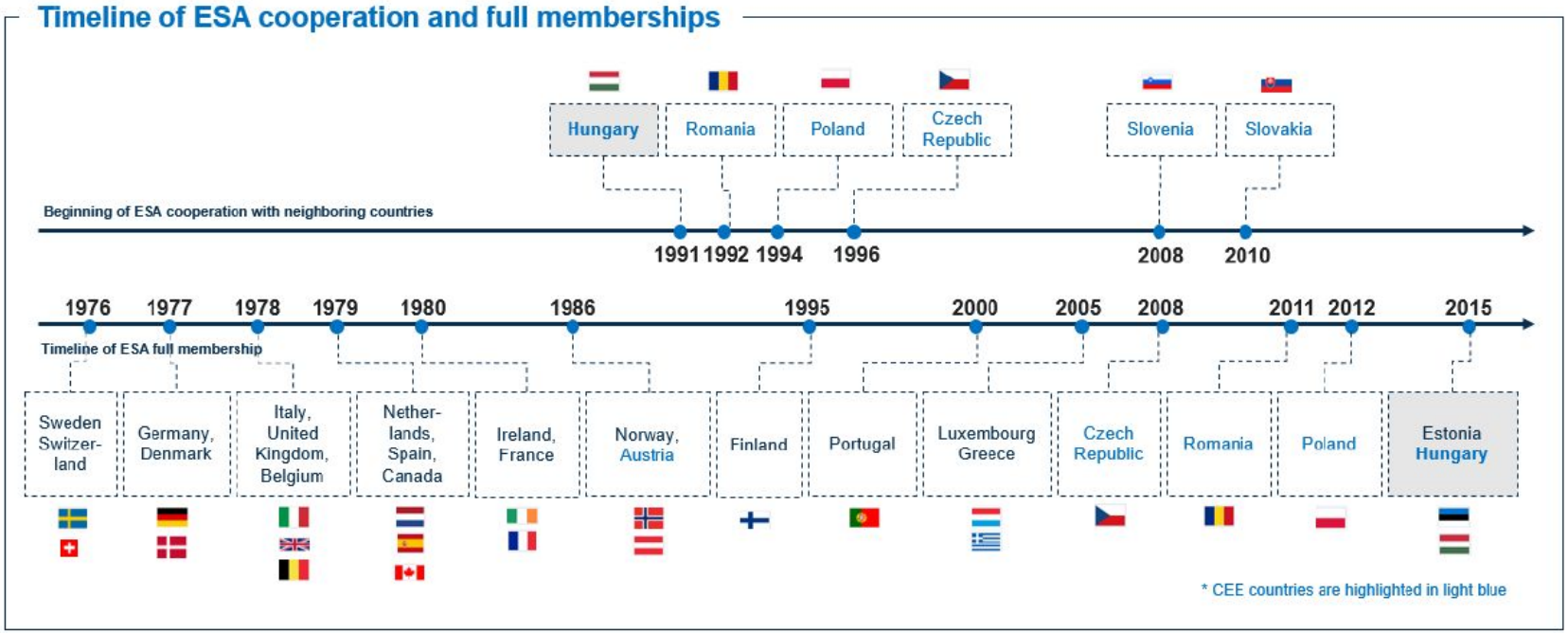
Credit: AFP

Hungary international context - I



Source: Hungarian National Space Strategy [2021]

Hungary, international context - II



Source: Hungarian National Space Strategy [2021]

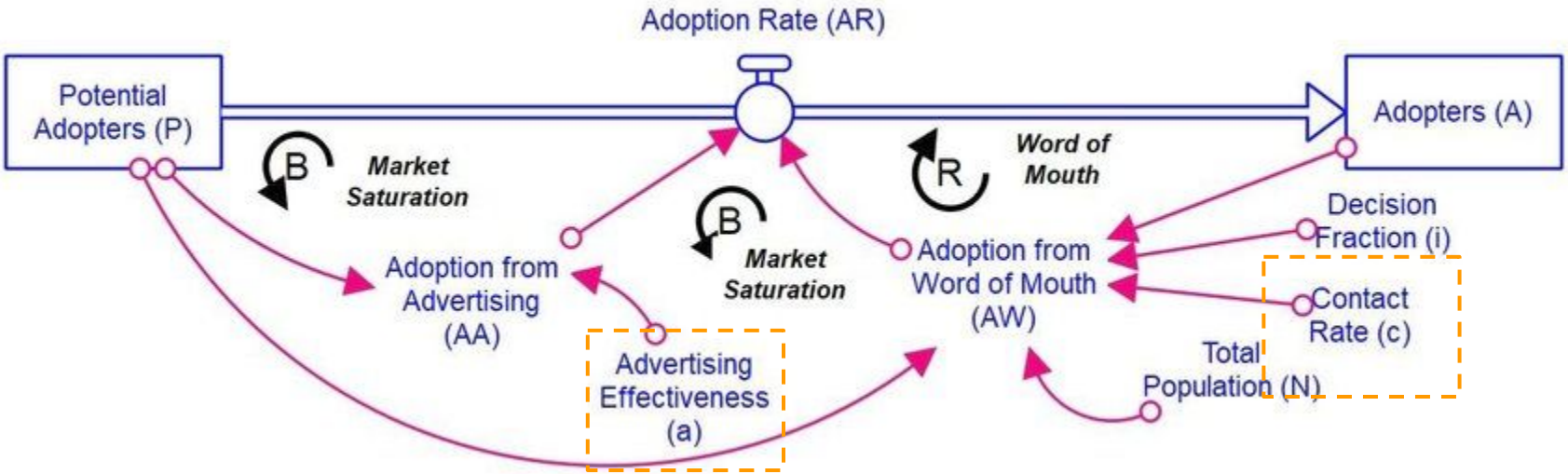
Hungary's motivations

- Surviving… lessons of the Bogota convention and common pool resources
- **Seizing the opportunities - the 5th industrial revolution! (paradigm shift)**
- Range of reasons in the context of power
  - **Military power**
    - **National security**
    - **Cooperation**
    - **Sovereignity**
  - **Economic power**
    - **Clear socio-economic benefits**
    - **Long-term sustainability and development (brain drain)**
  - **Soft power**
    - **Prestige - external and internal**
- What's good for "the Rest" is good for the West - external effects

Systems dynamics and governmental involvement

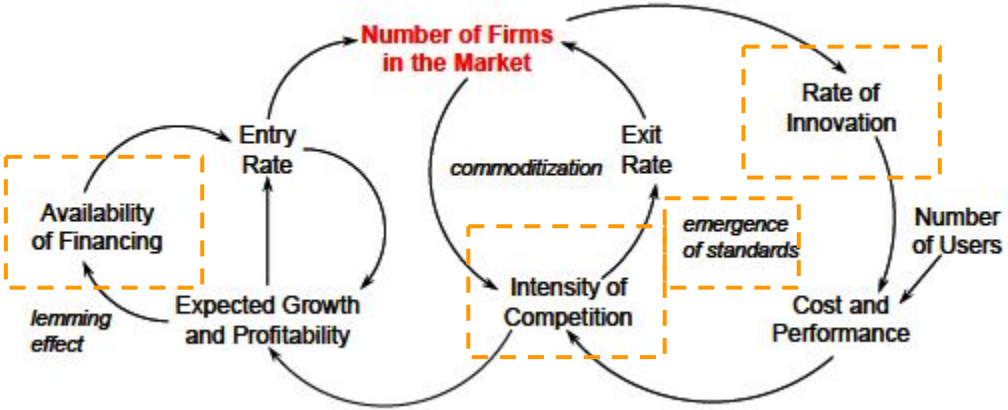
Dan Erkel

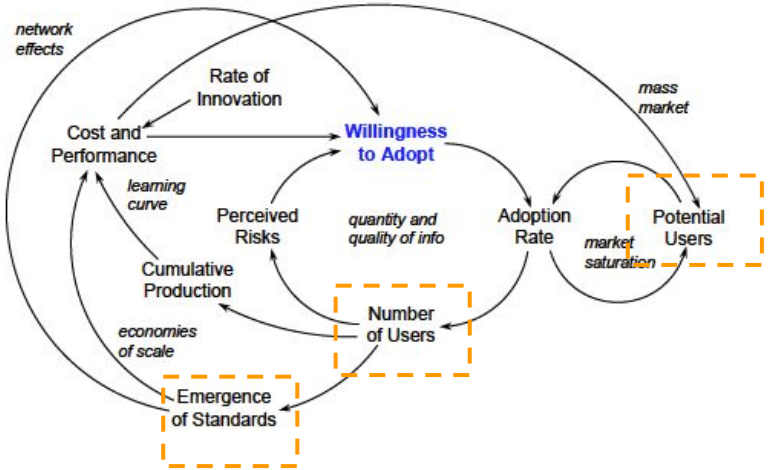
System dynamics in action - technology diffusion and governmental involvement



Source: Sterman [2000]

