KEMENTERIAN PENDIDIKAN, KEBUDAYAAN,
RISET, DAN TEKNOLOGI
UNIVERSITAS JENDERAL SOEDIRMAN
Jalan Prof. Dr. Bunyamin No. 708 Kotak Pos 115 – Purwokerto 53122
Telepon (0281) 635292(Hunting),638337, 638795 - Facs. 631802 Kode Pos.53122
Surel:info@unsoed.ac.id Laman: www.unsoed.ac.id

KEPUTUSAN REKTOR UNIVERSITAS JENDERAL SOEDIRMAN
NOMOR 1309/UN23/HK.02/2021

TENTANG

PELAKSANA PENELITIAN DASAR
UNIVERSITAS JENDERAL SOEDIRMAN TAHUN ANGGARAN 2021

REKTOR UNIVERSITAS JENDERAL SOEDIRMAN,

Menimbang :
a. bahwa berdasarkan Kontrak Penelitian Tahun Tunggal Penelitian Dasar dan Pembinaan/Kapasitas Tahun Anggaran 2021 antara Direktorat Riset dan Pengabdian Masyarakat, Deputi Bidang Penguatan Riset dan Pengembangan, Kementerian Riset dan Teknologi/Badan Riset dan Inovasi Nasional dengan Ketua Lembaga Penelitian dan Pengabdian Kepada Masyarakat Unsoed Nomor 030/SP2H/LT/DRPM/2021;
b. bahwa berdasarkan Kontrak Penelitian Tahun Jamak Penelitian Dasar dan Pembinaan/Kapasitas Tahun Anggaran 2021 antara Direktorat Riset dan Pengabdian Masyarakat, Deputi Bidang Penguatan Riset dan Pengembangan, Kementerian Riset dan Teknologi/Badan Riset dan Inovasi Nasional dengan Ketua Lembaga Penelitian dan Pengabdian Kepada Masyarakat Unsoed Nomor 117/SP2H/LT/DRPM/2021;
c. bahwa perguruan tinggi mempunyai tugas menyelenggarakan pendidikan, penelitian, dan pengabdian kepada masyarakat;
d. bahwa untuk memenuhi kualitas dan kuantitas penelitian di Universitas Jenderal Soedirman, maka perlu dilakukan penelitian secara kompetitif dan memenuhi standar mutu;
e. bahwa untuk itu perlu diangkat pelaksana Penelitian Dasar dengan Keputusan Rektor Universitas Jenderal Soedirman;

Mengingat :
1. Undang-Undang RI Nomor 5 Tahun 2014 tentang Aparatur Sipil Negara;
2. Undang-Undang RI Nomor 20 Tahun 2003 tentang Sistem Pendidikan Nasional;
3. Undang-Undang RI Nomor 12 Tahun 2012 tentang Pendidikan Tinggi;
4. Peraturan Pemerintah RI Nomor 4 Tahun 2014 tentang Penyelenggaraan Pendidikan Tinggi dan Pengelolaan Perguruan Tinggi;
5. Keputusan Presiden Republik Indonesia Nomor 195 Tahun 1963 jo Kept. Menteri PTIP No. 153 Tahun 1963 tentang Pendirian Unsoed;
6. Peraturan Menteri Riset, Teknologi, dan Pendidikan Tinggi Nomor 28 Tahun 2017 tentang Statuta Universitas Jenderal Soedirman;
7. Peraturan Menteri Riset, Teknologi, dan Pendidikan Tinggi RI Nomor 10 Tahun 2016 jo Nomor 23 Tahun 2017 tentang Organisasi dan Tata Kerja Unsoed;

8. Peraturan Menteri Keuangan RI Nomor 112/PMK.02/2020 tentang Standar Biaya Keluaran (SBK) Tahun Anggaran 2021;
9. Keputusan Menteri Riset, Teknologi, dan Pendidikan Tinggi RI Nomor 222/M/KPT.KP/2018 tanggal 30 April 2018 tentang Pemberhentian dan Pengangkatan Rektor Universitas Jenderal Soedirman Periode 2018 – 2022;

MEMUTUSKAN :

Menetapkan	:	KEPUTUSAN REKTOR UNIVERSITAS JENDERAL SOEDIRMAN TENTANG PELAKSANA PENELITIAN DASAR UNIVERSITAS JENDERAL SOEDIRMAN TAHUN ANGGARAN 2021.
KESATU	:	Menugaskan kepada dosen yang namanya tercantum dalam lampiran keputusan ini untuk melaksanakan penelitian yang judul, biaya, waktu dan tugas dalam penelitian masing-masing termaktub dalam keputusan ini selanjutnya disebut "Peneliti".
KEDUA	:	Dalam melaksanakan tugasnya "Peneliti" membuat laporan dan bertanggung jawab kepada Rektor Universitas Jenderal Soedirman.
KETIGA	:	Penelitian dilakukan selama 9 (Sembilan) bulan mulai 14 April 2021 sampai dengan 19 Desember 2021.
KEEMPAT	:	Biaya pelaksanaan penelitian dibebankan kepada DIPA Direktorat Penelitian dan Pengabdian Masyarakat Kementerian Riset, Teknologi, dan Pendidikan Tinggi.
KELIMA	:	Keputusan ini mulai berlaku pada tanggal ditetapkan.

Ditetapkan di Purwokerto
Pada tanggal, 28 Mei 2021

REKTOR,

KEMENTERIAN PENDIDIKAN, KEBUDAYAAN, RISET, DAN TEKNOLOGI
UNIVERSITAS JENDERAL SOEDIRMAN
REKTOR

SUWARTO

-lppm/unsoed/dyt

LAMPIRAN
KEPUTUSAN REKTOR
UNIVERSITAS JENDERAL SOEDIRMAN
NOMOR 1309/UN23/HK.02/2021
TANGGAL 28 MEI 2021
TENTANG
PELAKSANA PENELITIAN RISET DASAR
UNIVERSITAS JENDERAL SOEDIRMAN TAHUN ANGGARAN 2021

No	Tahun	Personalia	Jabatan	Judul Penelitian	Dana Disetujui (Rp)	Fakultas
1	Tunggal	Ari Asnani Oedjijono Dwi Utami Anjarwati	Ketua Peneliti Anggota Peneliti I Anggota Peneliti II	Produksi Senyawa Bioaktif yang Antagonis terhadap Methicillin Resistant Staphylococcus aureus (MRSA) dari Aktinomisetes Laut	132,200,000	MIPA
2	Tunggal	Suharno	Ketua Peneliti Anggota Peneliti I	Model Pengelolaan Tripartite Untuk Menyiapkan Kawasan Konservasi Segara Anakan	173,715,000	Ekonomi dan Bisnis
3	Tunggal	Imam Santosa Muslihudin Wiwiek Rabiatul Adawiyah	Ketua Peneliti Anggota Peneliti I Anggota Peneliti II	Menggugat Teori Resiprositas Dari G. C. Homans Dan P. M. Blau Pada Hubungan Sosial Kekinian Antara Petani Pemilik Lahan Dengan Buruh Tani	300,000,000	Ilmu Sosial dan Ilmu Politik
4	Jamak	Mardiyah Kurniasih Ratna Stia Dewi Purwati	Ketua Peneliti Anggota Peneliti I Anggota Peneliti II	Nanopartikel Kitosan sebagai Agen Antimikroba pada Kain	189,078,000	MIPA
5	Jamak	Retno Supriyanti Yogi Ramadhani Haris Budi Widodo	Ketua Peneliti Anggota Peneliti I Anggota Peneliti II	Ekstraksi Informasi Citra X-Ray Thorax pada Penderita Covid 19 Berbasis Segmentasi Citra	146,660,000	Teknik
6	Jamak	R Wahyu Widanarto Mukhtar Effendi	Ketua Peneliti Anggota Peneliti I	Sintesis komposit biosilika/barium ferit dan karakterisasinya sebagai penyerap gelombang mikro	123,975,000	MIPA
7	Jamak	Mukhtar Effendi Wahyu Tri Cahyanto	Ketua Peneliti Anggota Peneliti I	Pengembangan Ce4+/Dy3+/Er3+- Stronsium ferit alam dengan metode solid state reaction sebagai material fungsional penyerap gelombang mikro	123,760,000	MIPA

8	Jamak	Nur Aini Budi Sustriawan Ervina Mela	Ketua Peneliti Anggota Peneliti I Anggota Peneliti II	Formulasi pangan bebas gluten dan laktosa serta rendah Indeks Glikemik dari tepung jagung fermentasi	98,750,000	Pertanian
9	Jamak	Sofa Marwah Wita Ramadhanti Oktafiani Catur Pratiwi	Ketua Peneliti Anggota Peneliti I	Perempuan Dalam Tradisi Masyarakat Pesisir Kilen :Sudut Pandang Sistem Sosial- Ekonomi, Politik, Agama, Dan Budaya	118,330,000	Ilmu Sosial dan Ilmu Politik
10	Jamak	Gito Sugiyanto Yanto	Ketua Peneliti Anggota Peneliti I	Pengembangan Model Pemetaan Lokasi Rawan Kecelakaan Lalu Lintas Berbasis "Machine Learning" dan Model Stepwise Akaike Information Criterion	148,520,000	Teknik
11	Jamak	Gito Sugiyanto Purwanto Bekti Santoso	Ketua Peneliti Anggota Peneliti I	Pengembangan Model Distribusi Logistik Angkutan Udara "Hub and Spoke" dan "Point to Point" pada Masa dan Pasca Pandemik Covid-19	140,360,000	Teknik

Ditetapkan di Purwokerto
REKTOR,

KEMENTERIAN PENDIDIKAN, KEBUDAYAAN, RISET, DAN TEKNOLOGI
UNIVERSITAS JENDERAL SOEDIRMAN
REKTOR

SUWARTO

-lppm/unsoed/dyt

LAPORAN AKHIR PENELITIAN MULTI TAHUN

ID Proposal: 9a81cf04-68ce-4b5f-a47b-c71e53edb44e
Laporan Akhir Penelitian: tahun ke-1 dari 3 tahun

1. IDENTITAS PENELITIAN

A. JUDUL PENELITIAN

Pengembangan Model Distribusi Logistik Angkutan Udara "Hub and Spoke" dan "Point to Point" pada Masa dan Pasca Pandemik Covid-19

B. BIDANG, TEMA, TOPIK, DAN RUMPUN BIDANG ILMU

Bidang Fokus RIRN / Bidang Unggulan Perguruan Tinggi	Tema	Topik (jika ada)	Rumpun Bidang Ilmu
Transportasi	Intelligent transportation system	Manajemen transportasi logistik	Transportasi

C. KATEGORI, SKEMA, SBK, TARGET TKT DAN LAMA PENELITIAN

Kategori (Kompetitif Nasional/ Desentralisasi/ Penugasan)	Skema Penelitian	Strata (Dasar/ Terapan/ Pengembangan)	SBK (Dasar, Terapan, Pengembangan)	Target Akhir TKT	Lama Penelitian (Tahun)
Penelitian Kompetitif Nasional	Penelitian Dasar	SBK Riset Dasar	SBK Riset Dasar	2	3

2. IDENTITAS PENGUSUL

Nama, Peran	Perguruan Tinggi/ Institusi	Program Studi/ Bagian	Bidang Tugas	ID Sinta	H-Index
GITO SUGIYANTO Ketua Pengusul	Universitas Jenderal Soedirman	Teknik Sipil		5975493	8
PURWANTO BEKTI SANTOSO S.T, M.T, S.T Anggota Pengusul 1	Universitas Jenderal Soedirman	Teknik Sipil	Analisis statistik	6141530	1

3. MITRA KERJASAMA PENELITIAN (JIKA ADA)

Pelaksanaan penelitian dapat melibatkan mitra kerjasama, yaitu mitra kerjasama dalam melaksanakan penelitian, mitra sebagai calon pengguna hasil penelitian, atau mitra investor

Mitra	Nama Mitra

4. LUARAN DAN TARGET CAPAIAN

Luaran Wajib

Tahun Luaran	Jenis Luaran	Status target capaian (*accepted, published, terdaftar atau granted, atau status lainnya*)	Keterangan (*url dan nama jurnal, penerbit, url paten, keterangan sejenis lainnya*)
1	Artikel di Jurnal Internasional Terindeks di Pengindeks Bereputasi	Accepted	Alexandria Engineering Journal (Terindek Scopus Q1)

Luaran Tambahan

Tahun Luaran	Jenis Luaran	Status target capaian (*accepted, published, terdaftar atau granted, atau status lainnya*)	Keterangan (*url dan nama jurnal, penerbit, url paten, keterangan sejenis lainnya*)
1	Artikel pada Conference/Seminar Internasional di Pengindeks Bereputasi	Terbit dalam Prosiding	The 3rd International Symposium of Civil, Environmental, and Infrastructure Engineering (ISCEIE) 2021

5. ANGGARAN

Rencana anggaran biaya penelitian mengacu pada PMK yang berlaku dengan besaran minimum dan maksimum sebagaimana diatur pada buku Panduan Penelitian dan Pengabdian kepada Masyarakat Edisi 12.

Total RAB 3 Tahun Rp. 532,787,000

Tahun 1 Total Rp. 177,207,000

Jenis Pembelanjaan	Komponen	Item	Satuan	Vol.	Biaya Satuan	Total
Bahan	ATK	Alat tulis/Ballpoint	buah	150	10,000	1,500,000
Bahan	ATK	Catridge epson warna	buah	1	725,000	725,000
Bahan	ATK	Catridge epson hitam	buah	1	615,000	615,000
Bahan	ATK	Materai tempel @6000	buah	10	6,000	60,000
Bahan	ATK	Kertas foto glossy	lembar	10	10,000	100,000
Bahan	ATK	Flashdisk 32 GB	buah	2	320,000	640,000
Bahan	Bahan Penelitian (Habis Pakai)	Bahan bakar minyak jenis pertalite untuk roda 4	liter	600	7,500	4,500,000
Bahan	Bahan Penelitian (Habis Pakai)	Fotocopy dan penjilidan proposal penelitian dasar	eksemplar	4	40,000	160,000
Bahan	Bahan Penelitian (Habis Pakai)	Fotocopy dan penjilidan laporan kemajuan penelitian dasar	eksemplar	4	55,000	220,000
Bahan	Bahan Penelitian (Habis Pakai)	Fotocopy dan jilid laporan akhir penelitian dasar	eksemplar	7	80,000	560,000

Jenis Pembelanjaan	Komponen	Item	Satuan	Vol.	Biaya Satuan	Total
Bahan	Bahan Penelitian (Habis Pakai)	Cetak poster penelitian dasar	buah	1	550,000	550,000
Bahan	Bahan Penelitian (Habis Pakai)	Fotocopy data-data sekunder	lembar	4985	200	997,000
Bahan	Bahan Penelitian (Habis Pakai)	Bahan kontak berupa buku agenda	buku	300	17,500	5,250,000
Bahan	Barang Persediaan	Kertas HVS 80gr	rim	6	60,000	360,000
Bahan	Barang Persediaan	Refill tinta printer warna (merah, kuning, biru)	botol	3	100,000	300,000
Bahan	Barang Persediaan	Refill tinta printer hitam	botol	2	100,000	200,000
Pengumpulan Data	FGD persiapan penelitian	FGD Persiapan Penelitian tahun pertama	paket	1	2,500,000	2,500,000
Pengumpulan Data	HR Pembantu Peneliti	HR Pembantu Peneliti	OJ	500	10,000	5,000,000
Pengumpulan Data	HR Sekretariat/Administrasi Peneliti	Administrasi penelitian dan keuangan	OB	3	1,750,000	5,250,000
Pengumpulan Data	HR Petugas Survei	Survei produksi lalu lintas penerbangan logistik (kargo udara)	OJ	24	80,000	1,920,000
Pengumpulan Data	HR Petugas Survei	Survei data kedatangan dan keberangkatan penumpang dan kargo di setiap bandara	OJ	26	80,000	2,080,000
Pengumpulan Data	HR Petugas Survei	Survei asal dan tujuan perjalanan transportasi udara di Indonesia	OH	30	80,000	2,400,000
Pengumpulan Data	Transport	Perjalanan lokal di Jakarta	OK (kali)	6	350,000	2,100,000
Pengumpulan Data	Tiket	Tiket KA Purwokerto-Yogyakarta	OK (kali)	4	300,000	1,200,000
Pengumpulan Data	Tiket	Tiket KA Purwokerto-Jakarta (Kemenhub , PT Angkasa Pura I, PT Angkasa Pura 2)	OK (kali)	6	450,000	2,700,000
Pengumpulan Data	Tiket	Tiket Pesawat Yogyakarta-	OK (kali)	4	1,150,000	4,600,000

Jenis Pembelanjaan	Komponen	Item	Satuan	Vol.	Biaya Satuan	Total
		Jakarta (PT Angkasa Pura 1 dan 2)				
Pengumpulan Data	Tiket	Tiket KA Purwokerto-Yogyakarta	OK (kali)	4	300,000	1,200,000
Pengumpulan Data	Tiket	Tiket KA Purwokerto-Surabaya (ke Bandara Juanda dan PT Angkasa Pura)	OK (Kali)	4	450,000	1,800,000
Pengumpulan Data	Uang Harian	Survei dan pengumpulan data di Jakarta	OH	6	375,000	2,250,000
Pengumpulan Data	Uang Harian	Survei dan pengumpulan data di Surabaya	OH	5	350,000	1,750,000
Pengumpulan Data	Uang Harian	Survei dan pengumpulan data di Surakarta (Bandara Adi Sumarmo, PT Angkasa Pura)	OH	7	300,000	2,100,000
Pengumpulan Data	Uang Harian	Survei dan pengumpulan data di Yogyakarta (Bandara YIA, Angkasa Pura, Bandara Adi Sucipto)	OH	8	325,000	2,600,000
Pengumpulan Data	Penginapan	Penginapan selama survei di Jakarta	OH	4	450,000	1,800,000
Pengumpulan Data	Penginapan	Penginapan selama survei di Surabaya	OH	4	450,000	1,800,000
Pengumpulan Data	Penginapan	Penginapan selama survei di Surakarta	OH	5	400,000	2,000,000
Pengumpulan Data	Penginapan	Penginapan selama survei di Yogyakarta	OH	6	400,000	2,400,000
Sewa Peralatan	Peralatan penelitian	Sewa LCD/LED TV untuk diskusi penelitian	unit	10	300,000	3,000,000
Sewa Peralatan	Peralatan penelitian	Sewa handycam/kamera	unit-bulan	5	250,000	1,250,000
Sewa Peralatan	Peralatan penelitian	Biaya langganan IndiHome untuk	unit-bulan	5	450,000	2,250,000

Jenis Pembelanjaan	Komponen	Item	Satuan	Vol.	Biaya Satuan	Total
		kajian literatur dan survei online				
Sewa Peralatan	Peralatan penelitian	Sewa aplikasi software pemodelan transportasi logit	unit	1	5,500,000	5,500,000
Sewa Peralatan	Obyek penelitian	Pengurusan perizinan dll	unit	1	2,500,000	2,500,000
Sewa Peralatan	Transport penelitian	Sewa kendaraan roda 4 dan sopir untuk survei di Yogyakarta	unit-hari	8	600,000	4,800,000
Sewa Peralatan	Transport penelitian	Sewa kendaraan roda 4 dan sopir untuk survei di Surakarta	unit-hari	8	600,000	4,800,000
Sewa Peralatan	Transport penelitian	Sewa kendaraan roda 4 dan sopir untuk survei di Surabaya	unit-hari	5	600,000	3,000,000
Analisis Data	HR Sekretariat/Administrasi Peneliti	Administrasi penelitian dan keuangan	OB	5	1,750,000	8,750,000
Analisis Data	HR Pengolah Data	HR Pengolah data (analisis)	Penelitian	1	1,540,000	1,540,000
Analisis Data	Biaya analisis sampel	Analisis model hub and spoke untuk domestik dan international flight	buah	2	1,540,000	3,080,000
Analisis Data	Biaya analisis sampel	Analisis efisiensi transportasi (et) logistik	buah	2	1,540,000	3,080,000
Analisis Data	Biaya analisis sampel	Analisis Herfindahl-Hirschmann Index (HHI) domestik dan internasional	buah	2	1,540,000	3,080,000
Analisis Data	Biaya analisis sampel	Analisis data Matriks asal tujuan untuk penumpang dan kargo	buah	2	1,540,000	3,080,000
Analisis Data	Tiket	Tiket KA Purwokerto-Yogyakarta	OK (kali)	4	300,000	1,200,000
Analisis Data	Tiket	Tiket KA Purwokerto-Jakarta	OK (kali)	4	450,000	1,800,000
Analisis Data	Uang Harian	Untuk diskusi model yang	OH	8	350,000	2,800,000

Jenis Pembelanjaan	Komponen	Item	Satuan	Vol.	Biaya Satuan	Total
		dihasilkan dengan pihak AP Logistik di Yogyakarta				
Analisis Data	Uang Harian	Untuk diskusi model yang dihasilkan dengan pihak Ditjenhubud dan PT Angkasa Pura di Jakarta	OH	8	375,000	3,000,000
Analisis Data	Transport Lokal	Perjalanan lokal selama diskusi di Yogyakarta	OH	5	250,000	1,250,000
Analisis Data	Transport Lokal	Perjalanan lokal selama diskusi di Jakarta	OH	4	350,000	1,400,000
Analisis Data	Penginapan	Penginapan selama diskusi di Yogyakarta	OH	6	400,000	2,400,000
Analisis Data	Penginapan	Penginapan selama diskusi di Jakarta	OH	4	450,000	1,800,000
Pelaporan, Luaran Wajib, dan Luaran Tambahan	HR Sekretariat/Administrasi Peneliti	Administrasi penelitian dan keuangan	OB	2	1,750,000	3,500,000
Pelaporan, Luaran Wajib, dan Luaran Tambahan	Uang harian rapat di luar kantor	Uang harian rapat di luar kantor	OH	8	350,000	2,800,000
Pelaporan, Luaran Wajib, dan Luaran Tambahan	Biaya konsumsi rapat	Biaya konsumsi rapat	OH	8	170,000	1,360,000
Pelaporan, Luaran Wajib, dan Luaran Tambahan	Biaya seminar internasional	Biaya pendaftaran Seminar Internasional dan publikasi	paket	1	6,500,000	6,500,000
Pelaporan, Luaran Wajib, dan Luaran Tambahan	Biaya seminar internasional	Biaya proofreading artikel seminar internasional	paket	1	2,500,000	2,500,000
Pelaporan, Luaran Wajib, dan Luaran Tambahan	Publikasi artikel di Jurnal Internasional	Biaya translate artikel ke bahasa inggris dan proofreading	paket	1	3,000,000	3,000,000
Pelaporan, Luaran Wajib, dan Luaran Tambahan	Publikasi artikel di Jurnal Internasional	APC (article processing charge) dan biaya publikasi artikel di Jurnal Internasional terindeks scopus	paket	1	22,500,000	22,500,000

Jenis Pembelanjaan	Komponen	Item	Satuan	Vol.	Biaya Satuan	Total
Pelaporan, Luaran Wajib, dan Luaran Tambahan	Luaran KI (paten, hak cipta dll)	Biaya penyusunan usulan hak cipta	buah	1	2,500,000	2,500,000
Pelaporan, Luaran Wajib, dan Luaran Tambahan	Luaran KI (paten, hak cipta dll)	Biaya pendaftaran usulan hak cipta	buah	1	1,000,000	1,000,000

Tahun 2 Total Rp. 177,670,000

Jenis Pembelanjaan	Komponen	Item	Satuan	Vol.	Biaya Satuan	Total
Bahan	ATK	Alat tulis/ballpoint	buah	150	10,000	1,500,000
Bahan	ATK	Catridge epson hitam	buah	1	650,000	650,000
Bahan	ATK	Materai tempel @6000	buah	5	6,000	30,000
Bahan	ATK	Kertas foto glossy	lembar	10	10,000	100,000
Bahan	ATK	Flashdisk 32 GB	unit	1	320,000	320,000
Bahan	Bahan Penelitian (Habis Pakai)	Bahan bakar minyak jenis pertalite untuk roda 4	liter	500	7,500	3,750,000
Bahan	Bahan Penelitian (Habis Pakai)	Fotocopy dan penjilidan proposal penelitian dasar	eksemplar	4	50,000	200,000
Bahan	Bahan Penelitian (Habis Pakai)	Fotocopy dan penjilidan laporan kemajuan penelitian dasar	eksemplar	4	60,000	240,000
Bahan	Bahan Penelitian (Habis Pakai)	Fotocopy dan penjilidan laporan akhir penelitian dasar	eksemplar	7	80,000	560,000
Bahan	Bahan Penelitian (Habis Pakai)	Cetak poster penelitian dasar	buah	1	550,000	550,000
Bahan	Bahan Penelitian (Habis Pakai)	Fotocopy data-data sekunder	lembar	2250	200	450,000
Bahan	Bahan Penelitian (Habis Pakai)	Bahan kontak berupa buku agenda	buku	250	25,000	6,250,000
Bahan	Barang Persediaan	Kertas HVS 80gr	rim	5	60,000	300,000
Bahan	Barang Persediaan	Refill tinta printer hitam	boto	2	100,000	200,000
Pengumpulan Data	FGD persiapan penelitian	FGD Persiapan Penelitian Tahun ke-2	paket	1	2,500,000	2,500,000

Jenis Pembelanjaan	Komponen	Item	Satuan	Vol.	Biaya Satuan	Total
Pengumpulan Data	HR Pembantu Peneliti	HR Pembantu Peneliti	OJ	500	10,000	5,000,000
Pengumpulan Data	HR Sekretariat/Administrasi Peneliti	Administrasi penelitian dan keuangan	OB	3	1,750,000	5,250,000
Pengumpulan Data	HR Petugas Survei	Survei produksi penerbangan domestik dan internasional	OH	40	80,000	3,200,000
Pengumpulan Data	HR Petugas Survei	Survei asal dan tujuan pergerakan penumpang dan kargo udara	OH	40	80,000	3,200,000
Pengumpulan Data	HR Petugas Survei	Survei stated preference pemilihan moda	OH	35	80,000	2,800,000
Pengumpulan Data	Transport	Perjalanan lokal selama survei pengumpulan data di Jakarta	OH	4	350,000	1,400,000
Pengumpulan Data	Transport	Perjalanan lokal selama pengambilan data di Bali	OH	6	350,000	2,100,000
Pengumpulan Data	Tiket	Tiket KA Purwokerto-Yogyakarta (Bandara YIA)	OK (kali)	4	300,000	1,200,000
Pengumpulan Data	Tiket	Tiket KA Purwokerto-Jakarta (Kemenhub , PT Angkasa Pura)	OK (kali)	6	450,000	2,700,000
Pengumpulan Data	Tiket	Tiket KA Purwokerto-Yogyakarta (Bandara YIA, bandara Adi Sucipto, Kantor AP 1))	OK (kali)	4	300,000	1,200,000
Pengumpulan Data	Tiket	Tiket Pesawat Yogyakarta-Bali (ke Bandara Ngurah Rai dan PT Angkasa Pura)	OK (kali)	4	1,250,000	5,000,000
Pengumpulan Data	Uang Harian	Survei pengumpulan data di Jakarta	OH	6	375,000	2,250,000
Pengumpulan Data	Uang Harian	Survei pengumpulan data di Bali	OH	6	350,000	2,100,000

Jenis Pembelanjaan	Komponen	Item	Satuan	Vol.	Biaya Satuan	Total
Pengumpulan Data	Uang Harian	Survei pengumpulan data di Yogyakarta	OH	8	325,000	2,600,000
Pengumpulan Data	Penginapan	Penginapan selama pengambilan data di Jakarta	OH	4	450,000	1,800,000
Pengumpulan Data	Penginapan	Penginapan selama pengambilan data di Bali	OH	5	450,000	2,250,000
Pengumpulan Data	Penginapan	Penginapan selama survei di Yogyakarta	OH	6	400,000	2,400,000
Sewa Peralatan	Peralatan penelitian	Sewa LCD/TV LED untuk diskusi penelitian	unit	9	300,000	2,700,000
Sewa Peralatan	Peralatan penelitian	Sewa handycam/kamera	unit	5	250,000	1,250,000
Sewa Peralatan	Peralatan penelitian	Biaya langganan IndiHome untuk kajian literatur dan komunikasi online	bulan	7	450,000	3,150,000
Sewa Peralatan	Peralatan penelitian	Sewa aplikasi software pemodelan transportasi logit binomial	paket	1	4,500,000	4,500,000
Sewa Peralatan	Transport penelitian	Sewa kendaraan roda 4 dan sopir untuk survei di Yogyakarta	unit-hari	10	600,000	6,000,000
Sewa Peralatan	Transport penelitian	Sewa kendaraan roda 4 dan sopir untuk survei di Bali	unit-hari	6	600,000	3,600,000
Analisis Data	HR Sekretariat/Administrasi Peneliti	Administrasi penelitian dan keuangan	OB	5	1,750,000	8,750,000
Analisis Data	HR Pengolah Data	Biaya analisis statistik	Penelitian	1	1,540,000	1,540,000
Analisis Data	Biaya analisis sampel	Analisis simulasi point to point penerbangan domestik dan penerbangan internasional	buah	2	1,540,000	3,080,000
Analisis Data	Biaya analisis sampel	Analisis Herfindahl-Hirschmann Index	buah	2	1,540,000	3,080,000

Jenis Pembelanjaan	Komponen	Item	Satuan	Vol.	Biaya Satuan	Total
		(HHI) untuk penerbangan domestik dan internasional				
Analisis Data	Biaya analisis sampel	Analisis elastisitas dan sensitivitas model	buah	1	1,540,000	1,540,000
Analisis Data	Biaya analisis sampel	Analisis data stated preference untuk merumuskan model pemilihan moda	buah	1	1,540,000	1,540,000
Analisis Data	Biaya analisis sampel	Analisis parameter point to point model	buah	1	1,540,000	1,540,000
Analisis Data	Tiket	Tiket KA Purwokerto-Yogyakarta	OK (kali)	4	300,000	1,200,000
Analisis Data	Tiket	Tiket KA Purwokerto-Jakarta	OK (kali)	4	450,000	1,800,000
Analisis Data	Uang Harian	Untuk diskusi model yang dihasilkan dengan pihak AP Logistik di Yogyakarta	OH	8	350,000	2,800,000
Analisis Data	Uang Harian	Untuk diskusi model yang dihasilkan dengan pihak Ditjenhubud, Angkasa Pura 1 di Jakarta	OH	6	375,000	2,250,000
Analisis Data	Transport Lokal	Perjalanan lokal untuk proses analisis data dan diskusi di Yogyakarta	OH	6	250,000	1,500,000
Analisis Data	Transport Lokal	Perjalanan lokal untuk proses analisis data dan diskusi di Jakarta	OH	4	350,000	1,400,000
Analisis Data	Penginapan	Penginapan selama proses analisis data dan diskusi di Yogyakarta	OH	6	400,000	2,400,000
Analisis Data	Penginapan	Penginapan selama proses analisis data dan diskusi di Jakarta	OH	4	450,000	1,800,000

