Contributions to Space Exploration: Global Objectives, Plans and Capabilities

Report of an AIAA / AAS Workshop

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Background

In the early 1990's, the International Activities Committee (IAC) of the American Institute of Aeronautics and Astronautics (AIAA)[1] initiated a series of workshops focused on international co-operation in space activities. At the 7th Workshop, held in Anchorage, Alaska, in May 2004, one of the working groups addressed the topic of "International Cooperation in the Context of the Implementation of a Space Exploration Vision." The modalities of defining and implementing an exploration vision as a coordinated international endeavor were discussed, and a new conceptual approach was developed. In this approach, exploration would not be undertaken as one large monolithic international program but would rather be based on a two tiered concept. One tier would involve the integration of global exploration efforts through broad international coordination. In the second tier, individual projects would be carried out either at the national level or through international partnerships. Collectively, the two tiers constitute a global program made up of national, bilateral and multilateral programs, effectively a "Program of Programs."

The overall concept was well received by the international space community, which led to the organization of a follow-on Workshop by the International Space University (ISU) and the Center for Aerospace Policy Research (CAPR)[2] of George Mason University. This single working group Workshop, on the theme of "Structuring Global International Cooperation in Space Exploration," took place at the ISU central campus in Strasbourg, France, in April 2005. The initiative, which represented a "spin-off" from the original Workshop series, was endorsed by the AIAA, and both the AIAA and the American Astronautical Society (AAS)[3] served as cosponsors. In Strasbourg, the Anchorage concept was further refined, leading to a proposal for the establishment of a permanent forum in which those governments and/or organizations with a vested interest in exploration would be able to exchange information about their national programs and plans in a manner that could lead to the development of "beneficial interdependencies." Central to this concept was the need for all stakeholders to be able to exchange information on their exploration objectives, plans and capabilities. Such an exchange could be greatly facilitated by the development of some sort of global space exploration database.

During the same time period, the AAS International Programs Committee (IPC) was engaged in running a series of seminars on aspects of international space cooperation, including one relating

[1] The AIAA provides a unique forum for discussions among experienced aerospace professionals. With more than 35,000 members worldwide, it is the largest professional society devoted to the progress of engineering and science in aviation and space. The AIAA International Activities Committee (IAC) addresses policies and procedures relating to space international activities.

[2] George Mason University (GMU) is a public university in the Commonwealth of Virginia, accredited by the Southern Association of Schools and Colleges, and located in Fairfax, Virginia, USA. Its School of Public Policy provides graduate academic programs and conducts research in a range of fields including space policy through its Center for Aerospace Policy Research, which assists in the development of the US aerospace sector by providing education and research resources relevant to this new policy environment.

[3] The AAS is the premier network of space professionals dedicated to advancing all space activities. The Society harnesses the intellectual energies of its technical and non-technical members to strengthen the space community, influence development of space policy, promote international dialogue on space activities and inspire students to undertake space-related careers.

to exploration that was also a “spin-off” from the Anchorage Workshop. In August of 2006, the AIAA-IAC and the AAS-IPC signed a Memorandum of Understanding (MoU) on collaboration “in the development and planning for international activities and programs.” As a first combined activity under the MoU, it was decided that the two organizations would undertake an initiative, organized in conjunction with CAPR, consisting of a series of events focused on developing a global space exploration database with certain interactive capabilities. This initiative was co-sponsored by the Center for Strategic and International Studies, the European Space Policy Institute, the International Astronautical Federation, the International Space University, the National Space Society and the Space Foundation.

A public Seminar was held November 1–2, 2006, at the GMU Arlington Campus where the full range of national exploration objectives, plans and industrial capabilities, including a number of purely commercial initiatives, was reviewed. Representatives from eight space agencies (Centre National d'Etudes Spatiales, Canadian Space Agency, German Aerospace Center (DLR), European Space Agency, Indian Space Research Organisation, Japanese Aerospace Exploration Agency, National Aeronautics and Space Administration and Russian Space Agency) and eight companies (Rocketplane Kistler, SpaceX, Lunar Transportation Systems, Bigelow Aerospace, Cisco Systems, Surrey Satellite, tSpace, and Caterpillar) gave presentations. The AAS took prime responsibility for the administration of this Seminar.

During the months of November, December and January, a small AAS/AIAA/GMU synthesis group developed an initial database from the Seminar input augmented by the “mining” of other data sources.

The invitation-only Workshop, which took place at the GMU Campus in Fairfax, Virginia, from 29 January to 1 February 2007, represents the culmination of this initiative. The AIAA had prime responsibility for its administration. For the AIAA, it represented the eighth workshop in its ongoing series, while for the AAS, it was the first workshop of its type. It was supported by a grant from Arianespace.

The major goals of the Workshop, as refined during the Opening Plenary, were:

- A validation of the synthesis exercise through a “Proof of Concept” of the database in terms of its overall structure and mode of use.
- A determination of the value and utility of the database, to both government agencies and the private sector, within the overall context of global space exploration, including its use with regards to the identification of gaps, overlaps and strategic redundancies.
- A discussion of what a Global Reference Architecture should look like, and the role the database could play in its development.
- A determination of the roles the database could play in the future, and the manner in which it should evolve to meet these roles.
- A discussion of related public/private partnership topics.

Approximately thirty-five space specialists (See Annex C) from government, industry, academia, organizations and space associations from around the world contributed generously of their time and expertise throughout the two-and-a-half days of presentations and working group discussions, for which the organizers wish to thank them. The contents of this report, however, while based on the output of the group's deliberations, remain the responsibility of its authors (See Annex C).

Database Value and Utility for Exploration

The Database Approach is Valued and Highly Useful

Prior to the Workshop, a copy of the Space Exploration Database (SEDB) developed following the November Seminar was sent to registered participants. This database, and an explanation of how it was developed and how it operates, can be found in Annex A of this Report. The SEDB was also presented at the Workshop Opening Plenary, where the manner in which a user could maneuver through its content was demonstrated. It, therefore, provided a basis for subsequent Workshop discussions.

The utility of the database to both space agencies and industry was acknowledged as was its timeliness, reference being made to the ongoing international agency level Global Exploration Strategy discussions. During the Workshop, it became clear that space agencies and industry have some similar yet distinct objectives and requirements for the database. Therefore, it was decided that separate government and industry databases should be developed somewhat independently but with an ability to be viewed and utilized as an integrated totality when required.

Database Value to the Space Agencies

The primary value/utility of the database to space agencies is as a professional tool to enable them to see the "overarching space exploration picture" and to help them in their development of strategies, including partnerships. It serves as a point of reference for where a particular nation/space agency is in the global picture of exploration. The database enables insight into future plans that provides opportunities for creating partnerships and developing interoperability. It provides a basis from which to plan and a potential roadmap for possible paths forward. The database can help space agencies pinpoint potential partnerships by identifying common or complementary interests and activities while maintaining individual autonomy. It can also inform the space agencies of new potential entrants of the "state of play" in space exploration, helping them identify opportunities and avoid duplication of on-going activities, and assisting them in staking a niche role in exploration.

A single integrated database among space agencies can also be used to leverage synergies. It would enable them to identify overlaps which they might agree to eliminate or cooperatively manage in order to more efficiently allocate resources. It has to be recognized, however, that for political, economic and competitiveness reasons, agencies may opt to forgo such opportunities. Nevertheless, some overlaps have the potential to be developed into strategic redundancies (i.e., programs or capabilities possessed by more than one agency, where this commonality constitutes a mutual benefit, such as backup in time of emergency or opportunity to explore alternative approaches or mutual building blocks). While strategic redundancies cannot be identified directly from the database, the database can identify what exists or is planned that offers potential to be evolved into strategic redundancies. Likewise, the database alone cannot identify gaps until a specific context is established; i.e. a Global Reference Architecture. However, the database *can* contribute to the development of such an architecture. Beyond this, the database can also help space agencies assess the downstream impact of mission failures and how best to recover from them (i.e., if there is redundancy available elsewhere).

The industrial database could also be a source to help space agencies become more aware of commercial capabilities and identify innovative low-cost approaches from current and emerging space companies. The evolving interactions between space exploration and space commerce are yielding a variety of previously unforeseen developments. Accordingly, neither space agencies nor industry has been in a position to deal with opportunities in the same way as with more established fields, such as telecommunications satellites or remote sensing. It may well be useful for space agencies to have a flexible tool that will provide a preliminary glimpse of which companies might deal with a particular area of government interest or need. Where there are many companies, it will of course be necessary to do further work to ascertain the actual level of their quality and their relevance to agency needs. Where there are no firms listed at all, each agency may need to address gaps that exist within its own industrial base as well as those of other space faring nations. It is important to note that an industry database would not be intended to replace traditionally accepted tools for agencies to learn about capabilities of industry in response to particular procurement needs, such as the Request for Information used frequently by NASA. An industry database would serve only as a supplement to such traditional tools, helping to broaden governments' knowledge of rapidly changing industry activities and capabilities both within and outside their countries.

Database Value to Industry

A space agency database would be of considerable value to industry because it would provide a useful overview of potential national and non-national government markets. However, just as an industry database would not replace traditional government tools for eliciting industry statements of capability, an agency database would not be a substitute for detailed research and networking by companies endeavoring to understand and anticipate government needs. An industry database would be of value not only to agencies but also to companies, in that it would suggest what other firms might be appropriate and available for joint ventures or subcontracting arrangements. Beyond this, companies engaging in strategic planning exercises could see how other industry and government entities are addressing challenges and options. Finally, companies might find information about unusual and innovative ideas that might serve as a stimulus to their own creative efforts.

Database Methodology, Scope and User Friendliness

The database methodology was endorsed as a good approach to depicting the overarching space exploration landscape and associated details. The SEDB enabled a proof of concept demonstration during the Workshop of how a database could be used. However, no attempt to validate the specific content in the database was made. It was acknowledged that the format and content of the database must be developed with the primary user community in mind, and that different requirements for type and depth of data exist. While the breadth of selected topics was adequate, the depth requires further work. It may be that the most useful portions of the database are the planned missions and studies, or data products, which will enable identification of potential partnerships.