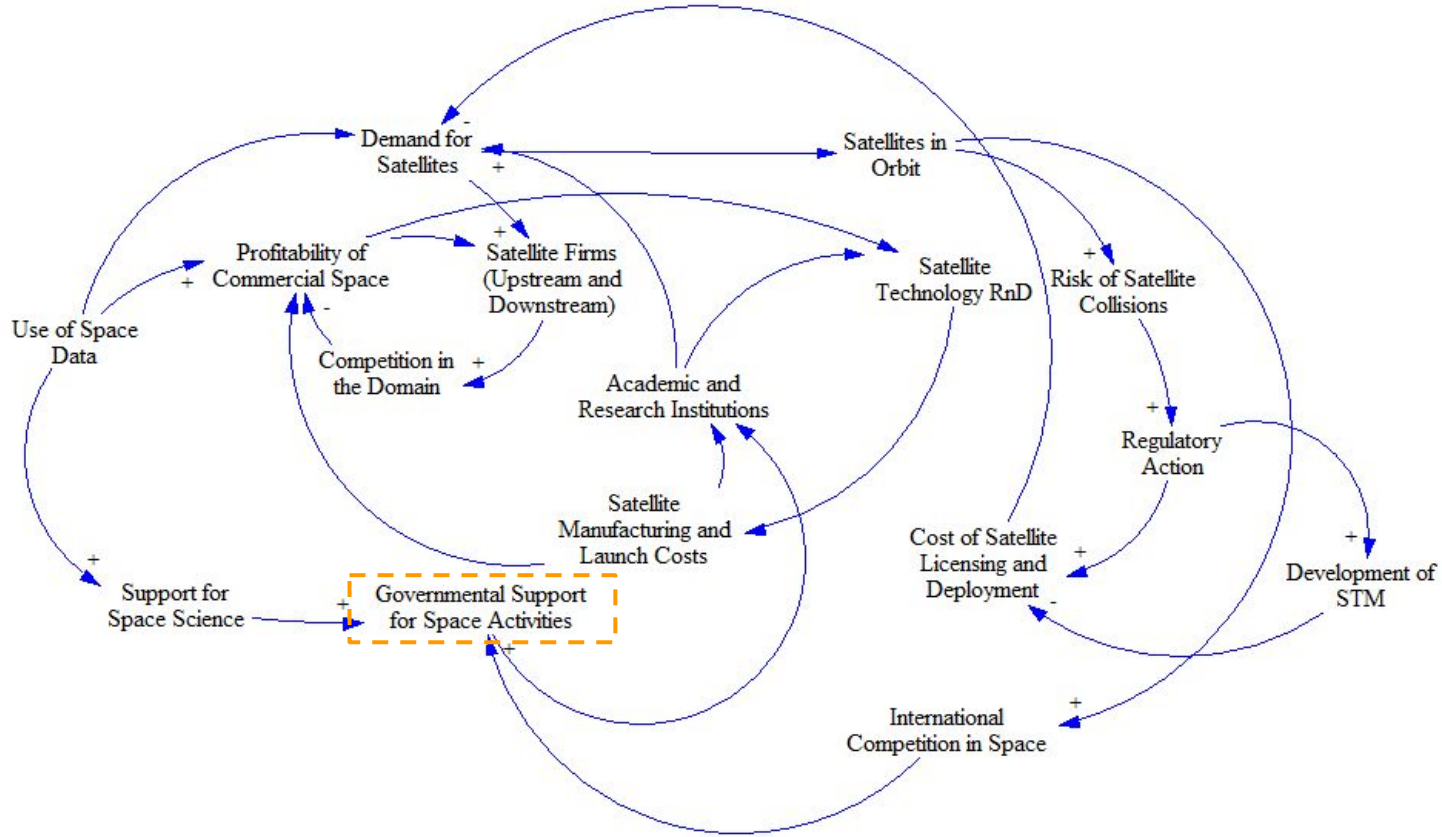
Governmental involvement in innovation models



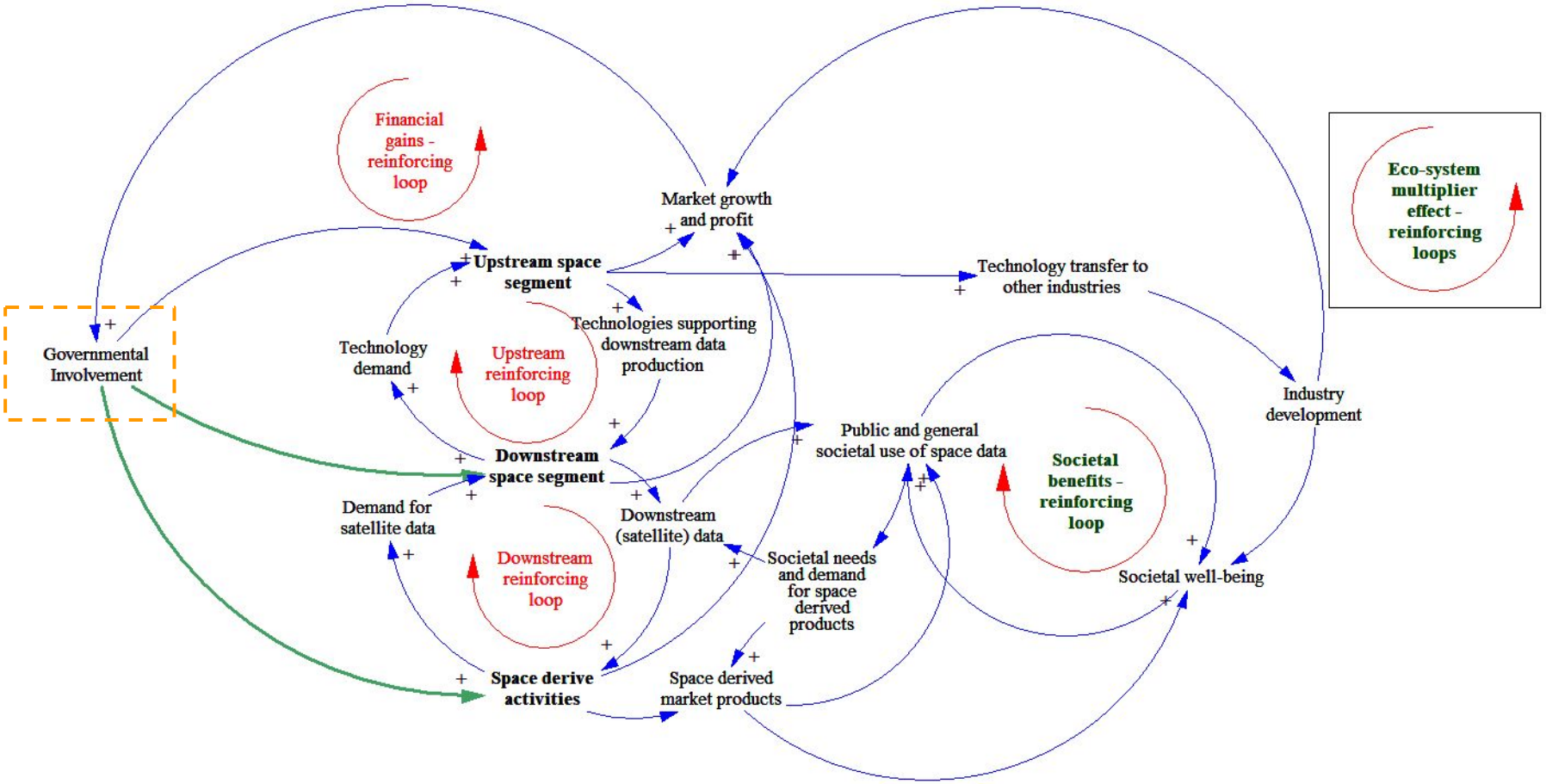


Source: Weil, Utterback - The Dynamics of Innovative Industries [2005]

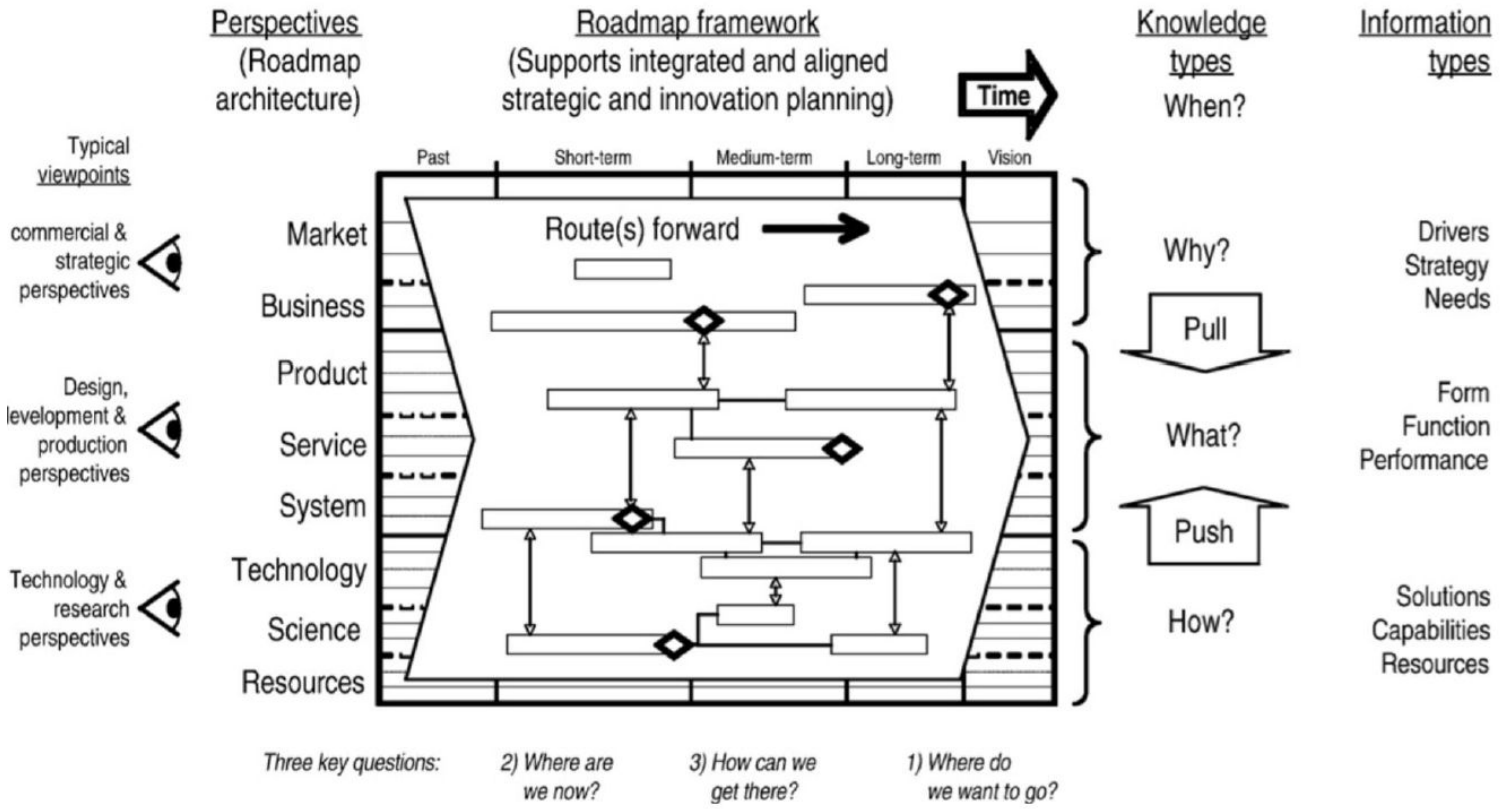
Dynamics of Innovation in the Space Domain



