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INTERNATIONAL AEROSPACEPLANE EFFORTS

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ABSTRACT

Although the U.S. began the reusable space booster effort first in the late 1950's, we no longer have an exclusive field. All the technologically advanced nations, and several groups of nations, have one or more reusable booster efforts in progress. Table 1 gives some suggestion of the number of entries in the field. The list is somewhat misleading,because it includes both fully reusable and partially reusable boosters, both manned and unmanned, and both flight test and operational proposals. Also, not all are funded, and only a few will survive. Let's look at the more likely candidates, country by country.

FRANCE/ESA: Probably the first foreign competitor to become operational will be the French Hermes, funded by European Space Agency (ESA). Hermes (Figure 1) is a mini-shuttle, to deliver 3 men and about 3,000 lbs of payload to the Columbus Space Station, and serve as a back-up to our Shuttle. Initially launched on an expendable Arien 5 booster, it should cost much less than a shuttle launch, because of the small size, and the low costs of the Arien 5.

Hermes is funded by ESA for $4.5 B, and scheduled to fly in 1999. Most European nations are participating. It is in final design, and fabrication could begin as soon as 1993. The design is generally low technological risk, although monolithic SiC/SiC is under consideration for the lower heat shield.

Later plans would mate the Hermes to the "Star" reusable booster. The lower stage is a Mach 6 air-breather, with the Hermes and an expendable upper stage nestled in the upper surface. There also are designs and plans for full Aerospaceplanes after the year 2000.

GERMANY/ESA: The system most likely to follow the Hermes is the German Sanger design, (Figure 2) a two stage, fully reusable booster, that has been in design and technology development since 1987. The lower stage would be a Mach 6 hydrogen-fueled turboramjet, that could later be converted to a hypersonic transport design. There are to be two reusable rocket upper stages , CARGUS, a 17,000 lb. payload cargo carrier, and HORUS, with identical mold lines, for personnel deliveries. The lower stage supersonic cruise capability will allow offset launches over the Equator or the Indian Ocean from bases in Europe.

A lower stage flight test vehicle, the "HYTEX" will be flown first.The technical risk on Sanger should be reduced by these flight tests. The regeneratively cooled turboramjet development will be difficult, but test engines have been running for about 4 years now.
In the vehicle, they plan extensive use of Li/Al, Gr/Ep, and SiC/C, but no Ti/Al components. The mass fraction demands should not be excessive with two stages.

The Sanger is in Phase 1b design, with over $1 B funding to date. It's fate depends upon eventual ESA funding to a total estimated at $12 B. There are funding problems, resulting from Germany's expensive rescue of East Germany, and from overruns of Hermes. Meanwhile, Germany is building political support for Sanger by negotiating subcontracts with practically all members of the European Community.

GREAT BRITAIN/ESA(/USSR): The initial British candidate was the HOTOL. This was a single stage-to-orbit, unmanned vehicle, with air-breathing engines convertible to rocket operation. The engine was a hydrogen fueled, pre-cooled air turborocket, of unspecified variety, by Rolls-Royce. The elimination of the pilots, and some other design choices, may have made single stage performance possible,

The technical risk was considered higher than the Sanger, although the engines might have been easier because of the precooling. The British were unable to fund it heavily, and it appeared to be losing the competition with Sanger for ESA funding.

At this point, in 1989, the Soviets made a dramatic proposal; mount your Hotol on the back of our Anatov 225 and we'll launch it at Mach 0.8 and 30,000 ft. The Anatov is the world's largest transport (Figure 3, with the HOTOL), and will lift at least 550,000 lb externally. It has structural hard points for such external payloads, and twin tails to provide launch clearance. The Soviets added an offer to provide operating Lacerocket engines for the HOTOL, and high temperature parts made of Ti/AL, C/SiC, and other materials wherever they will improve the HOTOL. They might buy Rolls-Royce turbo-fans to increase the lift capability. A year and a half of design studies resulted in a proposal to ESA last year. The present design replaces the HOTOL air-breathers with very high performance Soviet rockets, and increases the GLOW to use the Anatov's maximum.

The Soviet capability in materials and engines that is now becoming more visible is outstanding. And the fact that the lower stage of this system is already operational, and much of the engine development work is done, could lead to a very low cost reusable booster solution.

If the ESA decision is delayed a year or two, this proposal might seriously challenge the Sanger. Questions such as the former USSR's economic and political condition, and their relation to the European Community, will be at issue.