Various space agencies have their own space exploration visions which differ in scope. The fourteen space agencies involved in the Global Exploration Strategy (GES) discussions are in the process of developing a working definition of "Space Exploration" to guide their discussions. This could serve as a starting point for defining the scope of the database. To remain useful, the database will need to evolve over time. There is also the need to engage other nations not already included in previous architecture processes (for example, Argentina, Brazil, Czech Republic, Israel, etc.).

Separate but Coordinated Development of Space Agency and Industry Databases Necessary

One significant finding was that a government database cataloguing space agency programs and plans would be quite different from an industry listing, as the latter would not be subject to government scrutiny with regard to its statements. However, because industry and government capabilities and programs are inextricably intertwined, it would not serve the interest of either group to develop databases that are not appropriately linked to each other. It is desirable to allow for comparisons across common government and industry categories, revealing both potential synergies to exploit and possible gaps to fill.

What Space Agencies Require

Space agencies need a database that provides an understanding of other nations' activities, plans, intentions, missions, timelines, budgets and capabilities. As such, it could contribute to the development of a Global Reference Architecture. The database is a tool that helps to identify and promote discussions on potential partnerships. The database should also contain information to enable them to broaden the range of companies they consider for collaboration and to help identify innovative low-cost approaches from current and emerging space companies.

What Industry Requires

Industry would find value in a clearer, more authoritative and comprehensive view of both public and private sector initiatives. It needs to have a place to list current and potential business activities and capabilities as well as to view the activities of other companies. Industry could also benefit from seeing the programs and plans of domestic and international space agencies. This would aid industry direction of investment of their resources to meet the needs of government and other industry.

Population of Government Database

For space agencies, the database will only be useful if they have a high level of confidence in the validity of its content. Data quality and timeliness will be essential. Therefore, data entry and updating will need to be controlled by the agencies. Different cultures and management systems will have varying comfort levels with respect to the supply and updating of data. Therefore, each would choose their approach towards populating the database and the level of granularity of the data they provide. There is also a need for sunset clauses on the database entries – data will be deleted after a certain time if no changes are made or it is not recertified. This would motivate space agencies to allocate the necessary effort and resources to keep their data current. It was recognized that user access to the database must be on a "read-only" basis to ensure the validity of its content. If a user wishes to propose a change to the content, this will be done through established channels in the overall database management scheme.

Population of Industry Database

As noted earlier, a fundamental difference between an agency and an industry database is that the industry tool is not subject to government scrutiny of its content. Because there is no universally accepted standard by which to determine who and what should and should not be in an industry database, the best approach would be to allow open access to all commercial entities showing an interest in being listed. It would be appropriate, however, to insist that all companies complete all fields in the database and provide contact information, so that the source of the information could be verified by the user and updating could be carried out periodically. Of course, the amount and type of content placed in database fields would be at the discretion of each company, and this might vary depending on the percieved value of the listing to each firm. In order to discourage frivolous filings, a nominal fee might be charged to all companies listed, which would have the added benefit of providing resources for database maintenance. Database users would in effect be presented with a catalogue, similar to directories used in a variety of other fields, where the user accepts full responsibility for drawing conclusions as to the usefulness of the information presented. The requirement that all industry database participants complete all data fields at least assures the user of the ability to compare entities across these fields, identifying who meets the user's criteria of relevance and who meets the user's standards of experience, capability, and the like. However, variations in the amount and type of content would render the database only a source of introductory information about each company of interest.

Finding the Right Balance – Uniqueness vs. Commonality

Although there will be a clear distinction between space agency and industry databases, the requirement for seeing both kinds of data together drives towards commonality of categories and data structure wherever possible. The ability to cross-reference topics across both the industry and government parts of the database, as well as to display similar categories of industry and government data at the same time, would be desirable for both public and private sector users. Data filters could be used to view only the information of interest. In addition, if agencies choose to include sensitive information in the government database, security partitions could be put in place to prevent access by unauthorized users. However, it would not be appropriate to put proprietary data in the industry database because of the numerous legal implications associated with any guarantee of data protection.

Industry Views on and Approach to the Development of its Database

An ad hoc Working Group of Workshop industry participants developed a list of proposed fields for the industry database that would include:

- Contact information, including website link
- Description of company (limit of 100 words)
- Number of employees
- Number of years in business
- Checklist of capabilities and core competencies
- Customer list
- Project list
- Other accomplishments list
- A free-form field, of limited length, to allow for a brief statement of other information deemed relevant by the lister

- A free-form field, of limited length, to allow for identification of areas in which the company is in need of external help in accomplishing its goals (e.g., teaming and contracting possibilities

Beyond this, there would be different levels, or "tiers," of data in an industry database that would parallel as much as possible those in the space agency database. These tiers, taken from an industry standpoint, would include:

- Tier One: category (i.e., type) of project
- Tier Two: specific projects, where "project" can refer both to: (1) a public-private partnership in which the private sector role is significant, and (2) a free-standing commercial effort where government involvement is minimal or absent altogether
- Tier Three: systems or subsystems (e.g., instruments, payloads)
- Tier Four: capabilities (i.e., technologies that can be configured in a variety of ways and that are not necessarily associated with any particular project, system, or subsystem)

Establishment of the industry database could be initiated by whatever organization is charged with the development of the agency database. Thereafter, the maintenance of the industry database would, as noted earlier, be financed at least in part by a nominal fee charged to each lister, probably on an annual basis. A requirement for continued listing in the catalogue would be the willingness of all listers to update their entries periodically, probably at least yearly. With this requirement, one aspect of quality—currency—could at least be assured. A "wiki" method of updating various parts of the database might be attempted, drawing on experience of such methods on the Internet and in various organizational intranets.

Database / Global Reference Architecture Synergy

In the short-term, one of the major uses of the database could be to serve as a reference for the development of a Global Reference Architecture. A single integrated database shared amongst space agencies would foster a better understanding of their activities, plans and intentions, and would serve as a tool to coordinate thinking that is going on in the development of specific national visions. To fully identify gaps, overlaps and strategic redundancies, both the SEDB and a Global Reference Architecture are needed, as the latter would provide context for the former. The Workshop participants recognized that what constitutes a Global Reference Architecture for exploration is still in the process of being defined by the Global Exploration Strategy Group. (Subsequent to the workshop, the Global Exploration Strategy Group renamed the Global Reference Architecture the "International Coordination Tool" which also includes the database. However, for purposes of this report, the term "Global Reference Architecture" is retained to distinguish it from the database.)

It was recognized that policies and technologies will evolve over the multi-decade span of the exploration endeavor. Therefore, flexibility and adaptability should be maintained in the development of the Global Reference Architecture across many dimensions, including:

- Objectives
- Participants
- Funding

- Schedules and Timelines
- Standards
- Interfaces
- Component modularity

As such, the Global Reference Architecture should address questions of interoperability, commonality, scalability and evolvability.

In general, to have flexibility in some factors, others need to be constrained. The development of the Global Reference Architecture could be used as a means of bringing the flexibility versus constraint discussion to the table. There will always be tension between those who want to inject new technologies as opposed those who seek commonality. The trick is to find the balance between the two. Hence, one of the key questions that should be addressed is where are benefits realized from freezing an aspect of technical design early, and where should such decisions be delayed. In other words, what are interface questions that can be deferred and what needs to be discussed now. As a terrestrial example, the dimensions of things such as inter-modal containers, railway gauge and highway lane width were established early. In these cases, limiting flexibility in one particular area achieved standardization while still allowing flexibility in others.

Flexibility is also a factor of time and cost. The shorter the time to reach an objective, the less flexibility there is. However, the longer flexibility is maintained, the greater the potential that additional costs could be incurred. Waiting too long to establish standards may result in national investments in hardware and software that are not interoperable. The architecture, however, would help the stakeholders to identify the possibilities for interoperability and commonality.

The Workshop participants recommended a process involving incremental steps along the following lines. This recommended methodology would preserve decisions until the end of the process in order to maximize the potential of interoperability and commonality:

- Develop an accurate and complete database
- Develop a Global Reference Architecture
- Identify gaps, overlaps and strategic redundancies
- Address issues of modularity and interfaces in a neutral and objective manner
- Conduct analysis and trade studies
- Allow discussions and decisions to take place

Ideally, all issues of what is supposedly “right” or “wrong” about the architecture should be set aside, and topics should be discussed in the abstract. One methodology might be to commission multiple global architectural views. These could then all be laid out together in a single forum for examination and discussion, but without an endorsement of any specific view. In such a hypothetical forum, no recommendations would be made on who does what. The only objective would be to provide a view of the overall architectures and objectives and to assess the implications for interoperability and strategic gaps and overlaps. The “hard” discussions on who does what are best left to the end of the process.

As yet, there is no formal participation from industry in the current discussions of a Global Reference Architecture. In order to motivate and take advantage of commercial investments in space exploration, the development and scope of the architecture should be expanded to include the private sector.

Additional Findings

It was recognized that the space agencies involved in the Global Exploration Strategy discussions are considering a space agency coordination mechanism. In order for the database to be useful, the space agencies must "own" it, and such a coordination mechanism could be an appropriate home for the database. Since decisions on this are several months away, interest was expressed in maintaining the database until a coordination mechanism is in place.

While the primary purpose of the space exploration database is to facilitate the development of strategies and partnerships, consolidating space exploration plans and activities could be useful for other purposes. For example, other organizations such as universities and research institutes could use the database to guide their research and activities. Communication experts could use the database to promote space exploration. It can demonstrate the full breadth of interest in exploration around the world and the investments that other nations are making.