Sector-wide governmental involvement

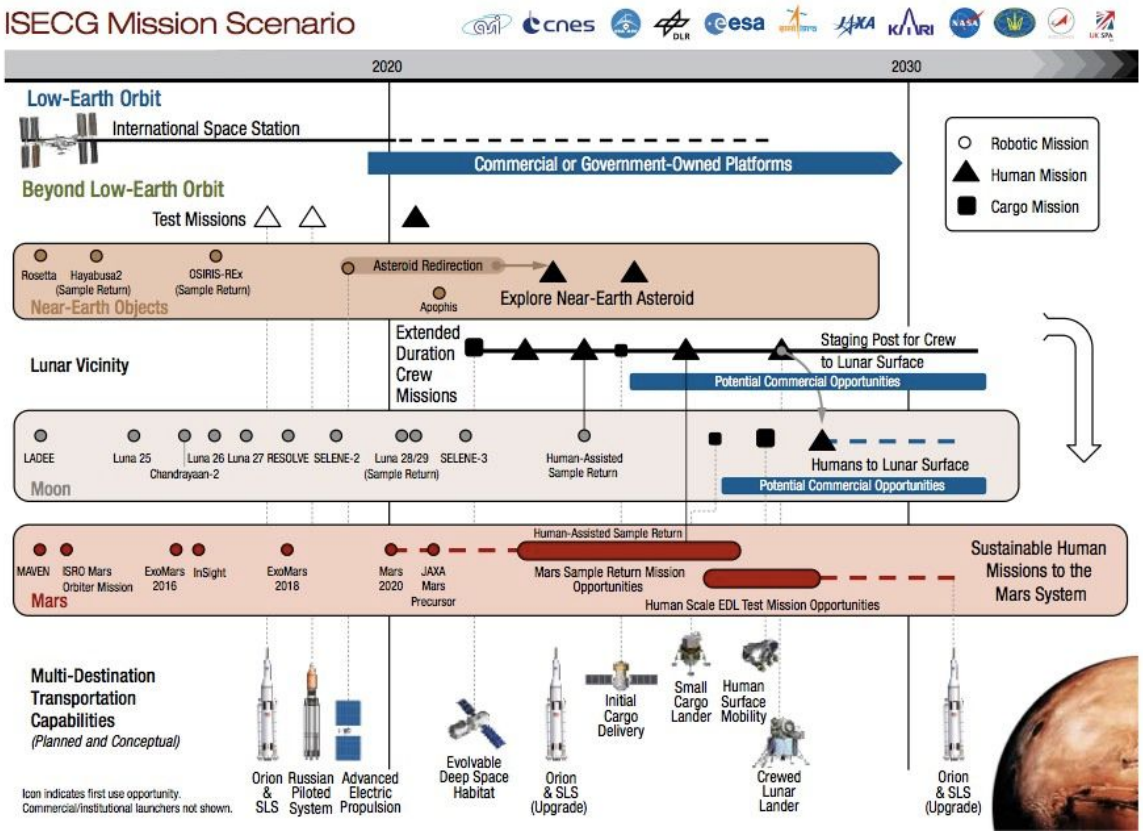


But this was only steady state



Source: Phaal [2009]

Roadmaps in practice…

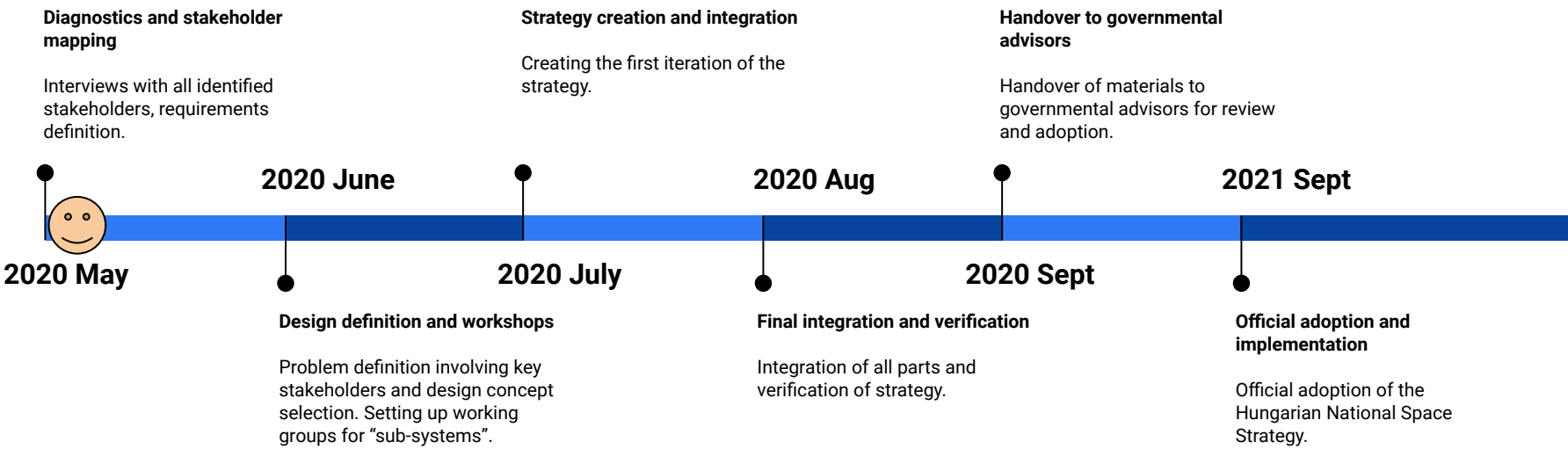


Source: Spacepolitics.com [2013]

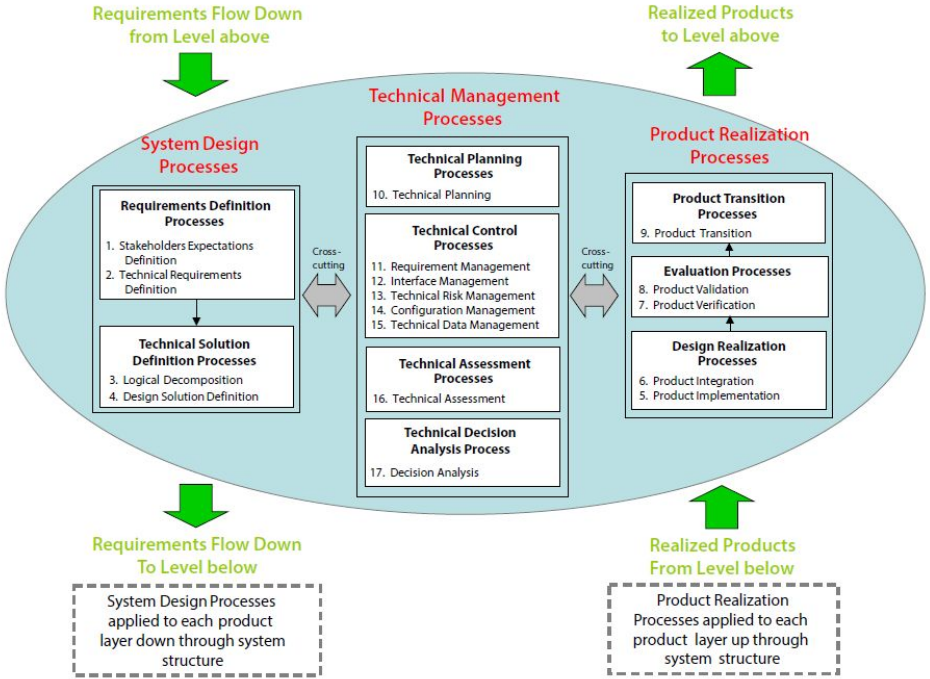
Architecting strategies - Conductors, orchestras, short strategies

