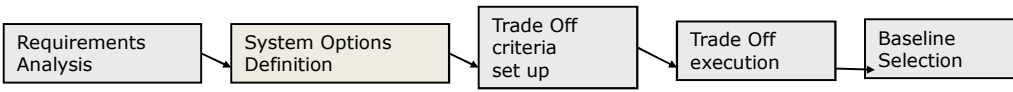# Satellite System Engineering

-- Options & Trade-offs

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Mission/System Options

Requirements Analysis → System Options Definition → Trade Off criteria set up → Trade Off execution → Baseline Selection

- Mission/System options are direct consequences of the Requirement Analysis (different perceived ways to comply with the requirements)

- Exhaustive search of all possible system options has to be done in the early stages of a project
  → In order to schematize, the options shall be organized on trade tree or a matrix (systematic)

- Option selection is performed via trade offs
  (supported by the previous trade tree)

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Mission/System Options
- Example of trade tree -

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OBJ1

OBJ1+OBJ2

NEO2

Possible back-up
not analysed

Impactor alone
+ ground based
measurements

Impactor + Orbiter

Single Launch

Single Launch

Double Launch

Smart-1 & LISA
PF modified

Existing bus
based Design

S/C fit to req.
based Design

DNEPR
DNEPR

DNEPR
ROCKOT

CYCLADE
DNEPR

DNEPR
DNEPR

DNEPR
ROCKOT
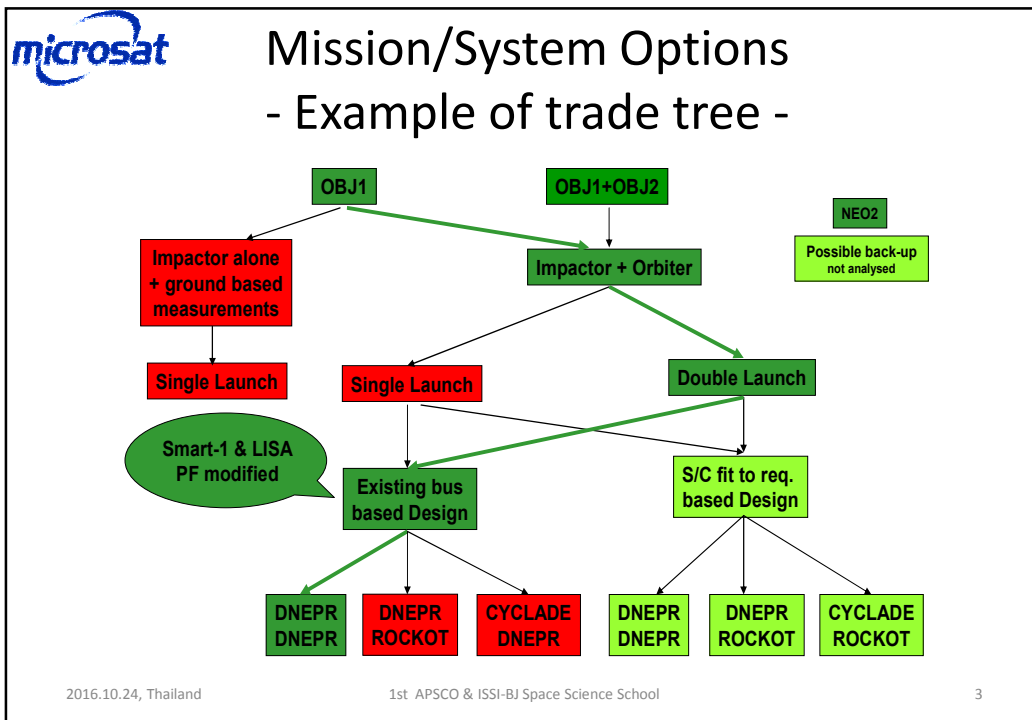
CYCLADE
ROCKOT

Mission/System Options
- Example of trade tree - 2

microsat

Orbit	Launcher	Launch strategy	Service Module Design
L2 halo	Soyuz 2.1b	Direct to orbit	Own design
			Re-use of Gaia SM
		Through Moon swing-by	Own design
			Re-use of Gaia SM
	Ariane 5 ECA	Shared GTO launch	Own design
			Re-use of Gaia SM
			Own design
			Re-use of Gaia SM
L2 Lissajous	Soyuz 2.1b	Direct to orbit	Own design
			Re-use of Gaia SM
		Through Moon swing-by	Own design
			Re-use of Gaia SM
	Ariane 5 ECA	Shared GTO launch	Own design
			Re-use of Gaia SM
			Own design
			Re-use of Gaia SM
HEO 3-day period	Soyuz 2.1b	Direct to orbit	Own design
			Re-use of XMM SM
Earth trailing	Soyuz 2.1b	Direct to orbit	Own design
			Re-use of Gaia SM

Mission/System Trade offs

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Requirements  →  System Options  →  Trade Off   →  Trade Off   →  Baseline
Analysis         Definition          criteria        execution       Selection
                                     set up
```

- Trade off shall be established for option selection in a clear way:
  - Trade off criteria
  - Relative weighting

- Trades shall be based as much as possible on quantitative criteria (but in early phases qualitative/parametric trades are common)

- Trade offs shall be well documented and recorded, as they may be re-opened in later phases

- Option selection will end with the definition of baseline and <u>back up</u> option(s)

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System Trade offs
- Example of table -

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Parameters	Weighting factors	Option 1 Ranking [1 - 5]	Option 1 Score	Option 2 Ranking [1 - 5]	Option 2 Score	Option 3 Ranking [1 - 5]	Option 3 Score
Total Mass	0.3	4	1.2	5	1.5	2	0.6
Payload Mass	0.3	2	0.6	4	1.2	2	0.6
Cost	0.2	3	0.6	1	0.2	5	1
Risk	0.1	2	0.2	2	0.2	4	0.4
Complexity	0.1	3	0.3	4	0.4	4	0.4
	1		**2.9**		**3.5**		**3**

<u>Notes:</u>

- Weighting factor: from 0 (less important) to 1 (more important)
              (Overall sum should be equal to 1)

- Ranking: From 5 (better) to 1 (worst). Scale is arbitrary.

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On Trade-offs

Trade-off tables are useful to clarify all the contrasting factors contributing to a decision <u>but</u> they should always be taken with a pinch of salt:

- Intrinsic subjectivity in the definition of the weighting factors
- Possible misleading conclusions when scores are very close

It is advisable to check the sensitivity of the results to weighting factors change

Often the result is the screening out of bad options rather than the selection of the best one