Lo stato del system thinking in INAF

Una visione personale della qualità della applicazione del system engineering nei progetti di astrofisica in INAF (e non solo)

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Summary

- Part 1 – Personal opinion of why we should follow this talk. (Luca Stringhetti)
- Part 2- Lean Principles for Astrophysical Projects: Evidence from a Survey (Valeria Belvedere)

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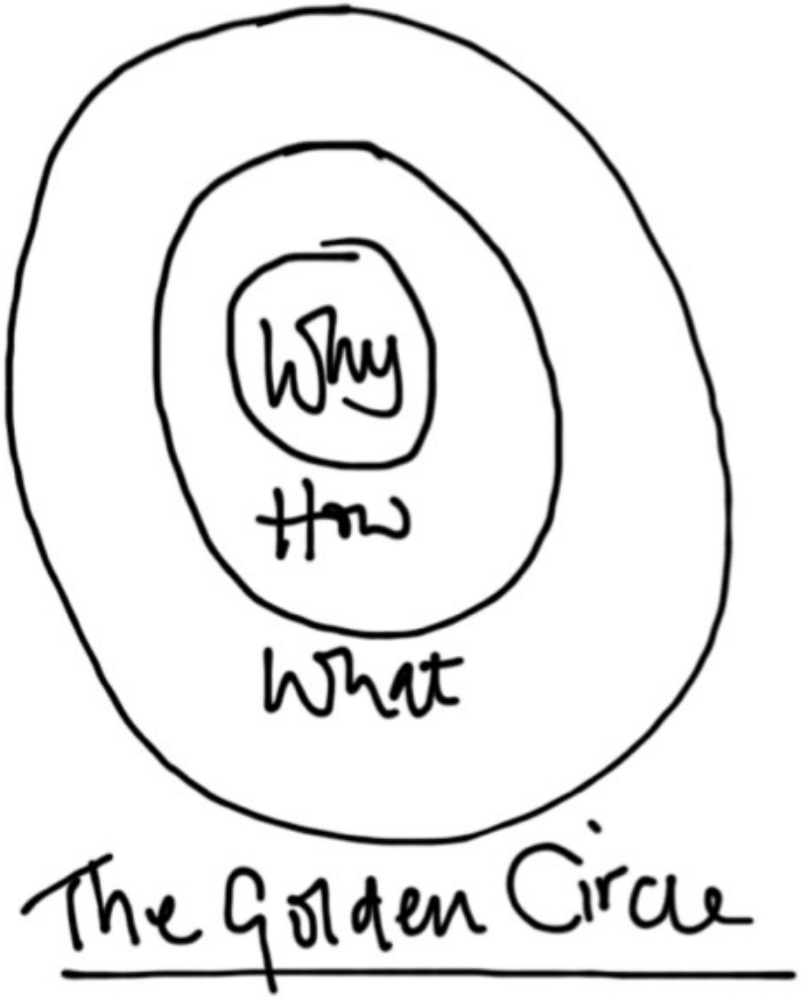
Part 1: The Golden Circle



Simon Sinek “Start with why”

WHY: Experiments are changing.

THE

AMERICAN JOURNAL OF SCIENCE.

[THIRD SERIES.]

ART. XXXVI.—*On the Relative Motion of the Earth and the Luminiferous Ether;* by ALBERT A. MICHELSON and EDWARD W. MORLEY.*

THE discovery of the aberration of light was soon followed by an explanation according to the emission theory. The effect was attributed to a simple composition of the velocity of light with the velocity of the earth in its orbit. The difficulties in this apparently sufficient explanation were overlooked until after an explanation on the undulatory theory of light was proposed. This new explanation was at first almost as simple as the former. But it failed to account for the fact proved by experiment that the aberration was unchanged when observations were made with a telescope filled with water. For if the tangent of the angle of aberration is the ratio of the velocity of the earth to the velocity of light, then, since the latter velocity in water is three-fourths its velocity in a vacuum, the aberration observed with a water telescope should be four-thirds of its true value.†

* This research was carried out with the aid of the Bache Fund.

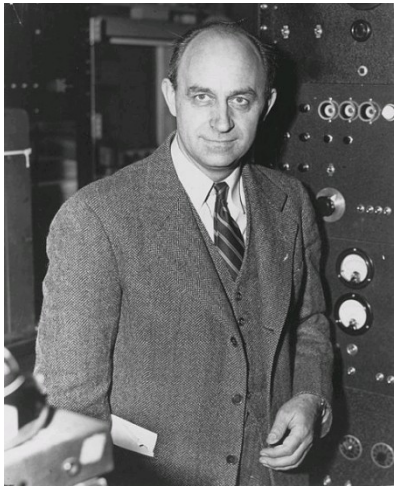
† It may be noticed that most writers admit the sufficiency of the explanation according to the emission theory of light; while in fact the difficulty is even greater than according to the undulatory theory. For on the emission theory the velocity of light must be greater in the water telescope, and therefore the angle of aberration should be less; hence, in order to reduce it to its true value, we must make the absurd hypothesis that the motion of the water in the telescope carries the ray of light in the opposite direction!

AM. JOUR. SCI.—THIRD SERIES, VOL. XXXIV, No. 203.—NOV., 1887.
22

1887 – Esperimento di Michelson Morsley

- Two people working together for four days
- Few thousands euro to set up the experiments
- In 1907 they get the Nobel

WHY: Experiments are changing.



