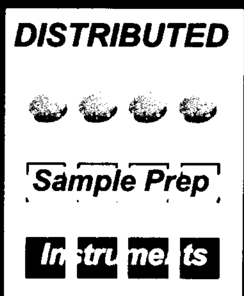
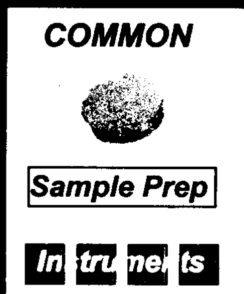
Mars In Situ Sample Preparation and Distribution (SPAD)

2002 Mars Sample Preparation Study Team (Beaty and Miller, eds., see authors at bottom)

A high-level Decision: Common or Distributed Sample Preparation



Each PI provides own Sample Prep



Sample Prep done in a facility system

Simplifying Assumptions

1. Provide common sample processing for instruments which have common sample preparation requirements.
2. Provide the capability to save sample material at only a single point in the sample flow
3. Only one sample is active in the SPAD system at a given time.
4. Each instrument specifies a single point in the sample processing flow from which it draws its sample split.

PROGRAMMATIC ANALYSIS OF COMMON SPAD SYSTEMS

Consensus Science Priorities

Roadmap of Common SPAD Science Priorities
(listed in approximate priority order)

First Decade Needs	Second Decade Needs
• **Coarse Crushing**	• **Selective Subsampling**
• **Splitting (of crushed material)**	• **Advanced surfacing**
• **Purging between samples**	• **Sample preservation**
• Temporary sample storage	• **Breaking, cutting of uncrushed rocks**
• Sieving	• Fine crushing
• Environment control	• Precision loading

Sometime Later: *Thin section, Mars H_2O filtration*

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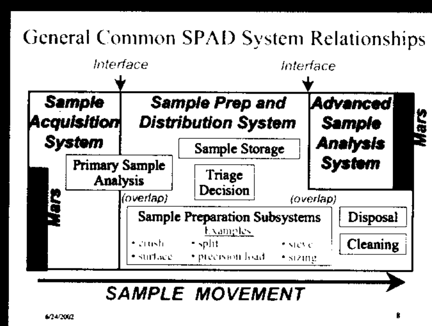
We need SOMEBODY to initiate work on 2nd decade technology NOW!!



Important to distinguish primary and advanced analysis.

Common SPAD Element Options/Trades

Sample Acquisition Interface							
Acquisition Device	Scoop	Drill	Mini-corer	Grabber	Rake	Mole	
Form of samples delivered	Core	Rock	Regolith	Cuttings	Ice	Water	Gas
Sample Processing							
Receiving interface	Bin	Port	Hopper	Cartridge	chamber	Other	
Sample storage	None	Single	Multiple	Open	Closed	Sealed	
Sample movement	Carousel	Wheel	Arm	Belt	u-fluid	Plunger	Gravity feed
Instrument injection	Gravity-fed	Volume	Sized	Other			
Discard system	None	Seperate	Common				
Sample Preparation							
Non-destructive assessment	None	Mass	Microscopy/spectroscop		Sniffer	TBD	
Preparation Processes	Crush	Cut	Reagents	Separators	Sieve	Polish	TBD
Sample splitting	None	Simple	Complex	Sized	TBD		
System-level issues							
Save sample after analysis	Yes	No					
Cross contamination control	None	Brush	Scrape	Gas	Liquid	Acoustic	
Airborne dust contam. control	None	Enclose	Brushing	Gas	Other?		
Autonomy	TBD	TBD	TBD				

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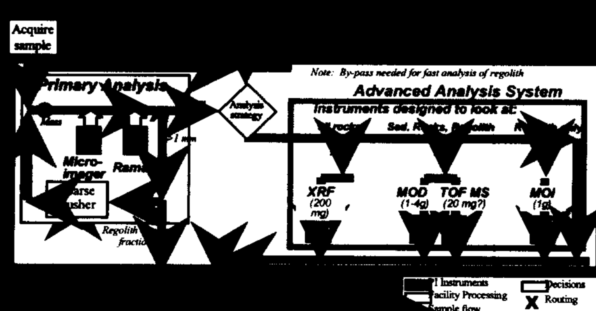
Conclusion: LOTS of potential ways to do SPAD.