Jenis Pembelanjaan	Komponen	Item	Satuan	Vol.	Biaya Satuan	Total
Pelaporan, Luaran Wajib, dan Luaran Tambahan	HR Sekretariat/Administrasi Peneliti	Administrasi penelitian dan keuangan	OB	2	1,750,000	3,500,000
Pelaporan, Luaran Wajib, dan Luaran Tambahan	Uang harian rapat di luar kantor	Uang harian rapat di luar kantor	OH	8	350,000	2,800,000
Pelaporan, Luaran Wajib, dan Luaran Tambahan	Biaya konsumsi rapat	Biaya konsumsi rapat	OH	8	175,000	1,400,000
Pelaporan, Luaran Wajib, dan Luaran Tambahan	Publikasi artikel di Jurnal Internasional	Biaya APC dan publikasi pada Jurnal Internasional Terindeks Scopus (Q2)	paket	1	15,000,000	15,000,000
Pelaporan, Luaran Wajib, dan Luaran Tambahan	Publikasi artikel di Jurnal Internasional	Publikasi artikel di Jurnal Internasional terindeks scopus (Q1)	paket	1	25,000,000	25,000,000
Pelaporan, Luaran Wajib, dan Luaran Tambahan	Publikasi artikel di Jurnal Internasional	Biaya translate artikel ke bahasa inggris dan proofreading	paket	2	2,500,000	5,000,000
Pelaporan, Luaran Wajib, dan Luaran Tambahan	Luaran KI (paten, hak cipta dll)	Biaya penyusunan usulan hak cipta	paket	1	2,500,000	2,500,000
Pelaporan, Luaran Wajib, dan Luaran Tambahan	Luaran KI (paten, hak cipta dll)	Biaya pendaftaran usulan hak cipta ke Kemenkum HAM	paket	1	1,000,000	1,000,000

Tahun 3 Total Rp. 177,910,000

Jenis Pembelanjaan	Komponen	Item	Satuan	Vol.	Biaya Satuan	Total
Bahan	ATK	Alat tulis/ballpoint	buah	150	10,000	1,500,000
Bahan	ATK	Catridge epson warna	buah	1	725,000	725,000
Bahan	ATK	Catridge epson hitam	buah	1	650,000	650,000
Bahan	ATK	Materai tempel @6000	buah	10	6,000	60,000
Bahan	ATK	Kertas foto glossy	lembar	14	10,000	140,000
Bahan	ATK	Hardisk eksternal 500 GB	buah	1	630,000	630,000

Jenis Pembelanjaan	Komponen	Item	Satuan	Vol.	Biaya Satuan	Total
Bahan	Bahan Penelitian (Habis Pakai)	Bahan bakar minyak jenis pertalite untuk roda 4	liter	500	7,500	3,750,000
Bahan	Bahan Penelitian (Habis Pakai)	Fotocopy dan penjilidan proposal penelitian dasar	eksemplar	4	50,000	200,000
Bahan	Bahan Penelitian (Habis Pakai)	Fotocopy dan penjilidan laporan kemajuan penelitian dasar	eksemplar	4	60,000	240,000
Bahan	Bahan Penelitian (Habis Pakai)	Fotocopy dan penjilidan laporan akhir penelitian dasar	eksemplar	7	82,500	577,500
Bahan	Bahan Penelitian (Habis Pakai)	Cetak poster penelitian dasar	buah	1	550,000	550,000
Bahan	Bahan Penelitian (Habis Pakai)	Fotocopy data-data sekunder	lembar	3800	200	760,000
Bahan	Bahan Penelitian (Habis Pakai)	Bahan kontak berupa buku agenda	buku	225	32,500	7,312,500
Bahan	Barang Persediaan	Kertas HVS 80gr	rim	6	65,000	390,000
Bahan	Barang Persediaan	Refill tinta printer warna (merah, kuning, biru)	botol	3	110,000	330,000
Bahan	Barang Persediaan	Refill tinta printer hitam	botol	2	110,000	220,000
Pengumpulan Data	FGD persiapan penelitian	FGD Persiapan Penelitian Tahun ke-1	paket	1	5,500,000	5,500,000
Pengumpulan Data	HR Pembantu Peneliti	HR Pembantu Peneliti	OJ	600	10,000	6,000,000
Pengumpulan Data	HR Sekretariat/Administrasi Peneliti	Administrasi penelitian dan keuangan	OB	3	1,800,000	5,400,000
Pengumpulan Data	HR Petugas Survei	Survei produksi penerbangan logistik udara	OH	35	80,000	2,800,000
Pengumpulan Data	HR Petugas Survei	Survei parameter penentuan lokasi hub and spoke dan point to point	OH	25	80,000	2,000,000
Pengumpulan Data	HR Petugas Survei	Survei analytical hierarchi process (AHP)	OH	30	80,000	2,400,000
Pengumpulan Data	Transport	Perjalanan lokal selama survei	OH	7	400,000	2,800,000

Jenis Pembelanjaan	Komponen	Item	Satuan	Vol.	Biaya Satuan	Total
		pengumpulan data di Jakarta				
Pengumpulan Data	Tiket	Tiket KA Purwokerto-Yogyakarta (Bandara YIA)	OK (kali)	6	325,000	1,950,000
Pengumpulan Data	Tiket	Tiket KA Purwokerto-Jakarta (Kemenhub , PT Angkasa Pura)	OK (kali)	6	450,000	2,700,000
Pengumpulan Data	Tiket	Tiket KA Purwokerto-Yogyakarta (Bandara YIA, Bandara Adi Sucipto, kantor AP 1)	OK (kali)	6	325,000	1,950,000
Pengumpulan Data	Uang Harian	Survei pengumpulan data di Jakarta	OH	7	375,000	2,625,000
Pengumpulan Data	Uang Harian	Survei pengumpulan data di Yogyakarta	OH	9	350,000	3,150,000
Pengumpulan Data	Penginapan	Penginapan selama proses pengumpulan data di Jakarta	OH	6	450,000	2,700,000
Pengumpulan Data	Penginapan	Penginapan selama proses pengumpulan data di Yogyakarta	OH	8	425,000	3,400,000
Sewa Peralatan	Peralatan penelitian	Sewa LCD/TV LED untuk diskusi penelitian	unit	12	300,000	3,600,000
Sewa Peralatan	Peralatan penelitian	Sewa handycam/kamera	unit	6	300,000	1,800,000
Sewa Peralatan	Peralatan penelitian	Biaya langganan IndiHome untuk kajian literatur dan survei online	bulan	6	450,000	2,700,000
Sewa Peralatan	Peralatan penelitian	Sewa aplikasi software pemodelan transportasi	paket	1	4,500,000	4,500,000
Sewa Peralatan	Transport penelitian	Sewa kendaraan roda 4 dan sopir untuk survei di Yogyakarta	unit-hari	12	600,000	7,200,000

Jenis Pembelanjaan	Komponen	Item	Satuan	Vol.	Biaya Satuan	Total
Analisis Data	HR Sekretariat/Administrasi Peneliti	Administrasi penelitian dan keuangan	OB	5	1,800,000	9,000,000
Analisis Data	HR Pengolah Data	Biaya analisis statistik	Penelitian	1	1,540,000	1,540,000
Analisis Data	Biaya analisis sampel	Analisis evaluasi model dengan metode point to point	unit	1	1,540,000	1,540,000
Analisis Data	Biaya analisis sampel	Analisis evaluasi model dengan metode hub and spoke	unit	1	1,540,000	1,540,000
Analisis Data	Biaya analisis sampel	Rekomendasi model yang terbaik	unit	1	1,540,000	1,540,000
Analisis Data	Biaya analisis sampel	Analisis AHP (Analitycah Hierarchi Process)	unit	1	1,540,000	1,540,000
Analisis Data	Biaya analisis sampel	Analisis simulasi dan optimasi model jaringan transportasi udara	unit	3	1,540,000	4,620,000
Analisis Data	Tiket	Tiket KA Purwokerto-Yogyakarta	OK (kali)	4	325,000	1,300,000
Analisis Data	Tiket	Tiket KA Purwokerto-Jakarta	OK (kali)	4	450,000	1,800,000
Analisis Data	Uang Harian	Untuk diskusi model yang dihasilkan dengan pihak AP Logistik di Yogyakarta	OH	8	350,000	2,800,000
Analisis Data	Uang Harian	Untuk diskusi model yang dihasilkan dengan pihak Ditjenhubud, PT Angkasa Pura 1 dan 2di Jakarta	OH	8	375,000	3,000,000
Analisis Data	Transport Lokal	Perjalanan lokal untuk proses analisis data dan diskusi di Yogyakarta	OH	6	300,000	1,800,000
Analisis Data	Transport Lokal	Perjalanan lokal untuk proses analisis data dan diskusi di Jakarta	OH	6	400,000	2,400,000
Analisis Data	Penginapan	Penginapan	OH	6	425,000	2,550,000

Jenis Pembelanjaan	Komponen	Item	Satuan	Vol.	Biaya Satuan	Total
		selama proses analisis data dan diskusi di Yogyakarta				
Analisis Data	Penginapan	Penginapan selama proses analisis data dan diskusi di Jakarta	OH	6	475,000	2,850,000
Pelaporan, Luaran Wajib, dan Luaran Tambahan	HR Sekretariat/Administrasi Peneliti	Administrasi penelitian dan keuangan	OB	2	1,800,000	3,600,000
Pelaporan, Luaran Wajib, dan Luaran Tambahan	Uang harian rapat di luar kantor	Uang harian rapat di luar kantor	OH	8	350,000	2,800,000
Pelaporan, Luaran Wajib, dan Luaran Tambahan	Biaya konsumsi rapat	Biaya konsumsi rapat	OH	8	185,000	1,480,000
Pelaporan, Luaran Wajib, dan Luaran Tambahan	Publikasi artikel di Jurnal Internasional	Biaya APC dan publikasi pada Jurnal Internasional Terindeks Scopus (Q2)	paket	1	15,000,000	15,000,000
Pelaporan, Luaran Wajib, dan Luaran Tambahan	Publikasi artikel di Jurnal Internasional	Publikasi artikel di Jurnal Internasional terindeks scopus (Q1)	paket	1	25,000,000	25,000,000
Pelaporan, Luaran Wajib, dan Luaran Tambahan	Publikasi artikel di Jurnal Internasional	Biaya translate artikel ke bahasa inggris dan proofreading	buah	2	2,000,000	4,000,000
Pelaporan, Luaran Wajib, dan Luaran Tambahan	Luaran KI (paten, hak cipta dll)	Biaya penyusunan usulan hak cipta	paket	1	2,000,000	2,000,000
Pelaporan, Luaran Wajib, dan Luaran Tambahan	Luaran KI (paten, hak cipta dll)	Biaya pendaftaran usulan hak cipta ke Kemenkum HAM	paket	1	1,000,000	1,000,000

6. HASIL PENELITIAN

A. RINGKASAN: Tuliskan secara ringkas latar belakang penelitian, tujuan dan tahapan metode penelitian, luaran yang ditargetkan, serta uraian TKT penelitian.

Permasalahan pelayanan angkutan logistik di Indonesia yaitu tingkat penyediaan infrastruktur yang masih rendah, adanya pungutan tidak resmi dan biaya transaksi yang menyebabkan biaya ekonomi tinggi serta kapasitas dan jaringan pelayanan penyedia jasa logistik nasional yang masih terbatas. Strategi yang dilakukan yaitu dengan memperkuat konektivitas nasional, meningkatkan efisiensi biaya transportasi dan efektivitas distribusi logistik angkutan udara. Sampai dengan sebelum adanya pandemik COVID-19, metode yang digunakan oleh maskapai penerbangan untuk mendapatkan efisiensi transportasi adalah dengan konsep hub and spoke. Namun akibat adanya pandemik COVID-19, jumlah penumpang dan angkutan kargo udara turun drastis sehingga perlu dilakukan kajian untuk mendapatkan metode jaringan bandar udara yang terbaik, apakah tetap mempertahankan konsep hub and spoke atau berubah ke konsep point to point. Upaya yang dilakukan melalui penelitian dasar ini yaitu dengan cara mengkaji dampak pandemik Coronavirus Disease (COVID-19) pada industri penerbangan dan distribusi logistik angkutan udara, menentukan parameter yang digunakan untuk menetapkan suatu bandara sebagai bandara hub, mengevaluasi penerapan model bandara hub and spoke dan point to point agar diperoleh lintasan terpendek, biaya termurah dan melakukan kajian efisiensi penerbangan dengan metode Herfindahl-Hirschmann Index dan Eigenvector Centrality. Lokasi penelitian di empat bandara internasional yaitu Bandar Udara Soekarno-Hatta Cengkareng, Bandar Udara Juanda Surabaya, Bandar Udara Adi Sumarmo Solo, dan Bandar Udara Yogyakarta International Airport. Penelitian direncanakan selama tiga tahun (2021-2023).

Tujuan penelitian tahun pertama mengkaji dampak pandemik Coronavirus Disease (COVID-19) pada distribusi logistik angkutan udara dan simulasi model jaringan bandara hub and spoke. Tujuan penelitian tahun kedua yaitu melakukan analisis dan simulasi model jaringan bandar udara point to point untuk mendapatkan lintasan terpendek dan efisiensi penerbangan. Tujuan penelitian tahun ketiga yaitu mengevaluasi penentuan bandar udara konsep hub and spoke berdasarkan metode Eigenvector Centrality dan metode point to point. Penerapan model bandara hub and spoke yang optimum akan meningkatkan nilai efisiensi biaya transportasi serta efektivitas distribusi logistik angkutan udara. Hasil penelitian digunakan oleh pihak operator atau maskapai penerbangan dan pihak regulator sebagai dasar evaluasi terhadap rute penerbangan eksisting dan pemilihan jenis pesawat terbang. Kegiatan yang dilaksanakan meliputi: studi pustaka, pengumpulan data primer dan sekunder, analisis dan evaluasi rute penerbangan eksisting, simulasi jaringan bandara dengan konsep point to point dan hub and spoke, dan pemodelan transportasi. Data sekunder berupa statistik pergerakan barang dan penumpang, produksi kargo udara, kedatangan dan keberangkatan penumpang dan kargo udara untuk penerbangan domestik dan internasional dari Kementerian Perhubungan dan PT Angkasa Pura I dan PT Angkasa Pura II. Data primer berupa preferensi dan persepsi pemangku kepentingan terhadap parameter yang mempengaruhi pemilihan bandara pengumpul berdasarkan Analytical Hierarchy Process (AHP). Data primer dikumpulkan melalui kuesioner dan wawancara.

Luaran wajib penelitan dasar yang ditargetkan yaitu 3 (tiga) artikel di jurnal internasional bereputasi yang terindeks scopus (Engineering and Applied Science Research (EASR), Journal of Engineering Research (JER), dan Suranaree Journal of Science and Technology) dan luaran tambahan berupa satu artikel pada seminar internasional dengan prosiding terindeks (ICETIR 2021) dan dua artikel di jurnal internasional bereputasi terindeks scopus (Jurnal Teknologi (Sciences & Engineering) dan Engineering and Applied Science Research (EASR). Penelitian dasar ini juga akan menghasilkan hak kekayaan intelektual berupa hak cipta penentuan bandar udara pengumpul.

Uraian Tingkat Kesiapterapan Teknologi (TKT) penelitian dasar yang diusulkan saat ini berada pada level 1 (prinsip dasar dari teknologi telah diteliti dan tercatat). Pada tahun kedua penelitian (2022) berada pada level 2 (formulasi konsep dan/atau aplikasi formulasi) yaitu desain secara teoritis dan empiris telah teridentifikasi dan komponen yang akan dikembangkan telah dikuasai/dipahami. Pada akhir penelitian tahun 2023 TKT penelitian berada pada level 3 (Pembuktian konsep fungsi dan/atau karakteristik penting secara analitis dan eksperimental) dibuktikan dengan model atau hasil simulasi dan optimasi penentuan bandar udara pengumpul sudah diperoleh.

B. KATA KUNCI: Tuliskan maksimal 5 kata kunci.

Hub-spoke; point-to-point; Herfindahl-Hirschmann_Index; distribusi_logistik; COVID-19

Pengisian poin C sampai dengan poin H mengikuti template berikut dan tidak dibatasi jumlah kata atau halaman namun disarankan seringkas mungkin. Dilarang menghapus/memodifikasi template ataupun menghapus penjelasan di setiap poin.

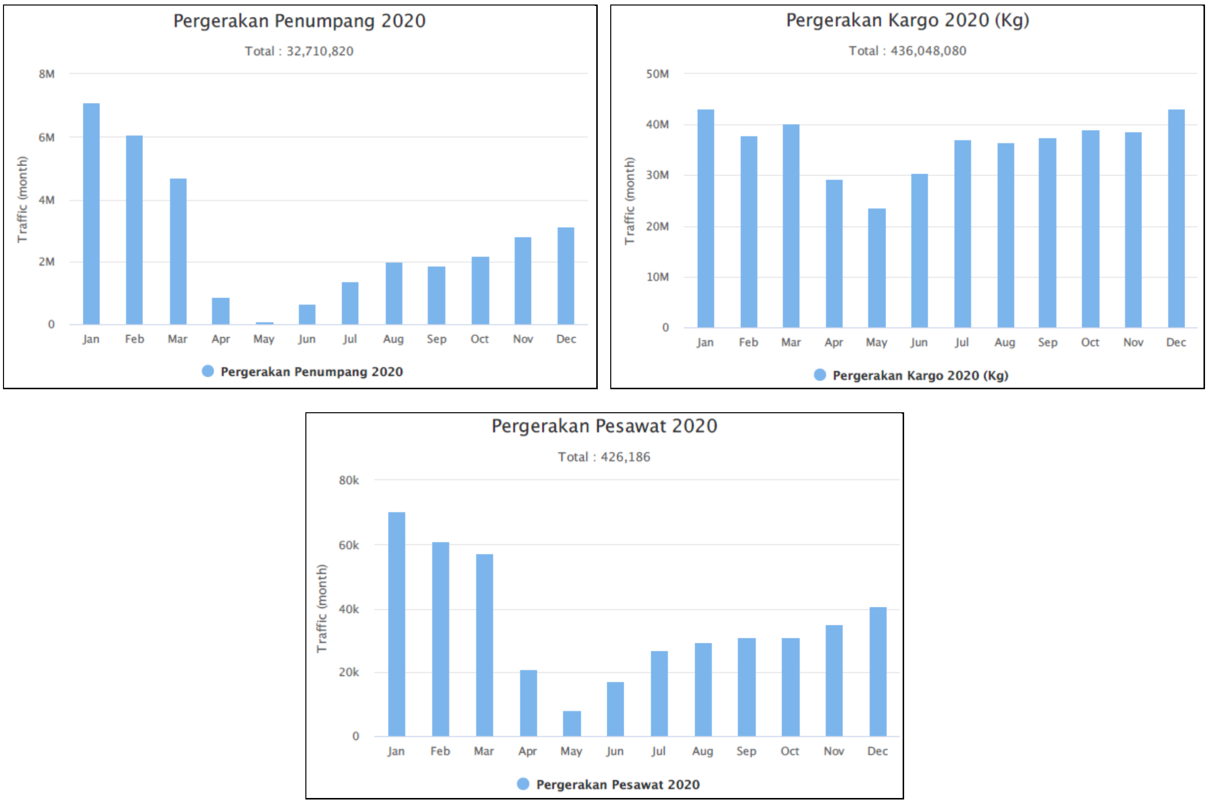
C. HASIL PELAKSANAAN PENELITIAN: Tuliskan secara ringkas hasil pelaksanaan penelitian yang telah dicapai sesuai tahun pelaksanaan penelitian. Penyajian dapat berupa data, hasil analisis, dan capaian luaran (wajib dan atau tambahan). Seluruh hasil atau capaian yang dilaporkan harus berkaitan dengan tahapan pelaksanaan penelitian sebagaimana direncanakan pada proposal. Penyajian data dapat berupa gambar, tabel, grafik, dan sejenisnya, serta analisis didukung dengan sumber pustaka primer yang relevan dan terkini.

Pengisian poin C sampai dengan poin H mengikuti template berikut dan tidak dibatasi jumlah kata atau halaman namun disarankan seringkas mungkin. Dilarang menghapus/memodifikasi template ataupun menghapus penjelasan di setiap poin.

C. **HASIL PELAKSANAAN PENELITIAN:** Tuliskan secara ringkas hasil pelaksanaan penelitian yang telah dicapai sesuai tahun pelaksanaan penelitian. Penyajian dapat berupa data, hasil analisis, dan capaian luaran (wajib dan atau tambahan). Seluruh hasil atau capaian yang dilaporkan harus berkaitan dengan tahapan pelaksanaan penelitian sebagaimana direncanakan pada proposal. Penyajian data dapat berupa gambar, tabel, grafik, dan sejenisnya, serta analisis didukung dengan sumber pustaka primer yang relevan dan terkini.

Data produksi penerbangan domestik dan internasional

Data pergerakan penumpang, pergerakan kargo dan pergerakan pesawat di Indonesia pada tahun 2020 seperti ditunjukkan pada **Gambar 1** berikut ini.



Gambar 1. Data pergerakan penumpang, pergerakan kargo dan pergerakan pesawat pada tahun 2020.

Bandar Udara Internasional Soekarno-Hatta

Penerbangan Domestik

Banyaknya penerbangan dan penumpang untuk penerbangan domestik di Bandar Udara Internasional Soekarno-Hatta tahun 2020 sebagai berikut:

a. Jumlah penerbangan datang 90.800 kali dan penerbangan berangkat 88.447 kali.
b. Jumlah penumpang datang 8.608.581 orang dan penumpang berangkat 7.653.277 orang.
c. Jumlah penumpang transit 252.410 orang dan penumpang transfer 965.803 orang.

Jumlah penumpang keberangkatan domestik di Bandara Internasional Soekarno-Hatta Tahun 2020 sebesar 7.653.277 orang, turun sebesar 57,35% dibandingkan tahun 2019. Jumlah penerbangan keberangkatan domestik di Bandara Internasional Soekarno-Hatta Tahun 2020 sebesar 90.800 kali, turun sebesar 37,19% dibandingkan tahun 2019.

Penerbangan Internasional

Banyaknya penerbangan dan penumpang untuk penerbangan internasional di Bandar Udara Internasional Soekarno-Hatta tahun 2020 sebagai berikut:

a. Jumlah penerbangan datang 16.728 kali dan penerbangan berangkat 16.781 kali.
b. Jumlah penumpang datang 1.542.512 orang dan penumpang berangkat 1.517.881 orang.
c. Jumlah penumpang transit 5.885 orang dan penumpang transfer 106 orang.

Jumlah penumpang keberangkatan internasional di Bandara Internasional Soekarno-Hatta tahun 2020 sebesar 1.542.512 orang, turun 80,74% dibandingkan data tahun 2019. Jumlah penerbangan keberangkatan internasional di Bandara Internasional Soekarno-Hatta tahun 2020 sebesar 16.781 kali, turun 65,28% dibandingkan tahun 2019.

Bandar Udara Internasional Ahmad Yani Semarang

Penerbangan Domestik

Banyaknya penerbangan dan penumpang untuk penerbangan domestik di Bandar Udara Internasional Ahmad Yani Semarang tahun 2020 sebagai berikut:

a. Jumlah penerbangan datang 8.345 kali dan penerbangan berangkat 8.347 kali.
b. Jumlah penumpang datang 675.907 orang dan penumpang berangkat 656.930 orang.

Jumlah penumpang keberangkatan domestik sebesar 656.930 orang, turun 63,78% dibandingkan data tahun 2019 yang sebesar 1.813.494 orang. Jumlah penerbangan keberangkatan domestik sebesar 8.347 kali, turun 52,63% dibandingkan dengan data tahun 2019 sebesar 17.621 kali.

Penerbangan Internasional

Banyaknya penerbangan dan penumpang untuk penerbangan internasional di Bandar Udara Internasional Ahmad Yani Semarang tahun 2020 sebagai berikut:

a. Jumlah penerbangan datang 206 kali dan penerbangan berangkat 207 kali.
b. Jumlah penumpang datang 22.120 orang dan penumpang berangkat 20.482 orang.

Jumlah penumpang keberangkatan internasional sebesar 20.482 orang, turun 82,06% dibandingkan tahun 2019 yang sebesar 114.140 orang. Jumlah penerbangan keberangkatan internasional sebesar 207 kali, turun 74,88% dibandingkan dengan data tahun 2019 sebesar 824 kali.

Bandar Udara Internasional Kualanamu

Jumlah pergerakan pesawat yang berangkat dari Bandar Udara Internasional Kualanamu pada tahun 2020 untuk penerbangan domestik turun sebesar 27,78% dan untuk penerbangan internasional turun 72,54%. Jumlah penumpang yang berangkat dari Bandar Udara Internasional Kualanamu pada tahun 2020 untuk penerbangan domestik mengalami penurunan sebesar 50,10% dan untuk penerbangan internasional turun sebesar 82,73%. Data jumlah pergerakan pesawat di Bandar Udara Internasional Kualanamu ditunjukkan pada **Tabel 1** dan jumlah penumpang untuk penerbangan internasional dan domestik ditunjukkan pada **Tabel 2**.

Tabel 1. Jumlah pergerakan pesawat di Bandar Udara Internasional Kualanamu Tahun 2016-2020

Tahun	Internasional (kali)		Domestik (kali)	
	Datang	Berangkat	Datang	Berangkat
2016	6.667	6.760	27.619	28.972
2017	8.112	8.176	32.026	32.902
2018	8.596	8.620	31.481	31.502
2019	7.366	7.361	22.074	22.069
2020	2.001	2.021	15.966	15.937

Sumber: Provinsi Sumatra Utara Dalam Angka 2021

Tabel 2. Jumlah penumpang internasional dan domestik melalui Bandar Udara Internasional Kualanamu Tahun 2016-2020

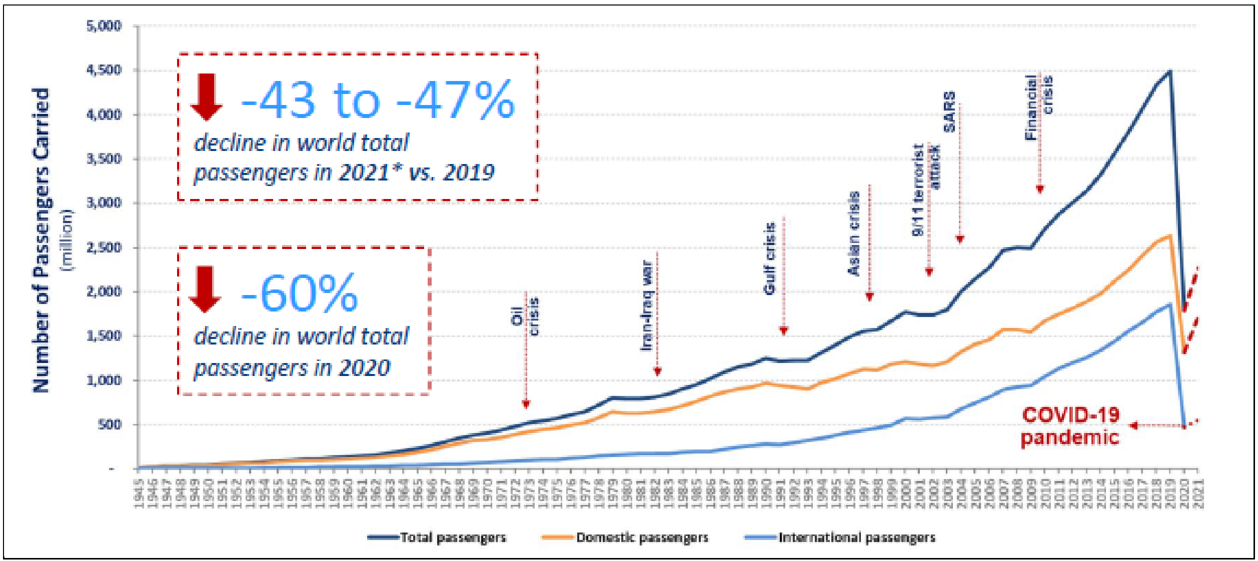
Tahun	Internasional (orang)			Domestik (orang)		
	Datang	Berangkat	Transit	Datang	Berangkat	Transit
2016	820.253	850.535	16.009	3.507.042	3.621.406	171.865
2017	1.005.247	987.335	23.370	3.897.074	3.667.846	422.927
2018	1.113.832	1.074.911	10.357	4.110.109	3.720.698	414.822
2019	1.130.524	1.090.912	27.854	2.903.787	2.631.399	279.848
2020	220.543	188.440	9.311	1.494.517	1.313.192	141.170

Sumber: Provinsi Sumatra Utara Dalam Angka 2021

Dampak Pandemi *Novel Coronavirus Disease* (COVID-19) pada Industri Penerbangan

Pada 11 Maret 2020, Organisasi Kesehatan Dunia atau *World Health Organization* (WHO) menyatakan bahwa wabah *Novel Coronavirus Disease* (COVID-19) sebagai pandemi. Pandemi COVID-19 melanda seluruh negara di dunia termasuk Indonesia. COVID-19 telah mempengaruhi banyak sektor seperti transportasi, kesehatan, pendidikan, ekonomi, pariwisata, perdagangan, dan sebagainya. Sektor transportasi udara menjadi salah satu industri global yang paling terpukul sejak adanya wabah pandemi. Pandemi COVID-19 telah mengakibatkan krisis transportasi global [1]. *Airports Council International* (ACI) mempublikasikan hasil kajian tentang dampak ekonomi dari pandemi COVID-19, pengaruhnya terhadap bisnis kebandarudaraan global dan jalur pemulihannya [1]. Sejak wabah COVID-19 diumumkan, jumlah kasus yang terinfeksi mencapai 254.723.915 sampai dengan tanggal 17 November 2021 dan 5.125.266 orang telah meninggal di seluruh dunia karena virus ini. Berdasarkan data Kementerian Kesehatan Republik Indonesia sampai dengan tanggal 17 November 2021, di Indonesia jumlah kasus terinfeksi COVID-19 mencapai 4.251.423 orang, sembuh dari COVID-19 sebanyak 4.099.399 orang dan 143.685 orang meninggal dunia [2].