Dan Erkel

Timeline of the strategy writing

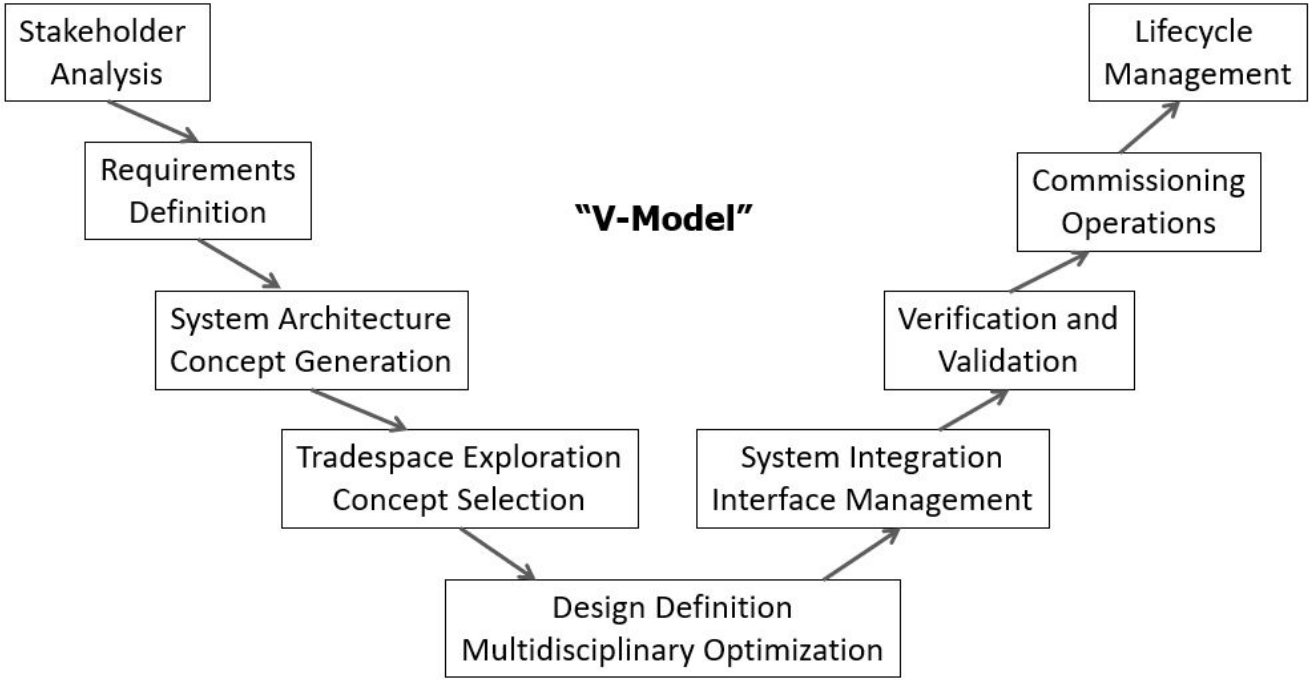


Systems engineering in the space industry



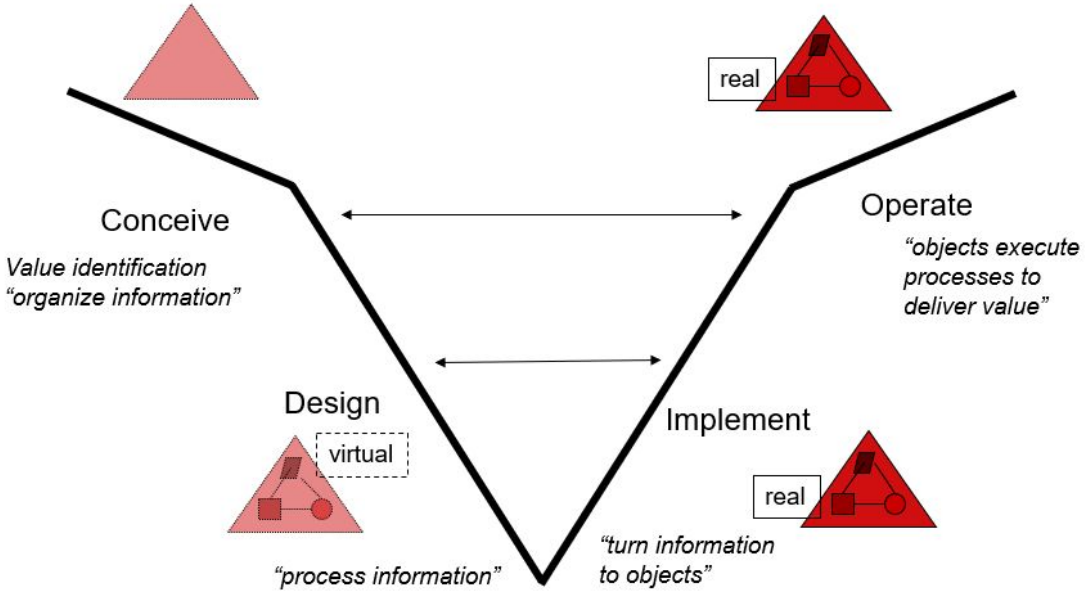
Source: NASA [2015]

Systems Engineering - the ‘V’ Model



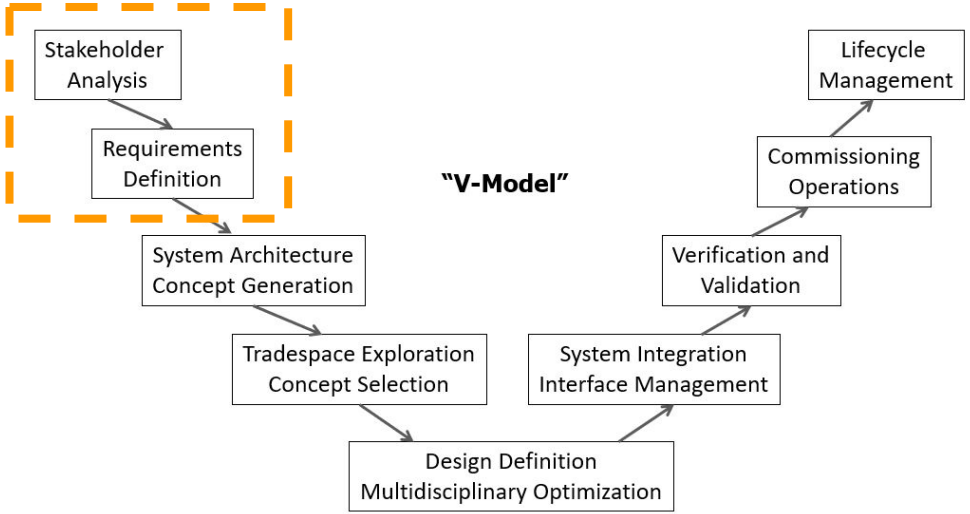
Source: Crawley et al. [2000]

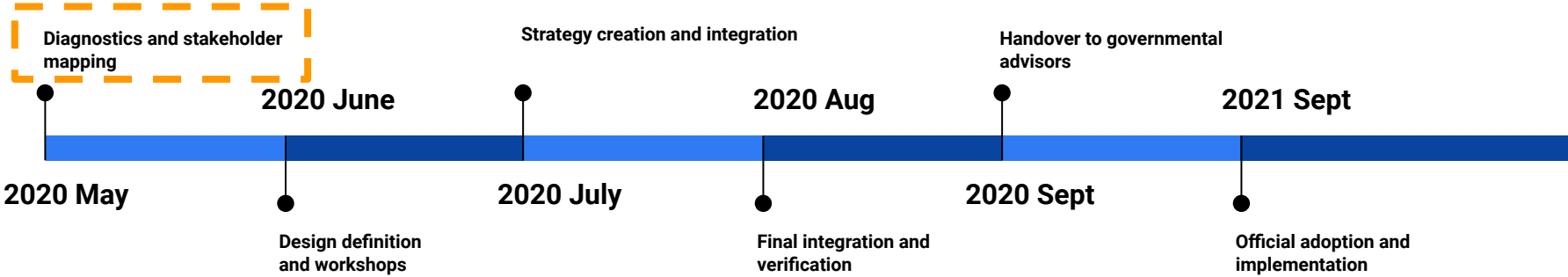
Systems Engineering - the ‘V’ Model



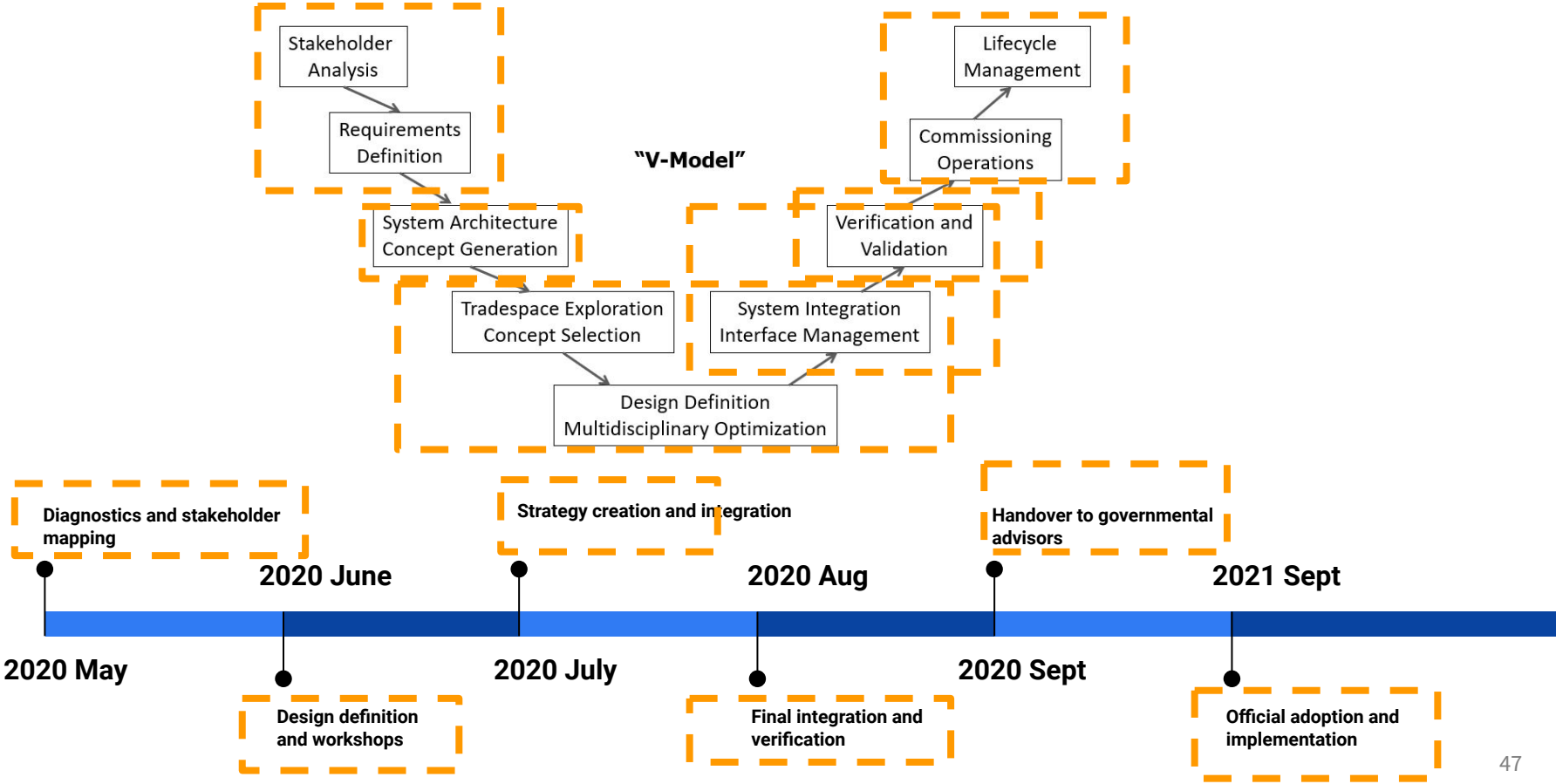
Source: Crawley [2021]