Finally, a lessons-learned archive that captures engineering and management experiences could provide a useful adjunct to the database.

Major Conclusions

The major conclusions reached at the Workshop can be summarized as follows:

- The value of the Workshop was the opportunity to address the utility of the SEDB and how it could be used, not the validation of the specific content or the improvement of its user friendliness.
- The value and usefulness of such a database to both government and industry was acknowledged.
- The use of the database to view and appreciate the overarching space exploration picture and develop strategies, including partnerships, was demonstrated.
- The activity was considered timely and supportive of ongoing government level discussions on space exploration.
- The overall database will need to contain separate government- and industry-developed components, while offering the capability to be viewed as a totality.
- Database development, to be fully effective, has to be owned by the stakeholders.
- Such a database is supportive to the development of a Global Reference Architecture.
- A Global Reference Architecture provides context for the evaluation of Gaps, Overlaps and Strategic Redundancies.
- A Global Reference Architecture will need to be both flexible and adaptable.
- Both the database and the Global Reference Architecture will evolve over time.
- There was a greater recognition of the private sector as real stakeholders. The Workshop furthered the dialogue between space agencies and companies on the potential for commercial participation in space exploration.

Annex A

The Space Exploration Database Explained

A copy of the Space Exploration Database (SEDB), as presented at the Opening Plenary of the Workshop, is included in this annex. It represents a proposal, on the part of the three principle organizers of the Seminar/Workshop initiative, of a way to capture and display the totality of the data available worldwide on space exploration objectives, plans and capabilities in a "user friendly" manner. The SEDB was developed using EXCEL. It is recognized that the approach adopted is not necessarily the only one that could be used but provides a means to display and evaluate the utility of such a database as a tool for exploration planners.

Following a review and categorization of the data obtained from the Seminar presentations made by numerous space agencies and industrial companies, it was decided to adopt a multi-tier approach to its organization (displayed in the Overall Topology chart) ensuring, where possible, traceability from one tier to the next. These tiers are:

- **Tier 0 (Exploration Drivers):** This tier summarizes the multitude of reasons different nations/space agencies have given for their interest in space exploration. As currently configured, it is limited to the fourteen agencies involved in an activity to develop a Global Exploration Strategy, some of whom (Color Coded in blue) have not yet been consulted in its development. It was recognized by the database developers that this represents an arbitrary limitation but, given the amount of time and effort available for the exercise, it was used to put a bound on the totality of the data to be addressed. Exploration Drivers have been sorted into five categories:
    - Fundamental
    - Scientific and Academic
    - Human
    - Infrastructure
    - Transportation

- **Tier 1 – Exploration Missions by Category:** This tier displays, in chronological order, the various exploration missions that are currently in operation or well along in their development (Green), planned (Yellow), or are under study (Red). In the first three charts, missions are classified into groupings that exhibit traceability by targeted body (Moon/Mars/Other), type (Robotic/Human) and mode of operation (Orbital/Surface). Charts 4 and 5, dealing with Habitats and Transportation respectively, adopt a somewhat different traceability.

- **Tier 2 – Specific Missions:** This tier provides, to the extent possible, information on the principal characteristics of the various missions identified in Tier 1. To date the Primary Mission Objectives of each mission have been listed, but an exercise to identify and eliminate the redundancy of objectives among missions (overlap) has not been undertaken. Certain portions of the tables have yet to be populated.

- **Tiers 3 and 4:** It was recognized by its developers that as the database evolved, the need for one or more additional tiers could become necessary. In fact, a case could be made for moving certain of the data categories in Tier 2 down to Tier 3; e.g. information on payload instruments cross-referenced to the data products they produce. The reference to Tiers 3 and 4 in the Overall Topology chart therefore appears as a placeholder.

In the EXCEL format, the SEDB contains numerous hypertext links that enable the user to track a particular mission or class of missions through the database.

It should be noted that due to the limited time available for the construction of the first version of the SEDB, certain data categories are duplicated (e.g. a number of references to "lunar topography" as a mission objective in Tier 2). Further effort is needed to review these categories in detail and remove as much duplication as possible.

Space Exploration Database: Global Drivers, Missions, Plans and Capabilities

Tier 0

Exploration Drivers (Objectives)

Fundamental | Scientific and Academic | Human | Infrastructure | Industrial

Tier 1

Exploration Missions by Category**

Moon | Mars | Other Bodies | Space Habitats* | Transportation*

*and Other Related Infrastructure

Tier 2

Specific Missions: Data

Moon				Mars				Other Bodies				Space Habitats*				Transportation*	
Robotic		Human		Robotic		Human		Robotic		Human		Leo		Moon		Cargo	Crew
Orbital	Surface	Orbital	Surface	Orbital	Surface	Orbital	Surface	Orbital	Surface	Orbital	Surface	Robotic	Human	Robotic	Human	Vehicle	Vehicle
4	1		1	3	5			7	1			1	3	0	0	16	3
4	5		0	1	2			0	0			0	0	0	0	7	2
2	3		3	4	2			4	3			0	2	3	2	1	4

Tier 3 ?

Tier 4 ?

* (green)	Flown/In Operation/Underdevelopment
* (yellow)	Planned
* (red)	Study /Concept
(blue)	No planned Missions at this time
**	Number in box indicates number of missions identified in the category in question

Tier 0 - Exploration Drivers (1)

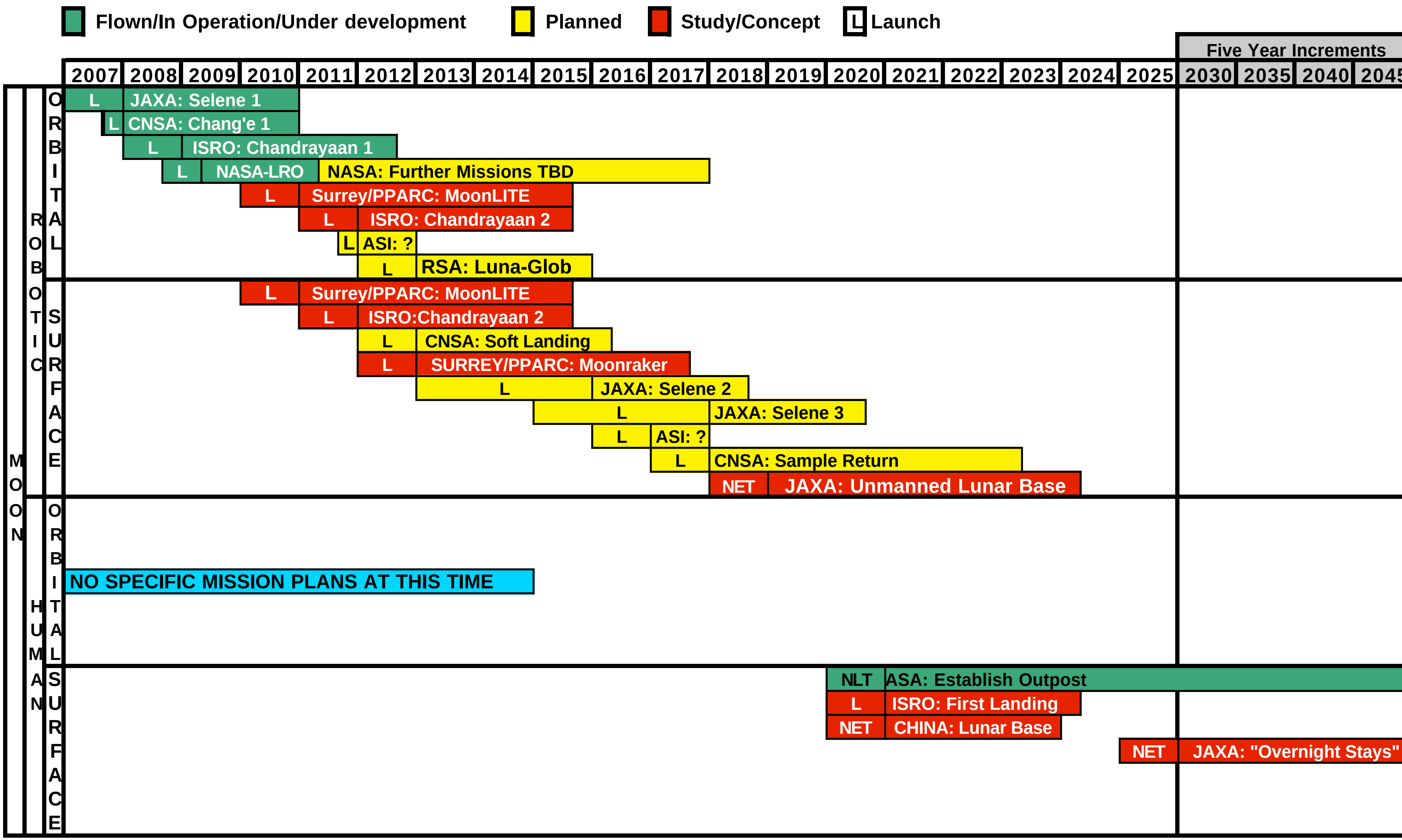
	Canada CSA	China CNSA	Europe ESA	France CNES	Germany DLR*	India ISRO	Italy ASI	Japan JAXA	Russia RSA	USA NASA	Australia CSIRO	S. Korea KARI	Ukraine NSAU	UK BNSC
Fundamental Objectives														
Exploration as a strategic priority in "nation's" space policy			x		x		x	x	x	x				
Moon and Mars two main targets			x		x		x	x		x				
Moon as stepping stone to Mars	x		x				x	x		x				
Moon as stepping stone to other solar system exploration		x						x		x				
Priority is set on Mars: Robotic			x	x	x		x		x	x				
Human (Mars Direct)														
Be active in other exploration areas			x		x		x	x	x	x				
Science as the driver (Quest for new knowledge)			x	x	x		x		x					
Seek for signs of extraterrestrial life	x		x				x		x					
Study and better understand Solar System and Universe	x	x	x				x	x	x	x				
Science driven-technology enabled human exploration of solar system	x	x					x	x	x					
Ensure continuous scientific access to space	x							x	x	x				
Promote Scientific excellence of PI's							x			x				
Develop and maintain science leadership	x				x		x							
Permanent presence on Moon offers new scientific perspectives			x	x			x	x	x	x				
Support demands from scientific community			x	x	x		x		x					
Establish and operate manned spaceflight system		x							x	x				
Ensure national human presence in space	x							x	x	x				
Prepare for permanent human presence in space and on planets	x							x	x	x				
Advance national excellence in certain fields			x		x		x		x	x				
Promote Industrial Know-how			x				x		x	x				
Economic Development and modernization		x	x		x				x					
Promote humankind's civilization and societal progress and benefit humankind		x	x						x					
Application of advanced technologies to the real problems of man and society			x		x	x								
Create a challenging environment to attract young engineers & scientists			x			x								
Enhancement of public interest, inspiration for young students			x	x				x		x				
Inherently International	x	x	x	x	x	x	x	x	x	x				
Contribute nationally in a significant manner			x				x	x	x	x				
Require independent "national" exploration plan	x	x	x	x	x	x	x	x	x	x				
Architecture Framework	x	x	In work				In work			x				
Roadmap	x	x	in work			x	In work	x	x	x				
Require independent autonomous multilateral exploration plans				x										
					*In Work									