Pandemi Covid-19 berdampak luas bagi masyarakat. Berdasarkan Laporan Komisi Eropa, dengan penurunan 50% dalam jumlah total penerbangan secara global selama bulan April-Mei 2020. Beberapa negara mengalami penurunan aktivitas transportasi udara lebih dari 90% selama dua bulan atau lebih [3]. Menurut Organisasi Penerbangan Sipil Internasional atau *International Civil Aviation Organization* (ICAO), dampak pandemi COVID-19 pada lalu lintas penumpang terjadwal untuk tahun 2020, dibandingkan dengan data 2019 adalah terjadi pengurangan keseluruhan sebesar 50% dari total kursi yang ditawarkan oleh maskapai penerbangan, pengurangan keseluruhan 2.699 juta penumpang (pengurangan 60%) dan kerugian mencapai sekitar USD 371 miliar dari pendapatan operasional penumpang kotor maskapai penerbangan [4]. Dampak pandemi COVID-19 pada perkiraan awal lalu lintas penumpang berjadwal dunia untuk tahun 2021, dibandingkan dengan tahun 2019 adalah terjadi pengurangan keseluruhan dari 35% menjadi 38% dari kursi yang ditawarkan oleh maskapai penerbangan, pengurangan keseluruhan dari 1.949 menjadi 2.116 juta penumpang (pengurangan 43% hingga 47%) dan sekitar USD 289 hingga USD 312 miliar kehilangan pendapatan operasional penumpang bruto maskapai penerbangan. Berdasarkan laporan ICAO, evolusi lalu lintas penumpang udara dunia dari tahun 1945-2021 seperti ditunjukkan pada **Gambar 2**.



Sumber: *International Civil Aviation Organization* (ICAO), 2021 [4].
Gambar 2. Evolusi Penumpang transportasi udara di Dunia tahun 1945-2021.

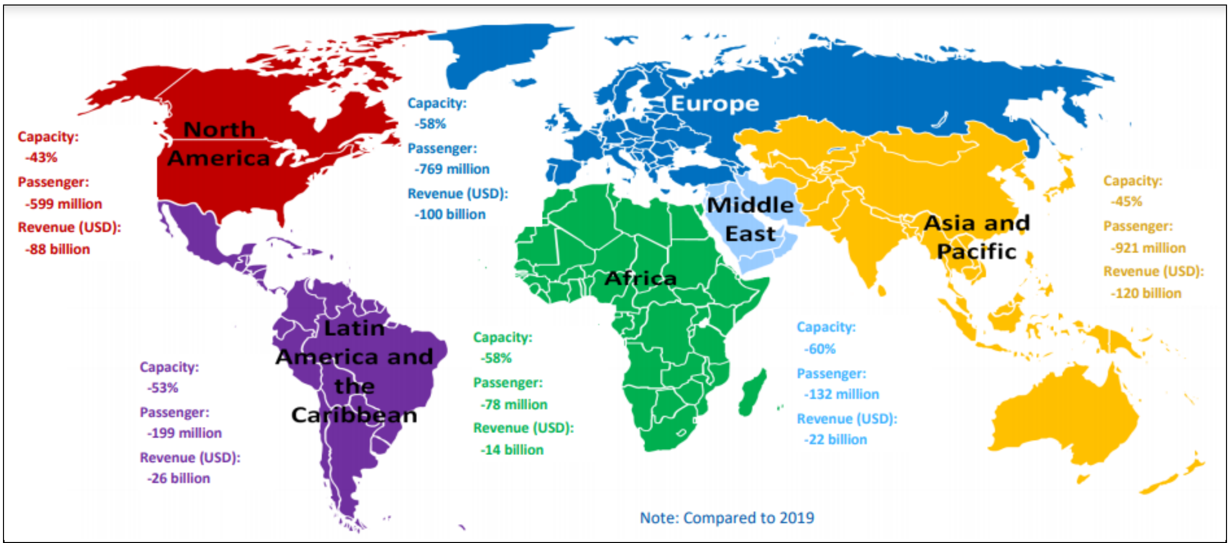
Berdasarkan **Gambar 2**, jumlah penumpang yang diangkut untuk penerbangan domestik, penerbangan internasional, dan total penumpang akibat pandemi COVID-19, terjadi penurunan atau penurunan drastis. Penurunan jumlah penumpang dunia lebih besar dari abu vulkanik Eyjafjallajokull di Islandia pada tahun 2010 [5] atau cuaca ekstrim [6], krisis minyak pada tahun 1973, perang Iran-Irak pada tahun 1982, krisis Teluk tahun 1991, krisis Asia 1997-1998, serangan teroris 9/11 (11 September 2001), *Severe Acute Respiratory Syndrome* (SARS) 2005, dan krisis keuangan 2010 [4]. Dampak pandemi COVID-19 terhadap angkutan udara di Indonesia, menurut Direktorat Jenderal Perhubungan Udara Kementerian Perhubungan Republik Indonesia, jumlah penumpang angkutan udara pada tahun 2020 tercatat sebanyak 32.711.088 orang. Jumlah ini menurun sebesar 57,76% *year on year* dari tahun 2019 sebanyak 76,69 juta orang [7]. Jumlah pergerakan pesawat pada tahun 2020 sebanyak 432.864 unit dan total kargo sebanyak 436.048.954 kg. Pendapatan PT Angkasa Pura (Persero) pada 2020 tercatat sebesar Rp 3,92 triliun. Jumlah ini turun sebesar 54,4% *year on year* dibandingkan tahun 2019 sebesar Rp 8,6 triliun.

Lalu Lintas Penumpang Domestik dan Internasional

Menurut Organisasi Penerbangan Sipil Internasional, efek pandemi COVID-19 pada lalu lintas penumpang domestik (2020 versus 2019) adalah pengurangan keseluruhan 38% kursi yang ditawarkan oleh maskapai penerbangan, pengurangan keseluruhan 1.323 juta penumpang (pengurangan 50%), dan sekitar USD 120 miliar kehilangan pendapatan operasional kotor maskapai penerbangan [4]. Dampak pandemi COVID-19 pada lalu lintas penumpang internasional (2020 versus 2019) adalah pengurangan keseluruhan 66% kursi yang ditawarkan oleh maskapai penerbangan, pengurangan keseluruhan 1.376 juta penumpang (pengurangan 74%), dan kerugian pendapatan operasional kotor maskapai penerbangan sekitar USD 250 miliar [4]. Penghindaran risiko dan jarak sosial yang dipaksakan sendiri dapat mengubah tren saat ini dalam permintaan penerbangan dan pilihan pengguna [8]. Pandemi COVID-19 mempengaruhi kapasitas bandar udara dan tingkat pelayanan yang diberikan [9]. Mengelola musiman di industri jasa transportasi udara, kasus manajemen harga dan faktor kursi di maskapai penerbangan, meskipun variasi musiman dan mingguan yang diharapkan [10], jaringan bandara agak stabil hingga pertengahan bulan Maret 2020. Dampak aktual akan tergantung pada durasi dan besarnya wabah dan tindakan penahanan, tingkat kepercayaan konsumen untuk perjalanan udara, dan kondisi ekonomi, jaringan bandara [11-12]. Jumlah dan frekuensi koneksi penerbangan berkorelasi kuat dengan pertumbuhan ekonomi [13] dan jaringan bandara *hub and spoke* [14]. Infrastruktur jalan merupakan salah satu faktor yang harus diperhatikan dalam menentukan lokasi bandara [15]. Penerapan jaringan bandar udara dengan konsep *hub and spoke* dapat meningkatkan efisiensi transportasi udara [16].

Kapasitas, Lalu Lintas Penumpang, dan Pendapatan Berdasarkan Wilayah Benua

Dampak pandemi COVID-19 terhadap kapasitas (jumlah kursi yang ditawarkan oleh maskapai penerbangan), jumlah lalu lintas penumpang, dan pendapatan berdasarkan wilayah dapat dilihat pada **Gambar 3**. Terdapat enam wilayah yaitu wilayah Amerika Utara, Amerika Latin dan Karibia, wilayah Eropa, wilayah Afrika, wilayah Asia dan Pasifik, dan wilayah Timur Tengah.



Sumber: *International Civil Aviation Organization*, 2021 [4].

Gambar 3. Pengaruh pandemi COVID-19 terhadap kapasitas, lalu lintas penumpang, dan pendapatan di enam wilayah pada tahun 2020.

Dampak pandemi COVID-19 terhadap kapasitas, jumlah lalu lintas penumpang, dan pendapatan di enam wilayah dapat dilihat pada **Tabel 3**.

Table 3. Dampak pandemi COVID-19 terhadap kapasitas, jumlah lalu lintas penumpang, dan pendapatan maskapai penerbangan tahun 2020

Nama wilayah	Penurunan kapasitas kursi yang ditawarkan(%)	Penurunan jumlah penumpang (juta orang)	Penurunan pendapatan (Milyar USD)
Wilayah Asia Pasifik	45	921	120
Wilayah Eropa	58	769	100
Wilayah Amerika Utara	43	599	88
Wilayah Amerika Latin dan Karibia	53	199	26
Wilayah Timur Tengah	60	132	22
Wilayah Afrika	58	78	14

Sumber: *International Civil Aviation Organization*, 2021 [4].

Efek Global dari Pandemi COVID-19

Dampak pandemi COVID-19 terhadap lalu lintas penumpang udara, bandar udara, maskapai penerbangan, pariwisata, dan perdagangan pada tahun 2020 sebagai berikut:

1. Berdasarkan hasil studi Organisasi Penerbangan Sipil Internasional atau *International Civil Aviation Organization*, dampak pandemi COVID-19 terhadap penerbangan global yang berfokus pada lalulintas penumpang udara adalah terjadi penurunan jumlah penumpang udara yang diangkut (baik untuk penerbangan internasional maupun domestik) secara keseluruhan sebesar 60% pada tahun 2020 jika dibandingkan dengan tahun 2019 (tahun ke tahun) [4].

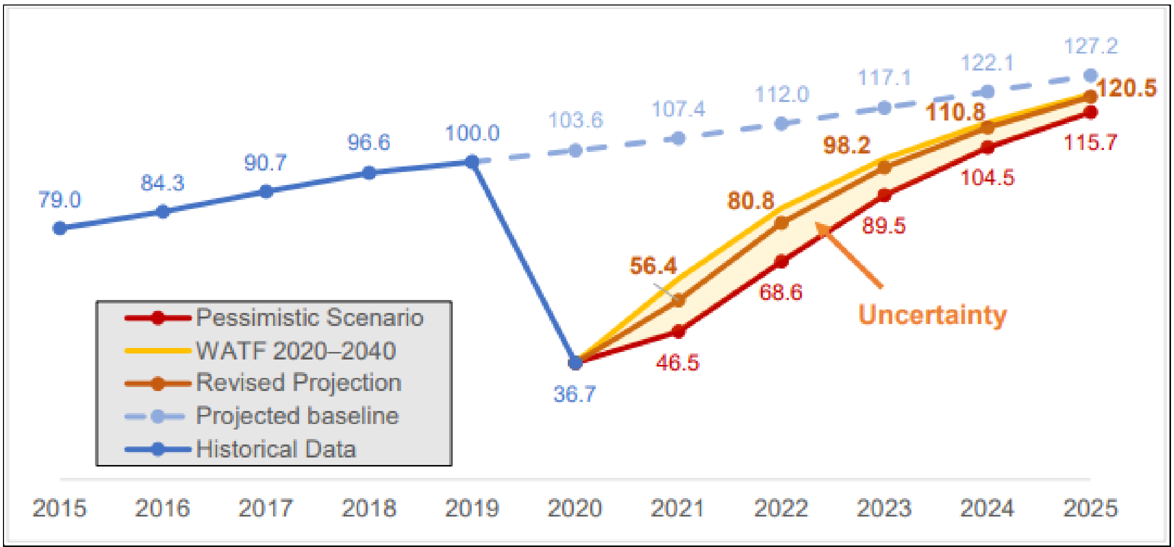
2. Berdasarkan hasil studi *Airports Council International*, dampak COVID-19 di bandar udara adalah diperkirakan terjadi kerugian sekitar 64,6% dari lalulintas penumpang yang dibawa dan 66,3% atau lebih dari USD 125 miliar pendapatan bandara pada tahun 2020 jika dibandingkan dengan bisnis seperti biasa [1].
3. Menurut kajian *International Air Transport Association* (IATA), dampak COVID-19 pada maskapai penerbangan adalah terjadi penurunan 65,9% pendapatan penumpang kilometer atau *revenue passenger kilometres* (RPKs), baik untuk penerbangan internasional maupun penerbangan domestik pada 2020 dibandingkan 2019 (tahun ke tahun) [17].
4. Berdasarkan hasil studi *United Nations-World Tourism Organization* (UNWTO), dampak COVID-19 di bidang pariwisata adalah terjadinya penurunan penerimaan pariwisata internasional sebesar USD 1,3 triliun pada tahun 2020, dibandingkan dengan USD 1,5 triliun yang dihasilkan pada tahun 2019.
5. Berdasarkan hasil studi *World Trade Organization* (WTO), dampak COVID-19 dalam perdagangan dunia adalah turunnya volume perdagangan barang global sebesar 5,3% pada tahun 2020 jika dibandingkan 2019 (*year on year*).

Proyeksi Lalu Lintas dan Jalur menuju Pemulihan

Menurut *Airports Council International* berikut ini dijelaskan terkait proyeksi lalu lintas dan jalur pemulihan lalu lintas penumpang bandara dalam penerbangan global dapat dianalisis dalam 3 (tiga) skenario, yang pertama yaitu menurut *The World Airport Traffic Forecasts* (WATF) 2020-2040, yang kedua adalah berdasarkan proyeksi yang direvisi, dan yang ketiga berdasarkan skenario pesimis. Proyeksi lalu lintas dan jalur menuju pemulihan selengkapnya diuraikan sebagai berikut [1]:

1. Skenario pertama, jika varian baru COVID-19 dapat dikendalikan secara efektif, maka *The World Airport Traffic Forecasts* (WATF) 2020-2040 masih yang paling mungkin, menghasilkan pemulihan jumlah lalu lintas penumpang global yang dibawa ke level 2019 akan terjadi pada akhir tahun 2023 [1].
2. Dalam skenario kedua, di bawah skenario *baseline*, lalu lintas penumpang global sekarang diperkirakan akan pulih ke level 2019 pada tahun 2024 terutama dengan didorong oleh pemulihan lalu lintas penumpang domestik tetapi sekarang sedikit diredam oleh pemulihan perjalanan internasional yang lebih lambat. Lalu lintas penumpang domestik diperkirakan akan mencapai level 2019 pada paruh kedua tahun 2023. Pemulihan lalu lintas penumpang internasional diperkirakan akan mencapai level 2019 pada tahun 2024.
3. Skenario ketiga adalah skenario pesimis, dimana pemulihan lalu lintas yang tertunda dengan munculnya varian baru COVID-19 yang mengakibatkan pemerintah memberlakukan tindakan yang lebih ketat, membuat penguncian baru dan pembatasan perjalanan. Di bawah skenario pesimis, lalu lintas penumpang global akan berakhir pada tahun 2021 hanya 46,5% dari level 2019, mengakhiri tahun 2022 hanya sekitar 68,6% dari level 2019. Dalam jangka panjang, lalu lintas global diperkirakan membutuhkan waktu hingga dua dekade untuk kembali ke tingkat yang diproyeksikan sebelumnya (perkiraan pra COVID-19).

Proyeksi lalu lintas penumpang penerbangan global menurut *Airports Council International* dapat dilihat pada **Gambar 4.** Pemulihan lalu lintas penumpang internasional atau jumlah penumpang udara yang diangkut akan membutuhkan waktu kurang lebih satu tahun lagi, sehingga kembali ke level 2019 pada tahun 2024. Pada akhir tahun 2021, nilainya dibandingkan dengan level 2019 hanya sebesar 56,4%; pada akhir tahun 2022 sekitar 80,8% dari level 2019; pada akhir 2023 sekitar 98,2% dari level 2019 dan pada akhir 2024 sekitar 110,8% dari level 2019 [1].



Sumber: *Airports Council International* (ACI), 2021 [1]

Gambar 4. Proyeksi lalu lintas penumpang global jangka pendek [1].

Kehadiran pandemi Covid-19 selama tahun 2020 telah melumpuhkan sebagian besar aktivitas transportasi udara akibat menurunnya mobilitas masyarakat dalam melakukan perjalanan melalui udara. Industri penerbangan dan bisnis maskapai penerbangan mengalami kontraksi yang sangat hebat akibat pandemi Covid-19 yang dapat diibaratkan dunia penerbangan "sedang terbang dalam situasi mega turbulensi". Pandemi Covid-19 telah berdampak secara luas terhadap sektor penerbangan di seluruh dunia termasuk di Indonesia yang juga berdampak pada pertumbuhan sektor ekonomi lainnya. Sejak awal tahun 2020, banyak negara yang telah menutup atau mengerem frekuensi penerbangan internasional guna menekan penyebaran virus Corona. Hal ini juga dirasakan di Indonesia, maskapai penerbangan dan operator bandar udara terdampak serius akibat pandemi Covid-19. Berkurangnya frekuensi penerbangan berjadwal pada bulan Maret, April, Mei dan pada bulan-bulan berikutnya selama tahun 2020 tanpa kejelasan waktu mengakibatkan banyak kerugian yang dialami pada industri penerbangan.

Upaya pemulihan industri penerbangan global tentunya bertumpu kepada penerbangan domestik. Pemulihan penerbangan internasional memerlukan waktu lebih lama. Salah satu tantangan memasuki masa pemulihan ialah arus kas (*cash flow*) maskapai penerbangan. Dunia penerbangan di Indonesia memiliki secercah harapan untuk lebih cepat bangkit mengingat bahwa jumlah penerbangan domestik yang signifikan dibandingkan dengan penerbangan internasional. Data jumlah penumpang melalui angkutan udara pada tahun 2018 dan 2019 menunjukkan besarnya pasar domestik dibandingkan dengan pasar internasional. Data tahun 2018, jumlah penumpang domestik sebesar 101 juta penumpang berbanding dengan jumlah penumpang internasional sebesar 17 juta. Demikian pula pada tahun 2019 jumlah penumpang domestik mencapai 80 juta orang sedangkan penumpang internasional 18 juta orang. Pada tahun 2020, jumlah kedatangan penumpang mencapai total 37.174.390 orang, dimana sebanyak 90% (33.636.091 orang) berasal dari penerbangan domestik, sedangkan sisanya sebanyak 10% (3.538.299 orang) adalah berupa penerbangan internasional [5].

Sampai dengan bulan November 2020 jumlah penumpang mengalami penurunan drastis. Sebagai contoh, Bandar Udara Internasional Soekarno-Hatta mencatat jumlah kedatangan penumpang hanya 9 juta orang dan keberangkatan penumpang sebesar 8 juta orang. Sangat berbeda jauh jika dibandingkan dengan data tahun 2019 dimana untuk jumlah kedatangan penumpang mencapai 26,7 juta orang dan keberangkatan penumpang sebesar 27,7 juta orang. Secara nasional, berdasarkan Data Penerbangan Siaga Covid-19 Direktorat Jenderal Perhubungan Udara Kementerian Perhubungan per tanggal 27 Desember 2020, jumlah kedatangan pesawat pada tahun 2020 turun drastis sebesar 407.006 dan keberangkatan pesawat sebesar 409.250 dibandingkan dengan data tahun 2019 yang mencapai pergerakan pesawat datang sebesar 684.637 dan pesawat berangkat 682.885. Demikian pula halnya dengan data penumpang, juga menunjukkan hal yang sama yaitu terjadi penurunan yang sangat drastis yakni jumlah penumpang datang pada tahun 2020 sebesar 33.636.091 orang dan penumpang berangkat sebesar 34.428.318 orang. Sangat berbeda jauh kondisinya dibandingkan dengan jumlah penumpang datang pada tahun 2019 mencapai 75.186.635 orang dan penumpang berangkat mencapai 76.255.105 orang. Pada tahun 2020 telah terjadi penurunan jumlah penumpang domestik diangkut sebesar 55% dibandingkan dengan tahun 2019. Hal serupa juga terjadi pada penerbangan internasional, dimana jumlah penumpang yang datang dan berangkat pada tahun 2020 hanya sebesar 3.538.299 orang dan 3.585.121 orang. Sangat berbeda jauh jika dibandingkan dengan tahun 2019 dimana jumlah penumpang yang datang mencapai 18.026.850 orang dan penumpang berangkat 18.706.261 orang. Pada tahun 2020 telah terjadi penurunan jumlah penumpang internasional diangkut sebesar 80% dibandingkan tahun 2019.

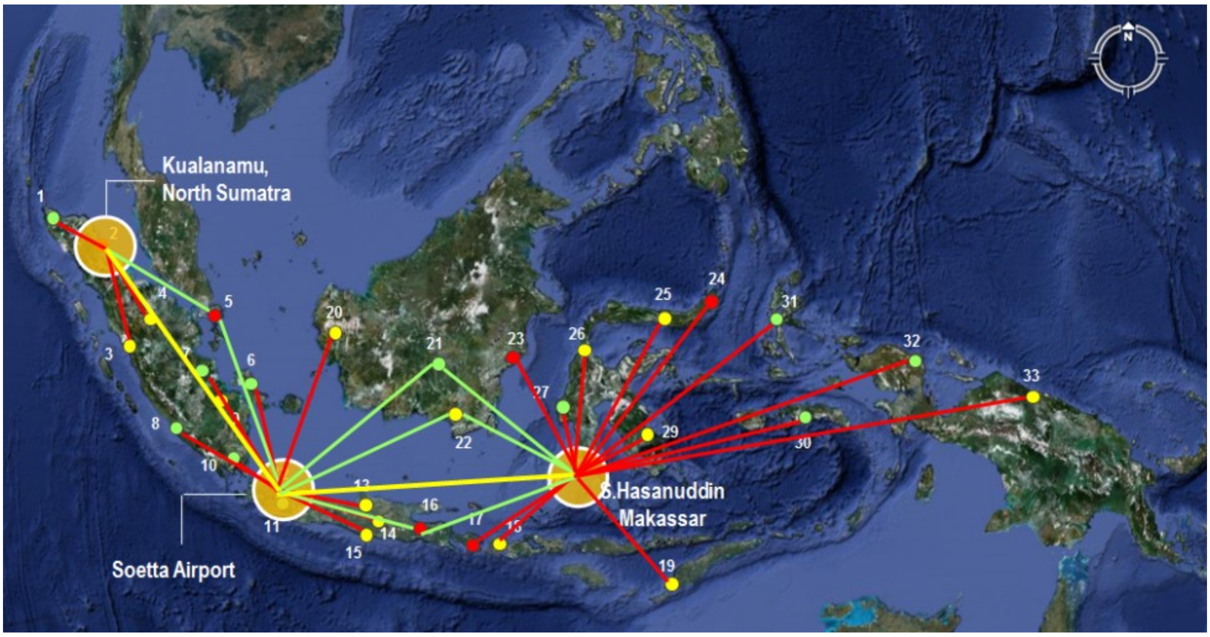
Hadirnya pandemi global Covid-19 pada tahun 2020 telah "meluluhlantakkan" aktivitas bisnis penerbangan di Indonesia. Tiga pemain utama dalam dunia penerbangan yakni *airlines*, *airport*, dan *air navigation*, khususnya *airlines* dan *airport* mengalami dampak yang sangat serius, yaitu anjloknya jumlah penumpang yang diangkut yang secara nasional mencapai 55%. Bahkan maskapai penerbangan Garuda Indonesia menyatakan bahwa pada bulan Juli-Agustus 2020 mengalami penurunan jumlah penumpang yang diangkut hingga 90%. Untuk *airport* sendiri yang memiliki peranan *multiflier effect* terhadap tumbuhnya bisnis-bisnis lainnya baik bisnis yang bersentuhan dengan penerbangan maupun non penerbangan mengalami nasib yang tidak berbeda jauh dengan *airlines*. Bandar udara menjadi sangat lengang pada masa-masa *low season*.

Pemerintah melalui kebijakan Pembatasan Sosial Berskala Besar (PSBB) baik yang diperketat maupun transisi dalam rangka mencegah penularan Covid-19 dan sekarang dengan penerapan Pemberlakuan Pembatasan Kegiatan Masyarakat (PPKM) berakibat pada menurunnya mobilitas masyarakat melakukan perjalanan dengan pesawat terbang. Pada prinsipnya masyarakat masih diperbolehkan melakukan penerbangan untuk tujuan yang betul-betul penting dengan penerapan protokol kesehatan yang ketat baik di bandar udara maupun di dalam pesawat. Namun faktanya, berdasarkan laporan dari Tim Satgas Pencegahan Penyebaran Covid-19, jumlah masyarakat yang perpapar Covid-19 semakin meningkat, bahkan Indonesia saat ini menduduki peringkat teratas di kawasan Asia Tenggara. Di tengah ketidakpastian kapan pandemi Covid-19 akan berakhir, muncul harapan baru dengan sudah ditemukannya vaksin untuk menangkal Covid-19.

Heinitz dan Meincke pada tahun 2011 mengembangkan opsi routing yang sistematis dalam model jaringan kargo udara global, serta metodologi untuk pembentukan set pilihan berikutnya [18]. Selanjutnya, Heinitz dan Meincke pada tahun 2013 [19] menangani masalah penugasan permintaan asal-tujuan. Empat tahapan dalam sistematisasi pilihan rute kargo udara meliputi segmentasi permintaan, penentuan ukuran pilihan, pembentukan dan kualifikasi pilihan, dan pilihan [18]. Segmentasi permintaan dibagi menjadi dua kategori, jenis komoditas dan kekritisan waktu. Penentuan ukuran kumpulan pilihan mencakup opsi jaringan pemasok dan opsi pasangan kota. Formasi dan kualifikasi kumpulan pilihan termasuk tautan akses atau jalan keluar, topologi jaringan, variasi permintaan mingguan, strategi pencarian jalur yang optimal, dan pengenaan batasan pencarian rute yang sulit. Pilihan termasuk model pilihan tingkat A/L dan model pilihan tingkat pengirim. Rangkaian lengkap dari tahapan ini diperlukan untuk sepenuhnya mencakup sisi pasokan yang kompleks, kebutuhan berbagai jenis konsinyasi kargo udara, dan ruang multidimensi yang dihasilkan dari rencana perjalanan yang dapat dibayangkan. Derajat kebebasan pemodelan ketika mengeksekusi dalam empat tahap sistematisasi pilihan rute kargo udara.

Simulasi model jaringan bandara *hub and spoke* berdasarkan metode *Herfindahl-Hirschmann Index* (HHI) pada penerbangan domestik

Analisis terhadap rute angkutan kargo untuk mendukung Sistem Logistik Nasional (Sislognas) memerlukan justifikasi dan asumsi sistem *hub and spoke* seperti apa yang akan diterapkan di lapangan. Berdasarkan Sislognas, jumlah *hub* yang dikembangkan pada tahap 2011-2015 adalah 3 (tiga) bandar udara. Dengan demikian, konsep *hub and spoke* dapat diturunkan dengan kombinasi 3-*hub* dan 30-*spoke* dan rute-rute penerbangan dapat diasumsikan seperti yang disampaikan pada **Gambar 5**.



Gambar 5. Interpretasi konsep *Hub and Spoke* berdasarkan Sistem Logistik Nasional (Sislognas).

Menurut penelitian Martin dan Roman pada tahun 2004, dua parameter yang mempengaruhi penentuan lokasi *hub* adalah lokasi bandar udara dan persaingan [20]. Krisis ekonomi telah mempengaruhi perilaku harga baik dari segi tingkat harga maupun dispersi, dengan kenaikan yang jelas pada tingkat harga dan penurunan dispersi harga [21]. Frekuensi rendah pesawat mungkin memiliki efek negatif yang besar pada biaya penjadwalan dan biaya menunggu di bandara *hub* [22]. Keuntungan penerapan *hub and spoke* di jaringan bandara adalah berkurangnya jumlah rute pesawat [23], peningkatan permintaan (frekuensi penerbangan), penurunan biaya [24]. Distribusi dan justifikasi jaringan bandar udara *hub and spoke* di Indonesia dapat dijelaskan seperti pada **Tabel 4.**

Tabel 4. Justifikasi *hub and spoke* sesuai Sistem Logistik Nasional

Bandara *Hub*	Bandara *Spoke*
Kualanamu International Airport (KNO) Medan	4 bandara: 1) Sultan Iskandar Muda International Airport di Banda Aceh, 2) Sultan Syarif Kasim II International Airport di Pekanbaru, 3) Minangkabau International Airport di Padang, and 4) Hang Nadim International Airport di Batam.
Soekarno-Hatta International Airport (CGK) Cengkareng	11 bandara: 1) Depati Amir Airport di Pangkal Pinang, 2) Sultan Thaha Saifuddin Airport di Jambi, 3) Fatmawati Soekarno Airport di Bengkulu, 4) Sultan Mahmud Badaruddin II International Airport di Palembang, 5) Raden Inten II International Airport di Lampung, 6) Husein Sastranegara International Airport di Bandung, 7) Ahmad Yani International Airport di Semarang, 8) Adi Sumarmo International Airport di Surakarta/Solo,

Bandara *Hub*	Bandara *Spoke*
	9) Adi Sutjipto International Airport di Yogyakarta/Yogyakarta International Airport di Kulon Progo 10) Juanda International Airport di Sidoarjo, and 11) Supadio International Airport di Pontianak. *) Hang Nadim International Airport di Batam, *) Tjilik Riwut Airport di Palangkaraya, *) Syamsudin Noor International Airport di Banjarmasin dan *) Ngurah Rai International Airport di Badung, Bali.
Sultan Hasanuddin International Airport (UPG) Makassar	15 bandara: 1) Sultan Aji Muhammad Sulaiman Sepinggan International Airport di Balikpapan, 2) Tjilik Riwut Airport di Palangkaraya, 3) Syamsudin Noor International Airport di Banjarmasin, 4) Ngurah Rai International Airport di Badung, Bali, 5) Zainuddin Abdul Madjid Lombok International Airport di Mataram, 6) Eltari International Airport di Kupang, 7) Sam Ratulangi International Airport di Manado, 8) Djalaluddin Airport di Gorontalo, 9) Mutiara SIS Al-Jufrie Airport di Palu, 10) Tampa Padang Airport di Mamuju, 11) Haluoleo (Wolter Monginsidi) International Airport di Kendari, 12) Pattimura International Airport di Ambon, 13) Sultan Babullah International Airport di Ternate, 14) Sentani Airport di Jayapura, and 15) Rendani Airport di Manokwari.