Hungarian National Space Strategy

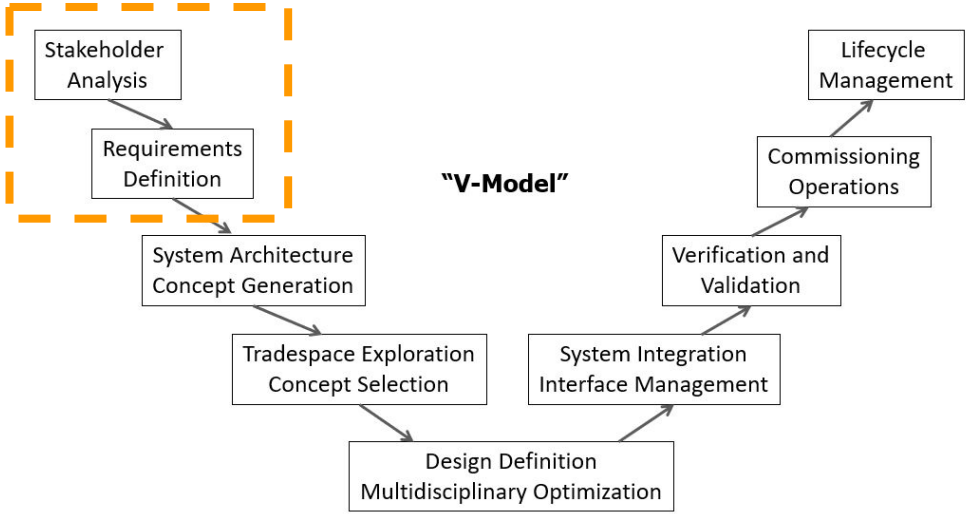


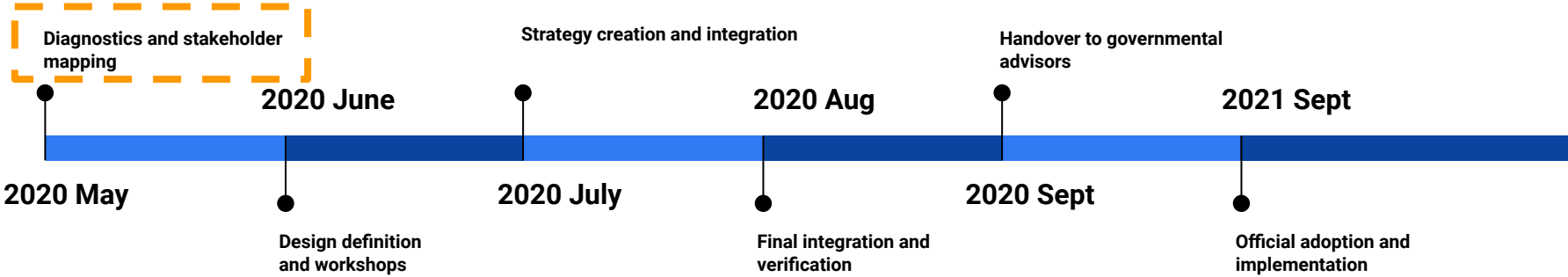


Hungarian National Space Strategy



Hungarian National Space Strategy





Stakeholders

Portugal

AED Cluster Portugal

- A total of 81 members in the Aeronautics, Space and Defense sections
- Addispace project: aims to use additive manufacturing processes to machine metals
- Project E2020: helps Portuguese aerospace companies to grow.
- Their KnowNow4Aero project promotes the space sector.
- In the Indupymes 4.0 project, SMEs are being developed

Staff: 16

Source: www.aedportugal.pt

Poland

Baltic Sea and Space Cluster (BSSC)

- 71 members: 11 SMEs, 12 large companies, 5 research and education institutions
- The composition of the staff and their projects also show that the focus of the cluster is the seas
- Their Galatea project will strengthen Europe's maritime economy
- In their Ecoprodigi program, they develop the eco-efficiency of the maritime industry with digital solutions

Staff: 17

Source: www.bssc.pl

Austria

Austrospace

- They have 16 members, 4 additional partners
- They deal with earth observation, including the analysis of data from an Austrian satellite launched in 2017
- Their main area is satellite navigation, and several of their members have been involved in the development of Galileo satellites
- Emphasis is placed on telecommunications
- They also deal with transport issues: Ariane delivers more members to 5 missiles and researches composite materials
- Space research is also in focus at Austrospace

Staff: 3

Romania

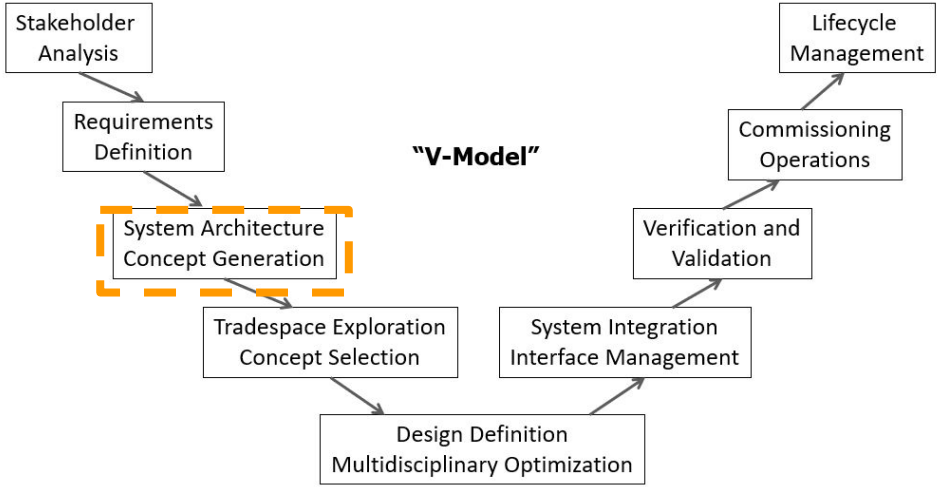
Romanian Cluster for Earth Observation (RO-CEO)

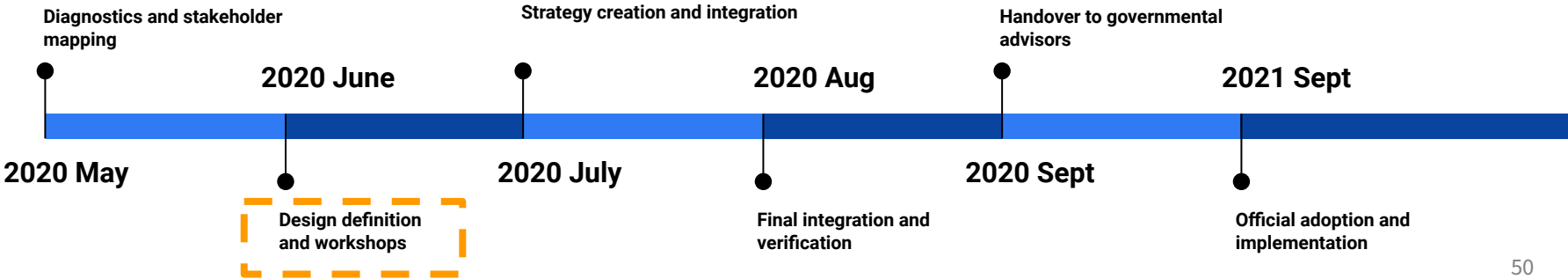
- In Romania, space activities are included in the profiles of several clusters and development agencies, but this is the main activity of the RO-CEO.
- Of the 7 competence centers of the STAR program, 4 are members of the cluster and 8 are additional members
- Their aim is to promote the activities of Romanian companies and to obtain several contracts (eg ESA) for them
- The sustainability of the Earth observation sector is also emphasized
- Improving the user experience of those involved in Earth observation services is also important for the RO-CEO

Staff: n.d.

Source: Hungarian National Space Strategy [2021]