Tier 0 - Exploration Drivers (2)

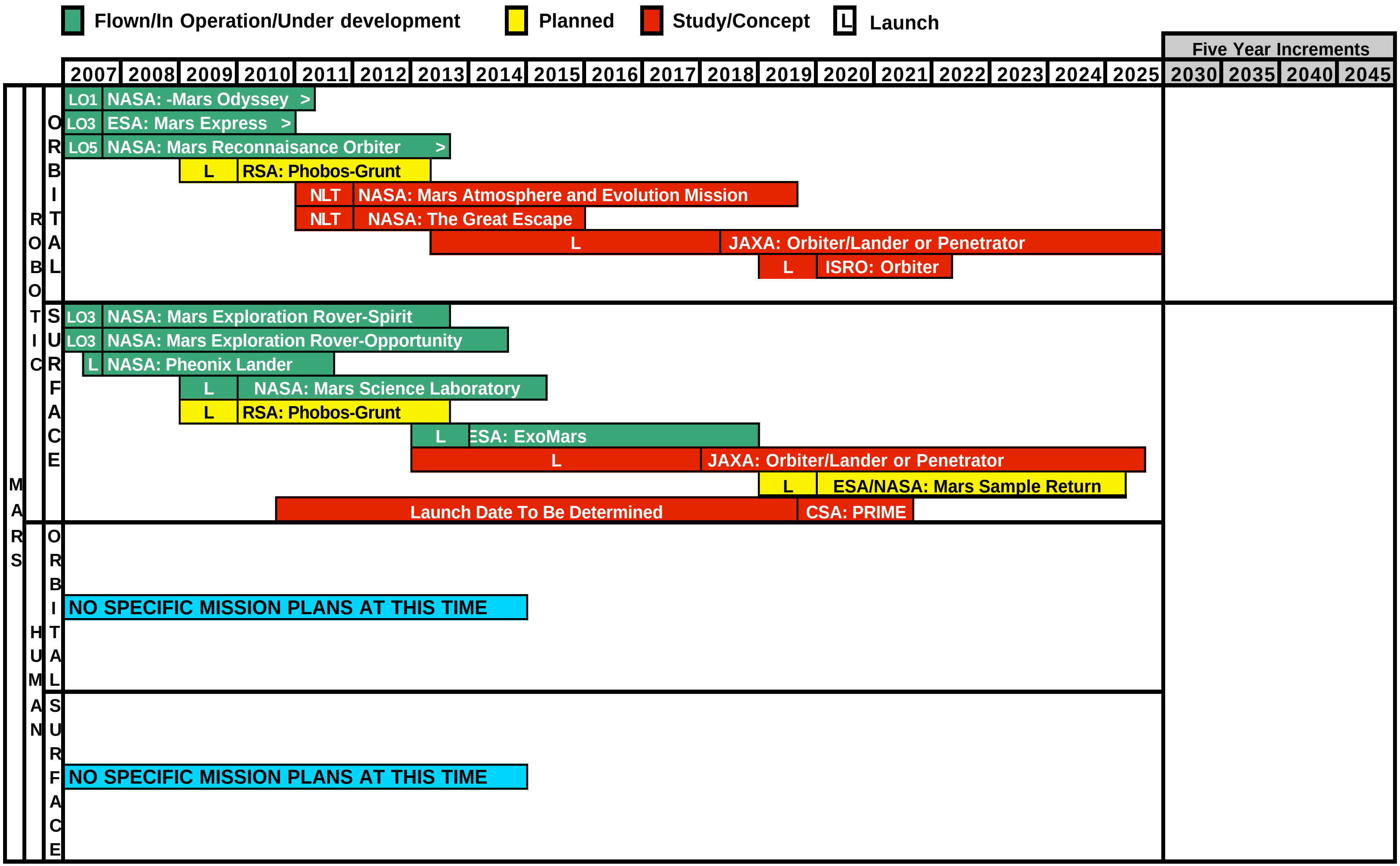
	Canada	China	Europe	France	Germany	India	Italy	Japan	Russia	USA	Australia	S. Korea	Ukraine	UK
	CSA	CHINA	ESA	CNES	DLR*	ISRO	ASI	JAXA	RSA	NASA	CSIRO	KARI	NSAU	BNSC
Scientific and Academic Objectives														
Solid Planetology	x		x	x	x		x		x					
Geology/Geoscience			x	x					x					
Atmospheric Sciences	x		x				x	x	x	x				
Material Science		x	x		x			x	x					
Life Science	x	x	x	x	x		x	x	x	x				
Space Environment		x	x				x		x	x				
Astronomy/Astrophysics		x	x	x	x		x		x	x				
Analogue Sites	x						x		x	x				
Increase National laboratories competencies				x			x		x					
Develop technologies for science or application programs		x	x	x			x	x	x	x				
Human Objectives:														
ISS Utilisation	x		x	x	x		x	x	x	x				
Astronaut Corps	x	x	x			x		x	x	x				
Advanced Robotic Assistance to Humans			x		x		x	x	x	x				
Manned spaceflight related scientific research & technology		x	x				x		x	x				
Infrastructure Objectives														
National Human Transportation Capability		x	(x)			x			x	x				
International Human Transportation Capability	x		x				x	x	x					
Robotic Transportation Capability		x	x	Via ESA	Via ESA	x	Via ESA	x	x	x				
Life support systems in support of long term exploration	x		x		x		x	x	x	x				
Surface Infrastructure	x						x	x	x	x				
Logistics Infrastructure			x				x	x	x	x				
Industrial Objectives:														
Establish a competitive national space industry base		x	x				x		x					
Support continuing competitiveness of national Industry			x	x	x		x		x					
Maintain national role in key technologies	x		x		x		x		x					
Achieve preferred supplier status	x													
Establish clear role(s) of national space companies				x					x					

*In Work

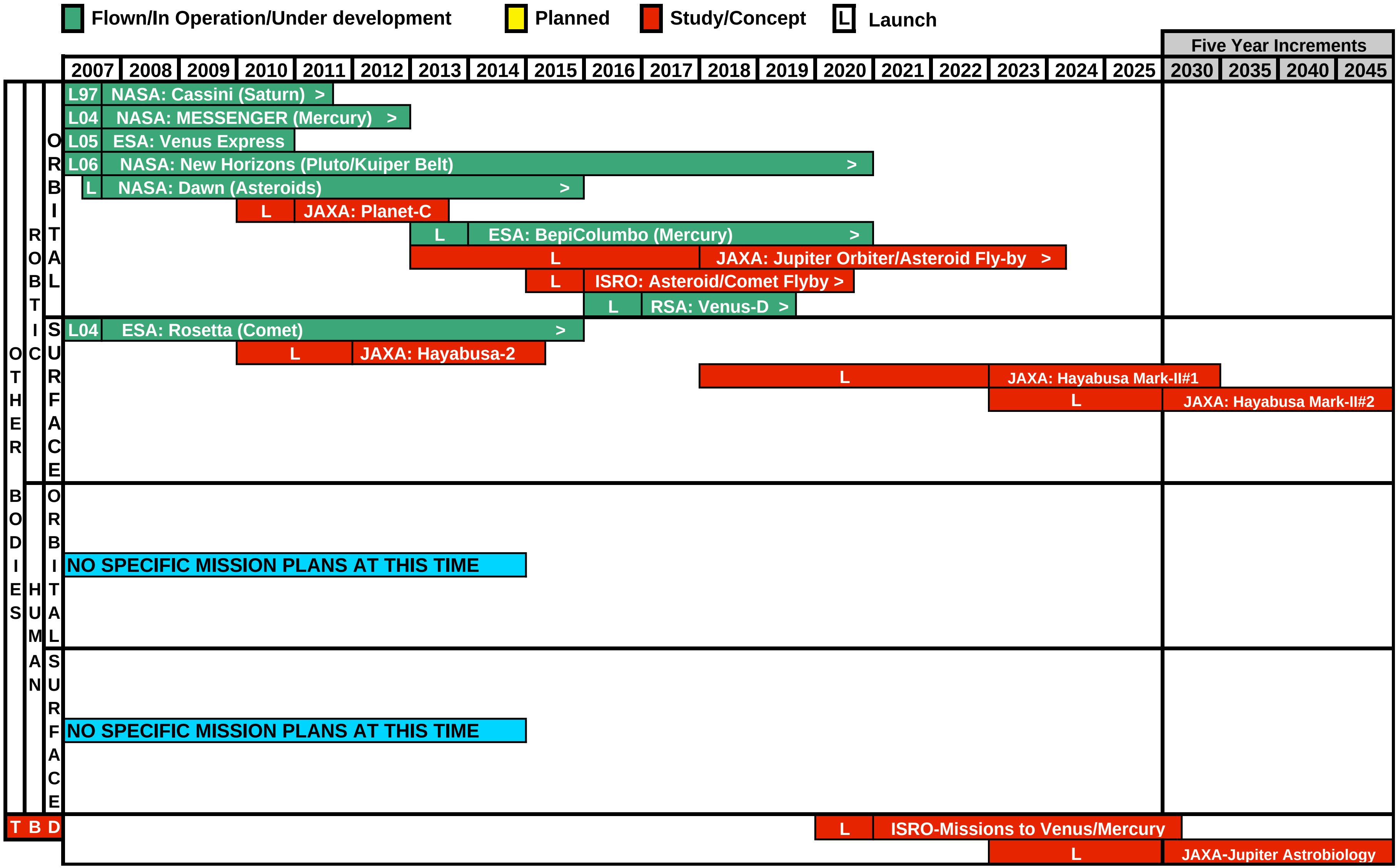
Tier 1 - Exploration "Missions" 1 - Moon