Mengingat 4 (empat) bandar udara yang bisa melakukan penerbangan langsung kedua bandar udara pengumpul (*hub airport*) berbeda yaitu Bandara Internasional Hang Nadim Batam, Bandara Tjilik Riwut Palangkaraya, Bandara Internasional Syamsuddin Noor Banjarmasin, dan Bandara Internasional Ngurah Rai Denpasar.

Analisis Rute Angkutan Kargo Udara Nasional

Rute-rute penerbangan berdasarkan konsep *hub and spoke* disampaikan pada **Tabel 5**. Rute-rute yang disampaikan tersebut adalah rute-rute penerbangan langsung (*point-to-point*). Adapun untuk rute-rute jarak jauh dapat menggunakan pola rute tersebut. Contoh kasus penerbangan dari Batam ke Manado maka rute yang perlu ditempuh adalah Batam-Jakarta-Makassar-Manado. Artinya rute-rute yang terjadi adalah Batam-Jakarta, Jakarta-Makassar dan Makassar-Manado. Untuk kasus-kasus penerbangan antarkota yang lain dapat mengacu pada tabel tersebut.

Tabel 5. Identifikasi kebutuhan rute penerbangan untuk menunjang angkutan kargo udara

No	Bandara Hub	Rute yang dibutuhkan
1.	Kualanamu International Airport (KNIA)	1. Medan - Banda Aceh (KNIA - Sultan Iskandar Muda International Airport) 2. Medan - Pekanbaru (KNIA - Sultan Syarif Kasim II International Airport) 3. Medan - Padang (KNIA - Minangkabau International Airport) 4. Medan - Batam (KNIA - Hang Nadim International Airport) 5. Medan - Jakarta (KNIA - Soekarno-Hatta International Airport)
2.	Soekarno-Hatta International Airport (SHIA)	6. Jakarta - Pangkal Pinang (SHIA - Depati Amir Airport) 7. Jakarta - Jambi (SHIA - Sultan Thaha Saifuddin Airport) 8. Jakarta - Bengkulu (SHIA - Fatmawati Soekarno Airport) 9. Jakarta - Palembang (SHIA - Sultan Mahmud Badaruddin II International Airport) 10. Jakarta - Lampung (SHIA - Raden Inten II International Airport) 11. Jakarta - Bandung (SHIA - Husein Sastranegara International Airport) 12. Jakarta - Semarang (SHIA - Ahmad Yani International Airport) 13. Jakarta - Solo (SHIA - Adi Sumarmo International Airport) 14. Jakarta - Yogyakarta (SHIA - Adi Sutjipto International Airport (SHIA - Yogyakarta International Airport) 15. Jakarta - Surabaya (SHIA - Juanda International Airport) 16. Jakarta - Pontianak (Supadio International Airport)

		17. Jakarta - Palangkaraya (SHIA - Tjilik Riwut Airport) 18. Jakarta - Banjarmasin (SHIA - Syamsuddin Noor International Airport) 19. Jakarta - Batam (SHIA - Hang Nadim International Airport) 20. Jakarta - Makassar (SHIA - Sultan Hasanuddin International Airport) 21. Jakarta - Denpasar (SHIA - Ngurah Rai International Airport)
3.	Sultan Hasanuddin International Airport Makassar (SHIAM)	22. Makassar - Balikpapan (SHIAM - Sultan Aji Muhammad Sulaiman Sepinggan International Airport) 23. Makassar - Palangkaraya (SHIAM - Tjilik Riwut Airport) 24. Makassar - Banjarmasin (SHIAM - Syamsuddin Noor International Airport) 25. Makassar - Denpasar (SHIAM - Ngurah Rai International Airport) 26. Makassar - Mataram (SHIAM - Zainuddin Abdul Madjid Lombok International Airport) 27. Makassar - Kupang (SHIAM - Eltari International Airport) 28. Makassar - Manado (SHIAM - Sam Ratulangi International Airport) 29. Makassar - Gorontalo (SHIAM - Djalaluddin Airport) 30. Makassar - Palu (SHIAM - Mutiara SIS Al-Jufrie Airport) 31. Makassar - Mamuju (SHIAM - Tampa Padang Airport) 32. Makassar - Kendari (SHIAM - Haluoleo (Wolter Monginsidi) International Airport) 33. Makassar - Ambon (SHIAM - Pattimura International Airport) 34. Makassar - Ternate (SHIAM - Sultan Babullah International Airport) 35. Makassar - Jayapura (SHIAM - Sentani Airport) 36. Makassar - Manokwari (SHIAM - Rendani Airport) 37. Makassar - Surabaya (SHIAM - Juanda International Airport)

Berdasarkan **Tabel 5** terlihat bahwa jumlah trayek yang diperlukan untuk membentuk sistem *hub and spoke* angkutan kargo menurut Sistem Logistik Nasional Indonesia berdasarkan skema Peraturan Presiden Republik Indonesia Nomor 26 Tahun 2012 adalah 37 trayek (2-arah perjalanan). Diperlukan 5 (lima) rute penerbangan untuk mendukung angkutan kargo udara dari Bandara Internasional Kualanamu (KNO), 16 (enam belas) rute penerbangan dari Bandara Internasional Soekarno-Hatta (CGK), dan 16 (enam belas) rute penerbangan dari Bandara Internasional Sultan Hasanuddin (UPG). Hasil penelitian ini mirip dengan Referensi [25] yang menggabungkan pemilihan bandara, perutean armada, dan pengaturan jadwal untuk mengembangkan model penjadwalan terintegrasi untuk rute pesawat [25]. Pemilihan konsep distribusi logistik transportasi udara yang terbaik merupakan salah satu kunci keberhasilan dalam menekan logistik dan biaya ekonomi yang tinggi [26]. Ketepatan waktu lalu lintas udara merupakan salah satu kriteria terpenting dalam memilih layanan penerbangan [24]. Parameter yang digunakan untuk mencari rute yang efisien dan efektif dengan menghitung jarak terbang, waktu terbang dan bahan bakar blok [27]. Liberalisasi transportasi udara akan menguntungkan konsumen dan industri penerbangan di wilayah tersebut meskipun tidak harus secara merata di seluruh atau di dalam kelompok [28]. Sebagian besar rute udara memiliki efisiensi alokasi dan efisiensi angkutan penumpang yang tinggi, sedangkan angkutan barang memiliki efisiensi angkutan barang yang rendah [29]. Topologi fisik jaringan dan jaringan fungsional dengan informasi lalu lintas sangat berkorelasi dengan Produk Domestik Bruto (PDB) suatu negara [30]. Menurut Bazargan, ada empat tahapan proses manajemen perencanaan penerbangan, yaitu penjadwalan penerbangan, penugasan armada, penentuan rute pesawat, dan penjadwalan kru [31].

D. **STATUS LUARAN**: Tuliskan jenis, identitas dan status ketercapaian setiap luaran wajib dan luaran tambahan (jika ada) yang dijanjikan pada tahun pelaksanaan penelitian. Jenis luaran dapat berupa publikasi, perolehan kekayaan intelektual, hasil pengujian atau luaran lainnya yang telah dijanjikan pada proposal. Uraian status luaran harus didukung dengan bukti kemajuan ketercapaian luaran sesuai dengan luaran yang dijanjikan. Lengkapi isian jenis luaran yang dijanjikan serta mengunggah bukti dokumen ketercapaian luaran wajib dan luaran tambahan melalui Simlitabmas mengikuti format sebagaimana terlihat pada bagian isian luaran

Luaran Penelitian tahun pertama (2021)

1. Pemakalah pada *The 3rd International Conference on Engineering, Technology and Innovative Researches* (**ICETIR**) 2021 tanggal 1 September 2021 dengan judul "***Aircraft Routes of Domestic Cargo Transport based on Indonesian National Logistics System***". Saat ini prosiding sedang proses di **AIP Conference Proceedings** (Terindeks Scopus).

2. Artikel pada *Conference*/Seminar internasional di pengideks bereputasi *The 3rd International Conference on Engineering, Technology and Innovative Researches* (**ICETIR**) 2021 tanggal 1 September 2021 dengan judul "***The Effect of Novel Coronavirus Disease (COVID-19) on Air Transport***". Saat ini prosiding sedang proses di **AIP Conference Proceedings** (Terindeks Scopus).
3. *Manuscript* publikasi ilmiah di jurnal internasional bereputasi ***Suranaree Journal of Science and Technology*** (Terindeks Scopus) dengan judul "***Aircraft Routes and Flight Frequency of Domestic Cargo Transport***". Saat ini artikel dalam **proses review**.
4. ***Book Chapter*** pada Buku **Sistem Transportasi** Bab 6 Sistem Transportasi Udara halaman 79-98 dengan No. ISBN 978-623-342-168-3, Penerbit Yayasan Kita Menulis Cetakan 1 terbit pada tanggal 5 Agustus 2021.
5. ***Book Chapter*** pada Buku **Perancangan Bandar Udara** Bab 7 Pengantar Perkerasan Fleksibel Lapangan Terbang halaman 99-116 dengan No. ISBN 978-623-342-177-5, Penerbit Yayasan Kita Menulis Cetakan 1 terbit pada tanggal 14 Agustus 2021.
6. Hasil kajian dampak pandemik *Coronavirus Disease* (COVID-19) pada industri penerbangan dan distribusi logistik angkutan udara.
7. Hasil simulasi model jaringan bandar udara *hub and spoke* berdasarkan metode *Herfindahl-Hirschmann Index* (HHI) untuk penerbangan domestik.

E**. PERAN MITRA:** Tuliskan realisasi kerjasama dan kontribusi Mitra baik *in-kind* maupun *in-cash* (jika ada). Bukti pendukung realisasi kerjasama dan realisasi kontribusi mitra dilaporkan sesuai dengan kondisi yang sebenarnya. Bukti dokumen realisasi kerjasama dengan Mitra diunggah melalui Simlitabmas mengikuti format sebagaimana terlihat pada bagian isian mitra

Pada riset dasar tahun pertama (2021) ini tidak melibatkan mitra penelitian.

F. **KENDALA PELAKSANAAN PENELITIAN**: Tuliskan kesulitan atau hambatan yang dihadapi selama melakukan penelitian dan mencapai luaran yang dijanjikan, termasuk penjelasan jika pelaksanaan penelitian dan luaran penelitian tidak sesuai dengan yang direncanakan atau dijanjikan.

Kendala yang dihadapi pada penelitian dasar ini adalah sebagai berikut:

1. Adanya Pemberlakuan Pembatasan Kegiatan Masyarakat (PPKM) oleh Pemerintah mengakibatkan beberapa perkantoran yang ada di Jakarta membuat kebijakan tidak menerima tamu dari luar secara langsung pada saat pengambilan data sekunder. Namun kendala ini sudah berhasil diatasi dengan mengirimkan berkas melalui surel (e-mail) dan penjelasan dilakukan dengan telepon. Untuk perkantoran yang ada di Yogyakarta seperti PT Angkasa Pura I (Persero) Cabang Yogyakarta, Bandar Udara Yogyakarta International Airport (YIA) pengambilan data dilakukan secara langsung dengan protokol kesehatan yang ketat. (Kendala yang ada sudah bisa diatasi).
2. Adanya pandemi COVID-19 sangat berdampak pada sektor transportasi yang mengakibatkan beberapa armada tidak beroperasi. Solusi yang dilakukan pada saat perjalanan untuk pengambilan data di PT Angkasa Pura Jakarta dan Kementerian Perhubungan yang semula direncanakan dengan menggunakan pesawat dari Bandar Udara Yogyakarta International Airport (YIA) ke Bandar Udara Internasional Soekarno-Hatta diubah menjadi moda darat yaitu dengan menyewa kendaraan pribadi dan sopir. (Kendala yang ada sudah bisa diatasi).

G. **RENCANA TINDAK LANJUT PENELITIAN:** Tuliskan dan uraikan rencana tindaklanjut penelitian selanjutnya dengan melihat hasil penelitian yang telah diperoleh. Jika ada target yang belum diselesaikan pada akhir tahun pelaksanaan penelitian, pada bagian ini dapat dituliskan rencana penyelesaian target yang belum tercapai tersebut.

Pemilihan konsep distribusi logistik angkutan udara yang paling baik merupakan salah satu kunci keberhasilan untuk menekan biaya logistik dan biaya ekonomi tinggi [26]. Mengingat peran besar dari sektor transportasi udara terhadap sistem distribusi logistik nasional, maka perencanaan jaringan distribusi logistik yang baik dengan angkutan udara merupakan keharusan [32]. Penyediaan infrastruktur yang mendorong konektivitas nasional akan menurunkan biaya transportasi dan biaya logistik sehingga dapat meningkatkan daya saing produk dan mempercepat gerak ekonomi [33]. Masalah pelayanan logistik antara lain tingkat penyediaan infrastruktur yang masih rendah, pungutan tidak resmi dan biaya transaksi menyebabkan biaya ekonomi tinggi serta kapasitas dan jaringan pelayanan penyedia jasa logistik nasional yang masih terbatas [32]. Mengingat peran besar transportasi udara terhadap sistem distribusi logistik nasional, maka perencanaan jaringan distribusi logistik yang baik dengan angkutan udara merupakan keharusan.

Perencanaan distribusi logistik perlu memperhatikan kondisi eksisting yang meliputi kondisi prasarana bandar udara baik sisi darat (*land side*) maupun sisi udara (*air side*), pergudangan dan tingkat permintaan logistik. Dengan demikian dapat ditentukan jenis pesawat dan pusat-pusat logistik yang memberikan efisiensi paling tinggi. Namun demikian, prasarana perlu menjadi obyek perencanaan sebagai masukan untuk pengembangan prasarana perhubungan udara. Perlu dikembangkan konsep distribusi untuk barang-barang yang mudah rusak (*perishable*) yang memerlukan kecepatan tinggi dan waktu yang singkat. Distribusi logistik dengan konsep sebaran *hub-spoke* dapat memberikan tingkat efisiensi yang tinggi. Namun dengan adanya pandemik COVID-19 sangat berdampak pada industri penerbangan. Pada tanggal 24 Maret 2020, 98% dari pendapatan penumpang global diperhitungkan oleh pasar transportasi udara dengan adanya pembatasan ketat (misalnya karantina untuk penumpang yang baru tiba, pelarangan sebagian perjalanan dan penutupan perbatasan), banyak maskapai penerbangan mengurangi operasi atau bahkan berhenti total [34]. Krisis akibat pandemik COVID-19 dengan cepat menyebar secara global. *Airports Council International* (ACI) memperkirakan bahwa COVID-19 memusnahkan dua perlima lalu lintas penumpang dan setengah dari pendapatan bandar udara pada tahun 2020 [35]. Hubungan antara jaringan penerbangan dan penyebaran virus global telah diteliti oleh Wu dkk. [36] [37] [38]. Nikolaou dan Dimitriou mengidentifikasi bandara kritis untuk pengendalian infeksi global wabah penyakit di Eropa [39]. Data perjalanan udara digunakan untuk memperkirakan ukuran wabah COVID-19 di Italia [40]. Namun belum ada penelitian yang mengkaji dampak COVID-19 terhadap angkutan logistik dan model jaringan bandar udara *hub and spoke* maupun *point to point*.

Penanganan distribusi angkutan barang yang baik pada akhirnya dapat menekan harga-harga barang produksi dan konsumsi atau menekan biaya ekonomi yang tinggi (*high cost economy*) sehingga dapat mengurangi beban belanja masyarakat. Upaya yang dilakukan pada penelitian dasar ini yaitu dengan mengkaji dampak pandemik COVID-19 pada industri penerbangan dan logistik angkutan udara, mengkaji parameter yang digunakan untuk menetapkan suatu bandara sebagai bandar udara pengumpul (*hub*), mengevaluasi dan menerapkan model bandara yang dijadikan *hub-spoke* agar diperoleh lintasan terpendek dan biaya termurah, menganalisis konsep *point to point*, dan melakukan kajian efisiensi penerbangan dengan menggunakan metode *Eigenvector Centrality* dan *Herfindahl-Hirschmann Index* (HHI).

Tujuan Penelitian

Tujuan jangka panjang penelitian adalah mengkaji dampak pandemik COVID-19 pada distribusi logistik angkutan udara dengan melakukan simulasi model jaringan bandar udara *hub and spoke* dengan *point to point* untuk meningkatkan efisiensi biaya transportasi dan efektivitas distribusi logistik angkutan udara.

Tujuan penelitian tahun kedua (2022) adalah:

1. Melakukan analisis jaringan bandar udara dengan konsep *point to point*.
2. Melakukan simulasi model jaringan bandara *point to point* pada penerbangan domestik dan internasional.

Tujuan penelitian tahun ketiga (2023) adalah:

1. Melakukan evaluasi penerapan jaringan bandara dengan konsep *hub and spoke* dan konsep *point to point* untuk mendapatkan lintasan terpendek dan efektivitas distribusi logistik angkutan udara.
2. Menentukan parameter yang digunakan dalam penetapan bandar udara pengumpul (*hub*).
3. Mengevaluasi penentuan jaringan bandar udara konsep *hub and spoke* berdasarkan metode *Eigenvector Centrality*.

Rencana Luaran Penelitian

Rencana luaran penelitian tahun kedua (2022):

a. Publikasi di jurnal internasional bereputasi ***Journal of Engineering Research* (JER),** (Terindeks Scopus Q2) dengan topik "*Hub and Spoke vs Point to Point Airport Networks-How Novel Coronavirus Disease* (COVID-19) *will Change Both Models?*".
b. Hasil simulasi model jaringan bandar udara *point to point* berdasarkan metode *Herfindahl-Hirschmann Index* (HHI) untuk penerbangan domestik dan internasional.

c. Luaran tambahan: Publikasi di jurnal internasional bereputasi ***Jurnal Teknologi (Sciences & Engineering)*** (Terindeks Scopus).

Rencana luaran penelitian tahun ketiga (2023):

a. Publikasi di jurnal internasional bereputasi ***Suranaree Journal of Science and Technology*** (Terindeks Scopus) dengan topik "*Evaluation of Hub and Spoke Airport Networks in Indonesia based on Eigenvector Centrality*".
b. Hasil evaluasi penerapan jaringan bandar udara dengan konsep *hub and spoke* dan konsep *point to point* untuk mendapatkan lintasan terpendek dan efektivitas distribusi logistik angkutan udara
c. Hasil evaluasi penentuan bandar udara *hub and spoke* dengan metode *Eigenvector Centrality*.
d. Luaran tambahan: Publikasi di jurnal internasional bereputasi ***Engineering and Applied Science Research*** **(EASR)** (Terindeks Scopus).

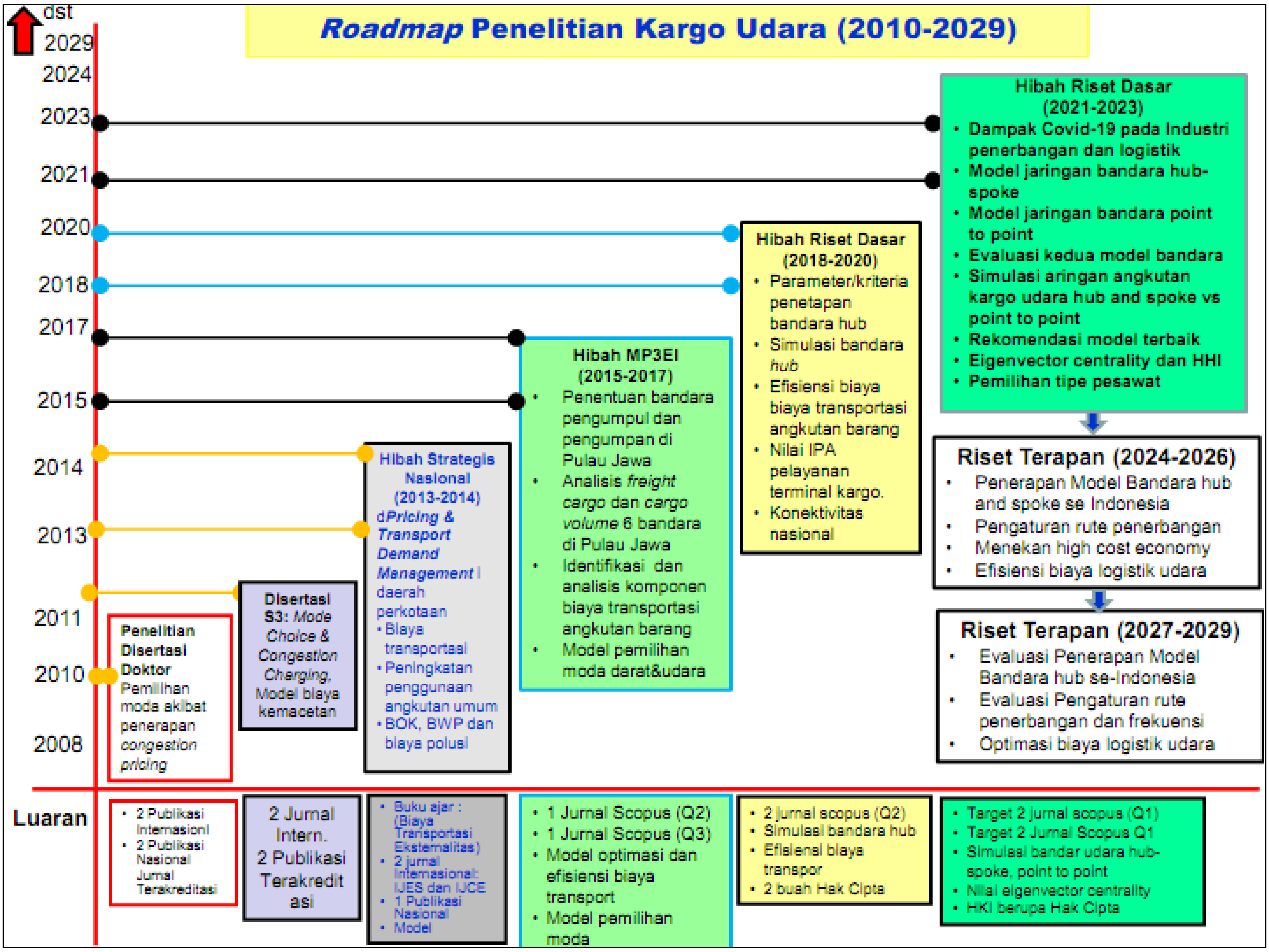
Hasil akhir dari penelitian dasar ini adalah model jaringan bandar udara dengan konsep *hub and spoke* dan konsep *point to point* yang akan dipilih oleh setiap maskapai penerbangan akibat adanya pandemik COVID-19, parameter yang akan digunakan dalam penetapan suatu bandar udara sebagai bandara pengumpul (*hub*) yang akan berpengaruh juga terhadap tipe pesawat yang akan digunakan oleh operator atau maskapai penerbangan untuk mendapatkan nilai efisiensi penerbangan tertinggi. Manfaat dari penelitian dasar ini dapat digunakan oleh pihak operator maskapai penerbangan dan pihak regulator sebagai dasar dalam melakukan evaluasi terhadap rute penerbangan eksisting, pembukaan rute penerbangan baru dan pemilihan jenis pesawat terbang. Kelanjutan penelitian dasar ini yaitu penyusunan kriteria pelayanan angkutan kargo udara dan terminal kargo agar bersinergi dengan Sistem Logistik Nasional (Sislognas) dan pengaturan rute penerbangan di Indonesia yang berubah akibat adanya pandemik COVID-19.

TINJAUAN PUSTAKA

Yuen melakukan kajian pemilihan kriteria yang mempengaruhi penentuan bandara *hub* di wilayah Pearl River Delta (PRD) ditinjau dari perkspektif pengirim barang (*shippers*). Tiga bandara di wilayah PRD yaitu HongKong *International Airport*, Guangzhou Baiyun Airport dan Macau *International Airport*. Tiga parameter terpilih yang mempengaruhi bandara *hub* yaitu *airport charges* (*cost*), kapasitas *handling* kargo, dan infrastruktur (jalan, bandara, jembatan dan utilitas) [41]. Penentuan bandara pengumpul (*hub*) dipengaruhi oleh permintaan penumpang dan area jangkauan [42] [43]. Penetapan bandara pengumpul (*hub*) dapat menurunkan biaya total baik untuk penumpang maupun kargo [44] [45].

Sugiyanto dkk. melalui skim penelitian MP3EI memperoleh hasil bahwa Bandara Soekarno Hatta memiliki nilai rasio angkutan (*freight ratio*) tertinggi sebesar 8,13 untuk penerbangan domestik dan 24,74 untuk penerbangan internasional. Persentase volume kargo di Bandara Soekarno-Hatta 39,42% untuk penerbangan domestik dan 78,77% untuk penerbangan internasional [23]. Konfigurasi *hub-spoke* mengikuti pola eksisting, yakni dengan 7 *hub* dan 26 *spoke* [46] [11]. Bandar udara sebagai bandara pengumpul (*hub*) adalah Bandara Internasional Kuala Namu, Bandara Internasional Hang Nadim, Bandara Internasional Soekarno-Hatta, Bandara Internasional Juanda, Bandara Internasional Ngurah Rai, Bandara Internasional Sepinggan Balikpapan, dan Bandara Internasional Sultan Hasanuddin.

Oktal dan Ozger menyatakan bahwa faktor-faktor yang mempengaruhi lokasi bandara pengumpul pada angkutan kargo adalah jangkauan pesawat dan biaya perjalanan, ketersediaan landasan pacu, dan kontinuitas lalu lintas kargo suatu bandara [47]. Faktor utama yang mempengaruhi pemilihan bandara pengumpul yaitu biaya, waktu bongkar, dan kualitas [48]. Lokasi geografis bandar udara adalah atribut pelayanan terpenting yang mempengaruhi perilaku pemilihan bandara pengumpul (*hub airport*) oleh maskapai penerbangan [49]. Kriteria yang paling berpengaruh dalam penentuan bandara pengumpul (*hub airport*) yaitu tarif bandara [14]. Penetapan bandar udara pengumpul dapat menurunkan biaya transportasi total baik untuk penumpang maupun kargo udara [12] [44]. Maskapai penerbangan harus memiliki akses yang cukup ke gerbang (*gates*), slot untuk lepas landas dan pendaratan di *hub airport* untuk menangani tingkat aktivitas tertinggi [50]. Ketepatan waktu lalu lintas udara adalah salah satu kriteria terpenting dalam memilih layanan udara [51] [52]. Peta jalan (*road map*) penelitian dasar ditunjukkan pada **Gambar 6**.



Gambar 6. Peta jalan (*road map*) penelitian dasar tema kargo udara.

Pola Jaringan *Hub* dan *Spoke*

Pola jaringan penerbangan *hub-spoke* adalah ketika semua penerbangan menuju satu pusat lokasi yang besar dan kemudian penumpang berganti penerbangan untuk mencapai tujuan akhirnya. Kedatangan pesawat di bandara pengumpul (*hub*) dari bandara pengumpan (*spoke*) dikoordinasikan dengan baik dan setelah beberapa saat penumpang/barang menuju bandar udara *spoke* lain [53]. Pola ini terdiri dari *hub-hub* yang berfungsi sebagai pusat kegiatan ekonomi dan aktivitas penerbangan di suatu wilayah dan kota-kota kecil sebagai *spoke* di sekitarnya yang berhubungan langsung dengannya. Jumlah penerbangan *hub* dipengaruhi oleh jumlah *spoke* dan jumlah pasangan kota [54].

Penentuan bandara pengumpul (*hub*) kargo menurut NCHRP Report 497 [55]

Ada dua kriteria penentuan hub kargo udara yaitu kriteria mutlak dan kriteria relatif [55].

a. Kriteria mutlak *hub* kargo udara

Ada dua kriteria mutlak hub kargo udara yaitu kriteria hub kargo udara menurut NCHRP *Report* 497 (2003) dan *blue print* transportasi udara nasional. NCHRP Report 497 (2003) menetapkan kriteria *hub* kargo udara yaitu bandara yang melayani produksi kargo tahunan 100.000 ton.

b. Kriteria relatif *hub* kargo udara [56]

Jika tidak ada bandara yang memenuhi persyaratan minimum melayani produksi kargo tahunan sebesar 100.000 ton maka perlu dikaji kandidat bandara lain yang dapat difungsikan sebagai *hub* kargo udara. Analisis tersebut menggunakan kriteria relatif *hub* kargo udara:

1. Berdasarkan perhitungan *Herfindahl-Hirschmann Index* (HHI), jumlah bandara efektif (n_e), dan jumlah bandara hub (h). Rumus-rumus untuk menghitung HHI, n_e, dan h adalah [56]:

   $HHI = \sum Pi^2$ dimana $Pi = x_i/\sum x_i$ (1)

   dengan x_i adalah produksi suatu bandara.

Selanjutnya, penentuan jumlah bandara *hub* (h) di kawasan tersebut dihitung dengan rumus berikut.

n_e = 1/HHI dan $h = 0{,}5\{n - (n^2 - (n \cdot n_e)^{-1/2}\}$ (2)

dengan n_e adalah jumlah bandara efektif di kawasan studi dan n adalah jumlah bandara di kawasan studi. Berdasarkan hubungan antara volume kargo udara dan transit kargo udara. Nilai transit kargo yang pernah digunakan untuk klasifikasi bandara *hub* adalah 40%.