USSR (PAST): The capability and past attainments of the former USSR suggest a large international role for them in the future, when their political and economic problems are under control. Paul Czysz may have covered these matters before this presentation, so we'll only review here.

They flight tested LAPOT and other lifting body reentry vehicles like our X-20 in the 1960's. Their "50/50" TSTO design looked almost identical to the French "Star", but the lower stage is said to have flown to Mach 6 in 1975. They flew the Buran Shuttle unmanned in 1989, but may never bother to man it. Stage recovery capabilities are incorporated in the huge Energia booster, but may or may not be implemented.

They have been operating LACE engines on the test stand since 1975. Their high temperature materials, such as RSR and metal matrix compounds appear to be somewhat ahead of ours. Many production parts of these materials are incorporated in their Shuttle, including C/SiC leading edges.

They could become a very competent participant in the reusable business, most likely with a Western partner.

JAPAN: The Japanese started late in the reusable booster business. Their Hope mini-shuttle (Figure 4) is to be an unmanned vehicle to fly in 1996. It will be used for deliveries to and from the Japanese space station module, and for space experiments. The Himes is a smaller flight test vehicle. The follow-on program plans to fly a full Aerospaceplane by 2006 (Figure 5).

They have committed long-term funding of ~$5 B at ~$900 M per year to a very broad and deep technology development program. There are material developments in high temperature materials, including SiC coating on C/C for leading edges. They have been flight testing small models of the HOPE configuration to gain experience with flight controls and thermal protection systems. They are also reported to have made a very large offer to the USSR to buy rights to a large block of engine designs.

The Japanese have had a Lacerocket running for 5 years. They are also ground testing the Otrex engine, a precooled Mach 5 turbo-rocket with afterburner, which gives them a footing in our RBCC world. They also have a design for a Scramlace with a unique LACE fuel economizer device, and are starting component technology development for it.

The Japanese consider this effort part of a long-range national plan to move into high technology industries for the future betterment of their nation. They assume that partnership arrangements with the West will become available when they prove their competence. Unlike most participants in the race, they do not appear to feel any economic stress from carrying the costs, so they are likely to stay the course.

CONCLUSIONS: All the technologically advanced nations have an effort under way in this area. They cover most reasonable varieties of configuration, size, and technical risk (Figure 6). While there may be a world need for more than one system, some of these efforts must fall by the wayside. In recognition of this fact, and of the financial stress on several national budgets, there is much negotiation going on to "split up the pie". This is occurring, not only between nations, but even more between multinational corporations. As a result, where some critical technology might be lacking in one nation, it can surely be obtained by international dealing.

It is impossible to determine which reusable boost programs will succeed, and with what nation's sponsorship. But it seems clear that someone will succeed. The world will have one or more reusable space boosters at or near the year 2000. It is possible, but not likely, that the U.S. will be the sole owner of this capability. What this means for us, politically, economically, and militarily, is very difficult to foresee.

INTERNATIONAL REUSEABLE BOOSTER PROGRAMS

NATION	VEHIC	STAGE	RECOVER	BOOST MANNED	STATUS: DATES	T/O	COMMENTS
USA	SHUTTLE*	2	N	N	1983	VTOHL	RECOVERS UPPER ENGS & P/L
	NASP	1	Y	Y	T/2005	HTOL	A/B; M = 12
	SDIO	1	Y	Y	D/1996	VTO?	ROCKET DESIGNS
	SEALAR	2	Y	N	T	VTOL	SEA-BASED
USSR	50/50	2	Y/N	Y/N	T/1975	HTOL	FLEW MACH 6
	ENERGIA	2	Y/?	N	(?)T	VTOL	PROVISION FOR CHUTES
	FLYBACK*	2	Y	N	D	VTOHL	WINGED
	BURAN*	2	N	N	O/1992/	VTOHL	RECOVERS P/L
	LAPOT*	2	N	N	D/T	VTOHL	RECOVERS P/L
	AN225/HOTOL	2	Y	Y/N	D~1997	HTOL	JOINT WITH GBR
GBR	HOTOL	1	Y	N	D~1997	HTOL	ESA COMPETITION
	AN225/HOTOL	2	Y	Y/N	D~1997	HTOL	JOINT WITH USSR
GERM	DORNIER	2	Y	Y	D~2000	VTOHL	DARK HORSE
	SANGER	2	Y	Y/?	D~2005	VTOL	ESA COMPETITION
	HYTEX	1	Y	Y	D~1994	HTOL	FLIGHT TEST
FRANC	HERMES*	2	N	N	D~1997	VTOHL	MINI-SHUTTLE
	STAR-H	2	Y/N	Y/N	D~2000?	HTOL	BOOSTER FOR HERMES
	ASP	1	Y	Y	D?	HTOL	A/B; DESIGN STUDIES
JAPAN	HIMES*	2	N	N	1994	VTOHL	FLIGHT TEST
	HOPE*	2	N	N	1997?	VTOHL	MINI-SHUTTLE
	ASP	1	Y	Y	D~?	HTOL	A/B; DESIGN STUDIES