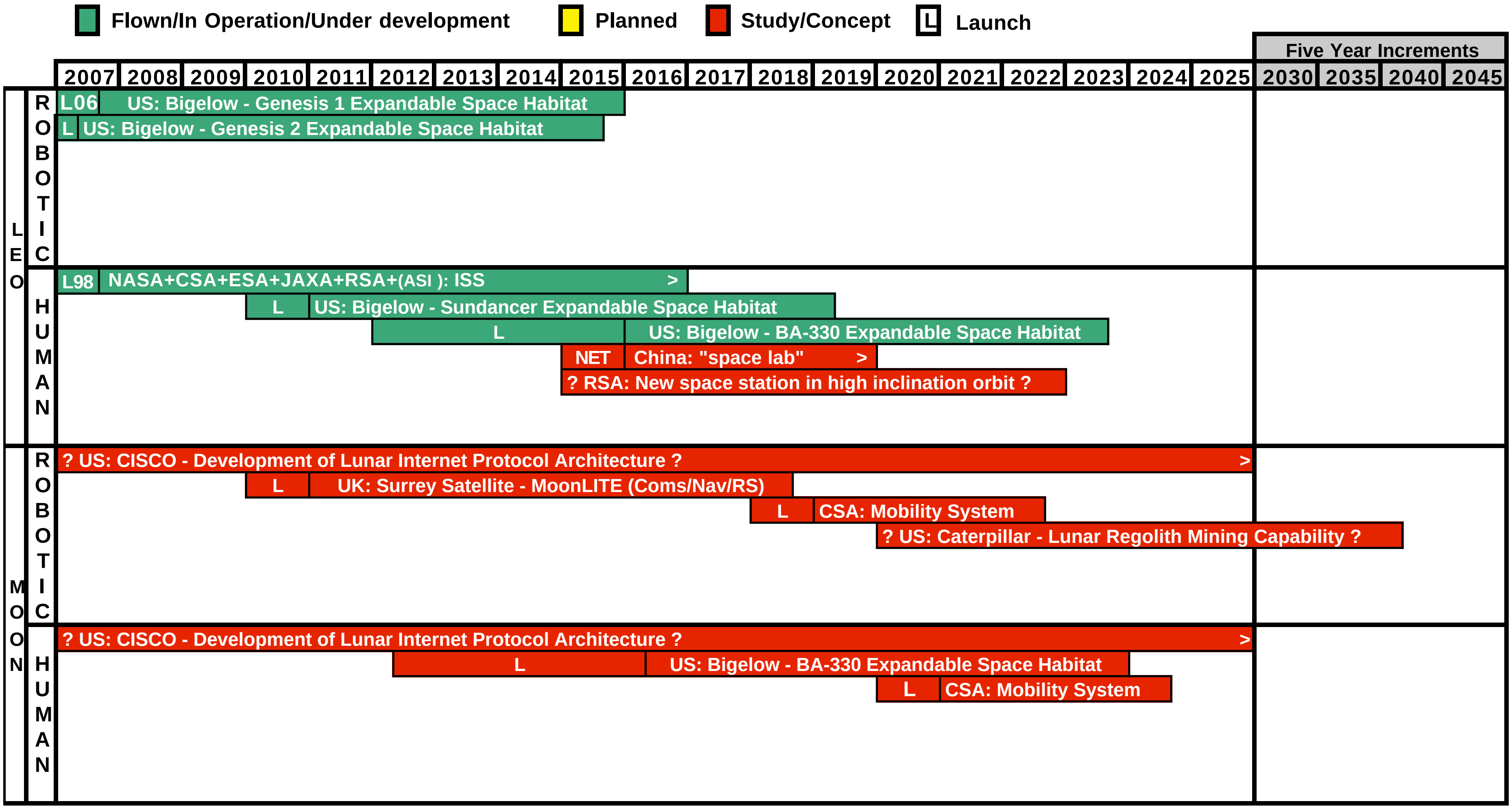
Tier 1 - Exploration "Missions" 2 - Mars



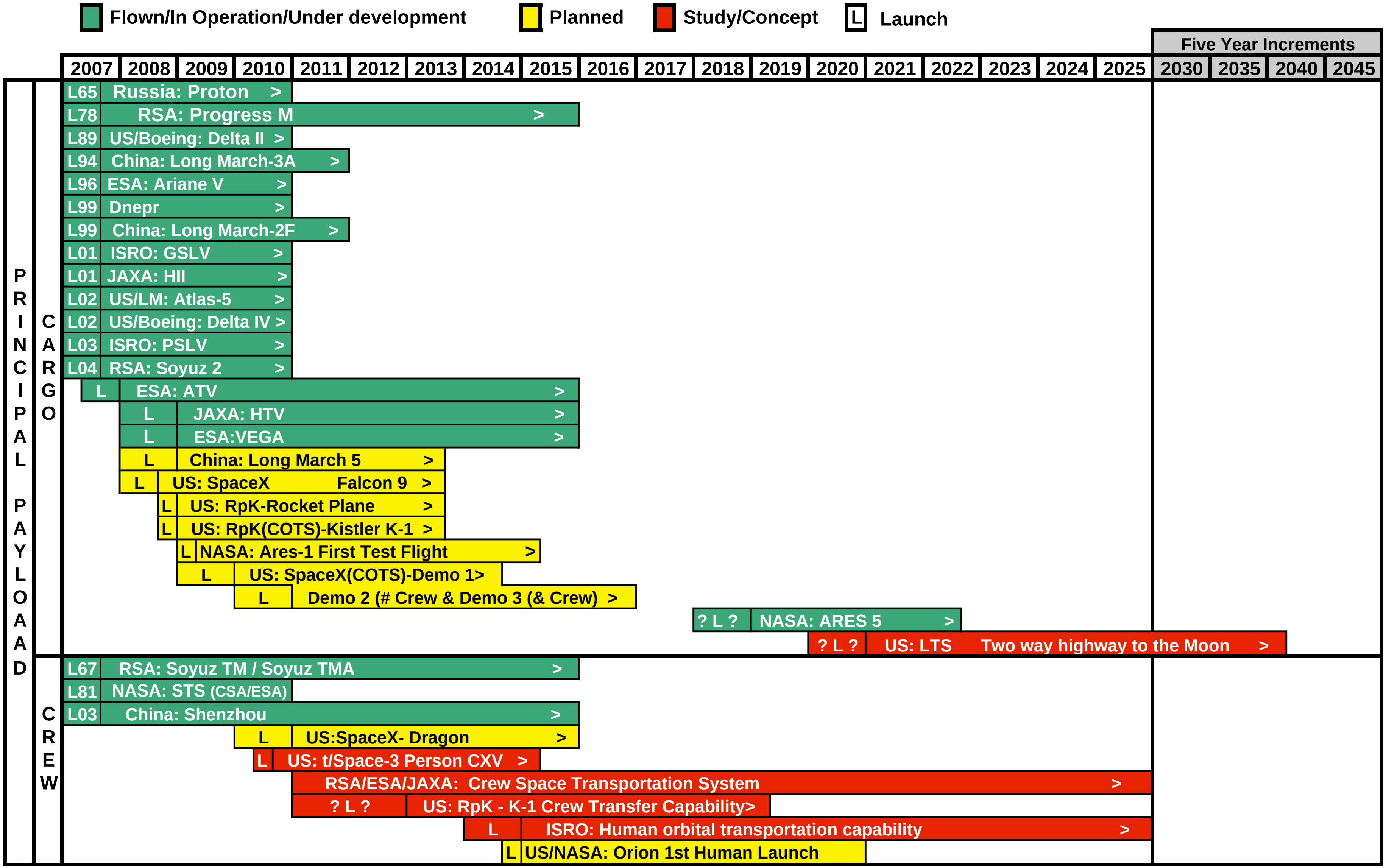
Tier 1 - Exploration "Missions" 3 - Other Bodies