APPLICATIONS TO 2009 MSL MISSION



Actions

1. NASA technology program started in 2003 to develop
   - Architecture
   - Components
2. Multiple other organizations now developing designs and prototype hardware
3. Reducing mission scope

Open Issues

1. Mass, readiness level, and integration issues of **distributed sample prep.**
2. How many instruments need to share a **common SPAD** system in order for it to be cost effective? *(Draft answer: probably 3 or more)*
3. How to fit $$ within cost cap?
4. Autonomy—this is BIG!
5. Scientific value of sharing **portions of a single sample among multiple instruments**
6. Resolve *BEFORE* AO

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SPAD Poster v6 Sept 18, 2002

Mars In-Situ Sample Preparation and Distribution (SPAD) Systems

Sept. 25, 2002

Mars Sample Preparation Team

(David Beaty and Sylvia Miller, leaders)

Science Contributors

Full Study Participants

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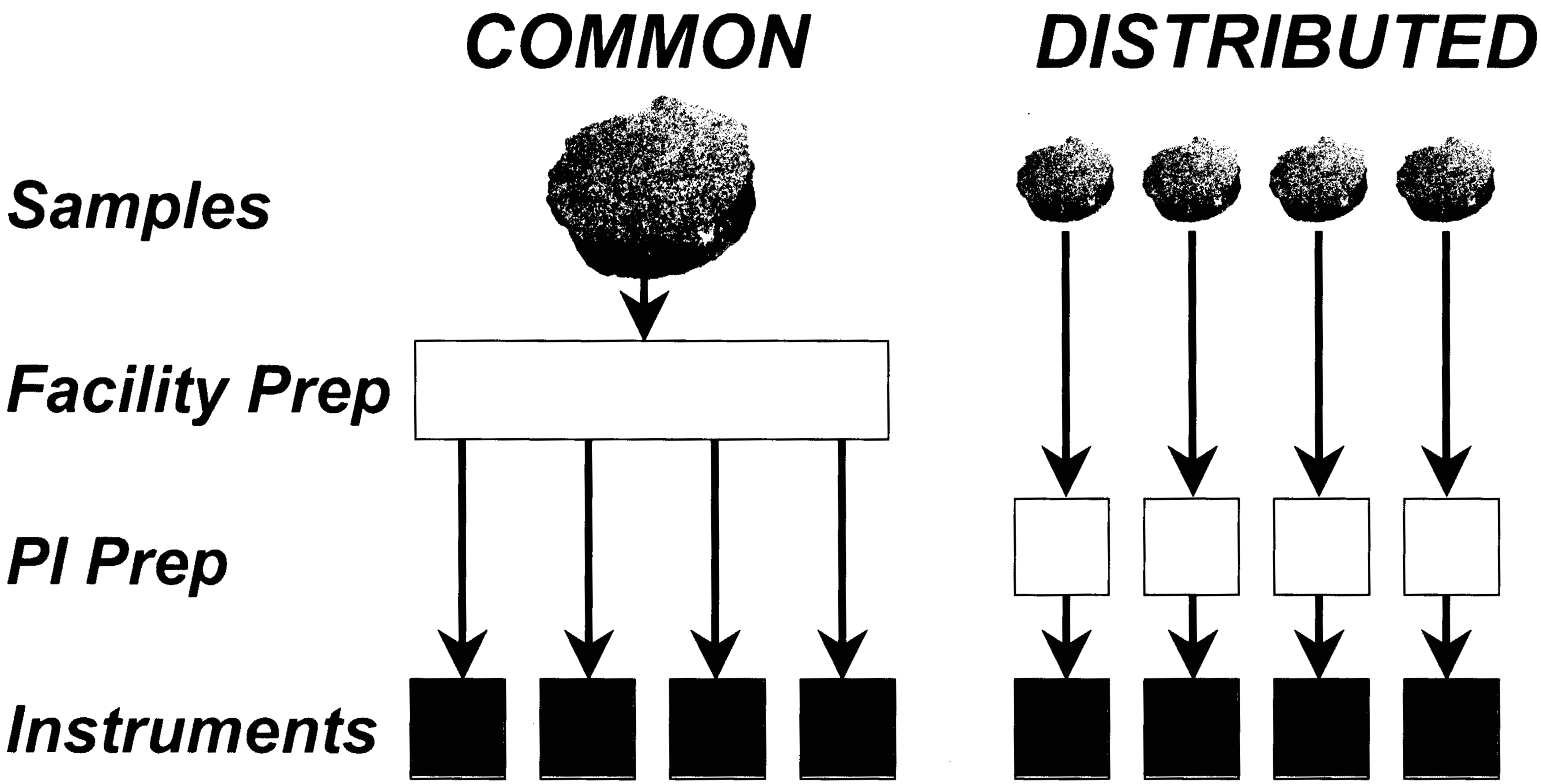
Introduction