Pola Jaringan *Point to Point*

Dengan semakin tingginya volume penerbangan yang melalui *hub* telah mengakibatkan terjadinya kepadatan di bandar udara *hub* tertentu telah menciptakan peluang baru bagi operator penerbangan untuk memberikan jasa yang lebih praktis yakni kembali ke pola transportasi *point-to-point* [54]. Pendekatan ini dimulai oleh operator penerbangan *Southwest Airlines* (SWA), yang berawal dari menawarkan jasa penerbangan jarak pendek (*short haul*), tanpa pelayanan extra (*no frills*) dan tiket murah (*low fare*) yang menghubungkan penerbangan antara negara-negara Bagian di Amerika. Dengan menghindari rute-rute kota besar, SWA menciptakan pasar *niche point-to-point* yang terus berkembang. Pada tahun 1990-an, *Southwest* masuk peringkat 10 operator penerbangan terbesar di Amerika. Beberapa contoh operator penerbangan yang menggunakan rute *point-to-point* adalah *Southwest Airlines* dan ***The Southwest Effect*.** Operator penerbangan baru ini tidak hanya menawarkan konsep bisnis pelayanan angkutan udara, namun memilih suatu pola rute penerbangan yang langsung (*direct flight*). Fenomena ini telah memicu munculnya lebih banyak penyedia jasa penerbangan *point-to-point* kepada pasar. Paradigma *Southwest* ini mereduksi sumber biaya tinggi, umumnya mereka memilih daerah-daerah yang kurang dilayani atau bandar udara sekunder di daerah perkotaan (*urban*), misalnya Bandara Love Field di Dallas. Model bisnis ini dikenal dengan *Low Cost Carrier* atau LCC. Model bisnis LCC ternyata lebih kuat menghadapi turbulensi ekonomi yang melanda dunia. *Southwest* dan operator penerbangan *point-to-point* mempunyai catatan profitabilitas yang tinggi [53].

Efisiensi Pola Jaringan Angkutan Kargo

Fry dan Delaurantis menyatakan bahwa penilaian efisiensi jaringan (transportasi atau logistik) dilakukan dengan cara sebagai berikut [57]:

1. Menghitung lintasan terpendek (**l^i_w**) yang telah dinormalisasi oleh *demand* kargo udara.
2. Menghitung nilai efisiensi jaringan (transportasi atau logistik) (**E_t**).

Nilai **l^i_w** dihitung dengan rumus:

$$l_w^i = \frac{\sum_j l_{ij} w_{ij}}{\sum_j w_{ij}} \qquad (3)$$

dengan:

l_{ij} adalah jumlah penerbangan minimum yang diperlukan untuk menghubungkan setiap pasangan bandara i dan bandara j dan **w_{ij}** adalah *demand* setiap pasangan bandara i dan j.

Nilai ***Et*** dihitung dengan rumus:

$$E_t = \frac{1}{N} \sum_i \frac{1}{l_i^w} \qquad (4)$$

Nilai ***Et*** berkisar antara 0-1. Nilai 1 tercapai jika setiap pasang bandara terhubung dengan penerbangan langsung atau *direct flight*. Nilai efisiensi transportasi (Et) sistem dengan konsep *hub-spoke* berkisar antara 49-52% [57].

Eigenvector Centrality

Suatu *node* yang penting/sentral dalam suatu sistem jejaring merupakan node yang terhubung dengan node penting/sentral. Semakin penting/sentral pasangan *node*-nya semakin penting/ sentral *node* tersebut. *Eigenvector centrality* dihitung dengan rumus:

$$C_E(i) = \frac{1}{\lambda} \sum_j E\, C_E(j) \qquad (5)$$

Dalam notasi matriks dapat dituliskan menjadi formula:

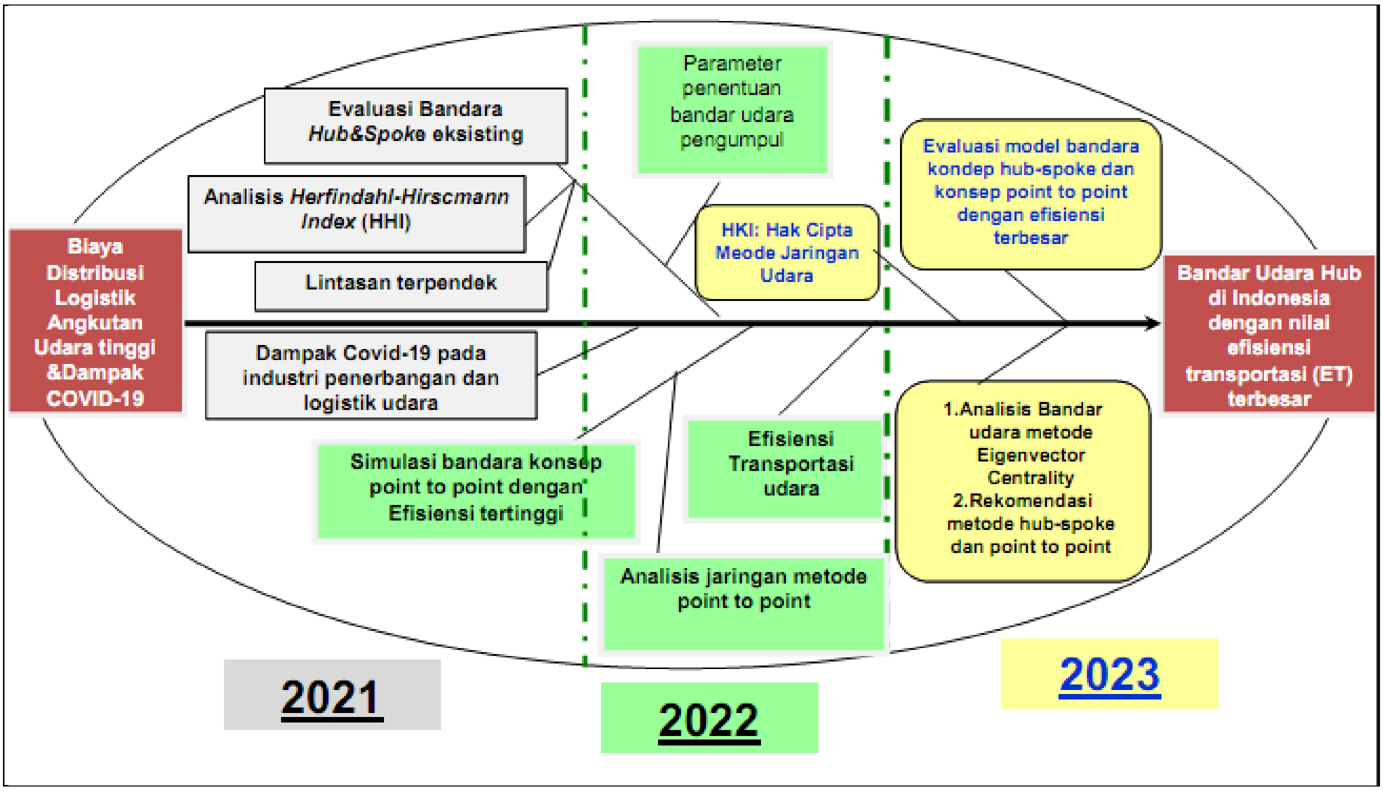
$$\lambda\, \bar{c} = E\, \bar{c} \qquad (6)$$

dengan λ = *eigen values*; E = *adjacency matrix* dengan $e_{ij} \in$ dan $\bar{c}$ = *eigenvectors*

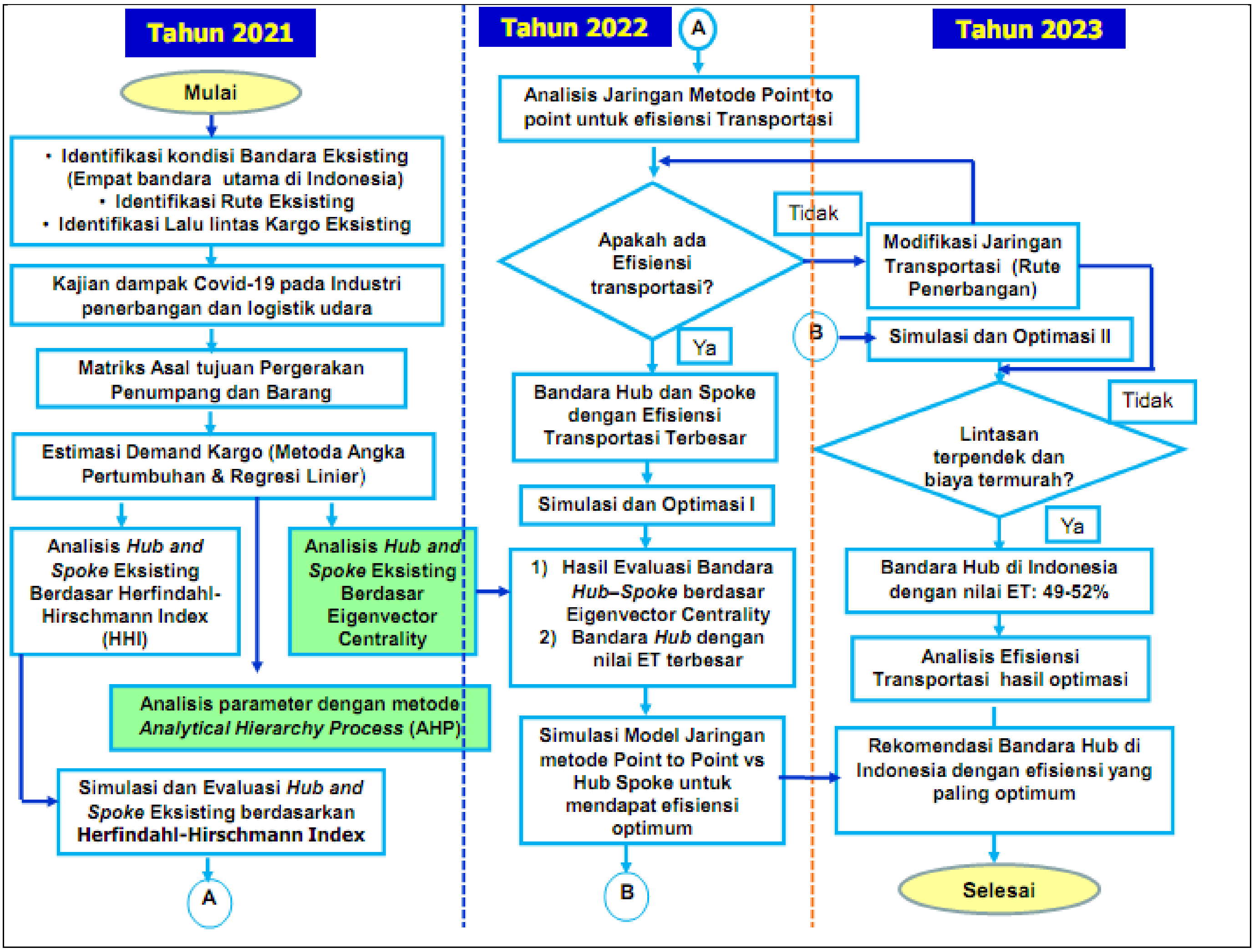
Sentralitas *node* merupakan nilai dari *eigenvectors* yang berkorespondensi dengan nilai *eigenvalues* yang terbesar [58].

Tahun pertama penelitian (2021) akan dilakukan analisis dampak COVID-19 pada industri penerbangan khususnya angkutan logistik udara, analisis *Herfindahl-Hirscmann Index* (HHI), dan simulasi bandara dengan konsep *hub and spoke*. Hasil yang diperoleh tahun pertama yaitu kajian dampak pandemik Coronavirus Disease (COVID-19) pada industri penerbangan dan distribusi logistik angkutan udara dan hasil simulasi model jaringan bandar udara *hub and spoke* berdasarkan metode *Herfindahl-Hirschmann Index* (HHI) untuk penerbangan domestik. Jumlah kedatangan pesawat pada tahun 2020 turun drastis sebesar 407.006 dan keberangkatan pesawat sebesar 409.250 dibandingkan dengan data tahun 2019 yang mencapai pergerakan pesawat datang sebesar 684.637 dan pesawat berangkat 682.885. Demikian pula halnya dengan data penumpang, juga menunjukkan hal yang sama yaitu terjadi penurunan yang sangat drastis yakni jumlah penumpang datang pada tahun 2020 sebesar 33.636.091 orang dan penumpang berangkat sebesar 34.428.318 orang. Sangat berbeda jauh kondisinya dibandingkan dengan jumlah penumpang datang pada tahun 2019 mencapai 75.186.635 orang dan penumpang berangkat mencapai 76.255.105 orang. Pada tahun 2020 telah terjadi penurunan jumlah penumpang domestik diangkut sebesar 55% dibandingkan dengan tahun 2019. Hal serupa juga terjadi pada penerbangan internasional, dimana jumlah penumpang yang datang dan berangkat pada tahun 2020 hanya sebesar 3.538.299 orang dan 3.585.121 orang. Sangat berbeda jauh jika dibandingkan dengan tahun 2019 dimana jumlah penumpang yang datang mencapai 18.026.850 orang dan penumpang berangkat 18.706.261 orang. Pada tahun 2020 telah terjadi penurunan jumlah penumpang internasional diangkut sebesar 80% dibandingkan tahun 2019. Jumlah rute penerbangan yang diperlukan untuk membentuk sistem *hub and spoke* angkutan kargo menurut Sistem Logistik Nasional Indonesia berdasarkan skema Peraturan Presiden Republik Indonesia Nomor 26 Tahun 2012 adalah 37 trayek (2-arah perjalanan). Diperlukan 5 (lima) rute penerbangan untuk mendukung angkutan kargo udara dari Bandara Internasional Kualanamu (KNO), 16 (enam belas) rute penerbangan dari Bandara Internasional Soekarno-Hatta (CGK), dan 16 (enam belas) rute penerbangan dari Bandara Internasional Sultan Hasanuddin (UPG).

Pada tahun kedua penelitian (2022) akan dilakukan analisis jaringan bandar udara dengan metode *point to point* dan simulasi jaringan transportasi udara di Indonesia jika menggunakan konsep *point to point*. Analisis *Eigenvector Centrality* untuk mengevaluasi penentuan bandar udara sebagai *hub* dan *spoke* pada kondisi eksisting dan simulasi model bandar udara *hub-spoke* di Indonesia untuk mendapatkan nilai efisiensi penerbangan tertinggi dengan analisis E_t (efisiensi transportasi) pada tahun ketiga penelitian (2023). Pada tahun ketiga juga akan dilakukan evaluasi model jaringan bandara dengan menggunakan dua pendekatan yaitu metode *hub and spoke* dan metode *point to point* untuk mendapatkan nilai efisiensi transportasi yang paling besar.



Gambar 7. *Fish-bone diagram* alir penelitian pada tahun 2021-2023.



Gambar 8. Tahapan penelitian tahun pertama (2021) s.d tahun ketiga (2023).

Pembagian tugas anggota tim pengusul:

Tahun 2 (2022): Melakukan analisis statistik data produksi kargo udara untuk penerbangan internasional dan membantu menyusun matriks asal tujuan perjalan transportasi udara.

Tahun 3 (2023): Melakukan analisis jaringan bandar udara metode *point to point* dan membantu menyusun matriks asal tujuan perjalanan transportasi udara untuk proses simulasi.

Jadwal Penelitian Riset Dasar

Penelitian Tahun ke-2 (2022)

No.	Nama Kegiatan	Bulan ke-											
		1	2	3	4	5	6	7	8	9	10	11	12
1.	Pembuatan revisi proposal penelitian dasar, RAB penelitian dan *literature review*	x	x	x	x	x	x	x	x	x	x		
2.	Penyusunan formulir survei untuk analisis jaringan metode *point to point* dan HHI		x	x									
3.	Pengurusan surat permohonan data sekunder dan ijin survei ke dinas terkait.		x	x									
4.	Pengumpulan data sekunder: Balitbang Kemenhub, PT Angkasa Pura I dan PT Angkasa Pura II, Maskapai penerbangan			x	x	x	x						
5.	Pengumpulan data primer preferensi di empat bandara internasional di Indonesia			x	x	x	x						
6.	Input dan rekapitulasi data sekunder dan primer			x	x	x	x						

No.	Nama Kegiatan	Bulan ke-											
		1	2	3	4	5	6	7	8	9	10	11	12
7.	Analisis data rute penerbangan dan matriks asal tujuan transportasi udara					x	x	x	x				
8.	Analisis *point to point* untuk rute penerbangan pada kondisi eksisting						x	x	x	x			
9.	Simulasi jaringan bandara *point to point*						x	x	x	x			
10.	Analisis data *stated preference* untuk untuk merumuskan model pemilihan moda							x	x	x	x		
11.	Analisis elastisitas model pemilihan moda									x	x		
12.	Penyusunan Laporan Kemajuan Tahun II				x	x	x	x					
13.	Penyusunan Laporan Tahunan (Tahun II)							x	x	x	x	x	
14.	Monitoring dan evaluasi penelitian dasar												x
15.	Pembuatan artikel, *proofreading*, revisi artikel untuk publikasi ilmiah di jurnal internasional bereputasi ***Journal of Engineering Research* (JER)** (Scopus Q2)							x	x	x	x	x	x
16.	Penyusunan usulan HKI berupa hak cipta										x	x	x
17.	Pembuatan artikel, *proofreading*, revisi publikasi ilmiah di jurnal internasional bereputasi ***Jurnal Teknologi (Sciences & Engineering)*** (Scopus Q3)							x	x	x	x	x	x

Penenlitian Tahun ke-3 (2023)

No.	Nama Kegiatan	Bulan											
		1	2	3	4	5	6	7	8	9	10	11	12
1.	Pembuatan revisi proposal penelitian dasar, RAB penelitian dan *literature review*	x	x	x	x	x	x	x	x	x	x		
2.	Penyusunan formulir survei parameter penentuan bandara *hub* AHP		x	x									
3.	Pengurusan surat permohonan data sekunder dan ijin survei ke dinas terkait.		x	x									
4.	Pengumpulan data sekunder: PT Angkasa Pura I dan II, Balitbang, Ditjen Hubud Kemenhub.			x	x	x	x						
5.	Pengumpulan data primer di empat bandara			x	x	x	x						
6.	Input dan rekapitulasi data sekunder dan primer			x	x	x	x						
7.	Evaluasi penerapan jaringan bandar udara dengan konsep *hub and spoke*				x	x	x	x	x				
8.	Evaluasi penerapan jaringan bandar udara dengan konsep *point to point*					x	x	x	x				
9.	Analisis *Analytichal Hierarchy Process* (AHP)						x	x	x	x			
10.	Analisis *hub-spoke* eksisting berdasarkan *Eigenvector Centrality*							x	x	x	x	x	
11.	Penyusunan Laporan Kemajuan Tahun III				x	x	x	x					
12.	Penyusunan Laporan Akhir Penelitian								x	x	x	x	x
13.	Monitoring dan evaluasi penelitian dasar												x
14.	Pembuatan artikel, *proofreading*, revisi publikasi ilmiah di jurnal internasional bereputasi ***Suranaree Journal of Science and Technology*** (Scopus Q3)							x	x	x	x	x	x
15.	Pembuatan artikel, *proofreading*, revisi publikasi ilmiah di jurnal internasional bereputasi ***Engineering and Applied Science Research* (EASR)** (Scopus Q3)							x	x	x	x	x	x

H. DAFTAR PUSTAKA: Penyusunan Daftar Pustaka berdasarkan sistem nomor sesuai dengan urutan pengutipan. Hanya pustaka yang disitasi pada laporan akhir yang dicantumkan dalam Daftar Pustaka.

1. Airports Council International (ACI), 2021. ACI Advisory Bulletin: The impact of COVID-19 on the airport business and the path to recovery. https://aci.aero/news/2021/03/25/the-impact-of-covid-19-on-the-airport-business-and-the-path-to-recovery/.
2. Ministry of Health Republic of Indonesia, 2021. Situation of COVID-19 per 7th August 2021. https://infeksiemerging.kemkes.go.id/.
3. European Commission, 2020. Future of Transport: Update on the Economic Impacts of COVID-19, Policy Brief JRC120625. https://ec.europa.en/jrc/sites/jresh/files/202005_future_of_transport_covid_sfp.brief_.pdf.
4. International Civil Aviation Organization (ICAO), 2021. Effects of Novel Coronavirus (COVID-19) on Civil Aviation: Economic Impact Analysis. Canada, Montréal.
5. Reichardt, U., Ulfarsson, G.F. and Petursdottir, G., 2019. Developing scenarios to explore impacts and weaknesses in aviation response exercises for volcanic ash eruptions in Europe, Journal of Air Transport Management, vol. 79, 101684. https://doi.org/10.1016/j.jairtraman.2019.101684.
6. Merkert, R. and Mangia, L., 2012. Management of airports in extreme winter conditions-some lessons from analysing the efficiency of Norwegian airports, Research in Transportation Business & Management, vol. 4, pp. 53-60. https://doi.org/10.1016/j.rtbm.2012.06.004
7. Ministry of Transportation Republic of Indonesia, Air Freight Traffic in Indonesia (Lalu Lintas Angkutan Udara). Jakarta: Directorate General of Air Transport Ministry of Transportation Republic of Indonesia, Retrieved on 2021-07-27, http://hubud.dephub.go.id/?id/produksi/index.
8. Abate, M., Christidis, P. and Purwanto, A.J., 2020. Government support to airlines in the aftermath of the COVID-19 pandemic, Journal of Air Transport Management, vol. 89, 101931. https://doi.org/10.1016/j.jairtraman.2020.101931.
9. Serrano, F. and Kazda, A., 2020. The future of airports post COVID-19, Journal of Air Transport Management, vol. 89, 101900. https://doi.org/10.1016/j.jairtraman.2020.101900.
10. Merkert, R. and Webber, T., 2018. How to manage seasonality in service industries-the case of price and seat factor management in airlines, Journal of Air Transport Management, vol. 72, pp. 39-46. https://doi.org/10.1016/j.jairtraman.2018.07.005.
11. Sugiyanto, G., Santosa, P.B., Wibowo, A., and Santi, M.Y., 2017. Airport classification based on federal aviation administration and freight ratio (case study in Indonesia). ARPN Journal of Engineering and Applied Sciences, vol. 12 no. 2, pp. 579-587. http://www.arpnjournals.com/jeas/volume_02_2017.htm
12. Sugiyanto, G., Santosa, P.B dan Santi, M.Y., 2020. Hub and spoke airport networks in Sulawesi Island, Indonesia based on freight ratio. ARPN Journal of Engineering and Applied Sciences, vol. 15 no. 10, pp. 1101-1110. http://www.arpnjournals.org/jeas/research_papers/rp_2020/jeas_0520_8218.pdf
13. Njoya, E.T., Christidis, P. and Nikitas, A., 2018. Understanding the impact of liberalisation in the EU-Africa aviation market, Journal of Transport Geography, vol. 71, pp. 161-171. https://doi.org/10.1016/j.jtrangeo.2018.07.014.
14. Sugiyanto, G., Santosa, P.B and Santi, M.Y., 2019. Determining the criteria for an air hub in Indonesia using an Analytical Hierarchy Process (AHP). Advances in Engineering Research, vol. 187, pp. 20-24. https://doi.org/10.2991/icosite-19.2019.4.
15. Sugiyanto, G. 2017. Marshall test characteristics of asphalt concrete mixture with scrapped tire rubber as a fine aggregate. Jurnal Teknologi, vol. 79 no. 2, pp. 55-64. https://doi.org/10.11113/jt.v79.6965.
16. Sugiyanto, G., Santosa, P.B, Jajang, Fadli, A. and Santi, M.Y., 2018. Evaluation of hub-spoke airport networks in Sumatra Island, Indonesia to increase efficiency of air transportation, MATEC Web of Conferences, vol. 195 (04009), pp. 1-9. https://doi.org/10.1051/matecconf/201819504009.
17. International Air Transport Association (IATA), Industry Losses to Top $84 Billion in 2020 (2020). https://www.iata.org/en/pressroom/pr/2020-06-09-01/.
18. Heinitz, F.M. and Meincke, P.A., 2011. Systematizing routing options in a global air cargo network model. Aerlines Magazine, vol. 49 no. 1, pp. 1-5, Amsterdam.
19. Heinitz, F.M. and Meincke, P.A., 2013. Modeling framework of origin and destination air cargo routing, Transportation Research Record: Journal of Transportation Research Board, vol. 2336 no. 1, pp. 83-90. https://doi.org/10.3141/2336-10.
20. Martın, J.C. and Roman, C., 2004. Analyzing competition for hub location in intercontinental aviation markets, Transportation Research Part E: Logistics and Transport Review, vol. 40 no. 2, pp. 135-150. http://dx.doi.org/10.1016/s1366-5545(03)00037-1.

21. Navarro, J.-L.A., Martínez, M.-E.A. and Trinquecoste, J.-F., 2015. The effect of the economic crisis on the behaviour of airline ticket prices: A case-study analysis of the New York-Madrid route, Journal of Air Transport Management, vol. 47, pp. 48-53. https://doi.org/10.1016/j.jairtraman.2015.04.004.
22. Rietveld, P. and Brons, M., 2001. Quality of hub-and-spoke networks: the effects of time table co-ordination on waiting time and rescheduling time, Journal of Air Transport Management, vol. 7 no. 4, pp. 241-249. https://doi.org/10.1016/S0969-6997(01)00012-6.
23. Sugiyanto, G., Santosa, P.B., Wibowo, A., Santi, M.Y. 2015. Analysis of hub and spoke airport networks in Java Island, Indonesia based on cargo volume and freight ratio. Procedia Engineering, vol. 125, pp. 556-563 Elsevier, http://dx.doi:10.1016/j.proeng.2015.11.061.
24. O'Kelly, M.E., 2014. Air freight hubs in the FedEx system: Analysis of fuel use, Journal of Air Transport Management, vol. 36, pp. 1-12. https://doi.org/10.1016/j.jairtraman.2013.12.002.
25. Yan, S., Chen, S.C. and Che, C.H., 2006. Air cargo fleet routing and timetable setting with multiple on-time demands, Transportation Research Part E Logist. Transp. Rev., vol. 42 no. 5, pp. 409-430. https://doi.org/10.1016/j.tre.2005.02.002.
26. Sugiyanto, G., Santosa, P.B., Wibowo, A., and Santi, M.Y., 2016. Hub and Spoke Airport Networks in Indonesia based on Herfindahl-Hirschmann Index (HHI). Journal of Engineering and Applied Sciences (JEAS), vol. 11 no. 8, pp. 1804-1810. http://www.medwelljournals.com/abstract/?doi=jeasci.2016.1804.1810
27. Feriyanto, N., Saleh, C., Fauzi, A., Dzakiyullah, N.R. and Iwaputra, K.R., 2016. The route analysis based on flight plan, IOP Conf. Ser.: Mater. Sci. Eng. vol. 114 012147. https://doi.org/10.1088/1757-899X/114/1/012147.
28. Adler, N., Fu, X., Oum, T.H. and Yu, C., 2014. Air transport liberalization and airport slot allocation: the case of the Northeast Asian transport market, Transportation Research Part A Policy and Practice, vol. 62, pp. 3-19. https://doi.org/10.1016/j.tra.2014.02.003.
29. Shao, Y. and Sun, C., 2016. Performance evaluation of China's air routes based on network data envelopment analysis approach, Journal of Air Transport Management, vol. 55, pp. 67-75. http://dx.doi.org/10.1016/j.jairtraman.2016.01.006.
30. Wandelt, S. and Sun, X., 2015. Evolution of the international air transportation country network from 2002 to 2013. Transportation Research Part E: Logistics and Transportation Review, vol. 82, pp. 55-78. https://doi.org/10.1016/j.tre.2015.08.002.
31. M. Bazargan, M., 2004. Airline Operations and Scheduling, Ashgate, Burlington, USA.
32. Kementerian Koordinator Bidang Perekonomian, 2011, Master Plan Percepatan dan Perluasan Pembangunan Ekonomi Indonesia (MP3EI) 2011-2025, 210 hal., Jakarta.
33. Bendinelli, W.E., Bettini, H.F.A.J., Oliveira, A.V.M., 2016. Airline delays, congestion internalization and non-price spillover effects of low cost carrier entry. Transportation Research Part A: Policy and Practice, vol. 85, pp. 39-52. https://doi.org/10.1016/j.tra.2016.01.001.
34. Sanchez, P.S., Dortac, A.V. and Escofet, N.C., 2020. An early assessment of the impact of Covid-19 on air transport: Just another crisis or the end of aviation as we know it?. Journal Transport Geography, vol. 86, 102749. https://doi.org/10.1016/j.jtrangeo.2020.102749.
35. Airports Council International (ACI), 2020. ACI Advisory Bulletin. The Impact of Covid-19 on the Airport Business. 1 April 2020. URL:https://aci.aero/wp-content/uploads/2020/03/200401-COVID19-Economic-Impact-Bulletin-FINAL-1.pdf.
36. Wu, J.T., Leung, K., Leung, G.M., 2020. Nowcasting and forecasting the potential domestic and international spread of the 2019-nCoV outbreak originating in Wuhan, China: a modelling study. Lancet, 395 (10225), pp. 689-697. https://doi.org/10.1016/S0140-6736(20)30260-9.
37. Boldog, P., Tekeli, T., Vizi, Z., Dénes, A., Bartha, F.A., Röst, G., 2020. Risk assessment of novel coronavirus COVID-19 outbreaks outside China. Journal of Clinical Medicine, vol.9 no.2, 571. https://doi.org/10.3390/jcm9020571.
38. Adiga, A., Venkatramanan, S., 2020. Evaluating the impact of international airline suspensions on Covid-19 direct importation risk. medRxiv. https://doi.org/10.1101/2020.02.20.20025882.
39. Nikolaou, P., Dimitriou, L., 2020. Identification of critical airports for controlling global infectious disease outbreaks: stress-tests focusing in Europe. Journal of Air Transport Management, vol. 85, 101819. https://doi.org/10.1016/j.jairtraman.2020.101819.
40. Tuite, A.R., Ng, V., Rees, E., Fisman, D., 2020. Estimation of COVID-19 outbreak size in Italy. Lancet Infection Disease. https://doi.org/10.1016/S1473-3099(20)30227-9.
41. Yuen, S.S.M., 2008. Selection Criteria of Air Hub in Pearl River Delta (PRD) Region: From Shippers' Perspective, International Forum on Shipping, Ports and Airports (IFSPA), Hongkong, 26-28 May 2008. https://www.polyu.edu.hk/lms/icms/ifspa2008/.../Simon,%20S.M.%20YUEN.pdf.