1942 E. Fermi and the Atomic Pile-2

- About 30 people for two years project
- US president gave 20k$ budget (70Keuro nowadays)
- This is not fair!...Fermi already got the Nobel in 1938
- He invented

- ***The Big Science***

WHY: World is changing….

1950ish – Simon Ramo

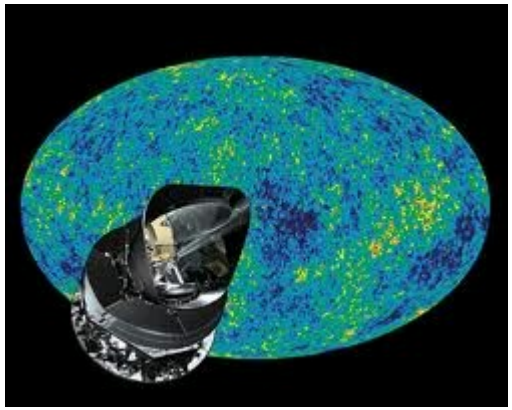
- He is the founder of the Wooldridge-Ramo that will be the TRW form 1958
- He is the father of the ICBM project(Inter Continental Ballistic Missile)
- He is acting as the major the supplier of the Gemini project vector

- ……and he started to call his way of managing technical projects “Systems Engineering”

WHY: Experiments are changing……back to INAF World

2009 - Planck

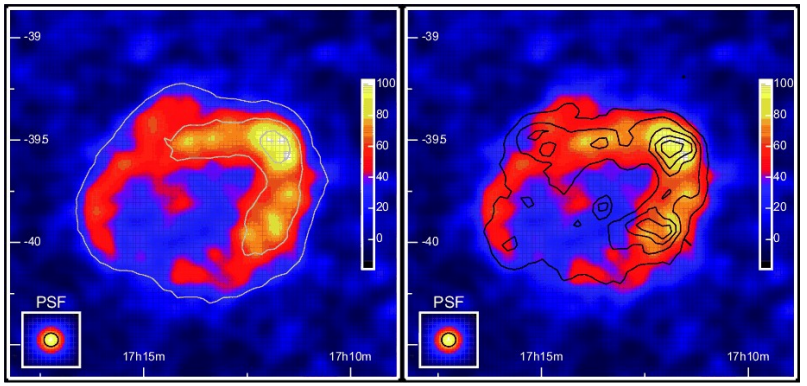
- More than 400 scientists working
- More than 300Meuro (ESA Cost)
- More than 18 years project….and still going!
- About 15 different nationalities.

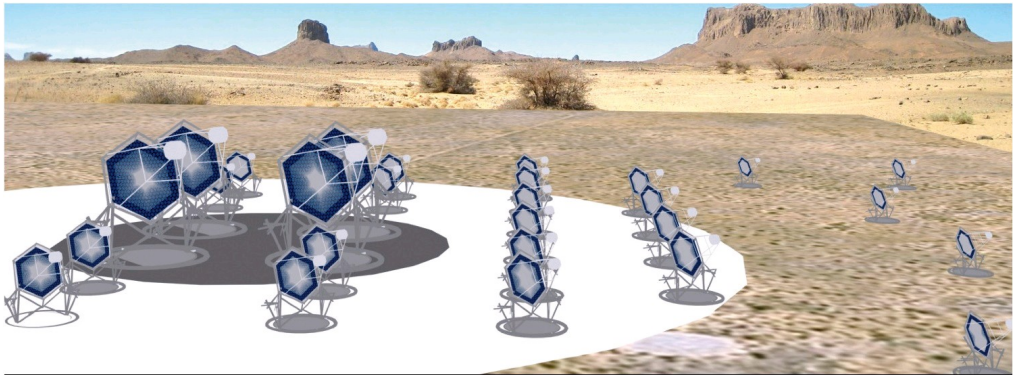


WHY: Experiments are changing.

2018 –CTA (http://www.cta-observatory.org/)

- 200M Euro to build the instrument
- 15M Euro Estimated for yearly operation
- 150 telescopes in two sites
- 800 scientists in 25 countries
- Construction phase 2017 - 2020
- 30 year of missions
- Still in the preparatory phase….





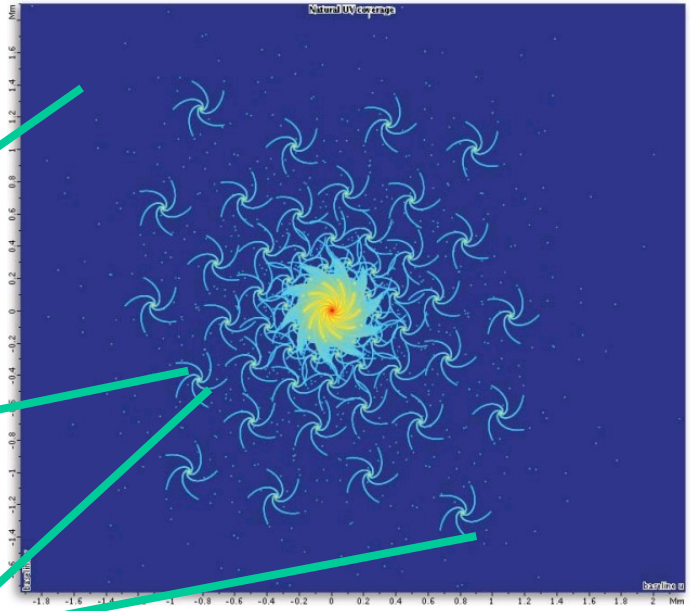
Galactic Gamma-Ray Sources
- Supernova Remnants
- Pulsar Wind Nebulae
- Pulsar Physics
- Star-Formation Regions
- The Galactic Centre
- X-Ray Binaries & Microquasars