- Purpose of study
  - Define science requirements for Mars in situ sample preparation systems
  - Determine PROs and CONs of a common (facility) vs. distributed (PI-provided) system
  - Assess required technology development.
- Scope
  - Mars Landers: 2009 (MSL) through 2020

Sample Preparation Options



Comments

COMMON
- *Sample Prep done in a facility system*

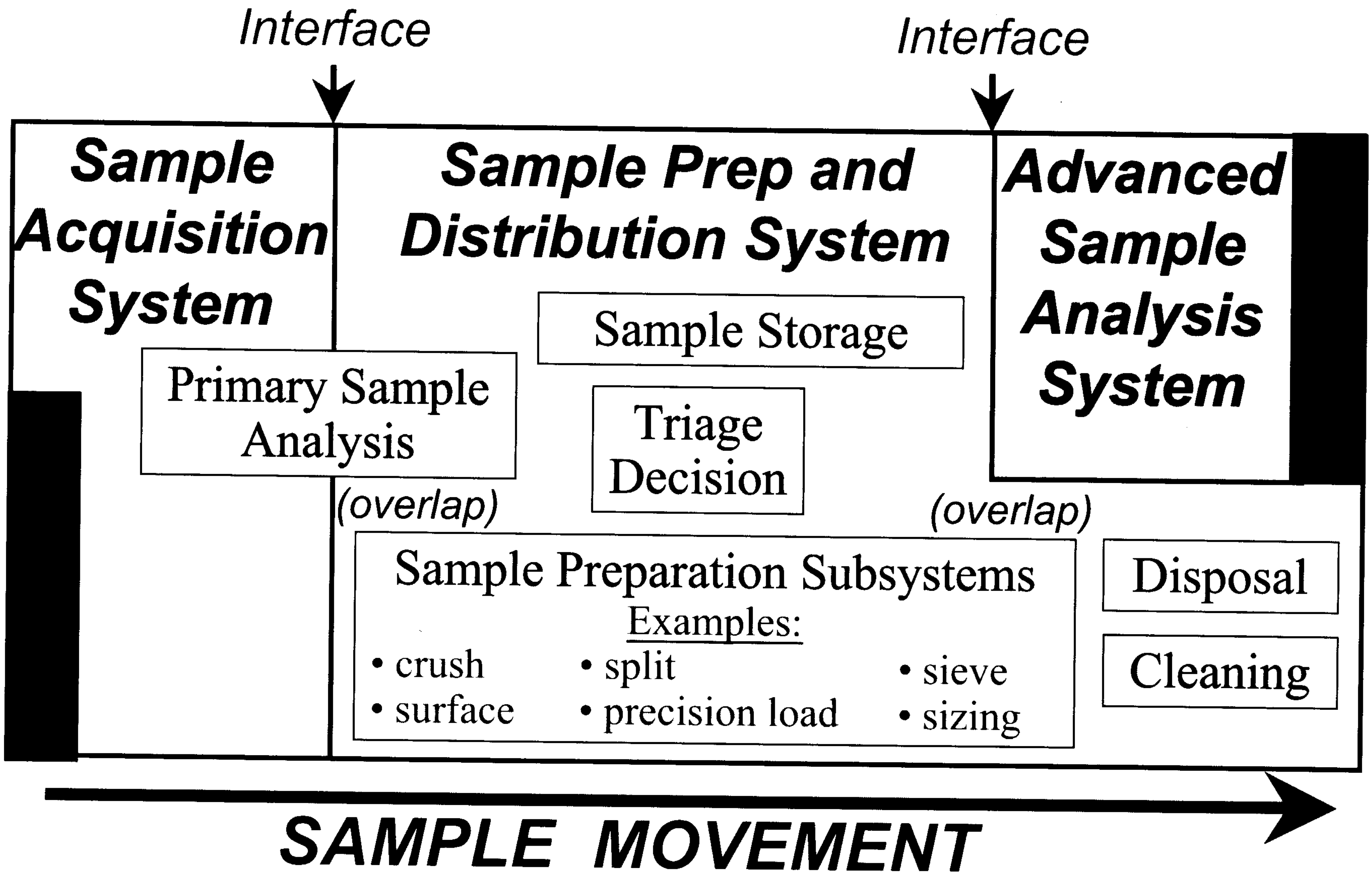
DISTRIBUTED
- *Each PI provides their instrument and their own sample prep.*