Stakeholders



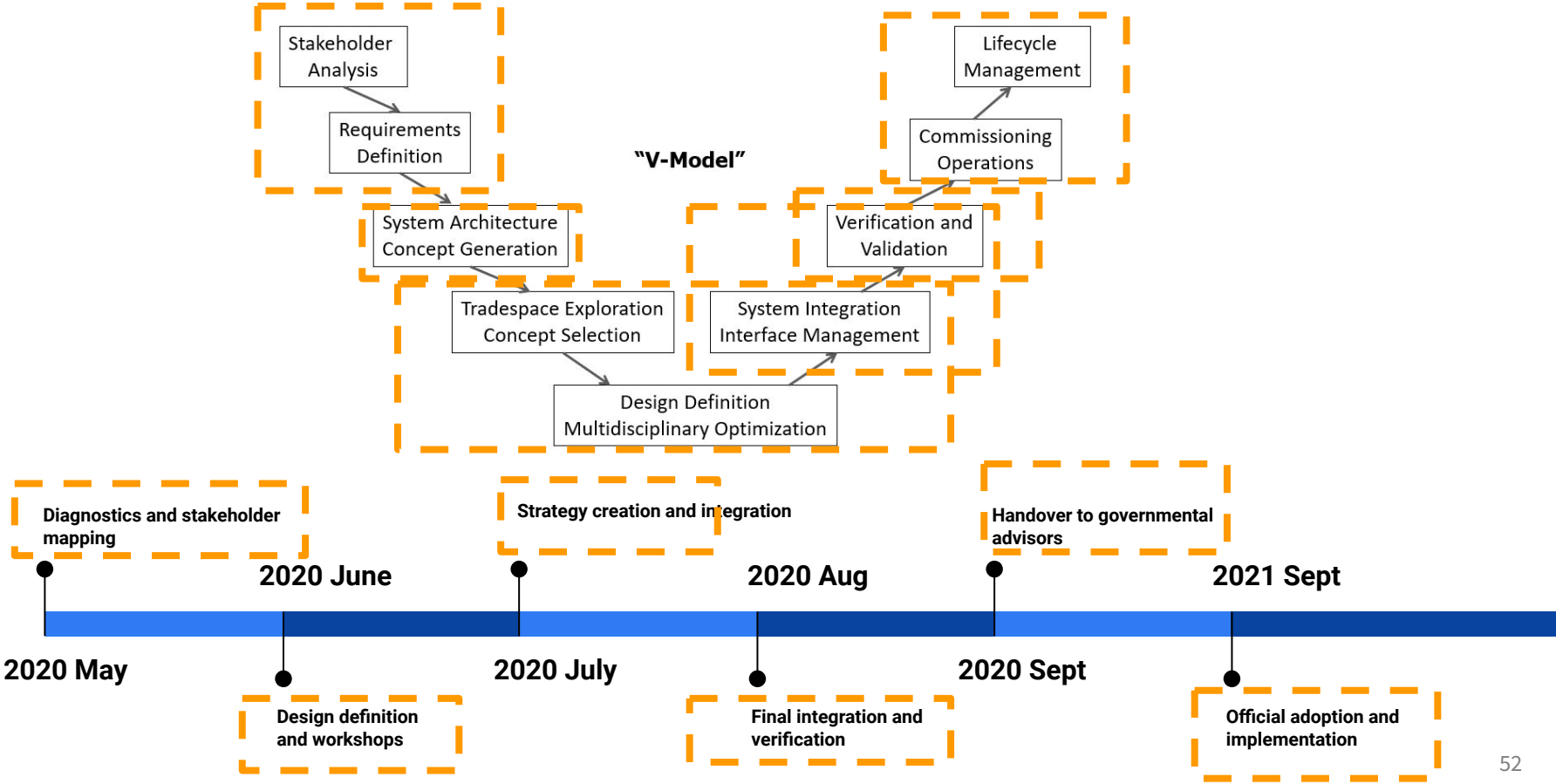


Trade studies

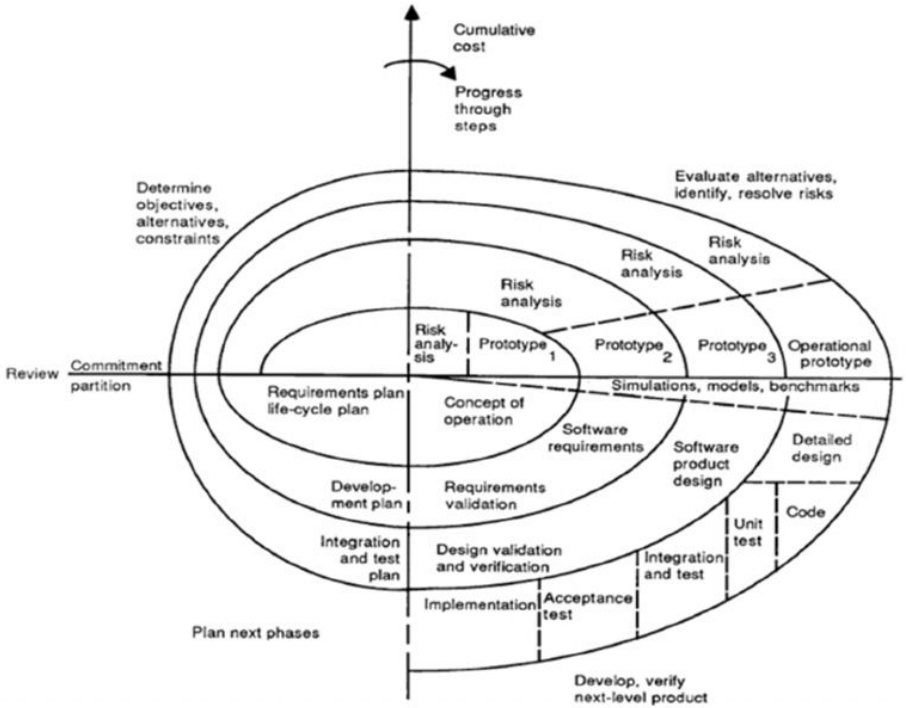
Comparison of the most common models			
	Space office	EgReconciliation commity (Czech)	Space agency
Extent, coverage			
Costs			
Process turnaround time			
Efficiency, organizational capacity			
Political stability			

Source: Hungarian National Space Strategy [2021]

Stakeholders

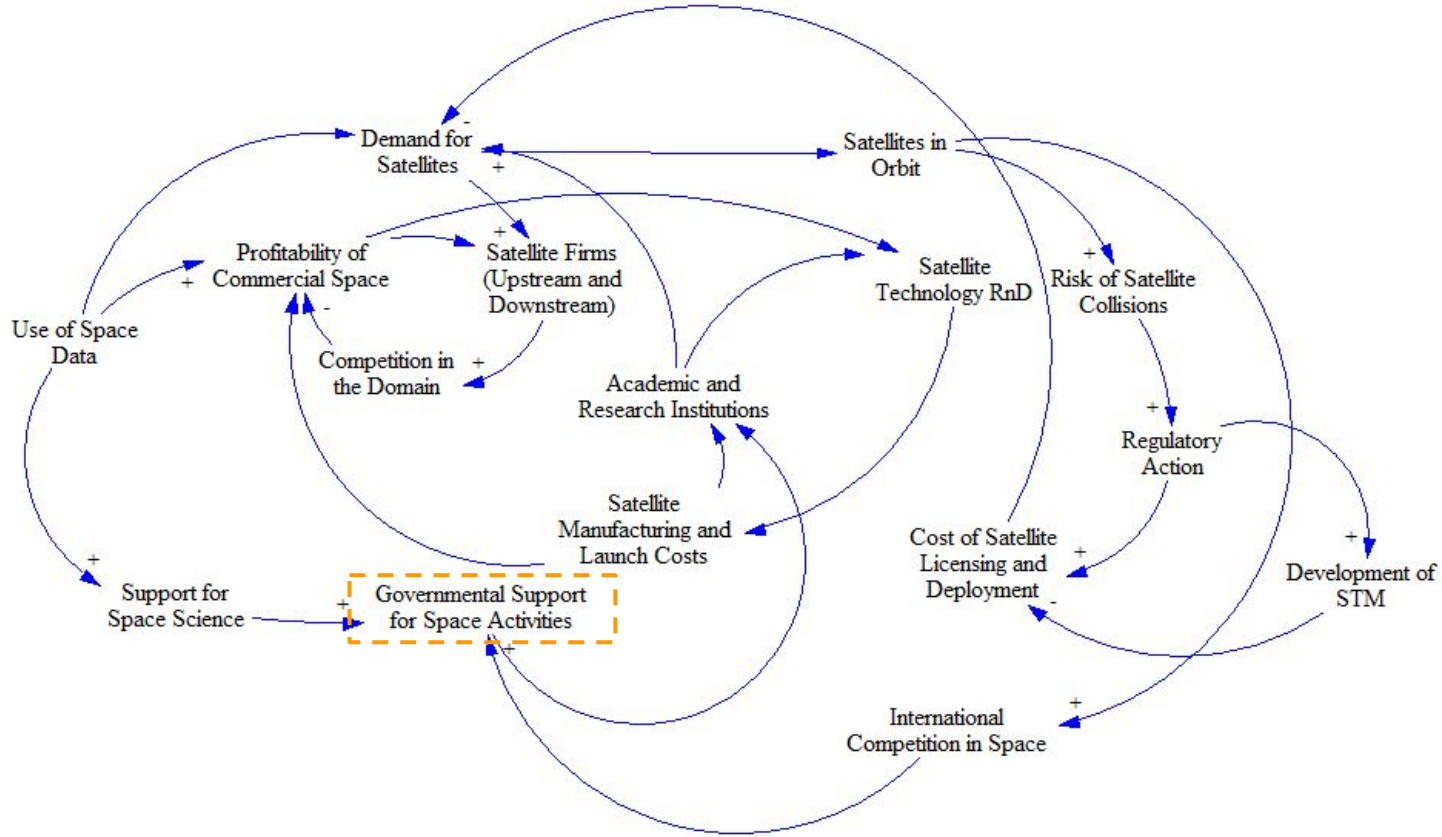


The reality - a “fake agile” process



Source: Crawley et al. [2000]