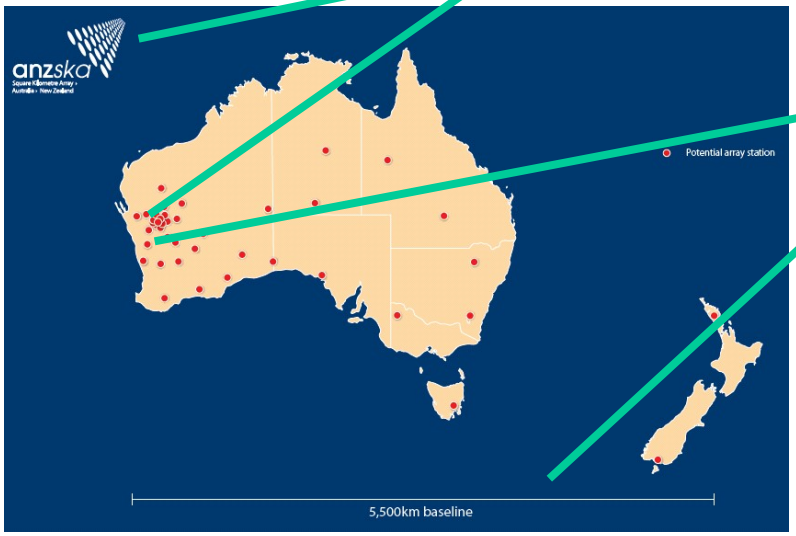
Extragalactic Gamma-Ray Sources
- Active Galactic Nuclei
- Extragalactic Background Light
- Gamma-Ray Bursts
- Galaxy Clusters

WHY: Experiments are changing.

2024 –SKA (http://www.skatelescope.org//)

- 1e6 Square meters antenna
- Circa 67 different organizations in 20 countries
- pre-costruzione phase 2013 – 2015
- Deployment completed in 2024
- ETC 1500 Meuro
- Estimate cost for operation 150Meuro anno
- **10 GB/SECOND**





- The milky way and local galaxies
- SETI, Stellar end products, Transient sources
- Cosmology and large scale structure
- Galaxy evolution
- Active galactic nuclei and super massive black holes
- The life cycle of stars
- The solar system and planetary science
- The intergalactic medium
- Magnetism

HOW: How can we keep going in this never ending rush?

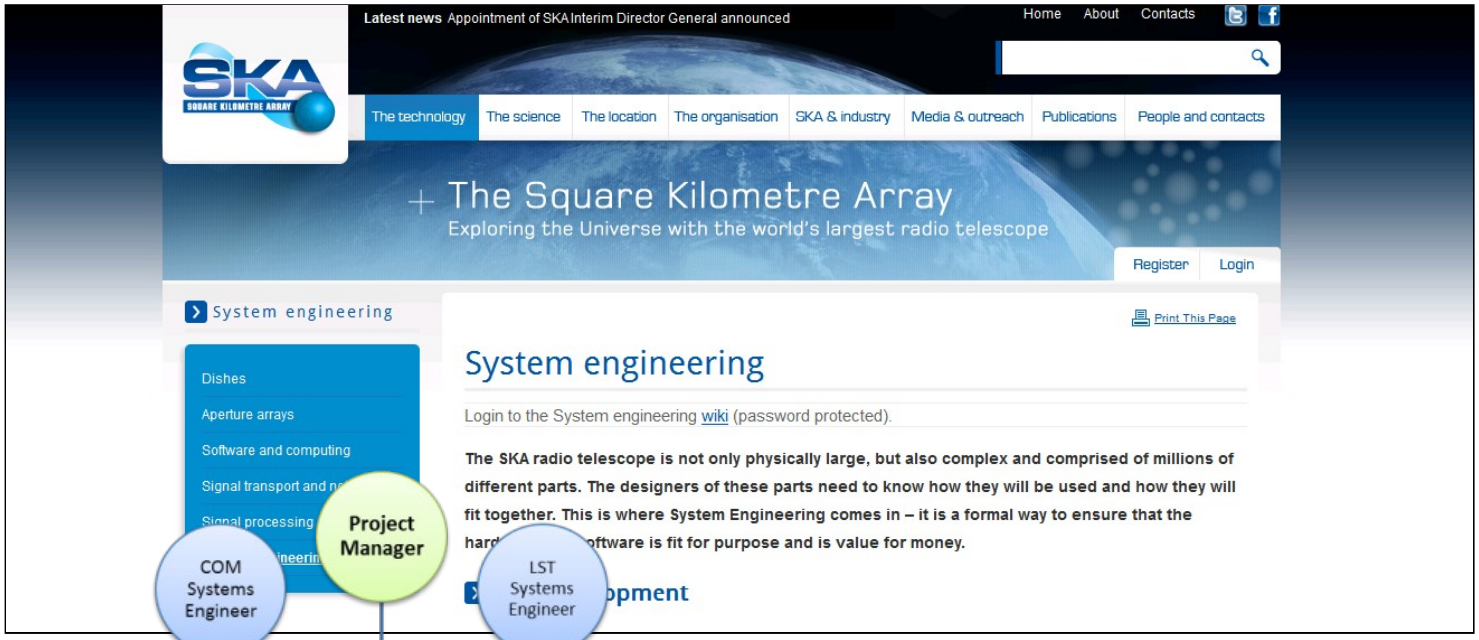
Modern astrophysics needs extreme technical challenges to keep exploring its scientific objectives