Tier 1 - Exploration "Missions" 4 - Space "Habitats" and Related Infrastructure



Tier 1 - Exploration "Missions" 5 - Transportation and Related Infrastructure



Tier 2- Moon-Robotic-Orbital

Mission	Selene 1	Chang'e 1	Chandrayaan 1	LRO	MoonLITE	Chandrayaan 2	?	Luna-Glob	?	?	?
Country	Japan	China	India	USA	UK	India	Italy	Russia	USA	Europe	Germany
Space Agency	JAXA	CNSA	ISRO	NASA	PPARC/SURREY	ISRO	ASI	RSA ?	NASA	ESA	DLR
Mission Characteristics											
Launch Date	FY 07 ?	Late 07	07-08 ?	Late 2008 ?	2010	2011	late 2011	2012	?	?	?
Launch Vehicle	H-IIA	LM-3A	PSLV	Atlas V	"Indian Rocket" TBC	PSLV ?	Vega				
Lunar Orbit Insertion Date	?	Late 07	?	?							
Nominal Mission Life Months)	?	12	24	12							
Orbital Altitude (Km)	100x100	200 Circular	?	30-50 Circular			100 x 100				
Orbital Inclination (Degs)	90		Polar ?	Polar ?							
International Partners											
Japan					TBC			TBC			
Primary Mission Objectives											
Elemental Abundance	X						x				
Minerological Composition	X						x				
Topography	X										
Geology	X						x				
Gravity	X						x				
Lun/Sol/Terr Plasma Environ.	X										
3-D Map		X									
Soil Depth		X									
Helium 3 Abundance		X									
Earth-Moon Environment		X									
High Resolution Imaging			X				x				
Chemical Mapping			X				x				
Mineralogical Mapping			X								
Topographic Mapping			X								
Radiation in Lunar Orbit				X							
Geodetic Global Topography				X							
High Res. Hydrogen mapping				X							
Temp Mapping in Shadowed Polar Regions				X							
Surface Imaging in Permanently Shadowed Regions				X							
Near Surface Water Ice in Polar Cold Traps				X							
Assess Features of Landing Sites				X							
Characterizeation of Polar Region Lighting Environment				X							
Remote Sensing					X						
In-situ Geophysics					X						
In-situ Geochemistry					X						
Terrain Mapping						X					
Hyperspectral Imaging						X					
Internal Structure								X			
Natural Resources								X			
Influence of Electromag. Rad								X			
Primary Payload Instruments											
	14	23	11 ?	6							
Secondary Payload(s)											
	VLBI Radio Sat. Relay Satellite		Impactor Probe	LACROSS	Penetrators	Lander		12 Penetrators			
Data Products											
Other information											
Mission web site*	* Hypertext links										

Tier 2 - Moon-Robotic-Surface

Mission	?	Chandrayaan 2	Soft Landing	Moonraker	Selene 2	Selene 3	?	Sample Return	Unmanned Outpost
Country	U.S.A.	India	China	UK	Japan	Japan	Italy	China	Japan
Space Agency/Company	NASA	ISRO	CNSA	SURREY	JAXA	JAXA	ASI	CNSA	JAXA
Mission Characteristics									
Launch Date		2011	2012	2012	2013-2015	2015-2017	2016	2017	NET 2018
Launch Vehicle									
Orbit Arrival Date									
Landing Date									
Nominal Mission Life (Months)									
Location		South Pole (TBC)		Northern Near Side			tbc		
International Partners									
Primary Mission Objectives									
Origin and Evolution		X					x		
Test Magma Ocean Hypothesis		X					x		
Crystal Heterogeneity		X							
Chemistry and Composition		X							
Resources		X							
Crust and Mantle		X (Far Side)							
Geophysics				X			x		
Geochemistry				X			x		
Initial Science					X				
Moon Utilization					X				
Sample Return						TBC		X	
Primary Payload Instruments									
Secondary Payload(s)									
Lander				X					
Rover		X		X	X				
Penetrators		X							
Data Products									
Other information									
Mission web site*	* Hypertext links								

Tier 2 - Moon-Human-Surface

Mission	Outpost	First Landing	Permanent Base	Overnight Stays
Country	USA	India	China	Japan
Space Agency/Company	NASA	ISRO	CNSA	JAXA
Mission Characteristics				
Launch Date				
Launch Vehicle				
Landing Date				
Initial Capability Date	NLT 2020	2020	NET 2020	NET 2025
Nominal Mission Life (Months)				
Location	Lunar Polar Region			
International Partners				
Primary Mission Objectives				
Foothold to Further Exploration	X			
Unique Laboratory	X			
Science, Research & Technological Development	X		X	
Study Moon as Earth's Early History	X		X	
Study Earth-Moon System	X			
Platform for Observations of the Universe	X		X	
Extend Human Presence on the Moon	X			
Create Enduring ,Sustainable Robotic Presence	X			
Create Enduring, Sustainable Human Presence	X			
Extraction of Hydrogen and Other Volatiles	X			
Regolith Mining	X			
Expand Earth's Economic Sphere	X		X	
Search for Energy Sources (for Earth & Moon)	X		X	
Enhance Collective Security	X			
Engage, Inspire & Educate Public	X			
Base for Further Exploration		X	X	
"Mining"		X		
Primary Payload Instruments				
Secondary Payload(s)				
Data Products				
Other information				
Mission web site*	* Hypertext links			

Tier 2 - Mars-Robotic-Orbital

Mission	Mars Odyssey	Mars Express	MRO	Phobos-Grunt	MAVEN	The Great Escape	"Orbiter"	"Orbiter"	PRIME
Country	USA	Europe	USA	Russia	USA	USA	Japan	India	Canada
Space Agency	NASA	ESA	NASA	RSA ?	NASA	NASA	JAXA	ISRO	CSA
Mission Characteristics									
Launch Date	04.07.01	06.02.2003	08.12.05	2009	NLT 2011	NLT 2011	2013-2017	2019	TBD
Launch Vehicle	Delta II	Soyuz/Fregat	Atlas V	Soyuz					TBD
Mars Orbit Insertion Date	10.24.01	12.25.03	Mar-10						TBD
Nominal Mission Life (Months)	6					Thru 2014			TBD
Orbital Altitude (Km)			300x45,000	PHOBOS					PHOBOS
Orbital Inclination (Degs)		86		PHOBOS					PHOBOS
International Partners									
Primary Mission Objectives									
Determine if life ever existed	X								
Map Sub-Surface Water, Chemical Elements & Minerals)	x								
Characterize Climate	X								
(Map Chemical Elements & Minerals)	x								
Characterize Geology	X								
(Map Chemical Elements & Minerals)	x								
Prepare for Human Exploration	X								
(Analyze Radiation Environment)	x								
High Resolution Imagery of Entire surface (10m)		X							
Super High Resolution Imagery of Selected Areas (2m)		X							
Map Mineral Composition (100 m Resolution)		X							
Map Atmospheric Composition and Circulation		X							
Study Structure of Sub-Surface (Depth of a few Km)		X							
Study Effect of Atmosphere on Surface		X							
Study Interaction of Atmosphere with Solar Wind		X							
Characterize Present Climate			X						
Study Physical Mechanism of Seasonal and Interannual Climate Change			X						
Determine Nature of Complex Layered Terrain			X						
Identify Water Related landforms			X						
Search for Sites Showing Evidence of Aqueous a/o hydrothermal activity			X						
Identify and Characterize sites with highest Potential for Landed Science (Inc. Sample Return)			X						
Collect Soil Samples from Phobos and Return them to Earth				X					
In-situ and Remote Studies of Phobos (inc. Soil Samples)				X					
Monitor Atmospheric Behavior of Mars (Inc Dust Storm Dynamics)				X					
Study Vicinity of Mars (Plasma, Dust Components,Rad Environment)				X					
Aeronomy					X				
(Climate)					x				
(Dynamic Processes of Upper Atmosphere)					x				
(Dynamic Processes of Ionosphere)					x				
Aeronomy					X				
(Loss of Atmosphere)					x				
(Structure and Dynamics of Upper Atmosphere)					x				
(Potentially Biogenic Atmospheric Constituents)					x				
Study Atmosphere								X	
Study Weather								X	
Study Solar Wind Interactions								X	
Study Magnetic Fields								X	
Study Plasma Environment								X	
Surface Mapping of Phobos									X
Studies of "Phobos Monolith"									X
Primary Payload Instruments									
Secondary Payload(s)									
Communications Relay	Mars Exp. Rovers		X						
Penetrators							?		
Lander		Beagle 2			PHOBOS		?		PHOBOS
Data Products									
Other information									
Mission web site*	* Hypertext links								

Tier 2 - Mars-Robitic-Surface

Mission	Rover - Spirit	Rover - Opportunity	Pheonix Lander	Mars Science Laboratory	ExoMars	Lander/Penetrators	Mars Sample Return
Country	U.S.A.	U.S.A.	U.S.A.	U.S.A	Europe	Japan	Europe/USA
Space Agency	NASA	NASA	NASA	NASA	ESA	JAXA	ESA/NASA
Mission Characteristics							
Launch Date	06.10.03	07.07.03	08.03.07	Fall 09	Apr-17	2013-2017	2019
Launch Vehicle	Delta II	Delta II	Delta 2925	Delta IV/Atlas 5	Soyuz OR Arine V		
Orbit Arrival Date					Mar-19		
Landing Date	01.03.04	01.24.04	May-12	Oct-14	2014		
Nominal Mission Life (Months)	3	3		2 Martian Years	L-6 Yrs/R-6 Mnths		
Location	Gusev Crater	Meridiani Planum	N. Polar Region		Between 15S & 45N		
International Partners							
CSA				X	X		
RSA				X			
Spain (Ministry of Education and Science)				X			
NASA					X		
Primary Mission Objectives							
Minerology, Texture & Structure of Local Terrain	X	X					
Temperature Profiles of Martian Atmosphere	X	X					
Minerology of Iron Bearing Rocks and Soils	X	X					
Abundance of Elements in Rocks and Soils	X	X					
Highr Resolution Imagery of Rocks and Soils	X	X					
Study the History of Water on Mars			X				
Search for Clues to the Origin of Ice			x				
Search for Evidence of Past Liquid Water			x				
Describe Mars Polar Climate			x				
Search for Habitable Zones			X				
Describe Mars Polar Climate			x				
Identify Possible Energy Source for Life			x				
Determine if Martian Dirt is Hostile to Life			x				
Biology				X			
Nature and Inventory of Organic Carbon Compounds				x			
Inventory of Chemical Building Blocks of Life				x			
Identify Features that may represent the Effects of Biological Processes				x			
Geological And Geochemical				X			
Investigate Chemical, Isotopic & Minerological Composition of Surface				x			
Investigate Chemical, Isotopic & Minerological Composition of Near-Surface				x			
Interpret Process that formed & modified Rocks and Soils				x			
Planetary Process				X			
Assess Long-Timescale (4 Billion Years atmospheric Evolution Processes)				x			
Determine Present State, Distribution & cycling of Water and Carbon Dioxide				x			
Surface Radiation				X			
Characterise Broad Spectrum of Surface Radiation				x			
Biological Environment of Surface					X		
Search for Possible Life, Past and Present					X		
Characterisation of Geochemistry & Water Distribution					X		
Identification of Possible Surface Hazards for Future Human Missions					X		
Improve Knowledge of Environment and Geophysics					X		
Primary Payload Instruments							
Secondary Payload(s)							
Mini-Rover							
Data Relay (Orbiting Carrier Spacecraft)					X		
Data Products							
Other information							
Mission web site*	* Hypertext links						