Sample shown is Mars meteorite NWA 998

Analysis of Sample Preparation Systems

- In order to decide between common and distributed sample preparation, we need comparative analysis
- This study describes the characteristics and constraints of a common system
  - Essential subsystems, flow logic, engineering constraints
  - Mass estimate
  - Technology development program needed
- Separate systems hard to document, since they are 100% dependent on PI selection, and their strategies.

General Common SPAD System Relationships



Roadmap of Shared SPAD Science Priorities

(listed in approximate priority order)

First Decade Needs	*Second Decade Needs*
• **Coarse Crushing**	• **Selective Subsampling**
• **Splitting (of crushed material)**	• **Advanced surfacing**
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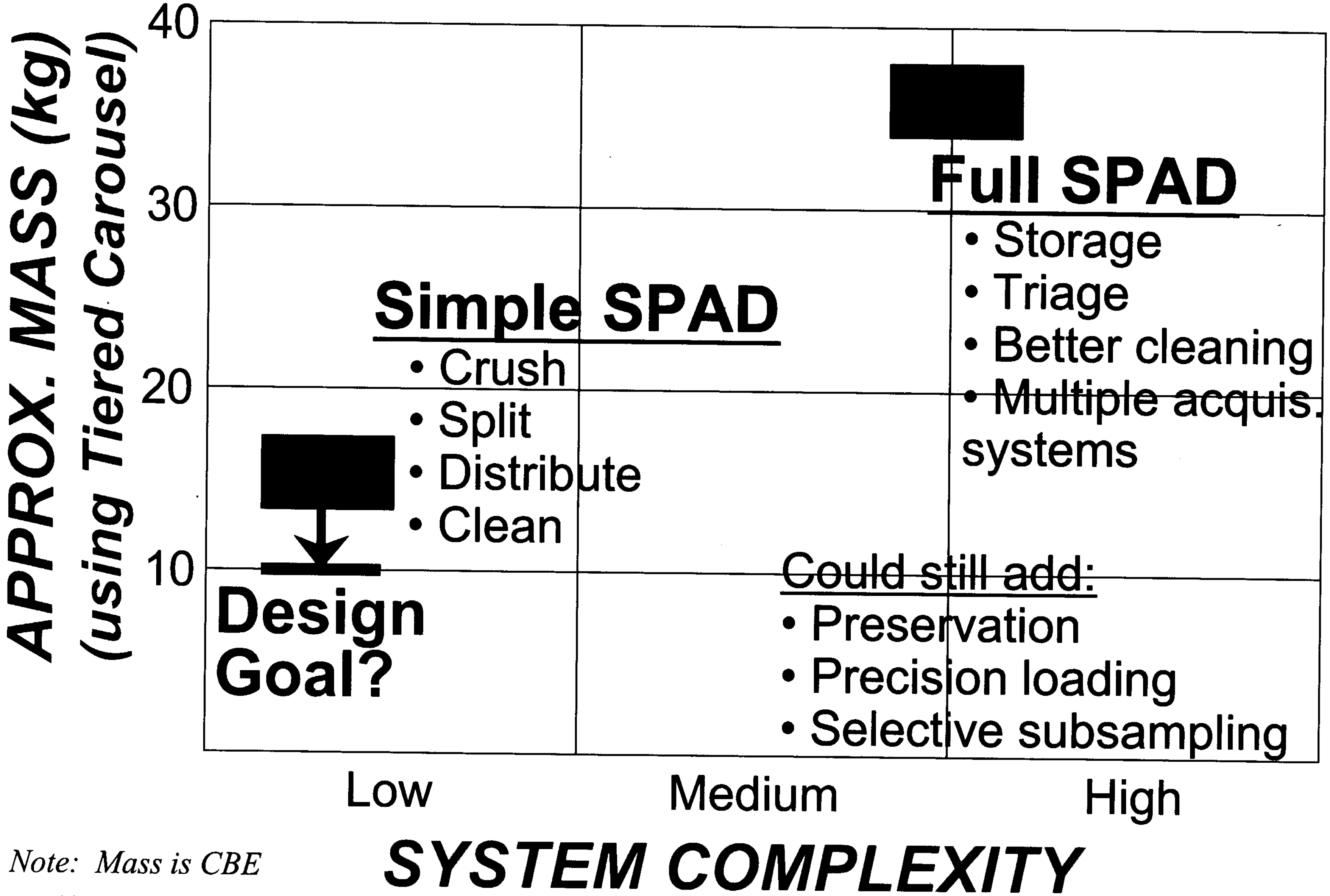
Common System: Mass vs. Performance