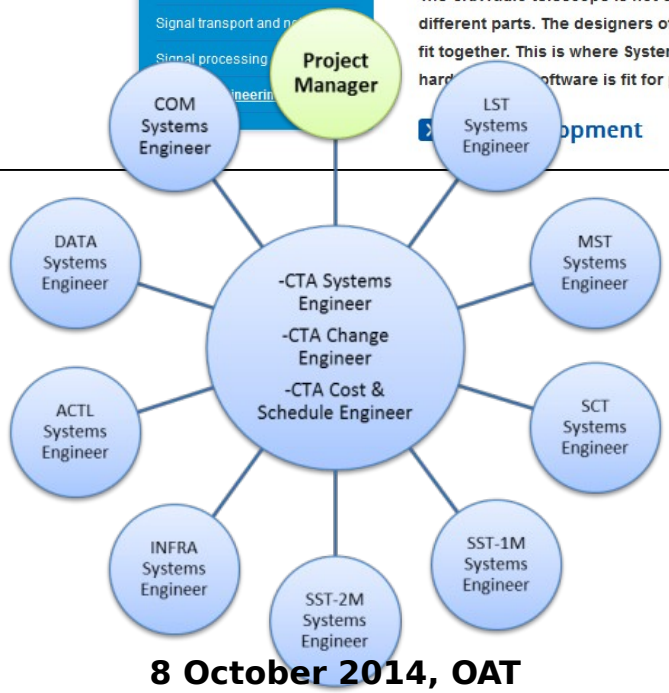
Modern astrophysics needs big scientific communities to have enough budget to sustain such challenges

Modern astrophysics needs common dictionary in order to bypass language/cultural differences

Modern astrophysics' challenge needs good organization to move in a time span of many years

WHAT: System approach is needed: two examples…..





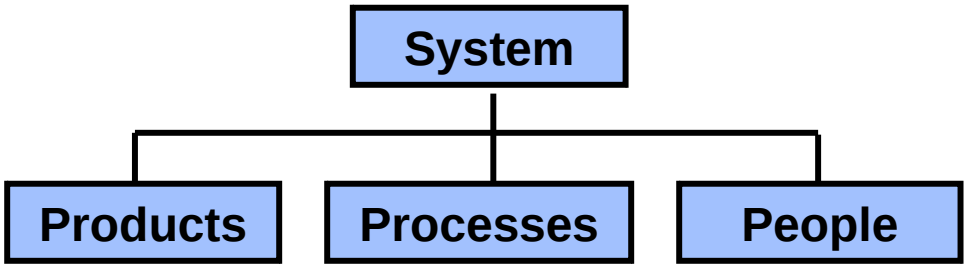
- For the two of the most important projects on astrophisics on ground more and more importance to System Engineering is given.
- System Engineering is considered a must for project success.

WHAT: What is this System Engineering you are talking about?

Modern experiments look more like complex projects

DEF: Progetto

Archibald (1992:31-32) A Project is "… a complex, unique effort that cuts across organizational lines, has a definite start and finish point, and has specific schedule, cost, and technical objectives. …."



DEF: System

A combination of interacting elements organized to achieve one or more stated purposes

An integrated set of elements, subsystems, or assemblies that accomplish a defined objective. These elements include products (hardware, software, firmware), processes, people, information, techniques, facilities, services, and other support elements. (**INCOSE**)

WHAT: What is this System Engineering you are talking about?

DEF: System Engineering

Systems engineering is a discipline that concentrates on the design and application of the whole (system) as distinct from the parts. It involves looking at a problem in its entirety, taking into account all the facets and all the variables and relating the social to the technical aspect. (**Ramo**)

Systems engineering is an interdisciplinary approach and means to enable the realization of successful systems. It focuses on defining customer needs and required functionality early in the development cycle, documenting requirements, and then proceeding with design synthesis and system validation while considering the complete problem: operations, cost and schedule, performance, training and support, test, manufacturing, and disposal. SE considers both the business and the technical needs of all customers with the goal of providing a quality product that meets the user needs. (**INCOSE**)