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TABLE 1

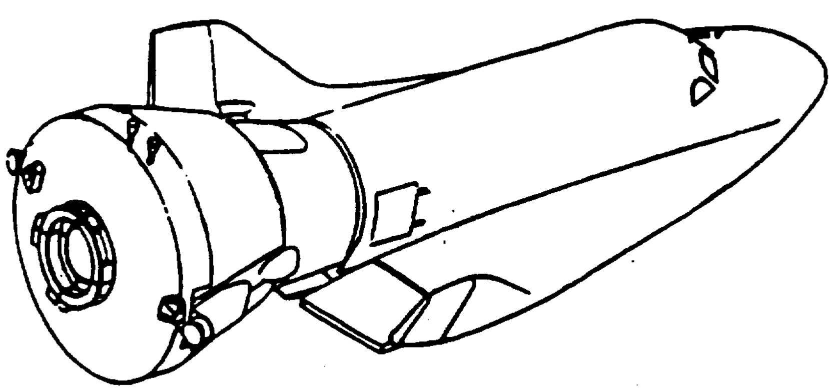

FIGURE 1. - HERMES AND EQUIPMENT MODULE.

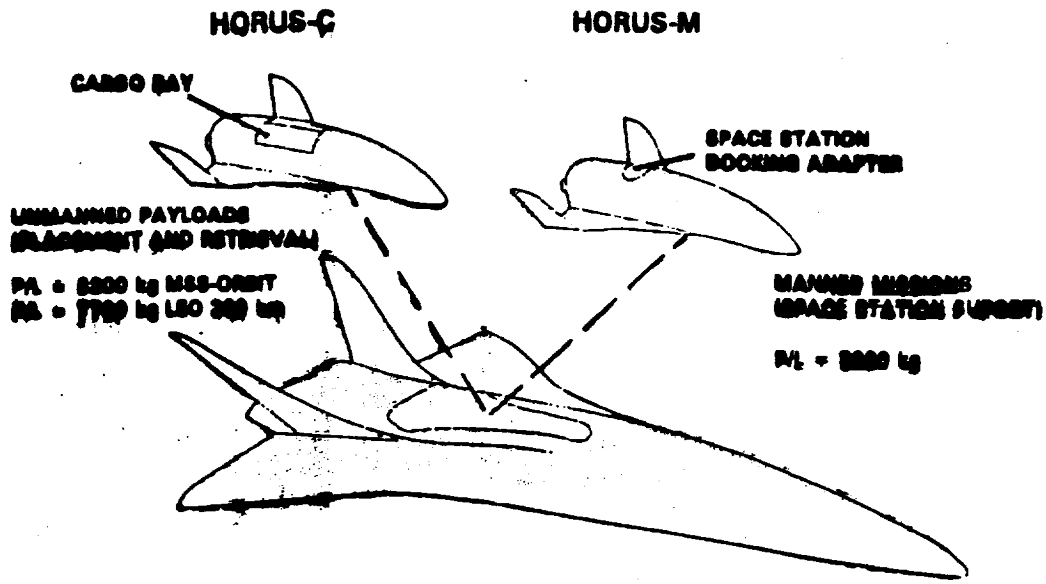

FIGURE 2. - SANGER SYSTEM CONFIGURATION.