42. Wu, C., Han, J., dan Hayashi, Y., 2011. Airport Attractiveness Analysis through a Gravity Model: A case study of Chubu International Airport in Japan. Proceedings of the Eastern Asia Society for Transportation Studies, vol. 8, pp. 419-426. https://doi.org/10.11175/eastpro.2011.0.419.0.
43. Çiftçi, M.E. and Sevkli, M., 2015. A new hub and spoke system proposal: A case study for Turkey's aviation industry. Journal of Air Transport Management, vol. 47, pp. 190-198. https://doi.org/10.1016/j.jairtraman.2015.06.003.
44. Yan, S., Shieh, C.Y., and Chen, M., 2002. A simulation framework for evaluating airport gate assignments. Transportation Research Part A: Policy and Practice, vol. 36 no. 10, pp. 885-898. https://doi.org/10.1016/S0965-8564(01)00045-3.
45. Wei, S. and Yanji, M., 2006, Hub-and-Spoke System in Air Transportation and Its Implications to Regional Economic Development-A Case Study of United States. Chinese Geographical Science, vol.16 no. 3, pp. 211-216. https://dx.doi:10.1007/s11769-006-0211-2.
46. Kementerian Perhubungan Republik Indonesia, 2012, Studi Kelayakan Hub dan Spoke Distribusi Logistik Angkutan Udara, Jakarta: Direktorat Jenderal Perhubungan Udara.
47. Oktal, H. and Ozger, A., 2013. Hub location in air cargo transportation: A case study. Journal of Air Transport Management, vol. 27, pp. 1-4. https://dx.doi.org/10.1016/j.jairtraman.2012.10.009.
48. Rezaei, J., Hemmes, A. and Tavasszy, L., 2017. Multi-criteria decision-making for complex bundling configurations in surface transportation of air freight. Journal of Air Transport Management, vol. 61, pp. 95-105. https://doi.org/10.1016/j.jairtraman.2016.02.006.
49. Lirn, T.C., 2010. Study of airlines' cargo hub airport selection-an empirical study in Taiwan. Journal of the Eastern Asia Society for Transportation Studies, vol. 8, pp. 2355-2364. https://doi.org/10.11175/easts.8.2355.
50. Bauer, P.W., 2015. Airline Hubs: A Study of Determining Factors and Effects. (Diunduh 15 Februari 2015). http://clevelandfed.org/research/review/.
51. O'Kelly, M.E., 2014. Air freight hubs in the FedEx system: Analysis of fuel use. Journal of Air Transport Management, vol. 36, pp. 1-12. https://dx.doi.org/10.1016/j.jairtraman.2013.12.002.
52. Ha, M.S., Namgung, J.I. and Park, S.H., 2015. Analysis of air-moving on schedule big data based on crisp-dm methodology. ARPN Journal of Engineering and Applied Sciences, vol. 10 no. 5, pp. 2088-2091.
53. Dennis, N., 1994. Airline hub operations in Europe. Journal of Transport Geography, vol. 2 no. 4, pp. 219-233. https://doi.org/10.1016/0966-6923(94)90047-7.
54. Graham, B., 1998. International Air Transport in Hoyle, Modern Transport Geography edition 2, 374 p. Wiley, Chichester.
55. National Cooperative Highway Research Program (NCHRP), 2003. NCHRP Report 497: Financing and Improving Land Access to U.S. Intermodal Cargo Hubs. Transportation Research Board (TRB).
56. Costa, T.F.G., Lohmann, G., and Oliveira, A.V., 2010. A Model to Identify Airport Hubs and Their Importance to Tourism in Brazil. Research in Transportation Economics, vol. 26, issue 1, pp. 3-11. https://doi.org/10.1016/j.retrec.2009.10.002.
57. Fry, D.N. and Delaurentis D.A., 2008. A New Systems Analysis: Perspectives on System-of-Systems and Regional Transportation Proof-of-Concept Study. 26th International Conference of Aeronautical Science. http://www.researchgate.net/publication/267238763.
58. Hansen, M., 2002. Micro-level analysis of airport delay externalities using deterministic queuing models: a case study. Journal of Air Transport Management, vol. 8 issue 2, pp.73-87. https://doi.org/10.1016/S0969-6997(01)00045-X.

Dokumen pendukung luaran Wajib #1

Luaran dijanjikan: Artikel di Jurnal Internasional Terindeks di Pengindeks Bereputasi

Target: Accepted
Dicapai: Sedang direview

Dokumen wajib diunggah:
1. Naskah artikel
2. Bukti sedang direview

Dokumen sudah diunggah:
1. Naskah artikel
2. Bukti sedang direview

Dokumen belum diunggah:
- Sudah lengkap

Nama jurnal: Suranaree Journal of Science and Technology
Peran penulis: first author | EISSN: 2587-0009
Nama Lembaga Pengindek: Scopus
URL jurnal: http://ird.sut.ac.th/e-journal/
Judul artikel: Aircraft Routes and Flight Frequency of Domestic Cargo Transport

Aircraft Routes and Flight Frequency of Domestic Cargo Transport

Gito Sugiyanto[1, a)], Purwanto Bekti Santoso[1, b)], Aris Wibowo[2, c)], and Mina Yumei Santi[3, d)]

[1] *Civil Engineering Department, Faculty of Engineering, Universitas Jenderal Soedirman, Purbalingga, Central Java, Indonesia*
[2] *Civil Engineer and Transport Planner in PT Nur Straits Engineering (NSE) Bandung, West Java, Indonesia*
[3] *Health Polytechnic Ministry of Health of Yogyakarta, Indonesia.*

[a)] *Corresponding author: gito.sugiyanto@unsoed.ac.id*
[b)] *purwanto1409@unsoed.ac.id*
[c)] *aris.wibowo.info@gmail.com*
[d)] *minayumeisanti80@gmail.com*

Abstract. Aircraft routes are essential for making airline timetables. Effective flight route planning will result in profitable schedules. The distance between two airports is an important geographical factor affecting air cargo transport demand. Analysis of cargo transportation routes is needed to support the Indonesian National Logistics System. Flight routes were developed based on hub-spoke airport networks concepts. This research aims to analyze the aircraft routes of domestic cargo transport in Indonesia based on the Indonesian National Logistics System. Three airports that serve as hub airports in Indonesia are Soekarno-Hatta International Airport in Cengkareng, Kualanamu International Airport in Deli Serdang, and Sultan Hasanuddin International Airport in Makassar. The results show that the number of aircraft routes needed to hub-spoke airport networks for domestic cargo transportation with the scheme of the Indonesian National Logistics System is 37 routes (2-way trips). The flight routes analyzed are direct flight routes (point to point). As for the long-distance routes, we can use this route pattern. The selection of the best air transport logistics distribution concept is one of the keys to success in reducing logistics and high economic costs.

Keywords: aircraft route, flight frequencies, hub and spoke, cargo

INTRODUCTION

One of the most important aspects of the management of an airline is determining flight schedules and routes for each aircraft. The services of air freight are crucial to supplying chains and logistic transport [1]. Aircraft routes are essential for making airline schedules, it is important to plan them effectively in order to achieve a profitable timetable [2]. Provision of infrastructure that encourages national connectivity will reduce transportation and logistic costs to increase product competitiveness and accelerate economic movement [3]. The problems of logistics transportation services in Indonesia are the low level of infrastructure provision, the existence of unofficial levies, and transaction costs that cause high economic costs and the limited capacity and network of national logistics service providers. The strategy is to strengthen national connectivity, improve transportation and logistic cost efficiency and the effectiveness of air transport logistics distribution. Although the services of air freight have just a relatively small share in tonnes if compared with ocean freight, not less than one-third of the values in international trade are conveyed by air freight [4].

The air freight movement analysis helps airline companies to evaluate their operating strategies, aircraft routes, flight frequency, and aviation authorities improve the infrastructure facilities and allocate resources. In previous studies, many researchers have studied commodity flow over space. Unfortunately, relatively few studies have been conducted on air freight demand through modelling, due to lack of data, data gathering and tracking are often difficult and costly. Previously published studies by Matsumoto in 2004 discussed international urban systems and air passenger and cargo flows [5], Matsumoto in 2007 discussed international air network structures and air traffic density of world cities [6] and Yamaguchi in 2008 discussed international trade and air cargo: analysis of the United States export and air transport policy [7] reveal that parameter has been used to develop gravity type of air cargo demand models only a few macro-economic and hinterland-derived factors, such as Gross Domestic Product (GDP) per capita, number of population and distance introducing city-dummy variables. Tokyo, Hong Kong and Singapore in Asia regions, London, Paris, Frankfurt and Amsterdam in Europe regions and New York and Miami in the American regions are strengthening their positions as international hubs [5].

The study by Arendal in 1992 [8] for Europe's emerging domestic market and the important role of air cargo road transport must have been anticipated early. Based on the theoretical basis of transport modelling laid by Ortùzar and Willumsen [9] the classic model is presented as a sequence of four sub-models: trip generation, distribution, modal split and assignment. A comprehensive description of the technological and economic background of air freight, in general, was studied by Morell and Klein in 2011 [10]. Air cargo makes the crucial difference between profit and loss on many long-haul routes [10]. Three dominant factors in air cargo namely: air cargo facilities at airports, institutional aspects, and cargo fleet planning. The previous study by Diamond in 2002 stated that air cargo models were proposed and implemented for the prediction of origin and destination market [11], air cargo schedule planning problems, algorithms, and models [12], the fleet assignment and cargo routing [13], air freight transport geography [14], the airport choice of freighter operators [15] as well as the optimization of truck handling operations at an air cargo terminal in the airport [16]. Airline network problems are often studied excluding the demand side.

Freight transport flights in Indonesia are the same as passenger transportation because they use combi aircraft. In addition, there are also several special flights for cargo transportation. This study aims to analyse the aircraft routes of domestic cargo transport in Indonesia based on the Indonesian National Logistics System. Three airports that serve as hub airports in Indonesia are Soekarno-Hatta International Airport (CGK) in Cengkareng, Banten; Kualanamu International Airport (KNO) in Deli Serdang, North Sumatra, and Sultan Hasanuddin International Airport (UPG) in Makassar, South Sulawesi.

AIR CARGO ROUTE CHOICE

Heinitz and Meincke in 2011 developed systematizing routing options in a global air cargo network model, as well as a methodology for subsequent choice set formation [17]. Furthermore, Heinitz and Meincke in 2013 [18] tackle the origin-destination demand assignment problem. Four stages in the systematization of air cargo route choice include demand segmentation, choice-set size determination, choice-set formation and qualification, and choice [17]. The demand segmentation is divided into two categories, commodity type and time criticality. Choice-set size determination includes the supplier network options and city-pair options. Choice-set formation and qualification include access or egress links, network topology, weekly variation of demand, optimal path search strategy, and imposition of hard route search constraints. Choices include the A/L level choice model and consignor level choice model. The full set of these stages is needed to fully cover the complex supply side, the needs of various air cargo consignment types, and the resulting multidimensional space of conceivable itineraries. As can be viewed in Table 1, the modeller's degrees of freedom when executing in the four stages systematization of air cargo route choice.

TABLE 1. Systematization of air cargo route choice [17].

Stage	Category	Possible specification
Demand segmentation	Commodity type	Definition of commodity set
	Time criticality	Distinction between: a. Overnight cargo b. Two (2) day cargo c. General freight/ standby
Choice-set size determination	Supplier network options	Definition of network alliances and sets of contributing A/L

	City pair options	Definition of airport catchment areas (for origin and destination)
Choice-set formation and qualification	Access or egress links	Assumptions on ground transportation times
	Network topology	Exemplary trunk network or complete flight schedule
	Weekly variation of demand	Distribution to and assumptions on days' latest acceptance times
	The optimal path search strategy	Minimum of the transport duration or minimum of the generalized costs in air transport
	Imposition of hard route search constraints	Required equipment, unitized shipment yes or no
Choice	A/L level choice model	Compensatory model or random utility maximization (set of explanatory variables)
	Consignor level choice model	Revenue-maximizing assignment to residual capacities

Policies of aviation reflect a balance between the interests of consumers and the aviation and tourism industries [19]. The planning of aircraft routes and flight frequencies in an airline network operations can be divided into two models; the first is based on the flight network and the second is based on the passenger network [4]. Air cargo alliance is likely to reduce passenger prices and increase total surplus [20]. The interaction of air cargo demand and global trade in the light of current modelling approaches was studied by Meincke and the result shows that the DLR air cargo supply-demand interaction model serves as the testing environment for the systematization framework [21]. In the other study, the key determinants of international air cargo flow from and to Taiwan include population, air freight rate and three dummy variables, including the regional economic bloc, long-established colonial links, and the Open Sky Agreements [22].

METHOD

Collection of Data

Data required in this research includes the production data from 33 airports in Indonesia for domestic flights. Flight traffic data consist of the number of aircraft traffic, number of passengers, number of passenger baggage, and number of cargo. Data production of each airport for the domestic flight is obtained from the Directorate General of Civil Aviation, Ministry of Transportation Republic of Indonesia [23], PT. (Persero) Angkasa Pura I, and PT. (Persero) Angkasa Pura II. National airport arrangements in Indonesia according to the Ministry of the Transportation Republic of Indonesia, PM Number 39 of 2019 [24].

RESULTS AND DISCUSSION

Air Cargo Route Analysis National: Hub and Spoke Concepts

Analysis of cargo transportation routes to support the Indonesia National Logistics System or *Sistem Logistik Nasional* based on Presidential Regulation Republic of Indonesia No. 26 of 2012 [25] requires justification and assumptions about what kind of hub and spoke system will be applied in the field. Based on the Indonesia National Logistics System, the number of hubs developed in 2011-2015 is 3 (three) airports namely Soekarno-Hatta International Airport (CGK) in Cengkareng, Banten; Kualanamu International Airport (KNO) in Deli Serdang, North Sumatra, and Sultan Hasanuddin International Airport (UPG) in Makassar, South Sulawesi. Thus, the concept of hub and spoke can be derived with a combination of 3 hub airports and 30 spoke airport and flight routes can be assumed as presented in Figure 1.

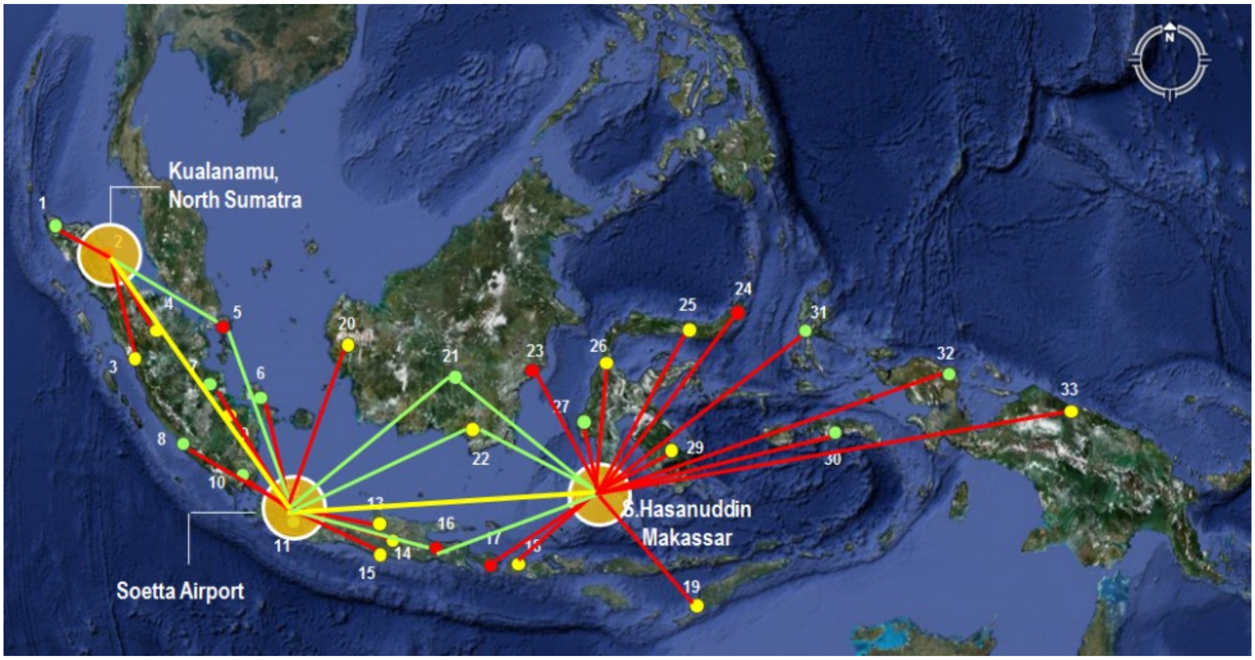


FIGURE 1. Hub and spoke airport networks based on the Indonesia National Logistics System.

Soekarno-Hatta International Airport (CGK) in Cengkareng, Banten is a central hub in Indonesia because all of the spoken cities in Indonesia connect flights into Soekarno-Hatta International Airport. There are aircraft route flights from Soekarno-Hatta International Airport to all of the spoke cities in Indonesia [26]. Based on the study of Sugiyanto *et al*. in 2017, the percentage of cargo volume in Soekarno-Hatta International Airport is 38.229% for domestic flights [27]. Furthermore, hub and spoke airport networks in Indonesia based on Herfindahl-Hirschman Index (HHI) analysis, Kualanamu International Airport (KNO) in Deli Serdang, North Sumatra is a hub airport for domestic flights in Sumatra Island, Indonesia [28].

According to the study of Martin and Roman in 2004, two parameters that influence the hub location are airport location and competition [29]. Road infrastructure is one of the factors that must be considered in determining the location of the airport [30-31]. The economic crisis has affected price behaviour both in terms of the price level and dispersion, with a clear increase in price level and decrease in price dispersion [32]. Low frequencies of aircraft may have substantial negative effects on scheduling costs and waiting costs at hub airports [33]. The advantages of the application of hub and spoke in the airport network are decreased the number of aircraft routes [34], increase demand (frequent flights), decrease costs [35], decrease externality cost [36-37]. Distribution and justification for the hub and spoke airport networks in Indonesia can be described in Table 2 as follows:

TABLE 2. Justification for the hub and spoke airport network

Hub Airport	Spoke Airport
Kualanamu International Airport (KNO) Medan	4 airports: 1) Sultan Iskandar Muda International Airport in Banda Aceh, 2) Sultan Syarif Kasim II International Airport in Pekanbaru, 3) Minangkabau International Airport in Padang, and 4) Hang Nadim International Airport in Batam.
Soekarno-Hatta International Airport (CGK) Cengkareng	11 airports: 1) Depati Amir Airport in Pangkal Pinang, 2) Sultan Thaha Saifuddin Airport in Jambi, 3) Fatmawati Soekarno Airport in Bengkulu, 4) Sultan Mahmud Badaruddin II International Airport in Palembang, 5) Raden Inten II International Airport in Lampung, 6) Husein Sastranegara International Airport in Bandung, 7) Ahmad Yani International Airport in Semarang, 8) Adi Sumarmo International Airport in Surakarta / Solo,

Hub Airport	Spoke Airport
	9) Adi Sutjipto International Airport in Yogyakarta/ Yogyakarta International Airport in Kulon Progo 10) Juanda International Airport in Sidoarjo, and 11) Supadio International Airport in Pontianak. *) Hang Nadim International Airport in Batam, *) Tjilik Riwut Airport in Palangkaraya, *) Syamsudin Noor International Airport in Banjarmasin and *) Ngurah Rai International Airport in Badung, Bali.
Sultan Hasanuddin International Airport (UPG) Makassar	15 airports: 1) Sultan Aji Muhammad Sulaiman Sepinggan International Airport in Balikpapan, 2) Tjilik Riwut Airport in Palangkaraya, 3) Syamsudin Noor International Airport in Banjarmasin, 4) Ngurah Rai International Airport in Badung, Bali, 5) Zainuddin Abdul Madjid Lombok International Airport in Mataram, 6) Eltari International Airport in Kupang, 7) Sam Ratulangi International Airport in Manado, 8) Djalaluddin Airport in Gorontalo, 9) Mutiara SIS Al-Jufrie Airport in Palu, 10) Tampa Padang Airport in Mamuju, 11) Haluoleo (Wolter Monginsidi) International Airport in Kendari, 12) Pattimura International Airport in Ambon, 13) Sultan Babullah International Airport in Ternate, 14) Sentani Airport in Jayapura, and 15) Rendani Airport in Manokwari.

*) Considering the 4 spoke airports that can make direct flights to 2 different hubs, namely Hang Nadim International Airport, Tjilik Riwut Airport, Syamsuddin Noor International Airport, and Ngurah Rai International Airport.

Aircraft Route Needs

Flight routes based on the hub and spoke airport network concept is presented in Table 3. The aircraft routes delivered are direct flight routes or point to point and two-way trips. We can use the aircraft route pattern of air cargo transportation for long-distance routes. For example, in the case of flights from Batam to Manado, the route that needs to be taken is Batam-Jakarta-Makassar-Manado. This means that the flight routes that occur are flight from Batam-Jakarta, flight from Jakarta-Makassar, and flight from Makassar-Manado. Flight routes needed to support air cargo transportation for the other intercity flight cases in Indonesia can be seen in Table 3.

TABLE 3. Identification of flight routes needs to support air cargo transportation.

No.	Hub Airport	Routes required
1.	Kualanamu International Airport (KNIA)	1. Medan - Banda Aceh (KNIA - Sultan Iskandar Muda International Airport) 2. Medan - Pekanbaru (KNIA - Sultan Syarif Kasim II International Airport) 3. Medan - Padang (KNIA - Minangkabau International Airport) 4. Medan - Batam (KNIA - Hang Nadim International Airport) 5. Medan - Jakarta (KNIA - Soekarno-Hatta International Airport)
2.	Soekarno-Hatta International Airport (SHIA)	6. Jakarta - Pangkal Pinang (SHIA - Depati Amir Airport) 7. Jakarta - Jambi (SHIA - Sultan Thaha Saifuddin Airport) 8. Jakarta - Bengkulu (SHIA - Fatmawati Soekarno Airport) 9. Jakarta - Palembang (SHIA - Sultan Mahmud Badaruddin II International Airport)

No	Hub Airport	Routes required
		10. Jakarta - Lampung (SHIA - Raden Inten II International Airport) 11. Jakarta - Bandung (SHIA - Husein Sastranegara International Airport) 12. Jakarta - Semarang (SHIA - Ahmad Yani International Airport) 13. Jakarta - Solo (SHIA - Adi Sumarmo International Airport) 14. Jakarta - Yogyakarta (SHIA - Adi Sutjipto International Airport (SHIA - Yogyakarta International Airport) 15. Jakarta - Surabaya (SHIA - Juanda International Airport) 16. Jakarta - Pontianak (Supadio International Airport) 17. Jakarta - Palangkaraya (SHIA - Tjilik Riwut Airport) 18. Jakarta - Banjarmasin (SHIA - Syamsuddin Noor International Airport) 19. Jakarta - Batam (SHIA - Hang Nadim International Airport) 20. Jakarta - Makassar (SHIA - Sultan Hasanuddin International Airport) 21. Jakarta - Denpasar (SHIA - Ngurah Rai International Airport)
3.	Sultan Hasanuddin International Airport Makassar (SHIAM)	22. Makassar - Balikpapan (SHIAM - Sultan Aji Muhammad Sulaiman Sepinggan International Airport) 23. Makassar - Palangkaraya (SHIAM - Tjilik Riwut Airport) 24. Makassar - Banjarmasin (SHIAM - Syamsuddin Noor International Airport) 25. Makassar - Denpasar (SHIAM - Ngurah Rai International Airport) 26. Makassar - Mataram (SHIAM - Zainuddin Abdul Madjid Lombok International Airport) 27. Makassar - Kupang (SHIAM - Eltari International Airport) 28. Makassar - Manado (SHIAM - Sam Ratulangi International Airport) 29. Makassar - Gorontalo (SHIAM - Djalaluddin Airport) 30. Makassar - Palu (SHIAM - Mutiara SIS Al-Jufrie Airport) 31. Makassar - Mamuju (SHIAM - Tampa Padang Airport) 32. Makassar - Kendari (SHIAM - Haluoleo (Wolter Monginsidi) International Airport) 33. Makassar - Ambon (SHIAM - Pattimura International Airport) 34. Makassar - Ternate (SHIAM - Sultan Babullah International Airport) 35. Makassar - Jayapura (SHIAM - Sentani Airport) 36. Makassar - Manokwari (SHIAM - Rendani Airport) 37. Makassar - Surabaya (SHIAM - Juanda International Airport)

From Table 3, it can be seen that the number of routes needed to form a hub and spoke system of cargo transportation according to the Indonesia National Logistics System or *Sistem Logistik Nasional* based on Presidential Regulation No. 26 of 2012 scheme is 37 routes (2-way trips). Five flight routes are needed to support air cargo transportation from Kualanamu International Airport (KNO), 16 flight routes from Soekarno-Hatta International Airport (CGK), and 16 flight routes from Sultan Hasanuddin International Airport (UPG). The result of this study is similar to Ref. [38] that combines airport selection, fleet routing, and timetable setting to develop an integrated scheduling model for aircraft routes [38]. The selection of the best air transport logistics distribution concept is one of the keys to success in reducing logistics and high economic costs [39]. The punctuality of air traffic is one of the most important criteria in selecting air services [35]. Parameters that are used to find efficient and effective routes by calculating flight distance, flight time and block fuel [40].

Air transport liberalization will benefit both consumers and the aviation industry in the region albeit not necessarily on an equal basis across or within groups [41]. Most air routes have high allocation efficiency and passenger transport efficiency, while they have low freight transport efficiency [42]. The network's physical topology and the functional network with traffic information are highly correlated to the Gross Domestic Product (GDP) of a country [43]. According to Bazargan, there are four stages of the flight planning management process, namely flight scheduling, fleet assignment, aircraft route determination, and crew scheduling [44].

CONCLUSIONS

Three airports that serve as hub airports in Indonesia are Soekarno-Hatta International Airport (CGK) in Cengkareng, Banten; Kualanamu International Airport (KNO) in Deli Serdang, North Sumatra, and Sultan Hasanuddin International Airport (UPG) in Makassar, South Sulawesi. The flight routes analysed are direct flight routes (point to point). The number of routes needed to form a hub and spoke airport network system of cargo transportation according to the Indonesia National Logistics System scheme is 37 routes.

ACKNOWLEDGMENTS

"This study is funded by the Ministry of Education, Culture, Research and Technology Republic of Indonesia for the approved fund of Basic Research in 2021 based on research contract No. 117/SP2H/LT/DRPM/2021". The authors are fully acknowledged for funding this research.

REFERENCES

1. F. Heinitz, M. Hirschberger and C. Werstat, The role of road transport in scheduled air cargo networks, Procedia Soc. Behav. Sci. **104**, 1198-1207 (2013). https://doi.org/10.1016/j.sbspro.2013.11.216.
2. D. Teodorovic and E. Kremar-Nozic, Multicriteria model to determine flight frequencies on an airline network under competitive conditions, Transp. Sci. **23** (1), 14-25 (1989). https://doi.org/10.1287/trsc.23.1.14.
3. W. E. Bendinelli, H. F. A. J. Bettini and A. V. M. Oliveira, Airline delays, congestion internalization and non-price spillover effects of low cost carrier entry, Transp. Res. A Policy Pract. **85**, 39-52 (2016). https://doi.org/10.1016/j.tra.2016.01.001.
4. S. Yan and C. R. Wang, The planning of aircraft routes and flight frequencies in an airline network operations, J. Adv. Transp. **35** (1), 33-46 (2001). https://doi.org/10.1002/atr.5670350104.
5. H. Matsumoto, International urban systems and air passenger and cargo flows: some calculations, J. Air Transp. Manag. **10** (4), 239-247 (2004). https://doi.org/10.1016/j.jairtraman.2004.02.003.
6. H. Matsumoto, International air network structures and air traffic density of world cities, Transp. Res. E Logist. Transp. Rev. **43** (3), 269-282 (2007). https://doi.org/10.1016/j.tre.2006.10.007.
7. K. Yamaguchi, International trade and air cargo: analysis of US export and air transport policy, Transp. Res. E Logist. Transp. Rev. **44** (4), 653-663 (2008). https://doi.org/10.1016/j.tre.2007.05.006.
8. R. T. Arendal, The role of RFS in the Europe of tomorrow, Cargo Network Solution FOCUS, **7** (2), 12-18.
9. J. de D. Ortùzar and L. G. Willumsen, Modeling Transport, Wiley: Chichester (2011).
10. P. S. Morell and T. Klein, Moving Boxes by Air: The Economics of International Air Cargo, Ashgate Publishing: Farnham Surrey (2011).
11. M. Diamond, Network Simulation Models. TRR E-C040: Aviation Demand Forecasting-A Survey of Methodologies, Washington (2002).
12. M. Lohatepanont, Airline Fleet Assignment and Schedule Design: Integrated Models and Algorithms, MIT Cambridge (2012).
13. D. Li, H. C. Huang, A. D. Morton and E. P. Chew, Simultaneous Fleet Assignment and Cargo Routing, OR Spectrum **28** (3), 319-335, (2006).
14. J. T. Bowen, The geography of freighter aircraft operations in the Pacific Basin, J. Transp. Geogr. **12** (1), 1-11, (2004). https://doi.org/10.1016/S0966-6923(03)00024-3.
15. F. Kupfer, R. Kessels, P. Goos, A. Verhetsel and E. V. de Voorde, The Airport Choice of Freighter Operators, in The 91st Conference Transportation Research Board (TRB) Washington (2012).
16. A. Franz, G. Selinka and R. Stolletz, Time-dependent performance approximation of truck handling operations at an air cargo terminal, Proceedings of the International Conference on Airport Operations Management, Munich (2012).
17. F. M. Heinitz and P. A. Meincke, Systematizing routing options in a global air cargo network model, Aerlines Magazine **49** (1), 1-5, Amsterdam (2011).
18. F. M. Heinitz and P. A. Meincke, Modeling framework of origin and destination air cargo routing, Transp. Res. Rec.: J. Transp. Res. Board. **2336** (1), 83-90 (2013). https://doi.org/10.3141/2336-10.