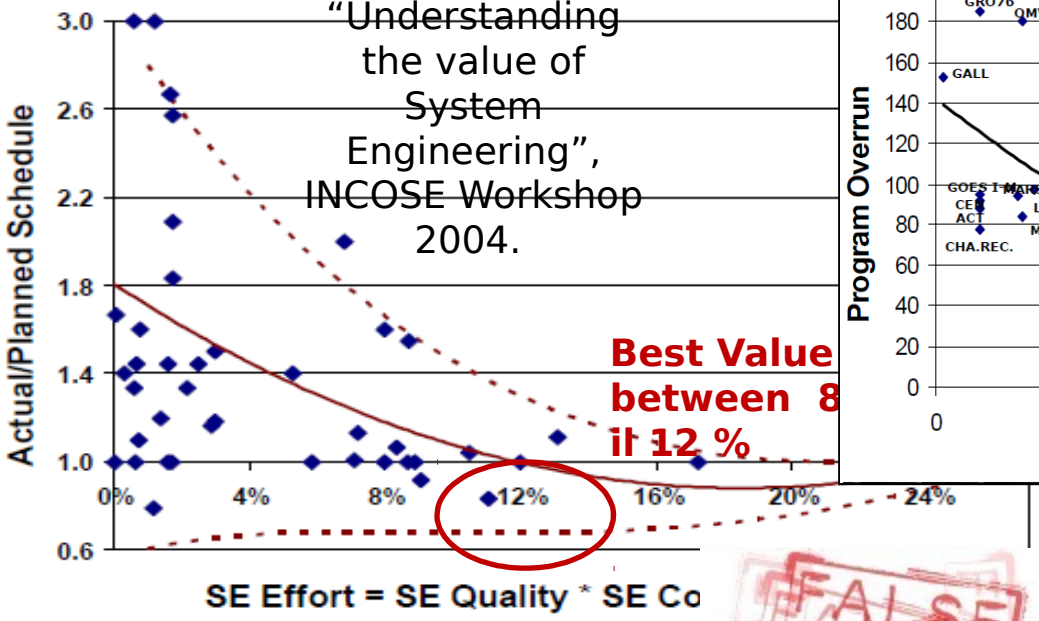
Wait a minute…….

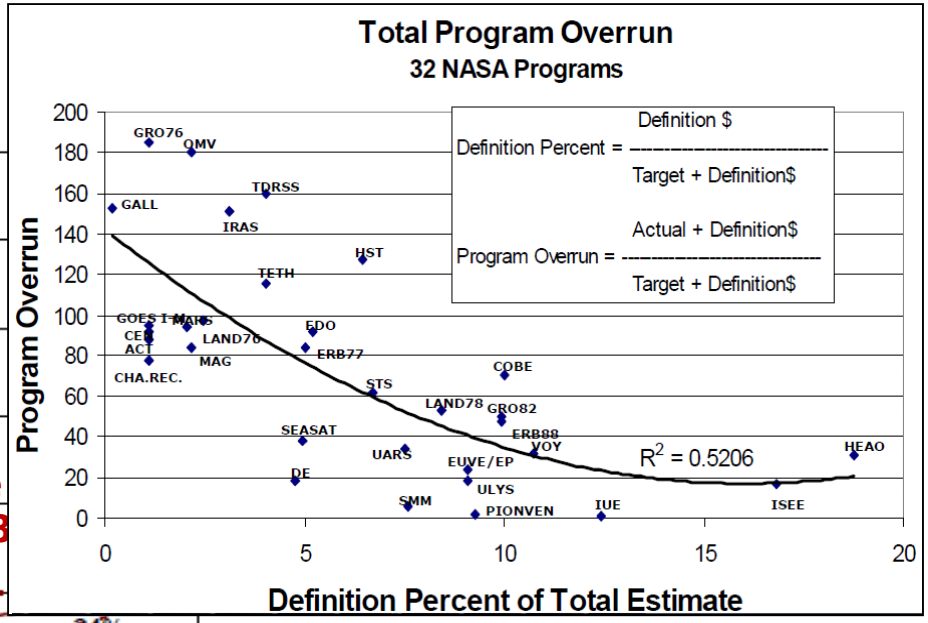
We already do this!…..so what is the point?

Wait a minute…..what is the point?

INAF is normally managing on daily basis (sophisticated, big, challenging….) projects and can therefore generate knowledge on project management processes, with the aim to improve its own efficiency.

Honour E. "Understanding the value of System Engineering", INCOSE Workshop 2004.





The answer seems that we sl application of systems engineering.

Start with the why : Elevator speech

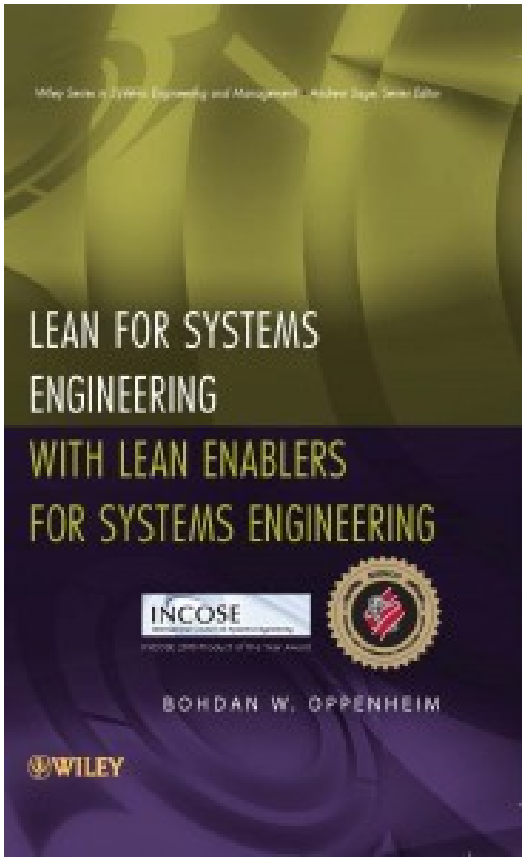
Our mission is to provide the bests answers to the big questions of the modern astrophysics. Our scope is having the role of the one that makes things happen and takes decisions. Our objective is to do that within the time and the resources we have.