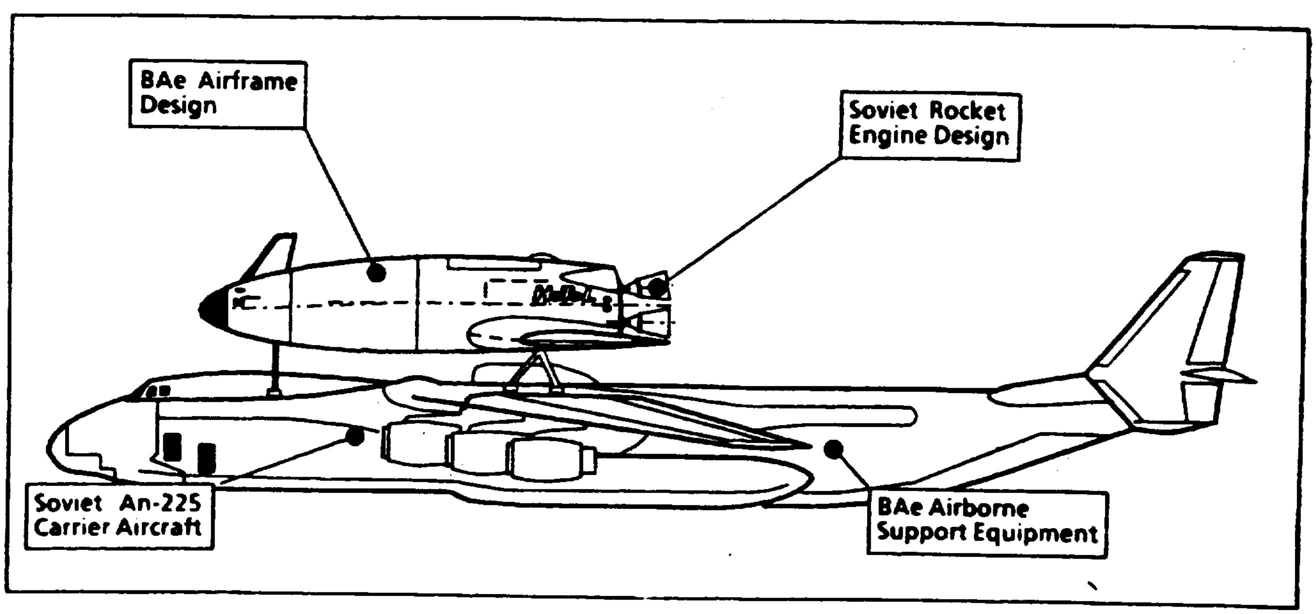

FIGURE 3. - ANATOV/HOTOL CONCEPT.

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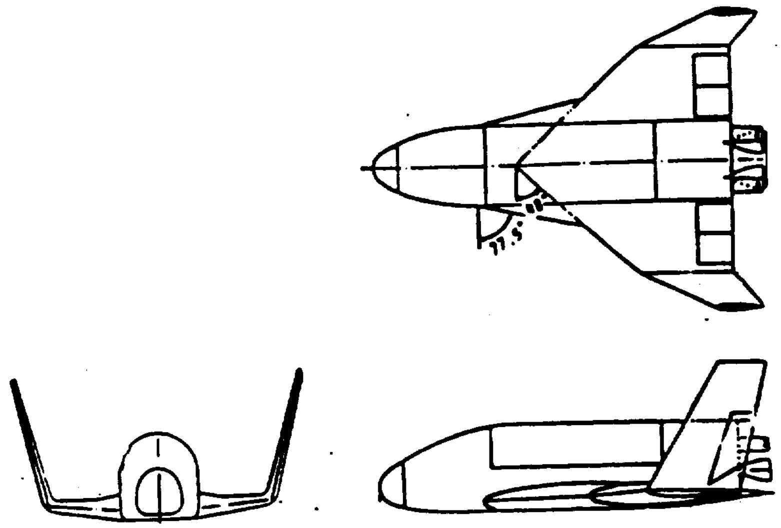

FIGURE 4. - HOPE MINI-SHUTTLE.