19. M. Abate, Economic effects of air transport market liberalization in Africa. Transport. Res. A Pol. Pract. **92**, 326-337 (2016). https://doi.org/10.1016/j.tra.2016.06.014.
20. A. Zhang, Y. V. Hui and L. Leung, Air cargo alliances and competition in passenger markets, Transport. Res. E Logist. Transport. Rev. **40** (2), 83-100 (2004). https://doi.org/10.1016/S1366-5545(03)00034-6.
21. P. A. Meincke, F. M. Heinitz and D. Steiger, Interaction of air cargo demand and global trade in the light of current modeling approaches, 11th Air Transport Research Society (ATRS) Conference, Berkeley CA, (2007).
22. C. C. Hwang and G. C. Shiao, Analyzing air cargo flows of international routes: an empirical study of Taiwan Taoyuan International Airport, J. Transp. Geogr. **19**, 738-744 (2011). https://doi.org/10.1016/j.jtrangeo.2010.09.001.
23. Ministry of Transportation Republic of Indonesia, *Lalu Lintas Angkutan Udara*. Jakarta: Directorate General of Air Transport Ministry of Transportation Republic of Indonesia, Retrieved on 2021-07-27, http://hubud.dephub.go.id/?id/produksi/index.
24. Ministry of Transportation Republic of Indonesia, *Peraturan Menteri Perhubungan Republik Indonesia Nomor PM 39 Tahun 2019 tentang Tatanan Kebandarudaraan Nasional*, Jakarta: Ministry of Transportation Republic of Indonesia (2019).
25. Ministry of State Secretariat of the Republic of Indonesia, *Peraturan Presiden Republik Indonesia Nomor 26 Tahun 2012 tentang Cetak Biru Pengembangan Sistem Logistik Nasional,* Jakarta: Ministry of State Secretariat of the Republic of Indonesia (2012).
26. G. Sugiyanto, P. B. Santosa and M. Y. Santi, Hub and spoke airport networks in Sulawesi Island, Indonesia based on freight ratio, ARPN J. Eng. Appl. Sci. **15** (10), 1101-1110 (2020). http://www.arpnjournals.org/jeas/research_papers/rp_2020/jeas_0520_8218.pdf.
27. G. Sugiyanto, P. B. Santosa, A. Wibowo and M.Y. Santi, Airport classification based on Federal Aviation Administration and freight ratio (case study in Indonesia), ARPN J. Eng. Appl. Sci. **12** (2), 579-587 (2017a). http://www.arpnjournals.com/jeas/volume_02_2017.htm
28. G. Sugiyanto, P. B. Santosa, Jajang, A. Fadli and M. Y. Santi, Evaluation of hub-spoke airport networks in Sumatra Island, Indonesia to increase efficiency of air transportation, MATEC Web Conf. **195** (04009), 1-9. (2018). https://doi.org/10.1051/matecconf/201819504009.
29. J. C. Martın and C. Roman, Analyzing competition for hub location in intercontinental aviation markets, Transp. Res. E: Logist. Transp. Rev. **40** (2), 135-150 (2004). http://dx.doi.org/10.1016/s1366-5545(03)00037-1.
30. G. Sugiyanto, Marshall test characteristics of asphalt concrete mixture with scrapped tire rubber as a fine aggregate. J. Teknol. **79** (2), 55-64 (2017). https://doi.org/10.11113/jt.v79.6965.
31. G. Sugiyanto, P. B. Santosa and M.Y. Santi, Determining the criteria of air hub in Indonesia using Analytical Hierarchy Process (AHP), Adv. Eng. Res. **187**, 20-24 (2019). https://doi.org/10.2991/icosite-19.2019.4.
32. J. -L. A. Navarro, M. -E. A. Martínez and J. -F. Trinquecoste, The effect of the economic crisis on the behaviour of airline ticket prices: A case-study analysis of the New York-Madrid route, J. Air Transp. Manag. **47**, 48-53 (2015). https://doi.org/10.1016/j.jairtraman.2015.04.004.
33. P. Rietveld and M. Brons, Quality of hub-and-spoke networks: the effects of time table co-ordination on waiting time and rescheduling time, J. Air Transp. Manag. **7** (4), 241-249 (2001). https://doi.org/10.1016/S0969-6997(01)00012-6.
34. G. Sugiyanto, P. B. Santosa, A. Wibowo and M. Y. Santi, Analysis of hub-and-spoke airport networks in Java Island, Indonesia based on cargo volume and freight ratio, Procedia Eng. **125**, 556-563 (2015). http://dx.doi.org/10.1016/j.proeng.2015.11.061.
35. M. E. O'Kelly, Air freight hubs in the FedEx system: Analysis of fuel use, J. Air Transp. Manag. **36**, 1-12 (2014). https://doi.org/10.1016/j.jairtraman.2013.12.002.
36. G. Sugiyanto, The effect of congestion pricing scheme on the generalized cost and speed of motorcycle, Walailak J. Sci. & Tech. **15** (1), 95-106 (2018). https://doi.org/10.48048/wjst.2018.2347.
37. G. Sugiyanto, A. Fadli and M. Y. Santi, Identification of black spot and equivalent accident number using upper control limit method, ARPN J. Eng. Appl. Sci. **12** (2), 528-535 (2017b).
38. S. Yan, S. C. Chen and C. H. Che, Air cargo fleet routing and timetable setting with multiple on-time demands, Transp. Res. E Logist. Transp. Rev. **42** (5), 409-430 (2006). https://doi.org/10.1016/j.tre.2005.02.002.
39. G. Sugiyanto, P. B. Santosa, A. Wibowo and M.Y. Santi, Hub and spoke airport networks in Indonesia based on Herfindahl-Hirschman Index (HHI), J. Eng. Appl. Sci. **11** (8), 1804-1810 (2016).
40. N. Feriyanto, C. Saleh, A. Fauzi, N. R. Dzakiyullah and K. R. Iwaputra, The route analysis based on flight plan, IOP Conf. Ser.: Mater. Sci. Eng. **114** 012147 (2016). https://doi.org/10.1088/1757-899X/114/1/012147.

41. N. Adler, X. Fu, T. H. Oum and C. Yu, Air transport liberalization and airport slot allocation: the case of the Northeast Asian transport market, Transport. Res. A Pol. Pract. **62**, 3-19 (2014). https://doi.org/10.1016/j.tra.2014.02.003.
42. Y. Shao and C. Sun, Performance evaluation of China's air routes based on network data envelopment analysis approach, J. Air Transp. Manag. **55**, 67-75 (2016). http://dx.doi.org/10.1016/j.jairtraman.2016.01.006.
43. S. Wandelt and X. Sun, Evolution of the international air transportation country network from 2002 to 2013. Transport. Res. E Logist. Transport. Rev. **82**, 55-78 (2015). https://doi.org/10.1016/j.tre.2015.08.002.
44. M. Bazargan, Airline Operations and Scheduling, Ashgate, Burlington, USA (2004).

A manuscript number has been assigned to Aircraft Routes and Flight Frequency of Domestic Cargo Transport - [EMID:edb0214785de110e]

From: SJST (em@editorialmanager.com)

To: gito_98@yahoo.com

Date: Tuesday, 10 August 2021, 12:04 pm GMT+7

CC: "Mina Yumei SANTI" minayumeisanti80@gmail.com

Dear Dr. Sugiyanto,

Your submission entitled " Aircraft Routes and Flight Frequency of Domestic Cargo Transport" has been been assigned the following manuscript number: SUJST-D-21-00439.

You will be able to check on the progress of your paper by logging on to Editorial Manager as an author.
The URL is https://www.editorialmanager.com/sujst/.

Thank you for submitting your work to this journal.

Kind regards,

Rattikorn Yimnirun
Chief Editor
Suranaree Journal of Science and Technology

____

Dokumen pendukung luaran Tambahan #1

Luaran dijanjikan: Artikel pada Conference/Seminar Internasional di Pengindeks Bereputasi

Target: Terbit dalam Prosiding
Dicapai: Accepted

Dokumen wajib diunggah:
1. Naskah artikel
2. Surat keterangan accepted dari editor

Dokumen sudah diunggah:
1. Naskah artikel
2. Surat keterangan accepted dari editor

Dokumen belum diunggah:
-

Peran penulis: first author
Nama Konferensi/Seminar: The 3rd International Conference on Engineering, Technology and Innovative Researches (ICETIR)
Lembaga penyelenggara: Fakultas Teknik Universitas Jenderal Soedirman Purwokerto-AIP Conference Proceedings
Tempat penyelenggara: Fakultas Teknik Universitas Jenderal Soedirman Pur
Tgl penyelenggaraan mulai: 1 September 2021 | Tgl selesai: 2 September 2021
Lembaga pengindeks: Scopus
Judul artikel: The Effect of Novel Coronavirus Disease (COVID-19) on Air Transport

The Effect of Novel Coronavirus Disease (COVID-19) on Air Transport

Gito Sugiyanto[1, a)], Purwanto Bekti Santoso[1, b)], and Mina Yumei Santi[2, c)]

[1] *Civil Engineering Department, Faculty of Engineering, Jenderal Soedirman University, Purbalingga, Central Java, Indonesia*
[2] *Health Polytechnic Ministry of Health of Yogyakarta, Indonesia.*

[a)] *Corresponding author: gito.sugiyanto@unsoed.ac.id*
[b)] *purwanto1409@unsoed.ac.id*
[c)] *minayumeisanti80@gmail.com*

Abstract. On 11 March 2020, the World Health Organization (WHO) declared the Novel Coronavirus Disease (COVID-19) outbreak a pandemic. The air transport sector has remained one of the hardest-hit global industries since the outbreak pandemic. Since the COVID-19 outbreak started, the number of infected cases reached 198,074,040 on 31 July 2021 and 4,225,437 people have died worldwide due to this Novel Coronavirus Disease. The strict travel ban restrictions to reduce the spreading of disease further amplified the reduction of air passenger demand and resulted in a large number of flight cancellations. The method used in this study is a literature review. Based on International Civil Aviation Organization in 2021, the effect of novel coronavirus disease pandemic on world scheduled passenger traffic for the year 2020, compared to 2019 levels are reduction of 50 % of seats offered by airlines, reduction of 2,699 million passengers (decreased 60 %), and approximately USD 371 billion loss of gross passenger operating revenues of airlines. The International Air Transport Association expressed an overall reduction of 48 % in terms of Revenue-Passenger Kilometres and 55 % in passenger revenues for 2020. The highest decrease in the number of passengers carried occurred in Asia and the Pacific region by 921 million people, followed by the European region by 769 million people and the North America region by 599 million people. Furthermore, the effect of the COVID-19 pandemic on air transport in Indonesia, the number of air transport passengers in 2020 was recorded at 32.711 million people. This number decreased 57.76 % year on year from 2019 which was 76.69 million people. The COVID-19 pandemic has indeed limited people's mobility and made the air transportation sector the hardest hit. The actual impacts of the COVID-19 pandemic depend on the duration and magnitude of the outbreak and preventive measures, the consumer confidence degree for air travel, and economic conditions.

Keywords: air transportation, Novel Coronavirus Disease, pandemic, civil aviation, effect

INTRODUCTION

On 11 March 2020, the World Health Organization (WHO) declared the Novel Coronavirus Disease (COVID-19) outbreak a pandemic. The COVID-19 pandemic is affecting all countries in the world including Indonesia. The COVID-19 has affected many sectors such as transportation, health, economy, tourism, trade, and so on. The current Novel Coronavirus Disease outbreak is an unprecedented event in air transportation. The air transport sector has remained one of the hardest-hit global industries since the outbreak pandemic. The COVID-19 pandemic has resulted in a global transportation crisis [1]. Airports Council International published the result of the study about the economic impact of the COVID-19 pandemic, its effects on the global airport business, and the path to recovery [1]. Since the COVID-19 outbreak started, the number of infected cases reached 198,074,040 on 31 July 2021 and 4,225,437 people have died worldwide due to this virus. Based on the Ministry of the Health Republic of Indonesia until 7 August 2021, in Indonesia, the number of infected cases COVID-19 reached 3,607,863 people, recovered from COVID-19 as many as 2,996,478 people and 104,010 people have died [2].

The increase of people mobility enabled by air transportation, owing to enhanced connectivity and efficiency [3-4]. Air mobility using aircraft has allowed more passengers to fly to more and remote destinations within a few hours at affordable prices [5-7]. It has also significantly contributed to the risk of spreading the novel coronavirus disease worldwide. It has been known that air transportation plays a critical role in the spread of contagious coronavirus diseases [8-10]. The strict travel ban restrictions to reduce the spreading of disease further amplified the substantial reduction of air passenger demand and resulted in a large number of flight cancellations. Although the total number of COVID-19 infected cases is surging, a few countries seem to have achieved certain or peak incidence [11].

The COVID-19 pandemic has had a major impact on the aviation industry. As of March 24, 2020, 98 % of global passenger revenue is accounted for by the air transport market with strict restrictions (e.g. quarantines for newly arrived passengers, partial travel bans, and border closures), many airlines reducing operations or even stopping operations [12]. The crisis due to the COVID-19 pandemic is rapidly spreading globally. Airports Council International (ACI) estimates that the COVID-19 pandemic will wipe out two-fifths of passenger traffic and half of the airport revenues by 2020 [13]. The relationship between aviation networks and global virus spread has been investigated by Wu in Ref. [14], Boldog in Ref. [15], Adiga and Venkatramanan [16]. Nikolaou and Dimitriou identified airports critical for global infection control of disease outbreaks in Europe [17]. Air travel data are used to estimate the size of the COVID-19 outbreak in Italy [18]. As of May 2020, most countries have active flight bans to reduce the spreading of disease. Several recent studies investigate how the air transportation mode and other modes do: land transportation mode, sea transportation mode, and train contribute to the spread of COVID-19? [19-21]. In this paper, we discuss investigating what is the effect of the COVID-19 pandemic on air transport that focused on global aviation.

The evolutionary dynamics of domestic airport networks are tightly correlated with the COVID-19 situation [11]. The COVID-19 pandemic has stronger impacts on international passenger traffic than a domestic flight of passengers [22]. In the study of the evolution of the international air transportation country network, nodes are countries and direct flights between countries represent links. Furthermore, in the domestic airport network, nodes are airports within a specific region and the direct flights between these airports in a country represent links [23]. The number of origin-destination pairs evolution and the number of aircraft in operation showed that the aviation industry has reacted to the COVID-19 pandemic with a delay of about two months [11]. With the knowledge degree about the novel coronavirus disease in early 2020, one would have expected a much more coordinated and informed global response [24]. Civil aviation is seen by most governments as a strategic sector closely linked with economic development [25]. Civil aviation policies reflect a balance between the consumers' interests and the aviation and tourism industries [26]. The support can be selective subsidies to operators, service providers, or manufacturers [27] or interventions that restrict market access to potential competitors [28] and create monopolistic bottlenecks [29].

This paper presents the effect of the COVID-19 outbreak on air transport. The effect of COVID-19 focused on the capacity decrease of seats offered by airlines, a decrease of passenger traffic, passenger revenue, and Revenue-Passenger Kilometres (RPKs).

METHODOLOGY

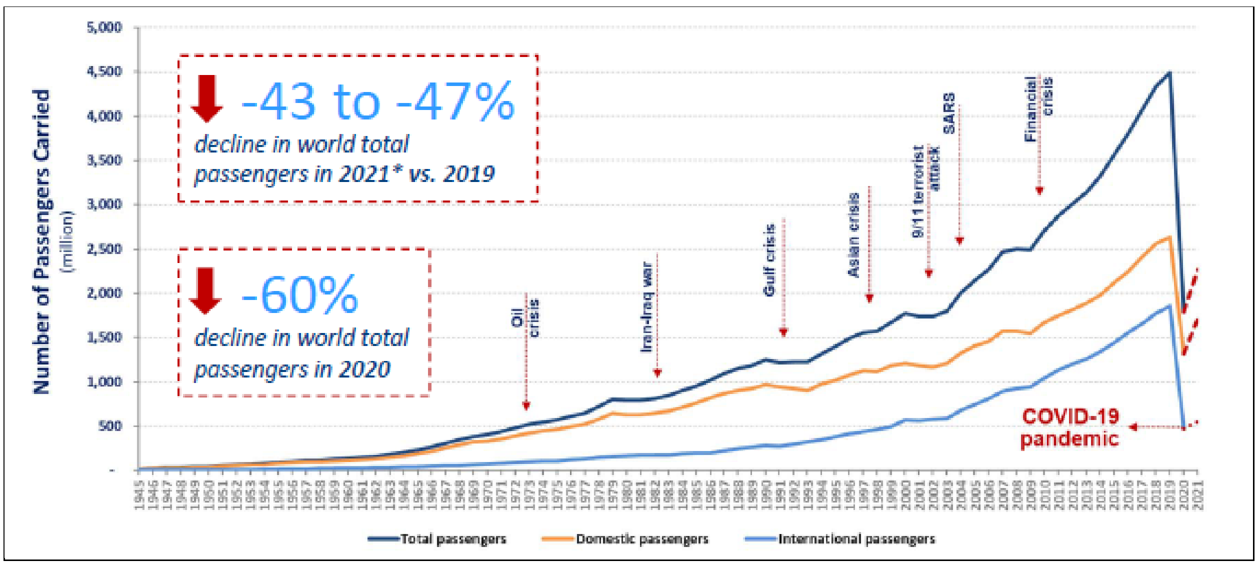
The methodology used in this study is a literature review and collecting data on the number of passengers for the domestic flights and international flights in Indonesia from the Directorate General of Civil Aviation, Ministry of Transportation Republic of Indonesia in 2019 and 2020 [30], PT. (Persero) Angkasa Pura I, and PT. (Persero) Angkasa Pura II. The effect of the COVID-19 pandemic focused on the capacity decreased of seats offered by airlines, decreased of passenger traffic, passenger revenue according to the International Civil Aviation Organization (ICAO) in six regions namely the North America region, Latin America and the Caribbean region, Europe region, Africa region, Asia and the Pacific region, and the Middle East region. The analysis of Revenue-Passenger Kilometres (RPKs) according to the International Air Transport Association.

RESULT AND DISCUSSION

Effect of Covid-19 on Air Transport

World Passenger Traffic Evolution

The COVID-19 pandemic has far-reaching implications for society. The aviation sector was particularly hit, according to the European Commission, with a 50 % decrease in the total number of flights globally during April and May 2020. Several countries saw their air transport activity decrease by over 90 % for two months or more [31]. According to the International Civil Aviation Organization (ICAO), the COVID-19 pandemic impact on world scheduled passenger traffic for the year 2020, compared to 2019 levels are overall reduction of 50 % of seats offered by airlines, an overall reduction of 2,699 million passengers (reduction of 60 %) and approximately USD 371 billion loss of gross passenger operating revenues of airlines [32]. The COVID-19 pandemic impact on world scheduled passenger traffic preliminary estimates for the year 2021, compared to 2019 levels are overall reduction of 35 % to 38 % of seats offered by airlines, an overall reduction of 1,949 to 2,116 million passengers (reduction of 43 % to 47 %) and approximately USD 289 to 312 billion loss of gross passenger operating revenues of airlines. According to the ICAO, the world passenger traffic evolution from 1945-2021 can be seen in Figure 1.



Source: International Civil Aviation Organization (ICAO), 2021 [32].

FIGURE 1. World passenger traffic evolution from 1945-2021.

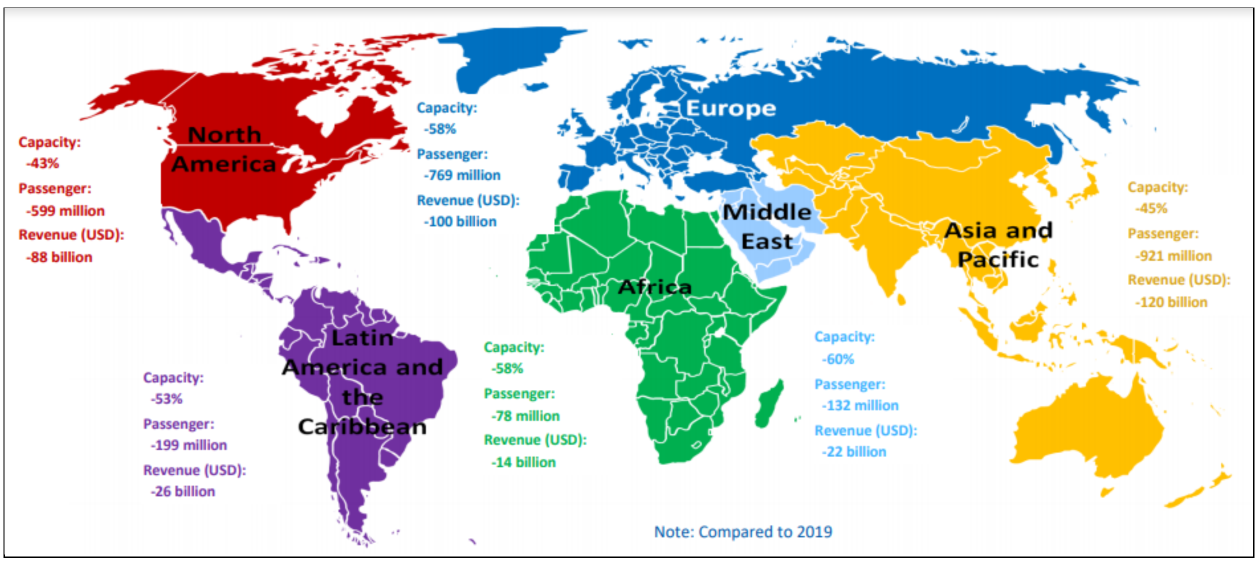
Based on Figure 1, the number of passengers carried for a domestic flight, international flight, and total passengers due to the COVID-19 pandemic, there has been a drastic drop or collapse. The decline in world total passenger is bigger than the volcanic ash of Eyjafjallajokull in Islandia in 2010 [33] or extreme weather [34], the oil crisis in 1973, the Iran-Iraq war in 1982, the Gulf crisis in 1991, the Asian crisis in 1997-1998, 9/11 terrorist attack on 11 September 2001, Severe Acute Respiratory Syndrome (SARS) in 2005, and financial crisis in 2010 [32]. The effect of the COVID-19 pandemic on air transport in Indonesia, according to the Directorate General of Air Transport Ministry of the Transportation Republic of Indonesia, the number of air transport passengers in 2020 was recorded at 32,711,088 people. This number decreased 57.76 % year on year from 2019 which was 76.69 million people [35]. The number of aircraft movement in 2020 is 432,864 unit and the total cargo is 436,048,954 kg. The revenue of PT Angkasa Pura in 2020 was recorded at IDR 3.92 trillion. This number decreased 54.4% year on year from 2019 which was IDR 8.6 trillion.

Domestic and International Passenger Traffic

According to the International Civil Aviation Organization, the COVID-19 pandemic effect on domestic passenger traffic (2020 versus 2019) is an overall reduction of 38 % of seats offered by airlines, an overall reduction of 1,323 million passengers (reduction of 50 %), and approximately USD 120 billion loss of gross operating revenues of airlines [32]. The impact of the COVID-19 pandemic on international passenger traffic (2020 versus 2019) is an overall reduction of 66 % of seats offered by airlines, an overall reduction of 1,376 million passengers (reduction of 74 %), and approximately USD 250 billion loss of gross operating revenues of airlines [32]. Risk aversion and self-imposed social distancing can modify current trends in aviation demand and user choices [36]. The COVID-19 pandemic will affect the capacity of airports and the level of services provided [37]. Managing seasonality in air transport service industries, the case of price and seat factor management in airlines, despite expected seasonal and weekly variations [38], the airport network was rather stable until the middle of March 2020. The actual impacts will depend on the duration and magnitude of the outbreak and containment measures, the degree of consumer confidence for air travel, and economic conditions, airport network [39-40]. The number and frequency of aviation connections are strongly correlated with economic growth [41] and hub and spoke airport networks [42]. Road infrastructure is one of the factors that must be considered in determining the location of the airport [43]. The application of hub and spoke airport networks can increase the efficiency of air transportation [44].

Capacity, Passenger Traffic and Revenues by Region

The COVID-19 pandemic impact on capacity (number of seats offered by airlines), number of passenger traffic, and revenue by region can be seen in Figure 2. There are six regions namely the North America region, Latin America and the Caribbean region, Europe region, Africa region, Asia and the Pacific region, and the Middle East region.



Source: International Civil Aviation Organization, 2021 [32].

FIGURE 2. Effect of COVID-19 on capacity, passenger traffic and revenues in six regions in 2020.

The effect of the COVID-19 pandemic in the North American region, decreased the capacity of 43 % of seats offered by airlines, the number of passengers carried decreased 599 million people, and approximately USD 88 billion loss of gross operating revenues of airlines. Furthermore, in Latin America and the Caribbean region, the capacity decreased 53 % of seats offered by airlines, the number of passengers carried decreased by 199 million people, and approximately USD 26 billion loss of gross operating revenues of airlines. In Asia and the Pacific region the capacity decreased 45 % of seats offered by airlines, the number of passengers carried decreased 921 million people, and approximately USD 120 billion loss of gross operating revenues of airlines. In the European region, the capacity decreased 58 % of seats offered by airlines, the number of passengers carried decreased 769 million people, and approximately USD 100 billion loss of gross operating revenues of airlines. In the Middle East region the capacity decreased 60 % of seats offered by airlines, the number of passengers carried decreased 132 million people, and approximately USD 22 billion loss of gross operating revenues of airlines. Furthermore, in the Africa region, the capacity decreased 58 % of seats offered by airlines, the number of passengers carried decreased 78 million people, and approximately USD 14 billion loss of gross operating revenues of airlines [32]. The highest decrease in seat capacity offered by airlines occurred in the Middle East Region by 60 %, followed by the European region by 58 % and the Africa region by 58 %. The highest decrease in the number of passengers carried occurred in Asia and the Pacific region by 921 million people, followed by the European region by 769 million people and the North America region by 599 million people. The highest loss of gross operating revenues of airlines occurred in Asia and the Pacific region by USD 120 billion, followed by the European region by USD 100 billion and the North America region by USD 88 billion. The COVID-19 pandemic impact on capacity, number of passenger traffic, and revenue in six regions can be seen in Table 1.

TABLE 1. The effect of COVID-19 pandemic on capacity, passenger carried, and revenues in six regions in 2020.

Name of Region	Decreased Capacity of Seats (%)	Decreased Passenger Carried (million people)	Decreased Revenue (Billion USD)
Asia and the Pacific Region	45	921	120
Europe Region	58	769	100
The North America Region	43	599	88
Latin America and the Caribbean Region	53	199	26
The Middle East Region	60	132	22
Africa Region	58	78	14

Source: International Civil Aviation Organization, 2021 [32].

Global Effect of COVID-19 Pandemic

The effect of the COVID-19 pandemic on air passenger traffic, airports, airlines, tourism, and trade in 2020 is as follow:

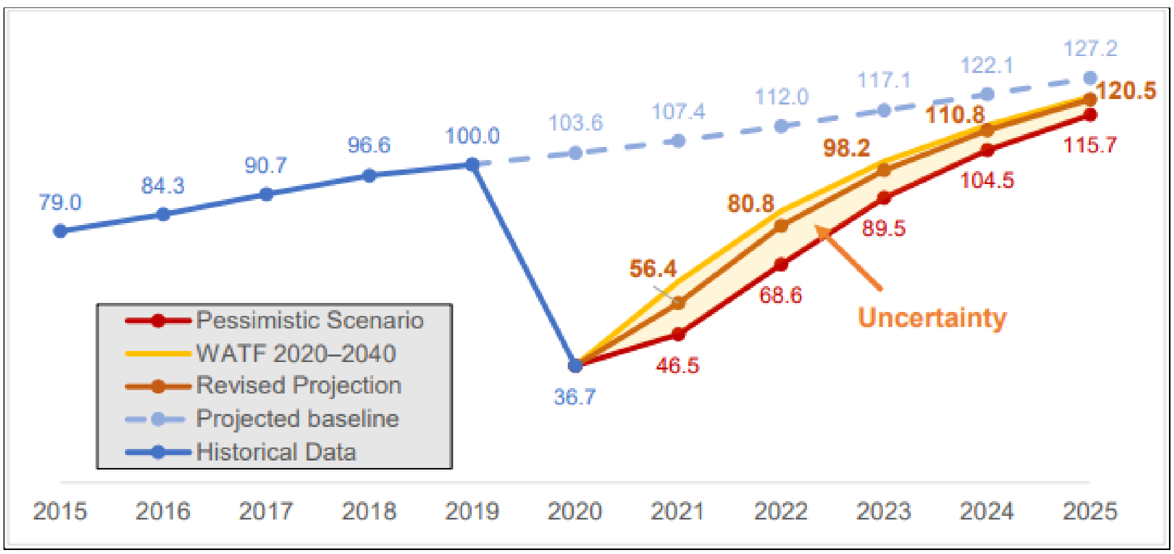
1. According to the study of the International Civil Aviation Organization, the effect of COVID-19 on global aviation focused on air passenger traffic is an overall reduction in the number of air passengers carried (both for the international flights and domestic flights) ranging from 60 % in 2020 compared to 2019 (year on year) [32].
2. According to the study of the Airports Council International, the effect of COVID-19 in airports is an estimated loss of approximately 64.6 % of passenger traffic carried and 66.3% or over USD 125 billion airport revenues in 2020 compared to business as usual [1].
3. According to the study of the International Air Transport Association (IATA), the effect of COVID-19 in airlines is a 65.9 % decline of revenue passenger kilometres or RPKs, both for the international flights and domestic flights in 2020 compared to 2019 (year on year) [45].
4. According to the study of the United Nations-World Tourism Organization (UNWTO), the effect of COVID-19 in tourism is a decline in international tourism receipts of USD 1.3 trillion in 2020, compared to the USD 1.5 trillion generated in 2019. The World Tourism Organization is the United Nations agency responsible for the promotion of responsible, sustainable, and universally accessible tourism.
5. According to the study of the World Trade Organization (WTO), the effect of COVID-19 in world trade is a fall of global merchandise trade volume by 5.3 % in 2020 compared to 2019 (year on year).