Now, to do this we are forced to set up projects that are huge, global, and unprecedentely complex (normally the tecnology requested is not available...yet). Therefore modern projects last years and involve hundreds, and sometimes thousands scientists with different culture working together.

More and more interdisciplinary approach is needed and common dictionary is mandatory to let such different disciplines talk. System thinking is by defininition that approach.

A help from recent litterature

There is no need to do MORE SE, but to perform BETTER SE.
(Oppenheim, 2011)



Bohdan Oppenheim's book *Lean for Systems Engineering with Lean Enablers for Systems Engi* contains detailed explanations for each of the 147 enablers, with examples, promoted value, prevented waste, implementation suggestions, lagging factors, and reading lists.

Walkthrough

- Tailor the application to INAF world
- Take a picture of the actual status of the application (knowledge) of these processes/concepts
- Analyze the picture

Summary

- Part 1 – Personal opinion of why we should follow this talk. (Luca Stringhetti)

- Part 2- Lean Principles for Astrophysical Projects: Evidence from a Survey (Valeria Belvedere)

Some basic definition: What is Lean Management?

- Lean Management is a philosophy that aims at eliminating all types of wastes, e.g.:
  - Excessive lead times and subsequent delays
  - Reworking defective products/activities
  - Workers or parts travelling excessive distances
  - Idle facilities
  - Too much space
  - Etc…
- Lean Management has been initially conceived at Toyota Motor Corporation, which starting from the ‘60s has established its “Toyota Production System” (TPS), whose objective was …"*making the vehicles ordered by customers in the quickest and most efficient way, in order to deliver the vehicles as quickly as possible“*
- Eventually, Lean Management has been applied in a number of both manufacturing and service environments

Some basic definition: What is Lean Management?

- The essential goal of Lean Management is to do more with fewer recources. To achieve this aim, Womack and Jones (1996) have identified 5 principles:
  - Specify **value** from the customer's perspective
  - Identify the **value stream**, i.e. the complete set of activities necessary to create the output valued by the customer
  - Make value **flow** through the value stream by eliminating non-value added activities and streamlining the value-added ones
  - Have the customer **pull** value through the value stream
  - Pursue **perfection**
- Eventually, one further principle has been added to the five listed above, i.e.:
  - Respect **people**

The aim of the research project

- **The aim** was to understand whether, according to INAF projects/WPs leaders, the implementation of Lean Management principles could be useful for the overall performance of INAF projects

- To pursue this aim, we decided to replicate a study conducted by Oppenheim et al. (2011), which was conceived for System Engineering **(Sept. 2012)**

- **The key steps** of this research, until now, have encompassed:
    - Interviews with Project Leaders of 6 different projects, aimed at understanding the features of typical INAF projects, in terms of phases, schedules and roles **(Sept.-Oct. 2012)**
    - Survey, carried out through the questionnaire developed and tested by Oppenheim et al. (2011), aimed at measuring: **(Nov. 2012)**
        - The actual implementation of Lean Principles at INAF
        - The perceived importance of Lean Principles as an improvement lever

The aim of the research project

- Oppenheim et al. (2011) proposed a check list that encompasses statements concerning all the so-called *lean enablers*, i.e. practices that enable the implementation of lean principles:
  - **Value**: 16 stat.
  - **Value stream**: 31 stat.
  - **Flow**: 53 stat.
  - **Pull**: 11 stat.
  - **Perfection**: 46 stat.
  - **People**: 31 stat.
- For all enablers, their questionnaire required an assessment on a 5 points scale for both **Use** and **Importance**

The survey

- We have replicated the checklist developed by Oppenheim et al. (2010) so as to assess the actual implementation and the usefulness of lean principles at INAF
- We simplified the original check list, eliminating some statements not consistent with INAF projects, and tailoring the definitions on INAF peculiarities
- We adopted a 1 to 6 scale to collect clearer opinions (e.g. *not important* from 1 to 3, *important* from 4 to 6)
- A Beta version of the questionnaire was tested with the interviewees and their suggestions have been implemented in order to improve the questionnaire
- Finally, our questionnaire was mailed to INAF Macroarea 5 and 40 usable questionnaires has been collected

The survey

- **PEOPLE:** *These enablers promote the enterprise culture of trust, openness, respect, empowerment, cooperation, teamwork, synergy, good communication and coordination; and enable people for excellence.*

- **VALUE:** *The enablers promote a robust process of establishing the value of the end-product or system to the customer with crystal clarity, and frequently involving the customer.*

- **PLAN:** *These enablers emphasize waste-preventing measures, solid preparation of the personnel and processes for subsequent efficient workflow and healthy relationships between stakeholders (customer, contractor, suppliers, and employees); detailed project planning; frontloading; and use of leading indicators and quality metrics.*