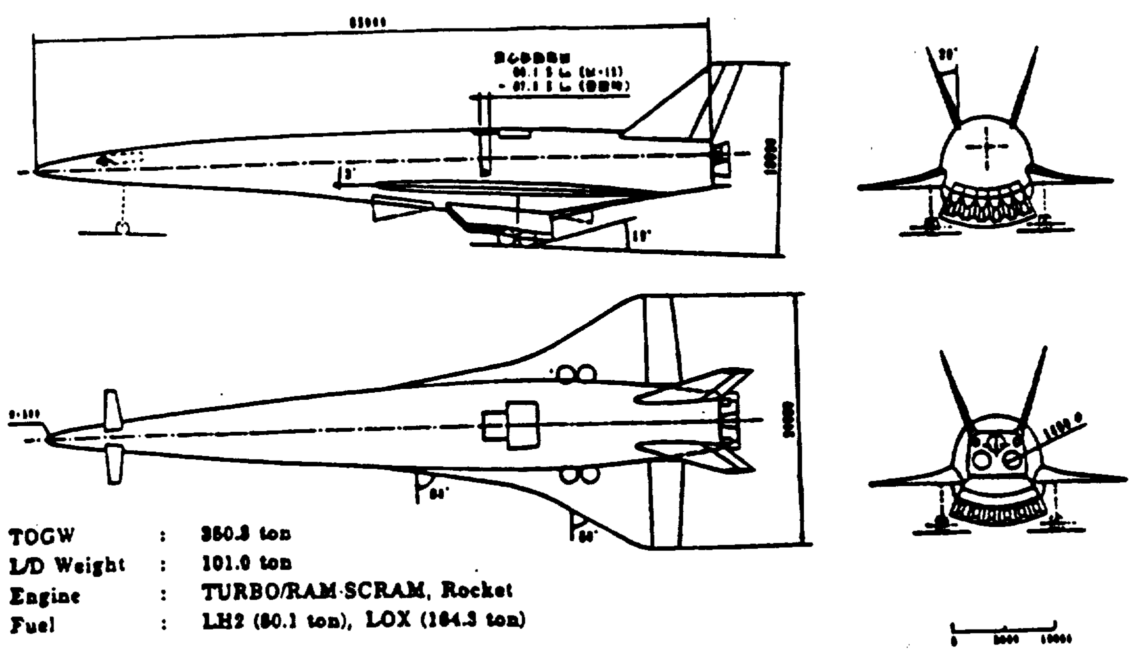

FIGURE 5. - JAPANESE SSTD CONFIGURATION.

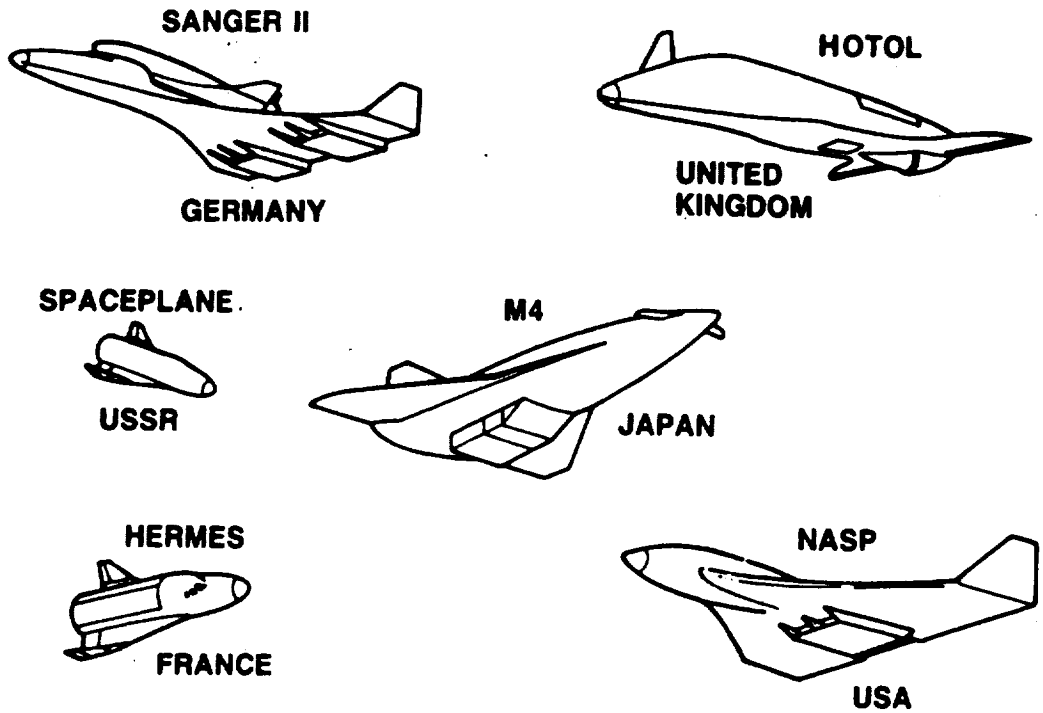

FIGURE 6. - ADVANCED SPACE TRANSPORTATION CONCEPTS.