Note: Mass is CBE

Common SPAD Technology Development

CRITICALITY FOR MSL	Low	Medium	High
High	• *Expose Rock Surface* • *Sizing* • *Process Monitoring / Automation*	• *Sample Volume Splitter*	• *Coarse Crush* • *Sample Movement* • *Contamination Control – Mechanical* • *System Architecture Design*
Med	• *Precision Loading, Manipulation*	• *Sample Storage*	
Low	**Start in FY04**	**FY03-05**	• *Rock Cleaver* • *Fine Crusher* • *Selective Subsampling* • *Sample storage + environmental controls*

LEAD TIME REQUIRED

Prep Functionality: Common or Distributed?

	PRO	CON	NEUTRAL/ UNKNOWN
COMMON	• *Synergy between instruments* • *Triage decision* • *Optimize analysis sequence* • *More prep capabilities*	• *Time driven by slowest instrument*	• *Lower mass, power* • *Enhance accuracy, detection limits* • *Sample quality* • *High throughput* • *Adds complexity* • *Cost optimization*
DISRIBUTED	• *Prepare samples EXACTLY as needed*	• *No synergy between instruments* • *Difficult for PIs, complex management*	

Conclusion: This analysis is VERY dependent on the number of instruments which share the prep system.

Long-Term Considerations

What can we do in the in-situ program to 2020?

- Given a reasonable technology program:
  - We can develop substantial robotic sample preparation capability for missions in the next two decades.
  - However, some MEPAG measurements are dependent on sample preparation capability that exceeds reasonable expectations of the robotic program
- Given landed missions of the size of MSL:
  - SPAD functionality will be limited by the mass fraction that can be allocated to it.
- Increasing complexity in sample preparation will limit in-situ sample science.

What Next?

- The decision on whether to use common or distributed sample preparation on MSL needs to be incorporated into the AO strategy.
  - ***COMMUNITY INPUT NEEDED ON THIS DECISION!***
  - PIs need to know this in order to respond properly to the AO.