The survey

- **FLOW:** *These enablers promote the uninterrupted flow of robust quality work and first-time right; frontloading, steady competence instead of hero behavior in crises; excellent communication and coordination; concurrency; frequent clarification of the requirements; and making project progress visible to all.*

- **PULL:** *These enablers are a powerful guard against the waste of rework and overproduction. They promote pulling tasks and outputs based on need (and rejecting others as waste) and better coordination between the pairs of employees handling any transaction before their work begins (so that the result can be first-time right).*

- **PERFECTION:** *These enablers promote excellence in the SE and enterprise processes; the use of the wealth of lessons learned from previous projects; the development of perfect collaboration policy across people and processes; and driving out waste through standardization and continuous improvement. This group of the enablers calls for a more important role of systems engineers, with responsibility, accountability and authority for the overall technical success of the project.*

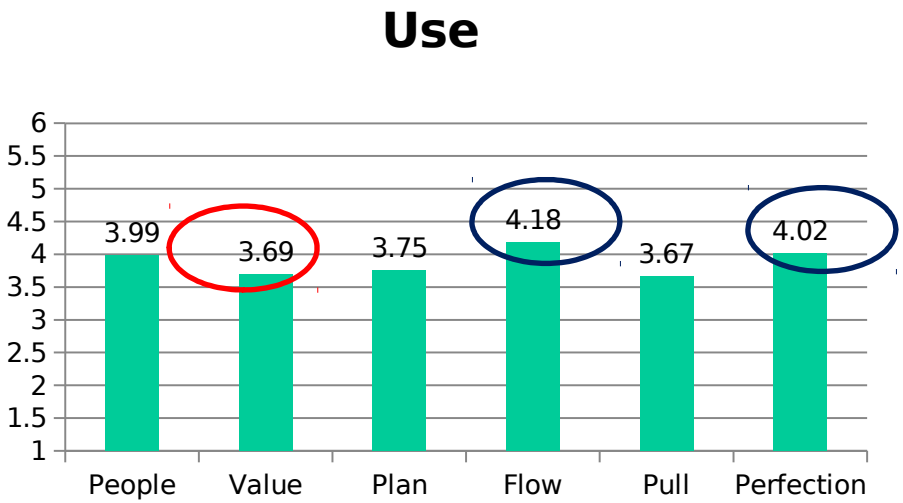
Preliminary Evidence and Implications

	No. Statements	Cronbach's α for Use	Cronbach's α for Importance
People	17	0.94	0.89
Value	9	0.88	0.89
Plan	15	0.92	0.92
Flow	10	0.87	0.91
Pull	4	0.79	0.51
Perfection	7	0.84	0.84

- Cronbach's alpha tell us whether a given set of statements properly describes a construct (e.g. Use of People Practices). It must be > 0.7

- This test is favourable in all cases but one (*Importance of Pull Practices*)

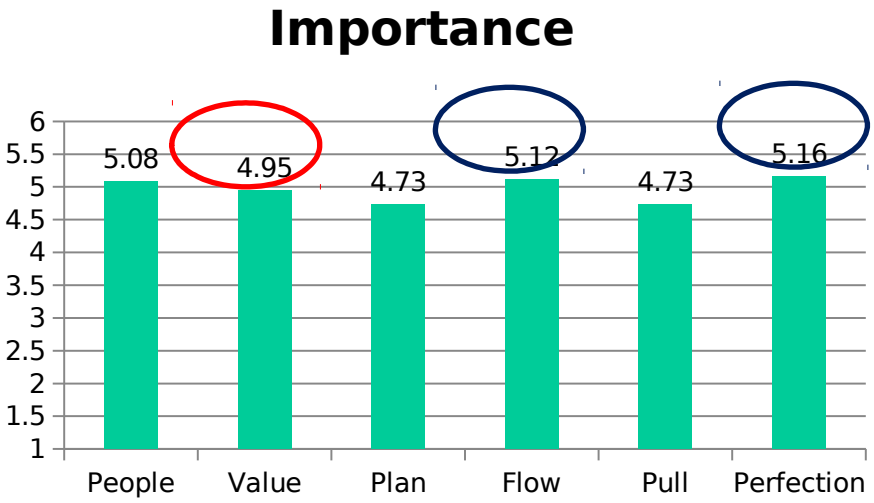
Preliminary Evidence and Implications



The most implemented set of enablers seems to be the one concerning "Flow" with an average value of 4.19, followed by "Perfection" (average: 4.02). This could be due to the fact that, in complex projects, keeping activities flow smoothly can be an issue that requires specific concerns and expertise, especially in order to prevent or to reduce delays as much possible.

