The Case for Air and Space Traffic Management: The Critical Case of the Protozone

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Comparing Airplanes, Jets, Sub-Orbital Space Planes and Rockets to Orbit

SIGNIFICANT DIFFERENCES IN AIRBORNE VEHICLES					
Comparative Factor	Airplane	Jet	Spaceplane	Rocket to Low Earth Orbit	Dark Sky Station & HAPS
Velocity (meters/sec)	250	500	1600	7800	0 to 5
Height (km)	Up to 10	Up to 15	Up to 120	200+	50
Specific Energy (Joules/kg)	0.13	0.7	14.5	324	Not applicable

Diversity of Technical Design Demonstrated in Commercial Space Transportation Concepts to Date

Launch Concept	Organizations (Some of Which Are Now Defunct or Merged)
Lighter than Air Ascender-Ion Engine lift from Dark Sky Station and High Altitude Platform Systems (HAPS)	JP Aerospace and several telecommunications organizations
Vertical Takeoff / Vertical landing (VTVL)	Armadillo Aerospace, Blue Origin, JAXA, Masten Aerospace, Lockheed Martin/EADS
Vertical Takeoff / Horizontal Landing (VTHL) at Spaceport	Aera Space Tours, Air Boss, Bristol Space Planes, C & Space, Energia, Lorrey Aerospace, Phoenix & Pre-X by EADS, Space Dev, Space Transportation Corp, Space X, Sub Orbital Corp, Myasishchev Corp. Design Bureau, t/Space, Vela Technologies, Wickman Space and Propulsion
Horizontal Takeoff / Horizontal Landing(HTHL)	Andrews, Scaled Composites, The Spaceship Corporation, Virgin Galactic, XCOR, Project Enterprise by TALIS Institute, DLR, Swiss Propulsion Lab
Tow Launch and Horizontal Landing	Kelly Space Technology
Vertical Launch to LEO from Space Port	Alliant, Inter Orbital Systems Technology, Rocketplane/Kistler, Space HAB, UP Aerospace
Launch to LEO from Jet Plane or Carrier Vehicle Drop	Triton, Stratolauncher, Launcher One (by Virgin Galactic)

Relative Market Size

Emerging Air & Space Service and their Estimated Market Size-2035	
Supersonic/Hypersonic Flights into the Extreme Stratosphere	$10-100 Bil/yr
Commercial launches to low earth orbit	$10 Bil/yr Upward
Space Tourism/ Space Adventures	$ 2 Bil/yr Upward
High Altitude Platform Systems-Commercial UAVs	$ 2Bil/yr Upward
Private Space Stations/Habitats	$1-2 Bil/yr Upward
Proto-Space Transport	$1 Bil/yr Upward
Dark Sky Station/Ion engine lift orbit & HAPS	$1-2 Bil/yr

Subsystems for Possible Standardization and Certification for Commercial Space Transportation

- **Environmental control and life support systems**
- **Main propulsion system and fuels**
- **Guidance**
- **Navigation and control systems**
- **Avionics and software**
- **Main structural systems**
- **Thermal protection systems**
- **Thermal control systems**
- **Health monitoring systems**
- **Electrical power system**
- **Mechanical systems**
- **Flight safety system and black boxes**
- **Crew systems**
- **High Altitude Platforms and Stratospheric Drones**

Issues to Address in New Aerospace Systems

Issue or Facility Involved	Regulatory/Legal Need	Technical Research Need	Int'l Agency	Additional Concerns	Comment
Airports servicing HTHL spaceplanes	Certification and periodic recertification	Advanced radar & possibly LIDAR systems	ICAO	Coordi-nation of regular aviation and space flights	Safety of surrounding area. Liability insurance
Spaceports supporting HTHL, VTHL, VTVL systems	Certification and periodic recertification. Range Safety Control	Advanced radar & possibly LIDAR systems	ICAO	Air & Space Traffic Management & Control	Safety of surrounding area. Liability insurance
Launch Sites supporting conventional and commercial rockets	Certification and periodic recertification. Range Safety Control	Advanced radar & possibly LIDAR systems	ICAO	Space Traffic Management & Control	Safety of surrounding area. Liability insurance
Rocket Launch from Balloon or Parachute	Range Safety Control and High Altitude Range Control	Advanced radar & possibly LIDAR systems	ICAO	Air & Space Traffic Management & Control	Safety of surrounding area. Liability insurance

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Rocket Launch from carrier aircraft	Range Safety Control and High Altitude Range Control	Advanced radar & possibly LIDAR systems	ICAO	Space Traffic Manage-ment & Control	Safety of surrounding area. Liability insurance
Rocket Launch from ocean	Range Safety Control and High Altitude Range Control	Advanced radar & possibly LIDAR systems	ICAO	Space Traffic Manage-ment & Control	Safety of surrounding area. Liability insurance
Ion Engine Craft launched from Dark Sky Station	Range Safety Control and High Altitude Range Control	Stratospheric collisions avoidance systems, Radiation shielding,. Warning Beacons,	ICAO	Space Traffic Manage-ment & Control	Liability insurance
Dark Sky Station and Lighter than Air Craft and HAPS	New types of certification & recertification plus ATC into Stratosphere. Collision avoidance.	Warning Beacons, Advanced radar & LIDAR	ITU and perhaps WMO and UNEP	Space Traffic Manage-ment & Control	Liability insurance