Backup Slides

Sample Types/Issues: Next Two Decades

Mini-core rocks
- Longitudinal zoning
- Regular shape
- Small mass

Loose scoop samples
- Heterogeneous

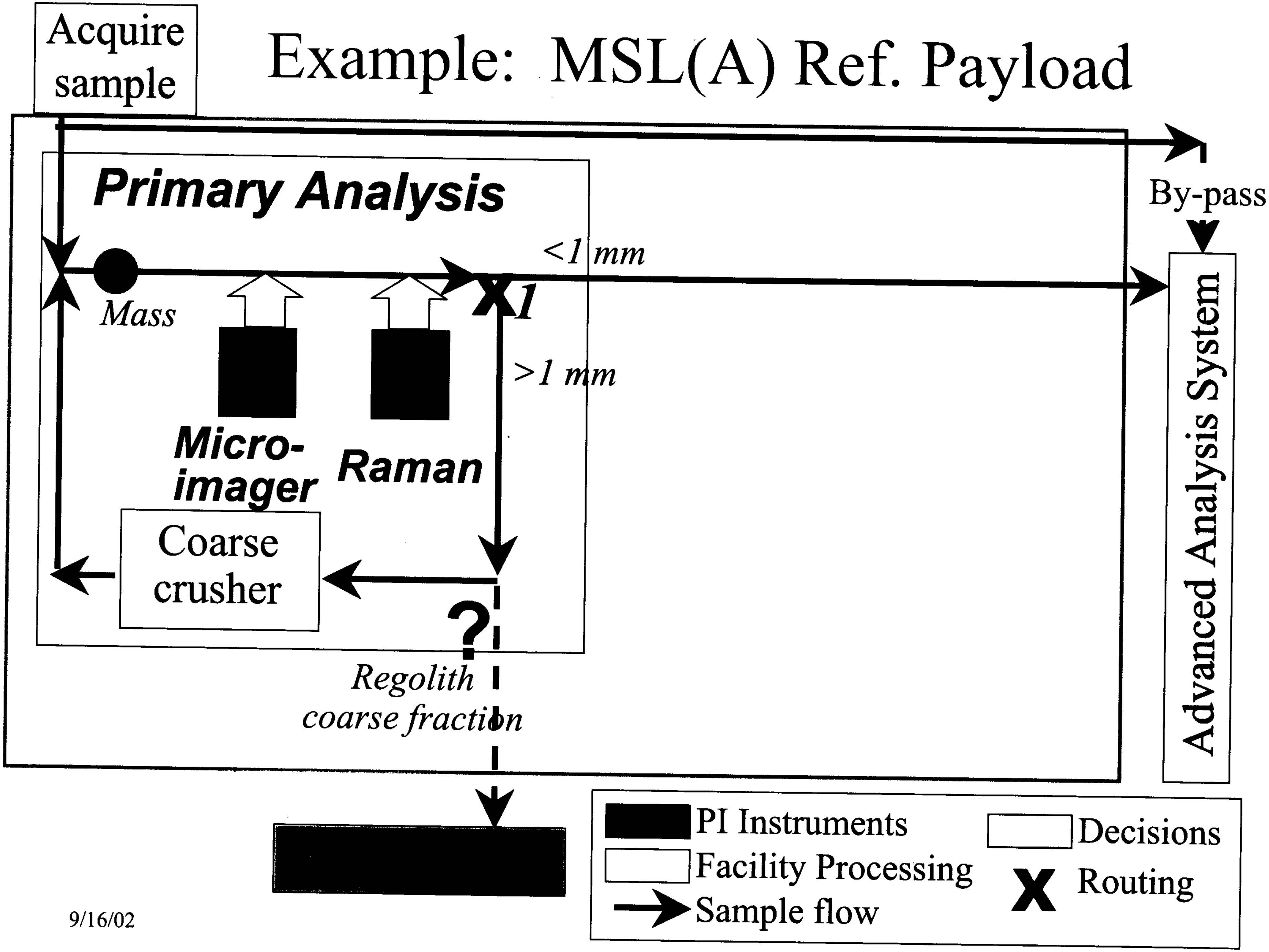
Rake, tong rocks
- Irregular size and shape
- Oxidized rim

Water
- Control evaporation, freezing
- Filtration

Deep drill rock, regolith
- High rate potential
- Regular shape
- High sample mass