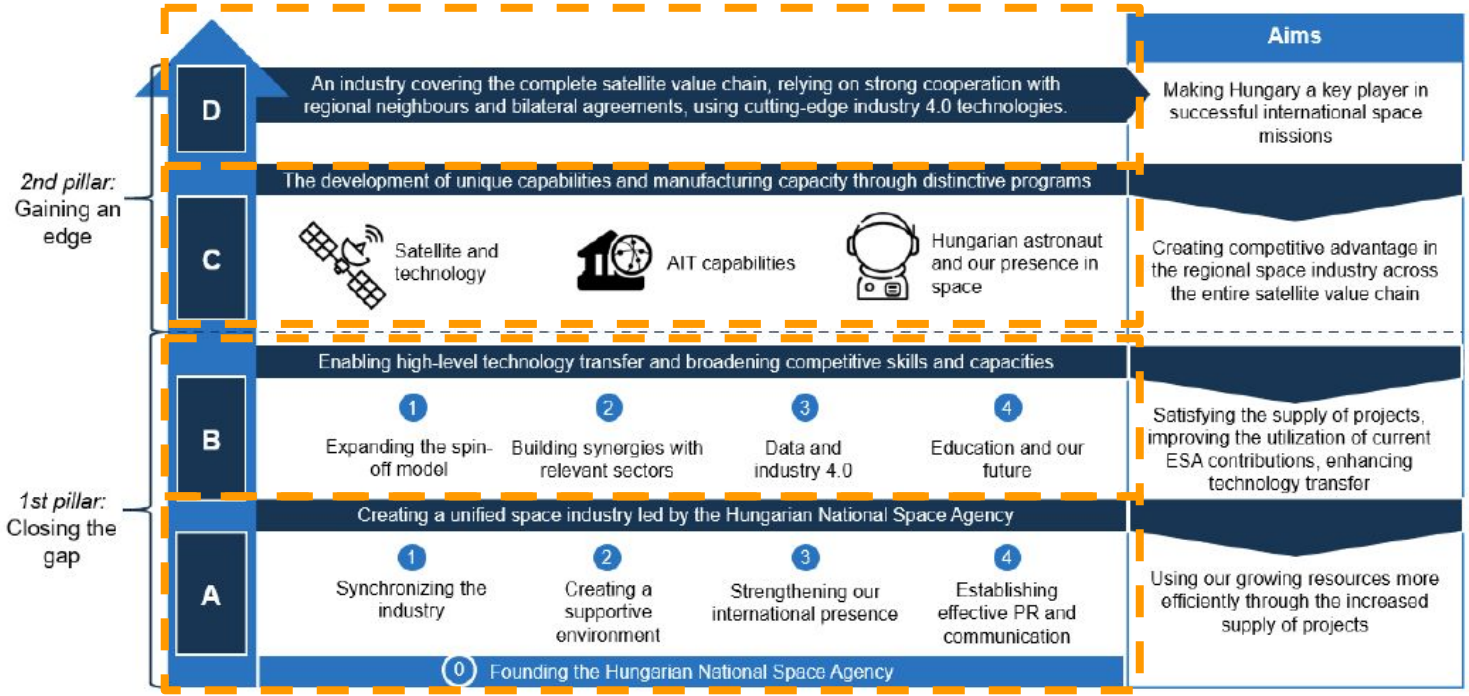
A reminder of the dynamics…



…and the motivations

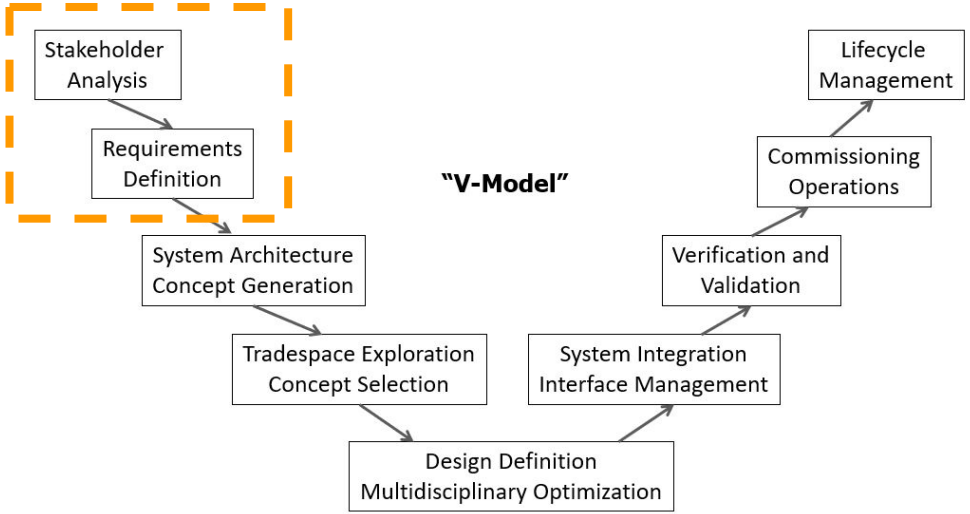
- Surviving… lessons of the Bogota convention and common pool resources
- **Seizing the opportunities - the 5th industrial revolution! (paradigm shift)**
- Range of reasons in the context of power
  - **Military power**
    - **National security**
    - **Cooperation**
    - **Sovereignity**
  - **Economic power**
    - **Clear socio-economic benefits**
    - **Long-term sustainability and development (brain drain)**
  - **Soft power**
    - **Prestige - external and internal**
- What's good for "the Rest" is good for the West - external effects

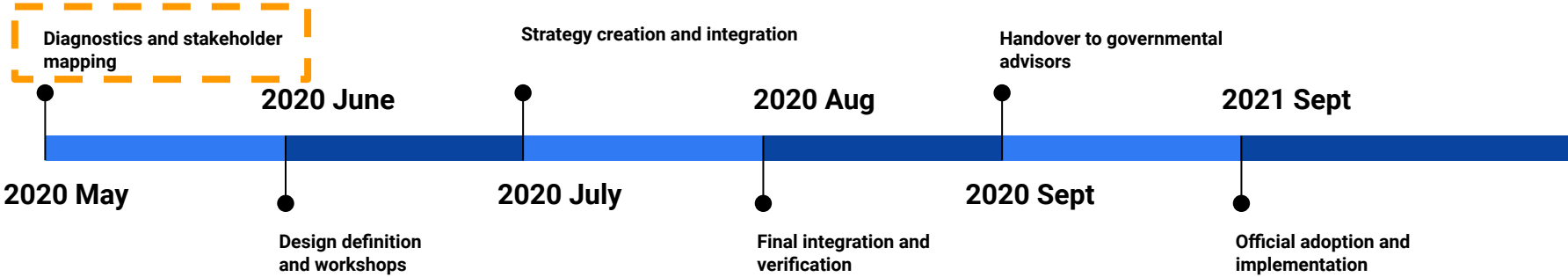
The Hungarian National Space Strategy



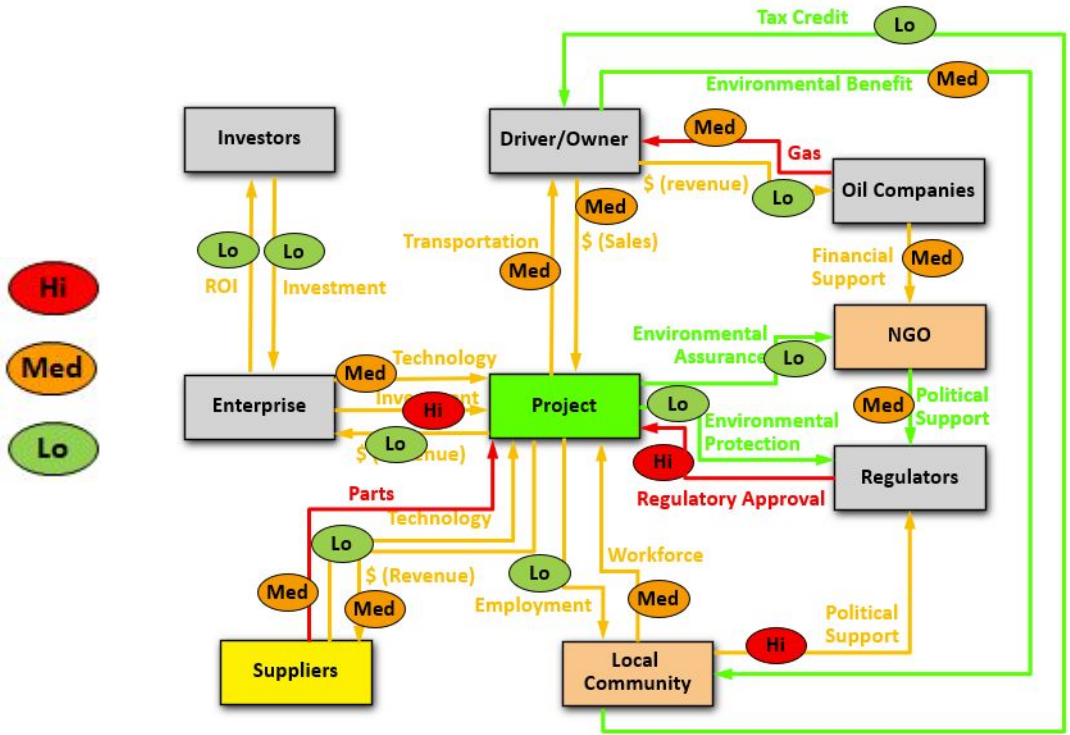
Source: Hungarian National Space Strategy [2021]

Lessons learnt - stakeholder analysis



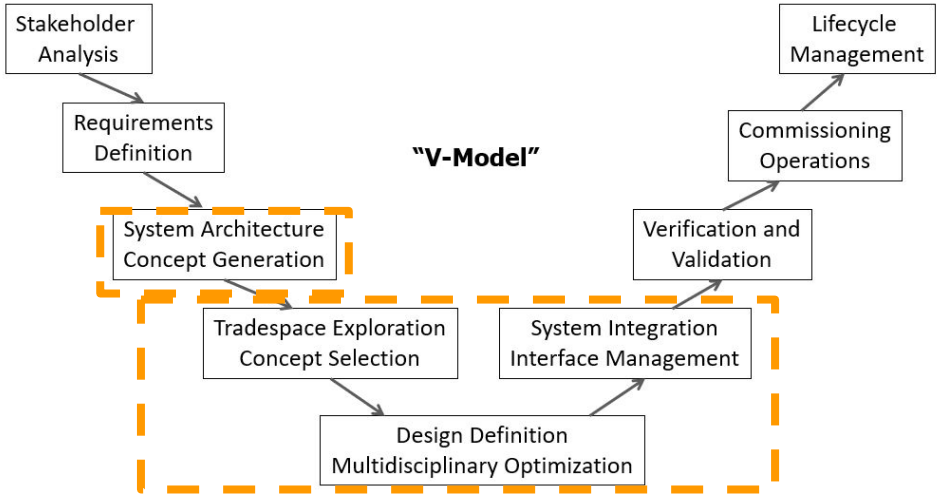


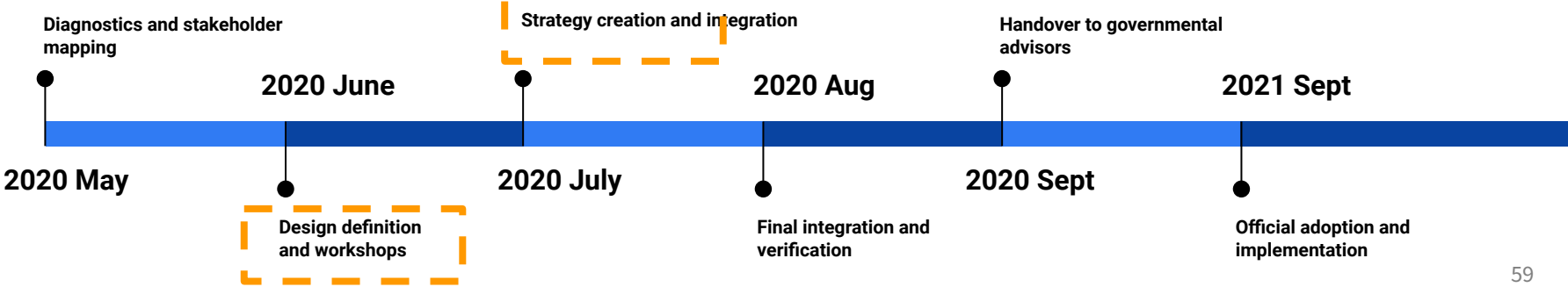
Stakeholder Mapping - a smarter way



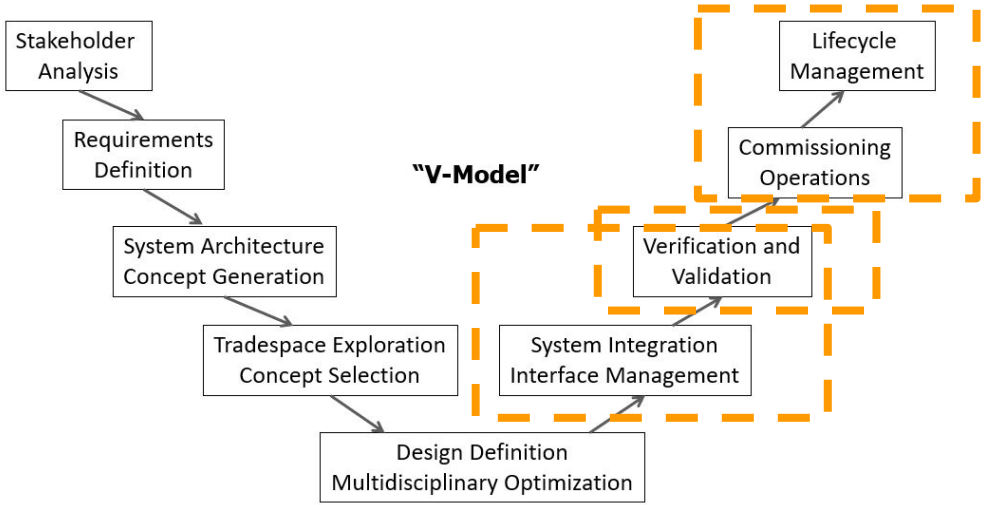
Source: Crawley et al. [2000]

