

PROJECT MANAGEMENT FOR SCIENTISTS

SCIENCE REQUIREMENTS

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OUTLINE

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- Science Objectives
- Science Requirements
- Other Requirements
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- Examples
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INTRODUCTION

- Requirements:
 - Systematic translation of scientific idea into requirements, eventually leading to accurate budget and schedule estimates can be determined
 - Describe ideal outcome of project
- Uncertainty in requirements -> uncertainty in cost and schedule -> uncertain success
- Many projects fail due to vague and / or undocumented requirements

REQUIREMENTS HIERARCHY

Top -> Down, Big -> Small, What -> How

1. Science rational
2. Science objectives
3. Measurement objectives
4. Science requirements
5. Technical Requirements
6. Design Requirements
7. ...

SCIENCE OBJECTIVES

- Science vision and strategy explained in detail by science rationale
- Science rationale leads to science objectives or science drivers
 - I would like to understand ...
 - We need to observe, measure, test, ...
 - This is how well I need to observe, measure, test ...

SCIENCE OBJECTIVES EXAMPLES

The long-term studies of the most important astronomical object to humanity will provide the fundamental data to help answer the following questions:

- What causes the solar cycle?
- How is energy stored and released in the solar atmosphere?
- How does the solar radiative and non-radiative output vary?

MEASUREMENT OBJECTIVES

- Measurements required to achieve science vision
- In astronomy: key observations
- Example:
 - Line-of-sight component of the photospheric magnetic field: averaged over 2 Mm squared projected area, sensitivity 1G, zero point stable to 0.1G, time for a full disk map: 15 minutes, shorter for smaller areas.
 - Transverse component of the photospheric magnetic field. Same parameters as line-of-sight component except sensitivity 20G.
 - Morphology of coronal magnetic fields from limb observations of coronal emission lines. Angular resolution about 3 arcsec, noise level $<10^{-4}$ of the disk brightness.

SCIENCE REQUIREMENTS

- Project scientist is responsible for science requirements
- Requirements follow from science vision and strategy
- Science visions not concrete enough to be science requirements
- If requirement too difficult to formulate, use examples of how things will work (use cases)
- Project team may need to interview scientists

SCIENCE REQUIREMENT EXAMPLE

SR.1 Science goals

Need:1 **Priority:1** **Source:** *SOLIS, Proposal to NSF dated 12 February 1997*

SOLIS will produce observations to understand (1) the causes of the solar activity cycle, (2) storage and explosive release of energy, and (3) causes of radiative variability.

SR.2 25-year lifetime

Need:1 **Priority:1** **Source:** *SOLIS, Proposal to NSF dated 12 February 1997*

Duration of the stream of regular observations will be at least 25 years.

SR.3 Relation to other activities

Need:1 **Priority:2** **Source:** *SOLIS, Proposal to NSF dated 12 February 1997*

SOLIS observations will be integrated into the National Space Weather Program, operational needs of NOAA/SEL, support of NASA mission, and collaboration with other organizations.

SR.4 Community access

Need:1 **Priority:2** **Source:** *SOLIS, Proposal to NSF dated 12 February 1997*

SOLIS observational capabilities will be made available to as many qualified users as possible.

SCIENCE REQUIREMENT EXAMPLE

Level	Req-ID	Title	Requirement	Comments
2	SC-020 1	Wavelength coverage	The METIS imager shall cover the LM band and the N band.	The objective is given in the summary table.
2	SC-020 2	Pixel sampling	The METIS imager shall provide Nyquist-Shannon sampling of the PSF at 3.5 μ m and 7 μ m.	The objective for the chosen wavelengths is to provide critical sampling over most of the LM band.
2	SC-020 3	Field of view	METIS shall provide an imaging field of view of at least 15". 15". The aspect ratio of the field should be close to unity.	The objective is to provide critically sampled, diffraction limited (AO-corrected) images over a field size that is sufficient for most individual targets and allow for on-chip chopping.

REQUIREMENT REQUIREMENTS

- Need to have scope flexibility:
 - Prioritized
 - Information on need (what if not fulfilled)
 - Requirements (“must”) and goals (“should”)
- Prepare de-scope options
- Need flexibility in fulfilling science requirements
 - Watch out for ‘over’-specifying
 - Do not limit design, implementation

OTHER REQUIREMENTS

- Functional requirements: specify a function that a system or system component must be capable of performing
- Performance requirements
- Interface requirements
- Operational requirements
- Resource requirements
- Verification requirements
- Acceptance testing requirements
- Documentation requirements
- Security, Portability, Reliability, Maintainability, Safety requirements

REQUIREMENTS CHECKLIST

Check for

- clear, unambiguous requirements
- verifiable requirements
- consistency among requirements
- gaps in requirements
- requirements from beyond project lifetime
- unnecessary requirements (design restrictions)
- traceable requirements (identification of underlying assumptions)
- unique identifier for every requirements

GOOD OR BAD?