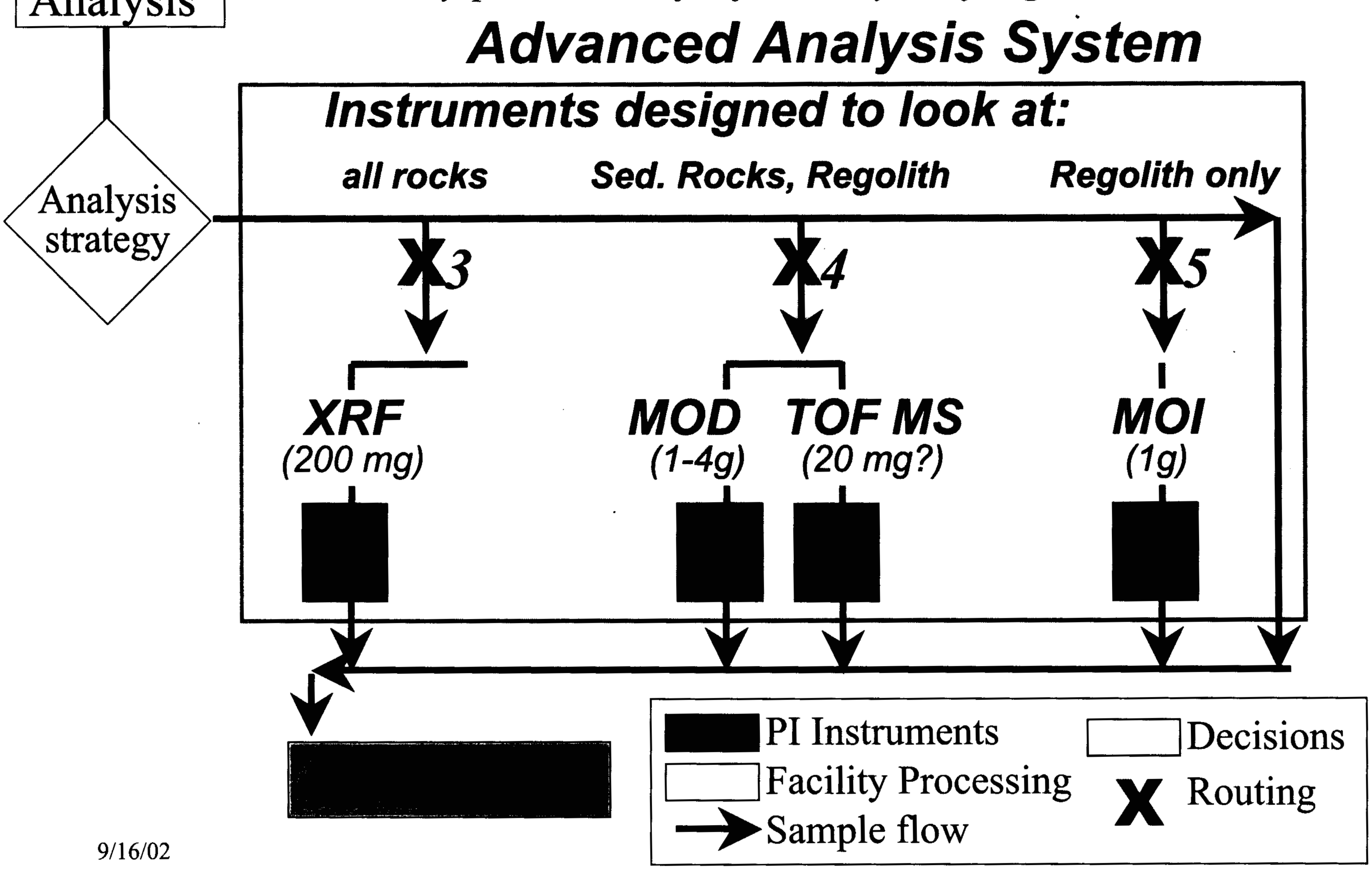
Ice
- Control sublimation, melting
- Admixed rock?

Example: MSL(A) Ref. Payload



Example: MSL(A) Ref. Payload

Note: By-pass needed for fast analysis of regolith



Longer Term Technology Development

Benefits to Future Missions	Lower	Medium	Higher
Higher		• Advanced Surfacing • Splitting/cleaving rocks	• Autonomous control • Sample Selection and Management • Selective Subsampling • Cross Contamination Control
Med	• Fine Crushing	Precision Loading and Manipulation	• Sample Preservation (incl. Environmental Controls)
Lower			

LEAD TIME REQUIRED