Issues to Address in New Aerospace Systems

Issue or Facility Involved	Regulatory/ Legal Need	Technical Research Need	Int'l Agencies	Additional Concerns	Comment
Super Sonic & Hypersonic Transport	Air Traffic Control into Stratosphere	Sonic Beam mitigation standards, Emission standards, Thermal Protection Systems	WMO, UNEP and ITU	Space Traffic Manage-ment & Control	Liability provisions, flight path coordination, solar CMEs
Radiation Exposure levels/Health Standards	Radiation Protection Standards, Flight Path Approvals	Ozone hole and Ozone layer investigations	World Health Org., WMO, UNDP	Genetic mutation	Liability provisions, flight path coordination, solar CMEs
Rocket Pollutant Emissions (N0x, Cox, Water Vapor	Standards for rocket emissions	Stratospheric emission studies. Improved propellants	WMO. UNDP	Climate Change, Strato-spheric pollution	Incentives for improved propellants.
Orbital Debris (Controlled /uncontrolled reentry)	Air Traffic Control and Space Traffic Management	Black boxes for all spacecraft. Warning beacons	UN COPUOS, IADC, SDA	Greater risk of Kessler Syndrome	Fund for debris mitigation. Fines for violations

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Issues to Address in New Aerospace Systems

Issue or Facility Involved	Regulatory/ Legal Need	Technical Research Need	Int'l Agencies	Additional Concerns	Comment
Electric Vehicles	Emission Standards and Incentives	Zero polluting aircraft	WMO. UNDP	Incentives for low emission aircraft	Transition planning
UAVs & HAPS and robotic freighters	Air Traffic Control and Space Traffic Management & Control. RF interference	Improved avionics, Emergency override safety systems	ITU	Warning beacons, collision avoidance systems	Improved network management tools
Radio Frequency Interference & allocations	RF Interference from Air & Space Traffic Control & Mgt	Improved Radio systems to avoid interference	ITU	Improvealloca-tions process	Coordi-nation processes/ enforcement powers

Conclusions

There are a wide range of new systems that need to be considered in terms of air & space traffic management and control. These include commercial orbital launches, private space habitats/platforms, dark sky stations, High Altitude Platform Systems (HAPS), Proto-space or sub-space transport, carrier vehicle or jet drop launches, balloon-based rocket launches, towed launched systems, vertical and horizontal launch and landing systems, commercial sub-orbital flights, and hypersonic transportation systems. In the future we may also possibly need to deal with space elevators/funiculars, ion engine-plasma thruster spiral deployment to Geo. This is a set of issues much larger that just “space tourism”. Protozone regulation is most urgent area.

International Regulation

- There are many issues that the ICAO, FAA-AST, EASA and like organizations can and should take on in terms of flight safety, but there are other international organizations such as the International Telecommunication Union, the World Meteorological Organization, and the UN Environmental Programme. Also the UN Committee on the Peaceful Uses of Outer Space, the Inter-Agency orbital Debris Coordination Committee (IADC), and the Space Data Association also have a role to play as well. For instance, the Virgin Galactic engine that runs on Nitrous Oxide and Neoprene is much more of a stratospheric pollutant than liquid fueled systems by more than an order of magnitude.

Technology Development

- Key new technology development. These areas include: (a) devising and agreeing global standards in key subsystems for new aerospace systems with regard to: (i) navigation and control systems, (ii) avionics and software; (iii) range control and tracking systems (lidar, improved radar, etc.); (iv) pollution standards (including “debris” in the protozone (i.e. non-controlled balloons, etc.) (b) development of international specifications for “black boxes” (or even better improved real time data relay and performance monitoring) from spacecraft, launchers, etc. (c) cost effective and improved systems for de-orbit of small satellites and active removal of orbital debris.

Next Steps

- A systematic review of the entire field needs to be undertaken. This process that might be undertaken by the ICAO, FAA, EASA and research institutes around the world might assist in identifying in a systematic way where regulatory oversight, standards or new technology development is required or useful and to identify which regulatory agency, governmental entity or private enterprise are or should be working in these areas. This could help to create a useful and globally accessible data base of key metadata.

Next Steps

- **Recognize that there are many regulatory issues and agencies involved. These include:**
  - **Air and space traffic safety**
  - **Health standards involving radiation & pollution**
  - **Environmental safety standards**
  - **National defense concerns**
  - **Frequency coordination and standards**
- **Assign one UN Agency primary responsibility for coordinating regulatory actions (i.e. ICAO??), especially for the 'Protozone' and its safety. Should also create a coordinative process to cover all areas of air and space safety, health standards, environmental pollution, frequency assignments and standards, and even national defense concerns.**