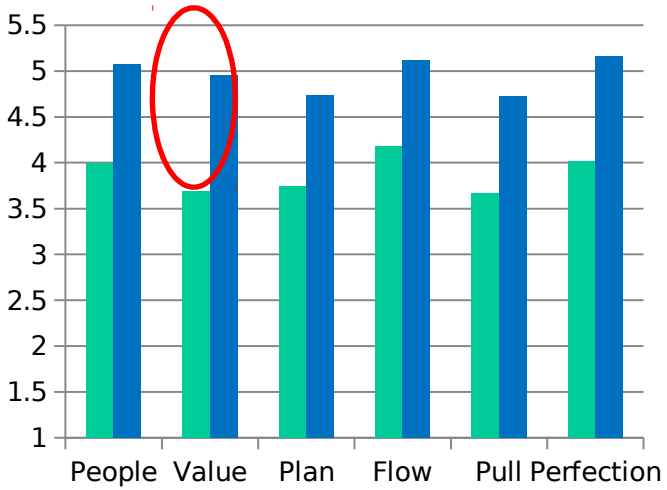
Among all other groups of enablers, what is noticeable is the rather low average of "Value", equal to 3.65. These statements concern the commitment of the organization toward stakeholders' value. In fact, the stakeholders (e.g. scientists, national agencies, suppliers) in an astrophysical project can be numerous and can differ in terms of needs and requirements. Thus, even the definition of a clear set of objectives can be hard to achieve. This seems to highlight an opportunity for improvement, which calls for a better understanding of the actual requirements of the "clients".

Preliminary Evidence and Implications



It is worthwhile noticing is that the rank among the six typologies of enablers is very similar to the one concerning “Use”. As a matter of fact, “Perfection” and “Flow” are in the top positions, the former being even more important than the latter (averages: 5.16, 5.07).

Preliminary Evidence and Implications

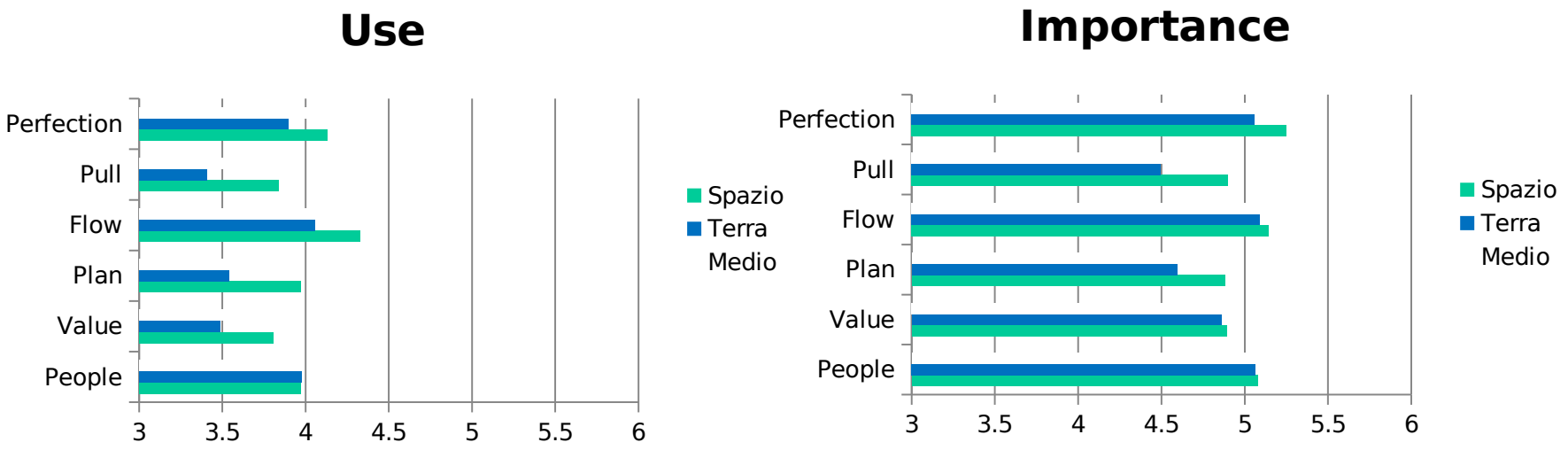


	Average Use	Average Importance	Average Gap
Value	3.65	4.88	1.23
Plan	3.76	4.74	0.98
Flow	4.19	5.07	0.88
Pull	3.63	4.70	1.07
Perfection	4.02	5.16	1.14
People	3.98	5.07	1.10

In all the case the average importance is bigger than the co-respective use. This means that there is margin to get things better.

But it is also noticeable that the highest average gap (i.e. “Importance-“Use”) is reported by “Value”. This could means that project leaders consider it necessary to achieve a much better understanding of the stakeholders’ needs.

Preliminary Evidence and Implications



Furthermore, an interesting difference has been observed between the responses of the leaders of “space” projects and those of “ground” projects. In fact, the latter, on average, gave lower scores than the former for all enablers, in both “Importance” and “Use” fields, and this seems to be due to the fact that traditionally scientists involved in “space” projects work with international agencies that have standardized their work procedures since long. Because of this different background, they know how beneficial it is to implement best practices, even if they seem to “constraint” the usual ways in which projects are carried out.

Conclusions

- Modern Astrophysical projects are going to be bigger, global and more expensive. Good coordination is mandatory
- System Engineering disciplines are more and more applied to modern projects: There is no need to do MORE SE, but to perform BETTER SE.

- From the survey in INAF there is a clear evidence that project leaders see lean enablers as an opportunity to improve
- Those who are engaged in space projects perceive a higher relevance of lean practices and think that they are somewhat already impletemented

- *Perfection* seems to be the key goal, while *Value* reports lower scores, especially in terms of Importance
- If *Perfection* has to be *the key goal*, it can be pursued leveraging lean principles and practices
- The gap in the Value principle is quite high and deserves some attention in order to improve the use.

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