Project Management for Scientists

Science Requirements

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Outline

- Introduction
- Project Objectives
- Science Objectives
- Science Requirements
- Other Requirements
- Template and Example
- Checklist

Introduction

- Science requirements:
  - 1 of 3 constraints driving scope
  - Influence cost and schedule
  - Describe ideal outcome of project
- Uncertainty in science requirements translates into uncertainty in cost and schedule and therefore uncertain success
- Many projects fail due to vague and/or undocumented requirements

Project Objectives

- **S**pecific: What is the project about?
- **M**easurable: How to determine success/failure?
- **A**greed: All key stakeholders agree.
- **R**ealistic: Sober realism based on budget, schedule
- **T**ime-constrained: Finite beginning and end
- Will be a measure of success
- Initial science goals
- May contain objectives regarding side effects

Project Objectives Example

Conceptual design of an instrument with

- Spectral range: 600-1800-nm (goal: 500 - 2500 nm)
- Observing modes
  - Spectral imaging with spectral resolution R > 50 (consider higher resolution if improvement in speckle rejection expected)
  - Differential polarimetry mode, tbc
- Spatial sampling: at least Nyquist at shortest wavelengths (consider finer sampling if improvement in speckle rejection expected)
- Field-of-View: 2 arcseconds (goal 4 arcsec in NIR), inner working angle: < 30 mas (goal 20 mas)

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

Science Objectives/Drivers

- 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

- Define new measurements required to achieve science vision
- Also called key observations
- Example:
  - Line-of-sight component of the photospheric magnetic field. Averaged over 2 Mm squared projected area, sensitivity = 1 gauss, zero point stable to 0.1 gauss, 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 larger than 20 gauss.
  - Morphology of coronal magnetic fields from limb observations of coronal emission lines. Angular resolution about 3 arcsec, noise level smaller 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)
- Often incomplete, fill in as project goes on
- Project team may need to interview scientists

Requirement Requirements

- Need to have scope flexibility:
  - Prioritized
  - Information on need (what if not fulfilled)
  - May use requirements and goals
- 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

Example (courtesy B.Goodrich)

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

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 2·10-9 (goal 1·10-9) at 100 mas, and 10-9 (goal: 4·10-10) 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	