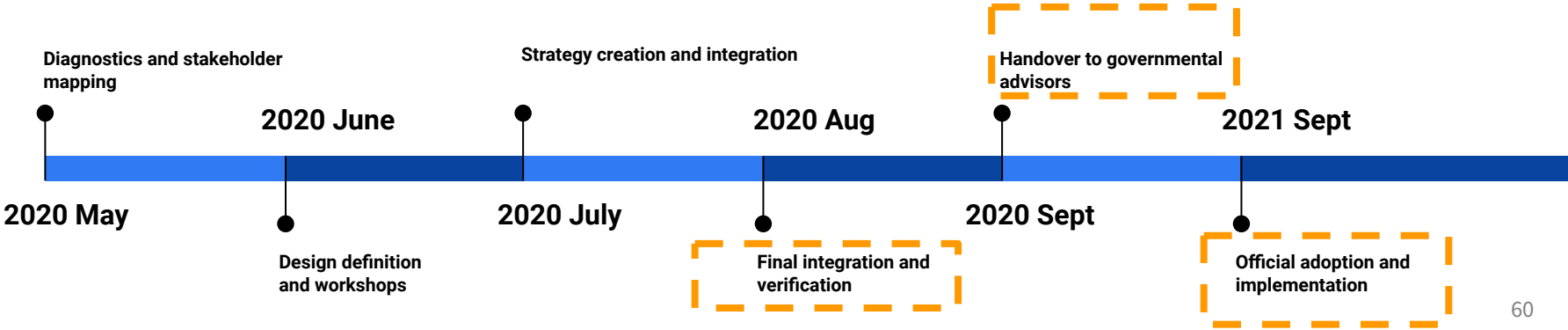
Lessons learnt - solutions and architectures



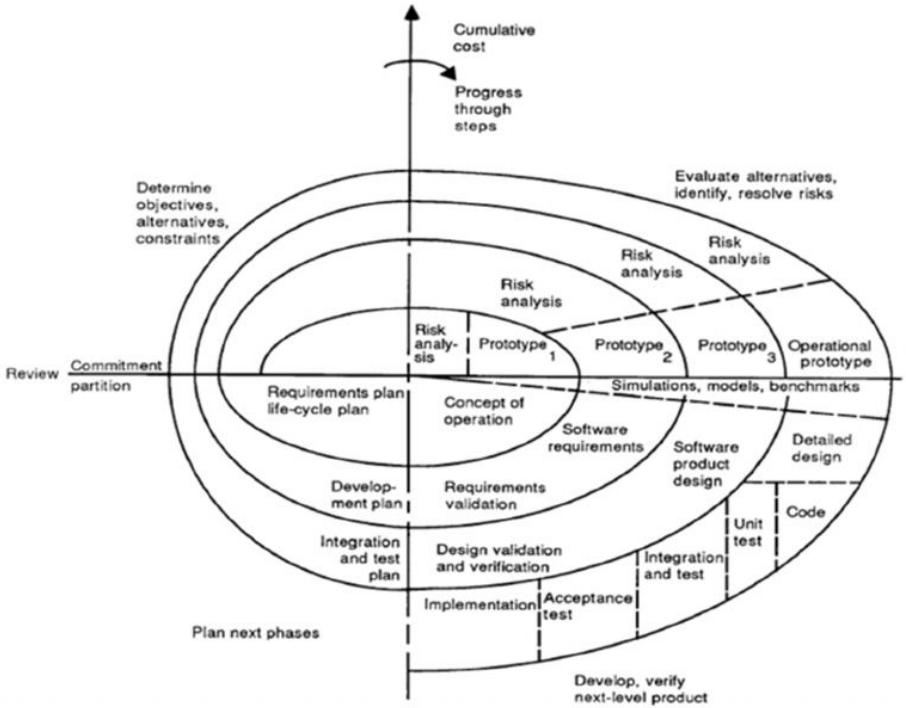


Hungarian National Space Strategy



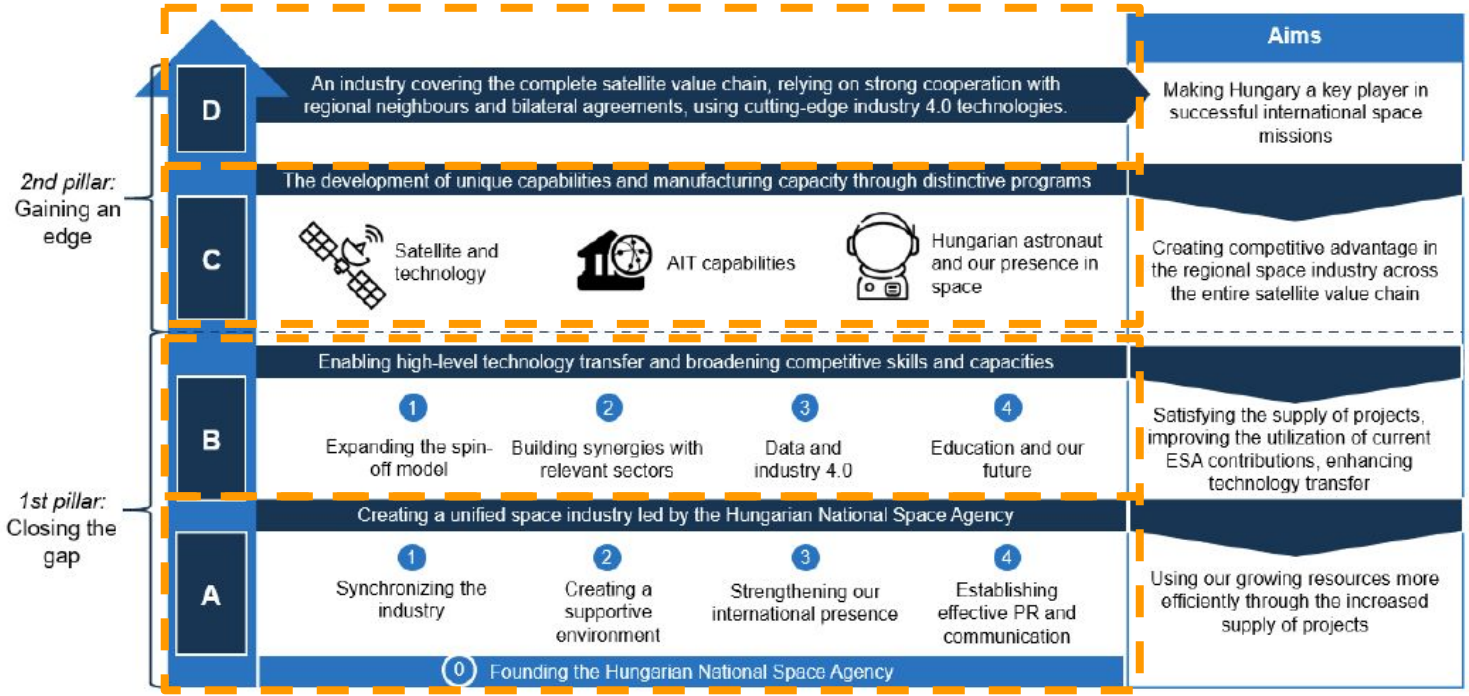


It probably shouldn't be an agile process…



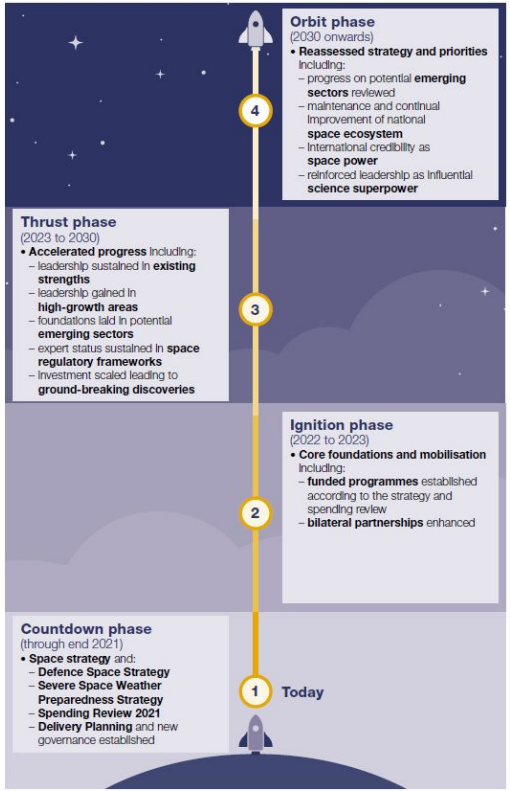
Source: Crawley et al. [2000]

Unique outcomes and continuing development



Source: Hungarian National Space Strategy [2021]

How did we do? A peek at the UK strategy



Source: British National Space Strategy [2021]

Concluding Remarks

Dan Erkel

Not a blueprint… but a useful approach

- **Are conclusions here universal?**
  - Generally no, that’s the point!
- **Is the systems approach useful?**
  - A holistic thinking is a must…
- **Key takeaways**
  - Understand your stakeholders and their real influence
  - Leapfrogging should be leapfrogging
  - Major projects are critical to bolster support

Major projects on the way…