Tier 2 - Other Bodies-Robotic-Orbital/Fly-by

Mission	Cassini	Messenger	Venus Express	New Horizons	Dawn	Planet-C	BepiColumbo	J Orbiter/A Fly-by	Fly-by	Venus-D	Jupiter
Country	USA	USA	Europe	USA	USA	Japan	Europe	Japan	India	Russia	Japan
Space Agency	NASA	NASA	ESA	NASA	NASA	JAXA	ESA	JAXA	ISRO	RSA ?	JAXA
Mission Characteristics											
Launch Date	10.15.97	08.03.04	11.09.05	01.19.06	Jun / Jul 07	2010	2013	2013-2017	2015	2016	2023 -2027
Launch Vehicle	Titan IV/B-Centaur		Soyuz / Fregat	Atlas V	Delta II		Soyuz / Fregat			Soyuz (TBC)	
Other Body(s)	Saturn	Mercury	Venus	Pluto/Kuiper Belt	Asteroids	Venus	Mercury	Jupiter/Asteroids	Asteroid/Comet	Venus	Jupiter
Orbit Insertion Date	Jul-08	03.18.11	May-10								
Fly-By				July 2015 (Pluto)							
Encounters				2016-2020 (K.B.)							
Nominal Mission Life (Months)	48 (at Saturn)		16+				2020				
Orbital Altitude (Km)				24 hr elliptical		300 x 60,000					
Orbital Inclination (Degs)				Quasi Polar							
International Partners											
NASA			X								
Japan							X				
ESA	X										
DLR					X						
ASI	X				X						
Primary Mission Objectives											
Terrestrial Planet Evolution	X	X			X	X					
Saturn	X										
In depth study of planet	x										
In depth study of its moon Titan	x										
Study of other moons	x										
Study of Rings	x										
Study of Magnetic Environment	x										
Mercury		X					X				
(Reason(s) for high density)		x									
(Geological History)		x									
(Structure of Core)		x									
(Nature of Magnetic Field)		x									
(Materials at Poles)		x									
(Study of Volatiles		x									
(Study magnetosphere)							x				
(Composition)							x				
(Geophysics)							x				
(Atmosphere)							x				
(History)							x				
Venus			X			X				X	
(Global Evolution of Atmosphere)			x								
(Atmosphere / Surface Interaction)			x								
(Atmosphere/ Interplan.etary Env. Interaction)			x								
(Meteorological Phenomena)						x					
(Surface Observations)						x				x	
(Atmospheric Particles Escaping to Space)						x					
(Observe Storm Winds)						x					
(Confirm Active Volcanos and Thunder)						x					
(Seismic Activity)										x	
(Chemical Composition of Atmosphere)										x	
Pluto and its moon Charon				X							
(Map Surface Composition)				x							
(Characterize Geology and Morphology)				x							
(Characterize Pluto's Neutral Atmosphere)				x							
(Search for Charon Atmosphere)				x							
(Map Surface Temeratures)				x							
(Search for Plutonian Rings)				x							
(Search for Additional Satellites)				x							
Kuiper Belt				X							
(Similar Investigations to Pluto & Charon)				x							
Asteroid					X			X	X		
(Evolution)					x						
1 Ceres / 4 Vesta					X						
(Internal Sturcture, Density, Homogeneity)					x						
(Shape, Size, Composition, Mass,Spin)					x						
(Surface Morphology and Cratering)					x						
(Thermal History and Size of Core)					x						
(Role of Water)					x						
Jupiter								X			X
(Astrobiology)											x
Comet									X		
Primary Payload Instruments											
Secondary Payload(s)											
Probe/Lander	Huygens / Titan										
Relay	X										
Data Products											
Other information											
Mission web site*	* Hypertext links										

Tier 2 - Other Bodies-Robotic-Surface				
Mission	Rosetta	Hayabusa-2	Hayabusa Mark-II#1	Hayabusa Mark-II#2
Country	Europe	Japan	Japan	Japan
Space Agency	ESA	JAXA	JAXA	JAXA
Mission Characteristics				
Launch Date	03.02.04	2010-2011	2018-2022 or earlier	2023-2027
Launch Vehicle	Ariane 5G			
Other Body(s)	Comet / Asteroid	NEO	Extinct Comet	Primative Body
Orbit Insertion Date	? (Comet)			
Nominal Mission Life (Months)	EOM 2015			
Orbital Altitude (Km)				
Orbital Inclination (Degs)				
International Partners				
Primary Mission Objectives				
Comets	X		X	
(Study Origin)	x			
(Relationship with Interstellar Material)	x			
(Implications with Regard to Origin of the Solar System)	x			
(Sample Return)			x	
Asteroids	X	X		
(Global Characterization)	x			
(Sample Return)		x		
Primitive Body				X
(Sample Return)				x
Primary Payload Instruments				
Secondary Payload(s)				
Lander	X			
Data Products				
Other information				
Mission web site*	* Hypertext links			

Tier 2 - "Habitats" & Related Infrastructure-LEO-Robotic

"Mission"	Genesis-2
Country	USA
Space Agency/Company	Bigelow
Mission Characteristics	
Launch Date	Around 1 April 2007
Launch Vehicle	Dnepr
Initial Capability Date	1st Quarter 2007
Nominal Mission Life (Months)	
Orbital Altitude (Km)	
Orbital Inclination (Degs)	
International Partners	
Primary Mission Objectives	
Habitat Demonstration	X
Microgravity R&D	X
Pharmaceutical/Biotech	X
Advanced Materials	X
Primary Payload Instruments	
Secondary Payload(s)	
Data Products	
Other information	
Mission web site*	* Hypertext links

Tier 2 - "Habitats" & Related Infrastructure-LEO-Human

"Mission"	ISS	Sundancer	BA-330	"Space-lab"	New Space Station
Country	Int'l Partnership	USA	USA	China	Russia
Space Agency/Company	Int'l Partnership	Bigelow	Bigelow	? CNSA ?	RSA
Mission Characteristics					
Launch Date	1998 (FEL)	2010	2012-2015	NLT 2015	TBD (Post 2014)
Launch Vehicle					
Initial Capability Date	2000 (Perm Occ)	2010	2012-2015		
Nominal Mission Life (Months)	TBD				
Orbital Altitude (Km)					
Orbital Inclination (Degs)	57				70
International Partners					
Primary Mission Objectives					
Support Space Exploration Goals	X				
Human Research & Countermeasure Development	X				
(Health)	x				
(Human Behavior)	x				
(Human Performance)	x				
(Radiation Studies)	x				
Physical Sciences	X				
Biological Sciences	X				
Technology Development	X				
Observation of the Earth	X				
Habitat Demonstration	X	X	X		
Microgravity R&D	X	X	X		
Pharmaceutical/Biotech	X	X	X		
Advanced Materials	X	X	X		
Human Habitat	X	X	X		
Scientific R&T	X			X	
Primary Payload Instruments					
Secondary Payload(s)					
Data Products					
Other information					
Mission web site*	* Hypertext links				

Perm Occ: Permanent Occupancy

Tier 2 - "Habitats" & Related Infrastructure-Moon-Robotic

"Mission"	Lunar IP Arch.	MoonLITE	Mobility System	Mining
Country	USA	UK	Canada	USA
Space Agency/Company	Cisco	SURREY	CSA	Caterpillar
Mission Characteristics				
Launch Date		2010		
Launch Vehicle				
Initial Capability Date	? 2008 ?		2018	? 2020 ?
Nominal Mission Life (Months)				
Orbital Altitude (Km)				
Orbital Inclination (Degs)		Polar		
Surface Location			TBD	TBD
International Partners				
Primary Mission Objectives				
Communications	X	X		
Navigation		X		
Mining Regolith				X
Primary Payload				
Secondary Payload(s)				
Penetrators		Near/Far Side		
Data Products				
Other information				
Mission web site*	* Hypertext links			

Tier 2 - "Habitats" & Related Infrastructure-Moon-Human

"Mission"	Lunar IP Arch.	BA-330	Mobility System
Country	USA	USA	Canada
Space Agency/Company	Cisco	Bigelow	CSA
Mission Characteristics			
Launch Date			
Launch Vehicle			
Initial Capability Date	? 2008 ?	TBD	2020
Nominal Mission Life (Months)			
Orbital Altitude (Km)			
Orbital Inclination (Degs)			
Surface Location			TBD
International Partners			
Primary Mission Objectives			
Communications	X		
Human Habitat		X	
Primary Payload			
Secondary Payload(s)			
Penetrators		Near/Far Side	
Data Products			
Other information			
Mission web site*	* Hypertext links		