- SR-1: JWST shall be capable of making astronomical observations at wavelengths from 0.6 to 27 micrometers.
- JWST shall have coronagraphic imaging capability over the wavelength ranges 2 to 27 micrometers.
- JWST shall have a primary mirror whose unobscured light collecting area is no less than 25 square meters.
- The Observatory shall be capable of observing at least 35% of the celestial sphere at any time.

GOOD OR BAD?

- SR-32: The JWST science mission lifetime, after commissioning, shall be a minimum of 5 years.
- As a goal, the JWST science mission lifetime shall be 10 years. In support of this goal, JWST shall meet the following requirement:
 - SR-33: Propellant shall be sized for 10 years of operation after launch.

GOOD OR BAD?

- List of priority 'A' products
 - SR 3.1.1 OMI shall retrieve the Earth radiance spectrum.
 - SR 3.1.2 OMI shall retrieve the solar irradiance spectrum.
- List of priority 'B' products
 - SR 3.1.15 OMI shall be able to retrieve the total SO₂ column.
 - SR 3.1.16 OMI shall be able to retrieve the total BrO column.

GOOD OR BAD?

- SR 3.2.7.1 Near Real Time (NRT) products shall be available within 3 hours after observation.
- SR 3.2.8.1 The OMI data (gathered above Europe and Scandinavia) shall be downloaded to the FMI ground station at Sodankylä (Finland) on one pass per day.
- The accuracy of the irradiance product shall be less than or equal to 2 %.

REQUIREMENT TEMPLATE

- **Identifier:** Unique enumeration
- **Title:** Few, descriptive words
- **Need:** Essential requirements marked '1'. Non-essential requirements marked '2', '3' in descending level of importance
- **Priority:** Priority for completion. Requirements with priority 1 will be completed first, followed by priorities of 2, 3, ...
- **Source:** Origin of requirement can be found in document referenced by this entry
- **Description:** Requirement itself

Courtesy B.Goodrich

SCIENCE REQUIREMENT

Entry	Content
EPOL Reqt ID	EPOL-S001
Parameter	Giant planets
Requirement Description	Detection and characterization of mature gas giants at orbital distances between ~5 and 15 AU in the solar neighbourhood (< ~20 pc)
Priority / Clarification	High priority
Upper Link	AD1 4-2
Upper Link	
Requirement document	E-SPE-ESO-556-0194 issue 2
Verification Method	

TOP-LEVEL FUNCTION REQU.

Entry	Content
EPOL Reqt ID	EPOL-0001
Parameter	Contrast I band
Requirement Description	10h, reference conditions etc. for mature gas giants (science case 2) contrast $2 \cdot 10^{-9}$ (goal $1 \cdot 10^{-9}$) at 100 mas, and 10^{-9} (goal: $4 \cdot 10^{-10}$) at 300 mas
Priority / Clarification	AI missing simultaneous wavelength range, missing polarization state of planet system. Need to get a reference where numbers come from
Upper Link	AD1 5-6b
Upper Link	EPOL-S001
Requirement document	E-SPE-ESO-556-0194 issue 2
Verification Method	

OPTICAL REQUIREMENTS

Entry	Content
EPOL Reqt ID	EPOL-0206
Parameter	Image quality over full field
Requirement Description	Optical WFE < 75 nm rms (goal 50 nm rms)
Priority / Clarification	The image quality degradation due to optics over the field should remain small as compared to atmospheric anisoplanatism.
Upper Link	RD2 8.3 A
Upper Link	EPOL-0001, EPOL-0002
Requirement document	VLT-SPE-SPH-14690-0083 issue 3
Verification Method	

DELIVERABLES

- What the project will produce
- Defines boundaries of the project
- Focuses team on project outcome
- Intermediate deliverables are used to manage project
- Final deliverables define project outcome

DELIVERABLES EXAMPLE

- 7101 Differential polarimetry **trade-off study**
- 7102 Fast modulator in front of AO system: **requirements** on wave front control
- 7201 Differential polarimetry **system design and analysis**
- 7301 **Models** for differential aberrations, and temporal wave front distortions of polarization modulators
- 7302 **Measurements** for the differential aberrations, and temporal wave front distortions of selected polarization modulators
- 7303 Wave front control with polarization modulation **test report**