Tier 2 - Transportation & Related Infrastructure	Country	Agency	Company	Operational	"Destination"					
					LEO	LEO to LEO	GTO	Moon	Mars	"Beyond"
Vehicle - Cargo										
Proton	Russia			Y	X		X (K)			
Progress M	Russia	RSA		Y		X				
Delta II	USA		Boeing	Y	X				X	
Long March-2F	China			Y	X		X			
Long March-3A	China			Y	X		X	X		
Ariane V	Europe	ESA	Arianespace	Y	X		X		X	X (G)
Dnepr	Russia		ISC Kosmotras		X					
GSLV	India	ISRO		Y	X		X			
H IIA	Japan	JAXA		Y	X		X	X		
Atlas 5	USA		Lockheed Martin	Y	X		X	X	?	X
Delta IV	USA		Boeing	Y	X		X	?	X	?
PSLV	India	ISRO		Y	X			X		
Soyuz 2	Russia			Y	X				X (Fregat)	X (Fregat)
ATV	Europe	ESA		Y		X				
HTV	Japan	JAXA		Y		X				
VEGA	Europe	ESA		2008	X			X		
China Long March 5	China			2008	X		X	X		
Falcon 9	USA		SpaceX	2008	X		X			
Rocket Plane	USA		Kistler	2008	X					
Kistler K1(COTS)	USA		Kistler	2008	X					
SpaceX (COTS)	USA		SpaceX	2009	X					
ARES 1	USA	NASA		2012	X					
ARES 5	USA	NASA		?	X			X		
Two way Highway to the Moon	USA		LTS*	NEL 2020	X			X		
New Generation Launchers	China			?	X		X			
Vehicle - Crew										
Soyuz TM / Soyuz TMA	Russia			Y	X	X				
STS (Shuttle)	USA	NASA		Y	X	X				
Shenzou	China			Y	X	X				
Dragon	USA		SpaceX	2010	X	X				
3 Person CXV	USA		t/Space	2010	X	X		X		
Crew Space Transportation System	Interenational	RSA/ESA/JAXA		NEL 2011	X	X				
K-1 Crew Transfer Capability	USA		Kistler	2011-12	X	X		X		
Human Orbital Transportation Cap.	India	ISRO		2014	X	X				
Orion	USA	NASA		2014 (FHL)	X	X		X		

* Lunar Transportation System

Tier 3 / Tier 4 Potential Content

Tier 3:

- Payload Instruments (cross referenced to goals and objectives)
- Data Access Policy (Agency / Mission / Instruments)
- Scientific Data versus Operational Planning Data
- Indication of “Search for Partners”
- Other - TBD

Tier 4:

- Systems Development
- Sensor Development
- Technology Development
- Other - TBD

Acronyms

ASI	Agencia Spaziale Italiana (Italian Space Agency)
Bigelow	Bigelow Aerospace
BNSC	British National Space Centre
CISCO	CISCO Systems Inc.
CNES	Centre National D'Etudes Spatiales
CNSA	China National Space Administration (Chinese Space Agency)
COTS	Commercial Orbital Transportation Services
CSA	Canadian Space agency
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DLR	Deutsches Zentrum fur Luft und Raumfahrt (German Aerospace Center)
EOM	End of Mission
ESA	European Space Agency
IP	Internet Protocol
ISRO	Indian Space Research Organization
ISS	International Space Station
JAXA	Japan Aerospace Exploration Agency
LRO	Lunar Reconaissance Orbiter
LTS	Lunar Transportation Systems Inc.
MAVEN	Mars Atmosphere and Volatile Evolution Mission
MRO	Mars Robotic Orbiter
NASA	National Aeronautics and Space Administration
NET	No Earlier Than
NLT	No Later Than
RSA	Russian Space Agency
PPARC	Particle Physics & Astronomy Research Council
SpaceX	Space Exploration Technologies
STS	Space Transportation System
Surrey	Surrey Satellite Technology Ltd
TBC	To Be Confirmed
TBD	To Be Determined
t/Space	Transformational Space Corp.

Annex B

Other Recommendations Made and Issues Raised Concerning the SEDB

In the course of discussions that took place in the opening and closing plenaries and during working group deliberations, a number of recommendations were made and issues raised relating to the manner in which the SEDB had been structured. These recommendations and issues have been summarized below. They only apply to the government database. The industry database would be the subject of a separate development as described in the main body of this report. In the event that further development of the database is undertaken, these recommendations will each need to be evaluated on their own merit and on the way they could impact each other and other aspects of the database before they could be adopted. Where possible, the authors have grouped the recommendations in relation to the manner in which they would impact the database topology.

General

Overall Content:

- Provide clear "traceability" with respect to the "heritage" of the data.
- Provide an indication as to how and when the data was last updated.
- If the data comes from a non-agency source, this must be indicated.
- Should ideas that get studied and dropped be kept in the database?
- Should data on failed missions be included?
- 2007 is an acceptable starting point. Earlier not necessary.
- The current "data volume" may be too large. Perhaps it would be better to focus on the Moon, Mars and Near-Earth Objects.
- Consider focusing on activities primarily directed to human exploration.

Operation / Maintenance / Updating:

- Agency Point of Contact information should not appear in the database if publicly available.
- It will be necessary to decide criteria as to when to drop missions from the database.
- It will be necessary to decide on the rate at which data must be updated (e.g. quarterly/annually). This may vary from tier to tier.
- To ensure quality and timeliness, one must establish "sunset clauses" on database entries.
- From a user standpoint, the database should be "read only."
- There is a need to develop a mechanism to enable the public to interact with the database, but, in structuring the database, remember that the public is a user, not the driver.
- Once the database is in use, it will be necessary to be prepared to change not only its content but its structure if experience shows ways in which it can be made more user-friendly.
- Criteria must be established as to when to remove missions from the database.

- A mechanism must be developed for all involved parties to agree on changes to/ extensions of database.
- The correct database format should allow for sorting information as required (e.g. science goals/timelines/etc)

SEDB Topology

General:

- Structure the database along the lines of : Tier 0: Themes (destination related) / Tier 1: Specific Objectives / Tier 2: Missions that attempt to meet Specific Objectives / Tier 3: Capabilities
- Structure the database along the lines of: Tier 0: Objectives / Tier 1: Architecture / Tier 2 Missions / Tier 3: Capabilities -Technologies.
- Technologies/instruments/sensors (Tier 3 a/o 4) should have traceability to Objectives. (Flow Theme to Objective to Mission to Instrument).

Tier 0:

- Structure Tier 0 as a function of "destinations", thus increasing traceability to subsequent tiers, as:
    - Fundamental Objectives
    - Lunar Objectives:
        - Science
        - Human
        - Infrastructure
        - Industrial
    - Mars Objectives:
        - Same
    - Other Bodies
        - Same
- A disconnect exists in traceability from Tier 0 to lower Tiers. Traceability is needed from Tier 0 to higher level mission objectives in Tier 2
- Add two columns, one for non-profits and one for commercial entities (Generic only: no naming of specific organizations).
- Examine the commonality between currently identified Tier 0 drivers and those defined in NASA planning.
- Consider scrubbing the objectives as listed to make them higher level (e.g. in GES development 180 lunar objectives were sorted into 40 categories)
- Is it possible to provide an indication of the certainty in objectives?
- Is it possible to include an industrial capabilities list?
- Indicate those agencies that are looking for others with "shared purposes".

Tier 1:

- Yellow and red categories offer the most flexibility in terms of assessing the possibilities for international cooperation.
- Consider further "color coding" in this and subsequent tiers (has to pass agency filter) as:

        - In operation (Flying)
        - Under development (Phase C/D)
        - Planned (Phases B and A)
- No Phase 0 missions. Start with Phase A
- Yellow - Pre Phase A
- Clarification of which missions are "pretty definite" and which are not.
- Have to decide where to draw the line between "study" and "planned." It is sometimes hard to draw a distinction between the two.
- Yellow category provides potential PI's with an indication of flight opportunities.
- Consider Communications and Navigation as a separate Tier 1 category, and the consequent "flow-down" to subsequent tiers.
- Consider revision to highlight government/industry connections (e.g. merge Moon government missions and industry lunar plans – habitats)
- Should there be a distinction between Moon and space habitats and related infrastructure for the Moon?
- Consider time phasing of lunar objectives.
- Should data from failed missions be included here and in subsequent tiers?
- Hyperlinks from this tier to web sites.
- Include NASA objectives for the Moon.

Tier 2

- Identify if a mission is open to international cooperation.
- Include possibility to "click" on a mission name to go to a few page mission summary (web site?).
- Consider the inclusion of a status bar under mission characteristics.
- Include status field category (e.g. one out of nine studies, Phase B, etc) Include a "ballpark cost" of each mission.
- Provide information on:
    - Satellite class – Nanosat / Microsat / Bigsat / etc
    - Interoperability standards
    - Orbit parameters
    - Foreseen data rates
    - Data policy (by agency / mission / instruments?). This could include:
        - What data, if any, is available?
        - Available at what cost?
        - Not available
        - Can be traded
        - Clarification with respect to Science data versus Operational data
- Yellow category should include data that could promote interoperability discussions.
- Indicate whether mission is open to foreign user interest.
- Indicate payload capacity to be made available for sensors from other agencies.
- Keep open the possibility of including new fields if needed, and agreed by all contributors.

Tier 3 and/or 4:

- Include agencies activities focused on technology, sensor development, etc that do not have designated missions - particularly for agencies that do not fly missions but only instruments aboard other countries missions.
- Be open to incorporating data on other technology capabilities / sensors / experiment / "rides."
- Include stand-alone capabilities not tied to specific missions
- Include technology capabilities that may have been developed for other missions.
- Focus on system and subsystem level - basically payload.
- Evaluate the inclusion of information on data products cross referenced to payload instruments and mission objectives.
- Consider possibility of principle investigator for a specific mission posting link to his / her own page.
- Tier does not have to be homogeneous as regards data.

Annex C

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Key

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WGCC	**Working Group Co-Chair**
WGC	**Chair, Ad-hoc Industry WG**
R	**Rapporteur**
RA	**Report Author**
ER	**Editorial Reviewer**