Traffic Projection and Path to Recovery

According to the Airports Council International the following related to traffic projection and path to recovery of airport passenger traffic in global aviation can be analysed in 3 scenarios, the first is according to The World Airport Traffic Forecasts (WATF) 2020-2040, the second is based on revised projection, and the third based on a pessimistic scenario as follows [1]:

1. The first scenario, if new variants of the COVID-19 are effectively contained, The World Airport Traffic Forecasts (WATF) 2020-2040 is still the most likely, resulting in a recovery in the number of global passenger traffic carried to 2019 level by the end of 2023 [1].
2. In the second scenario, under the baseline scenario, global passenger traffic is now expected to recover to 2019 levels in 2024 mainly driven by the recovery of domestic passenger traffic but now slightly dampened by a slower recovery of international travel. Domestic passenger traffic is expected to reach 2019 levels in the second half of 2023. The recovery of international passenger traffic is expected to reach 2019 levels in 2024.
3. The third scenario, a pessimistic scenario, is a delayed recovery with the appearance of new variants of the COVID-19 resulting in governments introducing more restrictive measures, creating new lockdowns and travel restrictions. Under the pessimistic scenario, the global passenger traffic will end in the year 2021 at only 46.5 % of the 2019 level, ending the year 2022 at only 68.6 % of the 2019 level. In the long run, it is predicted that the global traffic may take up to two decades to return to previously projected levels (pre-COVID-19 forecast).

The passenger traffic projection in global aviation according to the Airports Council International can be seen in Figure 3. The recovery of international passenger traffic or the number of air passengers carried will require one more year, thus getting back to 2019 levels only in 2024. By the end of 2021, the value compared with the 2019 level is only 56.4 %; in the end 2022 approximately 80.8 % of 2019 level; in the end 2023 approximately 98.2 % of 2019 level and at the end 2024 approximately 110.8 % of 2019 level [1].



Source: Airports Council International (ACI), 2021 [1]

FIGURE 3. The short-term global passenger traffic projection [1].

CONCLUSIONS

Based on the International Civil Aviation Organization, the effect of the COVID-19 pandemic on global aviation and world scheduled passenger traffic is a reduction of 50 % of seats offered by airlines, reduction of 2,699 million passengers (decreased 60 %), and approximately USD 371 billion loss of gross passenger operating revenues of airlines. According to the International Air Transport Association, an overall reduction of 48 % in terms of Revenue-Passenger Kilometres and 55 % in passenger revenues for 2020. The highest decrease in the number of passengers carried occurred in Asia and the Pacific region by 921 million people, followed by the European region by 769 million people and the North America region by 599 million people. The effect of COVID-19 on air transport in Indonesia, the number of air transport passengers in 2020 was recorded at 32.711 million people. This number decreased 57.76 % year on year from 2019 which was 76.69 million people. The COVID-19 pandemic has indeed limited people's mobility and made the air transportation sector the hardest hit. The actual impacts of the COVID-19 pandemic depend on the duration and magnitude of the outbreak and preventive measures, the consumer confidence degree for air travel, and economic conditions.

ACKNOWLEDGMENTS

"This study is funded by the Ministry of Education, Culture, Research and Technology Republic of Indonesia for the approved fund of Basic Research in 2021 based on research contract No. 117/SP2H/LT/DRPM/2021". The authors are fully acknowledged for funding this research.

REFERENCES

1. Airports Council International (ACI), ACI Advisory Bulletin: The impact of COVID-19 on the airport business and the path to recovery (2021). https://aci.aero/news/2021/03/25/the-impact-of-covid-19-on-the-airport-business-and-the-path-to-recovery/.
2. Ministry of Health Republic of Indonesia, Situation of COVID-19 per 7 August 2021 (2021), https://infeksiemerging.kemkes.go.id/
3. G. Sugiyanto, P. B. Santosa, A. Wibowo and M. Y. Santi, Analysis of hub-and-spoke airport networks in Java Island, Indonesia based on cargo volume and freight ratio, Procedia Eng. **125**, 556-563 (2015). http://dx.doi.org/10.1016/j.proeng.2015.11.061.
4. G. Sugiyanto, P. B. Santosa, A. Wibowo and M.Y. Santi, Hub and spoke airport networks in Indonesia based on Herfindahl-Hirschman Index (HHI), J. Eng. Appl. Sci. **11** (8), 1804-1810 (2016). http://medwelljournals.com/abstract/?doi=jeasci.2016.1804.1810.
5. M. Janic, An assessment of risk and safety in civil aviation, J. Air Transp. Manag. **6** (1), 43-50 (2000). https://doi.org/10.1016/S0969-6997(99)00021-6.
6. D. S. Lee, D. W. Fahey, P. M. Forster, P. J. Newton, R. C. Wit, L. L. Lim, B. Owena and R. Sausen, Aviation and global climate change in the 21st century, Atmos. Environ. **43** (22-23), 3520-3537 (2009). https://doi.org/10.1016/j.atmosenv.2009.04.024.
7. L. Diaconu, The evolution of the European low-cost airlines business models Ryanair case study, Procedia Soc. Behav. Sci. **62**, 342-346 (2012). https://doi.org/10.1016/j.sbspro.2012.09.054.
8. A. Likhacheva, SARS revisited, Ama J. Ethics Virtual Mentor **8** (4), 219-222 (2006). https://doi.org/10.1001/virtualmentor.2006.8.4.jdsc1-0604
9. A. M. Zaki, S. van Boheemen, T. M. Bestebroer, A. D. Osterhaus and R. A. Fouchier, Isolation of a novel coronavirus from a man with pneumonia in Saudi Arabia. N. Engl. J. Med. **367** (19), 1814-1820 (2012). https://doi.org/10.1056/NEJMoa1211721.
10. I. I. Bogoch, M. I. Creatore, M. S. Cetron, J. S. Brownstein, N. Pesik and J. Miniota, Assessment of the potential for international dissemination of Ebola virus via commercial air travel during the 2014 west African outbreak. Lancet **385** (9962), 29-35 (2015). https://doi.org/10.1016/S0140-6736(14)618286.
11. X. Sun, S. Wandelt and A. Zhang, How did COVID-19 impact air transportation? A first peek through the lens of complex networks, J. Air Transp. Manag. **89**, 101928 (2020) https://doi.org/10.1016/j.jairtraman.2020.101928.
12. P. S. Sanchez, A. V. Dortac and N. C. Escofet, An early assessment of the impact of Covid-19 on air transport: Just another crisis or the end of aviation as we know it?, J. Transp. Geogr. **86**, 102749. https://doi.org/10.1016/j.jtrangeo.2020.102749.
13. Airports Council International (ACI), ACI Advisory Bulletin: The impact of COVID-19 on the airport business, (2020).URL:https://aci.aero/wp-content/uploads/2020/03/200401-COVID19-Economic-Impact-Bulletin-FINAL-1.pdf.
14. J. T. Wu, K. Leung and G. M. Leung, Nowcasting and forecasting the potential domestic and international spread of the 2019-nCoV outbreak originating in Wuhan, China: a modelling study, Lancet **395** (10225), 689-697 (2020). https://doi.org/10.1016/S0140-6736(20)30260-9.
15. P. Boldog, T. Tekeli, Z. Vizi, A. Dénes, F.A. Bartha and G. Röst, Risk assessment of novel coronavirus COVID-19 outbreaks outside China, J. Clin. Med. **9** (2), 571-582 (2020). https://doi.org/10.3390/jcm9020571
16. A. Adiga and S. Venkatramanan, Evaluating the impact of international airline suspensions on COVID-19 direct importation risk, medRxiv (2020). https://doi.org/10.1101/2020.02.20.20025882.
17. P. Nikolaou and L. Dimitriou, Identification of critical airports for controlling global infectious disease outbreaks: stress-tests focusing in Europe, J. Air Transp. Manag. **85**, 101819 (2020). https://doi.org/10.1016/j.jairtraman.2020.101819.

18. A. R. Tuite, V. Ng, E. Rees and D. Fisman, Estimation of COVID-19 outbreak size in Italy, Lancet Infection Disease (2020). https://doi.org/10.1016/S1473-3099(20)30227-9.
19. P. Christidis and A. Christodoulou, The predictive capacity of air travel patterns during the global spread of the COVID-19 pandemic: risk, uncertainty and randomness, Int. J. Environ. Res. Publ. Health **17** (10), 3356 (2020). https://doi.org/10.3390/ijerph17103356.
20. M. Gilbert, G. Pullano, F. Pinotti, E. Valdano, C. Poletto and P.-Y. Boelle, Preparedness and vulnerability of African countries against importations of COVID-19: a modelling study. Lancet **395** (10227), 871-877 (2020), https://doi.org/10016/S0140-6736(20)30411-6.
21. Y. Zhang, A. Zhang and J. Wang, Exploring the roles of high-speed train, air and coach services in the spread of COVID-19 in China. Transport Pol. **94**, 34-42 (2020). https://ssrn.com/abstract=3600619.
22. S. Wandelt and X. Sun, Evolution of the international air transportation country network from 2002 to 2013, Transport. Res. E Logist. Transport. Rev. **82**, 55-78 (2015). https://doi.org/10.1016/j.tre.2015.08.002.
23. S. Wandelt, X. Sun and J. Zhang, Evolution of domestic airport networks: a review and comparative analysis, Transport. Bus.: Transp. Dyn. **7** (1), 1-17 (2019). https://doi.org/10.1080/21680566.2017.1301274.
24. D. Brockmann and D. Helbing, The hidden geometry of complex, network-driven contagion phenomena, Science **342** (6164), 1337-1342 (2013). https://doi.org/10.1126/science.1245200.
25. F. Zhang and D. Graham, Air transport and economic growth: a review of the impact mechanism and causal relationships, Transport Rev. **40** (4), 506-528 (2020). https://doi.org/10.1080/01441647.2020.1738587.
26. M. Abate, Economic effects of air transport market liberalization in Africa. Transport. Res. A Pol. Pract. **92**, 326-337 (2016). https://doi.org/10.1016/j.tra.2016.06.014.
27. S. Gössling, F. Fichert, P. Forsyth and H. M. Niemeier, Subsidies in aviation, Sustainability **9** (8), 1295 (2017). https://doi.org/10.3390/su9081295.
28. P. Christidis, Four shades of open skies: European union and four main external partners, J. Transport Geogr. **50**, 105-114 (2016). https://doi.org/10.1016/j.jtrangeo.2015.04.005.
29. G. Knieps, Market versus state in building the aviation value chain, J. Air Transport. Manag. **41**, 30-47 (2014). https://doi.org/10.1016/j.jairtraman.2014.06.013.
30. Ministry of Transportation Republic of Indonesia, Air Freight Traffic in Indonesia (*Lalu Lintas Angkutan Udara*). Jakarta: Directorate General of Air Transport Ministry of Transportation Republic of Indonesia, Retrieved on 2020-12-31, http://hubud.dephub.go.id/?id/produksi/index.
31. European Commission, Future of Transport: Update on the Economic Impacts of COVID-19, Policy Brief JRC120625 (2020). https://ec.europa.en/jrc/sites/jresh/files/202005_future_of_transport_covid_sfp.brief_.pdf.
32. International Civil Aviation Organization (ICAO), Effects of Novel Coronavirus (COVID-19) on Civil Aviation: Economic Impact Analysis. Canada, Montréal (2021).
33. U. Reichardt, G. F. Ulfarsson and G. Petursdottir, Developing scenarios to explore impacts and weaknesses in aviation response exercises for volcanic ash eruptions in Europe, J. Air Transport. Manag. **79**, 101684 (2019). https://doi.org/10.1016/j.jairtraman.2019.101684.
34. R. Merkert and L. Mangia, Management of airports in extreme winter conditions-some lessons from analysing the efficiency of Norwegian airports. Res. Transp. Bus. Manag **4**, 53-60 (2012). https://doi.org/10.1016/j.rtbm.2012.06.004.
35. Ministry of Transportation Republic of Indonesia, Air Freight Traffic in Indonesia (*Lalu Lintas Angkutan Udara*). Jakarta: Directorate General of Air Transport Ministry of Transportation Republic of Indonesia, Retrieved on 2021-07-27, http://hubud.dephub.go.id/?id/produksi/index.
36. M. Abate, P. Christidis and A. J. Purwanto, Government support to airlines in the aftermath of the COVID-19 pandemic, J. Air Transp. Manag. **89**, 101931 (2020). https://doi.org/10.1016/j.jairtraman.2020.101931.
37. F. Serrano and A. Kazda, The future of airports post COVID-19, J. Air Transp. Manag. **89**, 101900, (2020). https://doi.org/10.1016/j.jairtraman.2020.101900.
38. R. Merkert and T. Webber, How to manage seasonality in service industries-the case of price and seat factor management in airlines, J. Air Transport. Manag. **72**, 39-46 (2018). https://doi.org/10.1016/j.jairtraman.2018.07.005.
39. G. Sugiyanto, P. B. Santosa, A. Wibowo and M.Y. Santi, Airport classification based on Federal Aviation Administration and freight ratio (case study in Indonesia), ARPN J. Eng. Appl. Sci. **12** (2), 579-587 (2017). http://www.arpnjournals.com/jeas/volume_02_2017.htm.
40. G. Sugiyanto, P. B. Santosa and M. Y. Santi, Hub and spoke airport networks in Sulawesi Island, Indonesia based on freight ratio, ARPN J. Eng. Appl. Sci. 15 (10), 1101-1110 (2020). http://www.arpnjournals.org/jeas/research_papers/rp_2020/jeas_0520_8218.pdf.

41. E. T. Njoya, P. Christidis and A. Nikitas, Understanding the impact of liberalisation in the EU-Africa aviation market, J. Transport Geogr. **71**, 161-171 (2018). https://doi.org/10.1016/j.jtrangeo.2018.07.014.
42. G. Sugiyanto, P. B. Santosa and M.Y. Santi, Determining the criteria of air hub in Indonesia using Analytical Hierarchy Process (AHP), Adv. Eng. Res. **187**, 20-24 (2019). https://doi.org/10.2991/icosite-19.2019.4.
43. G. Sugiyanto, Marshall test characteristics of asphalt concrete mixture with scrapped tire rubber as a fine aggregate. J. Teknol. **79** (2), 55-64 (2017). https://doi.org/10.11113/jt.v79.6965.
44. G. Sugiyanto, P. B. Santosa, Jajang, A. Fadli and M. Y. Santi, Evaluation of hub-spoke airport networks in Sumatra Island, Indonesia to increase efficiency of air transportation, MATEC Web Conf. 195 (04009), 1-9. (2018). https://doi.org/10.1051/matecconf/201819504009.
45. International Air Transport Association (IATA), Industry Losses to Top $84 Billion in 2020 (2020). https://www.iata.org/en/pressroom/pr/2020-06-09-01/.

MINISTRY OF EDUCATION, CULTURE, RESEARCH AND TECHNOLOGY
UNIVERSITAS JENDERAL SOEDIRMAN
FACULTY OF ENGINEERING
ICETIR COMMITTEE
Jl. Mayjen Sungkono Km 5, Blater, Purbalingga 53371 Phone (0281) 6596700 Fax.(0281) 6596801
Website: http://bit.ly/icetir2021, email: icetir@unsoed.ac.id

Letter of Acceptance

Date: August 18th 2021
No: 113/LOA/ICETIR-2021

To,
Mr. /Ms. **Gito Sugiyanto**

Subject: Full Paper Acceptance Letter

Dear **Gito Sugiyanto, Purwanto Bekti Santoso, and Mina Yumei Santi**

Thank you for submitting an article in the International Conference on Engineering, Technology and Innovative Researches (ICETIR), Faculty of Engineering, Universitas Jenderal Soedirman. We are pleased to inform you that your paper has been reviewed, with title:

The Effect of Novel Coronavirus Disease (COVID-19) on Air Transport

Submission Number : #2105
Decision : **Accepted**

You are invited for oral presentation which will be held online on September 1st , 2021 using the Zoom application. The link to join the meeting will be emailed later. Please submit full paper (camera ready) before August 20th, 2021. Presenting authors are required to fill the registration form as Author Batch 2 on the website and finish the payment by August 25th 2021. Instruction on payment will be emailed separately.

We look forward to your participation in the ICETIR 2021

With best regards,
Program Chair

FACULTY OF ENGINEERING ICETIR UNIVERSITAS JENDERAL SOEDIRMAN

Yanto, Ph.D.

Aircraft routes of domestic cargo transport based on the Indonesian National Logistics System

Cite as: AIP Conference Proceedings **2482**, 050015 (2023); https://doi.org/10.1063/5.0110640
Published Online: 21 February 2023

Gito Sugiyanto, Purwanto Bekti Santoso, Aris Wibowo, et al.

Aircraft Routes of Domestic Cargo Transport based on the Indonesian National Logistics System

Gito Sugiyanto[1, a)], Purwanto Bekti Santoso[1, b)], Aris Wibowo[2, c)], and Mina Yumei Santi[3, d)]

Author afilitations
[1] *Civil Engineering Department, Faculty of Engineering, Universitas Jenderal Soedirman, Purbalingga, Central Java, Indonesia*
[2] *Civil Engineer and Transport Planner in PT Nur Straits Engineering (NSE) Bandung, West Java, Indonesia*
[3] *Health Polytechnic Ministry of Health of Yogyakarta, Indonesia.*

Author emails
[a)] *Corresponding author: gito.sugiyanto@unsoed.ac.id*
[b)] *purwanto1409@unsoed.ac.id*
[c)] *aris.wibowo.info@gmail.com*
[d)] *minayumeisanti80@gmail.com*

Abstract. Aircraft routes are essential for making airline timetables. Effective flight route planning will result in profitable schedules. The distance between two airports is an important geographical factor affecting air cargo transport demand. Analysis of cargo transportation routes is needed to support the Indonesian National Logistics System. Flight routes were developed based on hub-spoke airport networks concepts. This research aims to analyze the aircraft routes of domestic cargo transport in Indonesia based on the Indonesian National Logistics System. Three airports that serve as hub airports in Indonesia are Soekarno-Hatta International Airport in Cengkareng, Kualanamu International Airport in Deli Serdang, and Sultan Hasanuddin International Airport in Makassar. The results show that the number of aircraft routes needed to hub-spoke airport networks for domestic cargo transportation with the scheme of the Indonesian National Logistics System is 37 routes (2-way trips). The flight routes analyzed are direct flight routes (point to point). As for the long-distance routes, we can use this route pattern. The selection of the best air transport logistics distribution concept is one of the keys to success in reducing logistics and high economic costs.

Keywords: aircraft route, flight frequencies, hub and spoke, cargo

INTRODUCTION

One of the most important aspects of the management of an airline is determining flight schedules and routes for each aircraft. The services of air freight are crucial to supplying chains and logistic transport [1]. Aircraft routes are essential for making airline schedules, it is important to plan them effectively in order to achieve a profitable timetable [2]. Provision of infrastructure that encourages national connectivity will reduce transportation and logistic costs to increase product competitiveness and accelerate economic movement [3]. The problems of logistics transportation services in Indonesia are the low level of infrastructure provision, the existence of unofficial levies, and transaction costs that cause high economic costs and the limited capacity and network of national logistics service providers. The strategy is to strengthen national connectivity, improve transportation and logistic cost efficiency and the effectiveness of air transport logistics distribution. Although the services of air freight have just a relatively small share in tonnes if compared with ocean freight, not less than one-third of the values in international trade are conveyed by air freight [4].

The 3rd International Conference on Engineering, Technology and Innovative Researches
AIP Conf. Proc. 2482, 050015-1–050015-9; https://doi.org/10.1063/5.0110640
Published by AIP Publishing. 978-0-7354-4298-6/$30.00

The air freight movement analysis helps airline companies to evaluate their operating strategies, aircraft routes, flight frequency, and aviation authorities improve the infrastructure facilities and allocate resources. In previous studies, many researchers have studied commodity flow over space. Unfortunately, relatively few studies have been conducted on air freight demand through modelling, due to lack of data, data gathering and tracking are often difficult and costly. Previously published studies by Matsumoto in 2004 discussed international urban systems and air passenger and cargo flows [5], Matsumoto in 2007 discussed international air network structures and air traffic density of world cities [6] and Yamaguchi in 2008 discussed international trade and air cargo: analysis of the United States export and air transport policy [7] reveal that parameter has been used to develop gravity type of air cargo demand models only a few macro-economic and hinterland-derived factors, such as Gross Domestic Product (GDP) per capita, number of population and distance introducing city-dummy variables. Tokyo, Hong Kong and Singapore in Asia regions, London, Paris, Frankfurt and Amsterdam in Europe regions and New York and Miami in the American regions are strengthening their positions as international hubs [5].

The study by Arendal in 1992 [8] for Europe's emerging domestic market and the important role of air cargo road transport must have been anticipated early. Based on the theoretical basis of transport modelling laid by Ortùzar and Willumsen [9] the classic model is presented as a sequence of four sub-models: trip generation, distribution, modal split and assignment. A comprehensive description of the technological and economic background of air freight, in general, was studied by Morell and Klein in 2011 [10]. Air cargo makes the crucial difference between profit and loss on many long-haul routes [10]. Three dominant factors in air cargo namely: air cargo facilities at airports, institutional aspects, and cargo fleet planning. The previous study by Diamond in 2002 stated that air cargo models were proposed and implemented for the prediction of origin and destination market [11], air cargo schedule planning problems, algorithms, and models [12], the fleet assignment and cargo routing [13], air freight transport geography [14], the airport choice of freighter operators [15] as well as the optimization of truck handling operations at an air cargo terminal in the airport [16]. Airline network problems are often studied excluding the demand side.

Freight transport flights in Indonesia are the same as passenger transportation because they use combi aircraft. In addition, there are also several special flights for cargo transportation. This study aims to analyse the aircraft routes of domestic cargo transport in Indonesia based on the Indonesian National Logistics System. Three airports that serve as hub airports in Indonesia are Soekarno-Hatta International Airport (CGK) in Cengkareng, Banten; Kualanamu International Airport (KNO) in Deli Serdang, North Sumatra, and Sultan Hasanuddin International Airport (UPG) in Makassar, South Sulawesi.

AIR CARGO ROUTE CHOICE

Heinitz and Meincke in 2011 developed systematizing routing options in a global air cargo network model, as well as a methodology for subsequent choice set formation [17]. Furthermore, Heinitz and Meincke in 2013 [18] tackle the origin-destination demand assignment problem. Four stages in the systematization of air cargo route choice include demand segmentation, choice-set size determination, choice-set formation and qualification, and choice [17]. The demand segmentation is divided into two categories, commodity type and time criticality. Choice-set size determination includes the supplier network options and city-pair options. Choice-set formation and qualification include access or egress links, network topology, weekly variation of demand, optimal path search strategy, and imposition of hard route search constraints. Choices include the A/L level choice model and consignor level choice model. The full set of these stages is needed to fully cover the complex supply side, the needs of various air cargo consignment types, and the resulting multidimensional space of conceivable itineraries. As can be viewed in Table 1, the modeller's degrees of freedom when executing in the four stages systematization of air cargo route choice.

TABLE 1. Systematization of air cargo route choice [17].

Stage	Category	Possible specification
Demand segmentation	Commodity type	Definition of commodity set
	Time criticality	Distinction between: a. Overnight cargo b. Two (2) day cargo c. General freight/ standby
Choice-set size determination	Supplier network options	Definition of network alliances and sets of contributing A/L
	City pair options	Definition of airport catchment areas (for origin and destination)
Choice-set formation and qualification	Access or egress links	Assumptions on ground transportation times
	Network topology	Exemplary trunk network or complete flight schedule
	Weekly variation of demand	Distribution to and assumptions on days' latest acceptance times
	The optimal path search strategy	Minimum of the transport duration or minimum of the generalized costs in air transport
	Imposition of hard route search constraints	Required equipment, unitized shipment yes or no
Choice	A/L level choice model	Compensatory model or random utility maximization (set of explanatory variables)
	Consignor level choice model	Revenue-maximizing assignment to residual capacities

Policies of aviation reflect a balance between the interests of consumers and the aviation and tourism industries [19]. The planning of aircraft routes and flight frequencies in an airline network operations can be divided into two models; the first is based on the flight network and the second is based on the passenger network [4]. Air cargo alliance is likely to reduce passenger prices and increase total surplus [20]. The interaction of air cargo demand and global trade in the light of current modelling approaches was studied by Meincke and the result shows that the DLR air cargo supply-demand interaction model serves as the testing environment for the systematization framework [21]. In the other study, the key determinants of international air cargo flow from and to Taiwan include population, air freight rate and three dummy variables, including the regional economic bloc, long-established colonial links, and the Open Sky Agreements [22].

METHOD

Collection of Data

Data required in this research includes the production data from 33 airports in Indonesia for domestic flights. Flight traffic data consist of the number of aircraft traffic, number of passengers, number of passenger baggage, and number of cargo. Data production of each airport for the domestic flight is obtained from the Directorate General of Civil Aviation, Ministry of Transportation Republic of Indonesia [23], PT. (Persero) Angkasa Pura I, and PT. (Persero) Angkasa Pura II. National airport arrangements in Indonesia according to the Ministry of the Transportation Republic of Indonesia, PM Number 39 of 2019 [24].

RESULTS AND DISCUSSION

Air Cargo Route Analysis National: Hub and Spoke Concepts

Analysis of cargo transportation routes to support the Indonesia National Logistics System or *Sistem Logistik Nasional* based on Presidential Regulation Republic of Indonesia No. 26 of 2012 [25] requires justification and assumptions about what kind of hub and spoke system will be applied in the field. Based on the Indonesia National

Logistics System, the number of hubs developed in 2011-2015 is 3 (three) airports namely Soekarno-Hatta International Airport (CGK) in Cengkareng, Banten; Kualanamu International Airport (KNO) in Deli Serdang, North Sumatra, and Sultan Hasanuddin International Airport (UPG) in Makassar, South Sulawesi. Thus, the concept of hub and spoke can be derived with a combination of 3 hub airports and 30 spoke airport and flight routes can be assumed as presented in Figure 1.

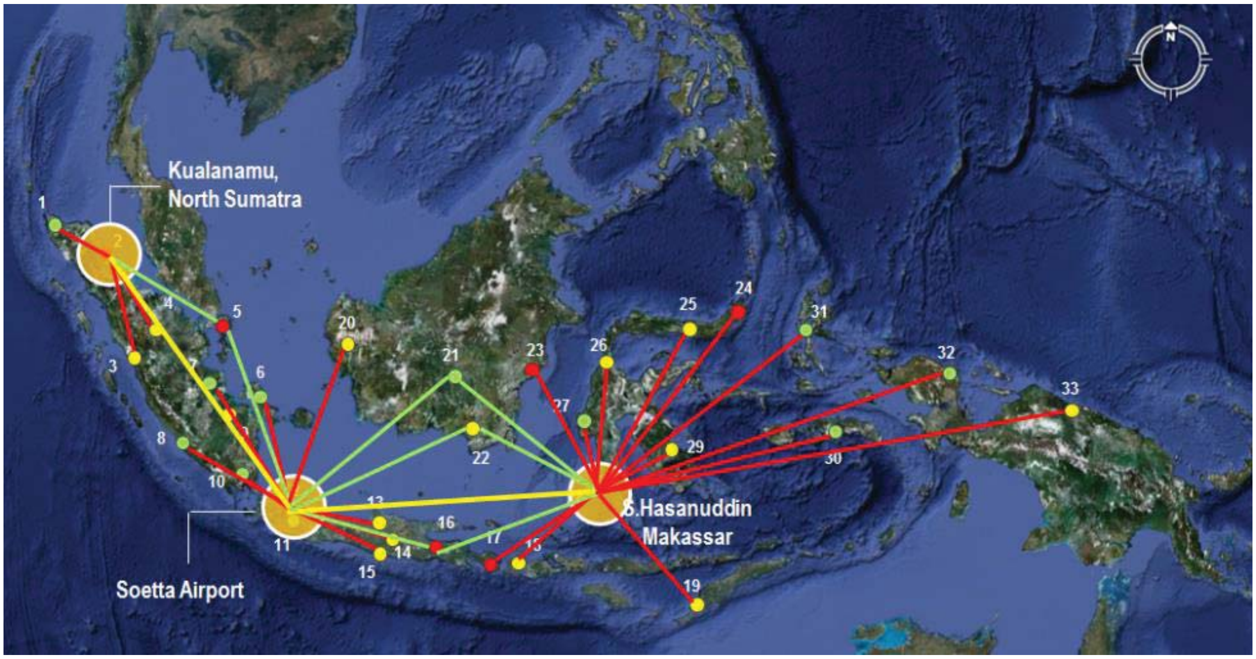


FIGURE 1. Hub and spoke airport networks based on the Indonesia National Logistics System.

Soekarno-Hatta International Airport (CGK) in Cengkareng, Banten is a central hub in Indonesia because all of the spoken cities in Indonesia connect flights into Soekarno-Hatta International Airport. There are aircraft route flights from Soekarno-Hatta International Airport to all of the spoke cities in Indonesia [26]. Based on the study of Sugiyanto *et al*. in 2017, the percentage of cargo volume in Soekarno-Hatta International Airport is 38.229% for domestic flights [27]. Furthermore, hub and spoke airport networks in Indonesia based on Herfindahl-Hirschman Index (HHI) analysis, Kualanamu International Airport (KNO) in Deli Serdang, North Sumatra is a hub airport for domestic flights in Sumatra Island, Indonesia [28].

According to the study of Martin and Roman in 2004, two parameters that influence the hub location are airport location and competition [29]. Road infrastructure is one of the factors that must be considered in determining the location of the airport [30-31]. The economic crisis has affected price behaviour both in terms of the price level and dispersion, with a clear increase in price level and decrease in price dispersion [32]. Low frequencies of aircraft may have substantial negative effects on scheduling costs and waiting costs at hub airports [33]. The advantages of the application of hub and spoke in the airport network are decreased the number of aircraft routes [34], increase demand (frequent flights), decrease costs [35], decrease externality cost [36-37]. Distribution and justification for the hub and spoke airport networks in Indonesia can be described in Table 2.

TABLE 2. Justification for the hub and spoke airport network

Hub Airport	Spoke Airport
Kualanamu International Airport (KNO) Medan	4 airports: 1) Sultan Iskandar Muda International Airport in Banda Aceh, 2) Sultan Syarif Kasim II International Airport in Pekanbaru, 3) Minangkabau International Airport in Padang, and 4) Hang Nadim International Airport in Batam.
Soekarno-Hatta International Airport (CGK) Cengkareng	11 airports: 1) Depati Amir Airport in Pangkal Pinang, 2) Sultan Thaha Saifuddin Airport in Jambi, 3) Fatmawati Soekarno Airport in Bengkulu, 4) Sultan Mahmud Badaruddin II International Airport in Palembang, 5) Raden Inten II International Airport in Lampung, 6) Husein Sastranegara International Airport in Bandung, 7) Ahmad Yani International Airport in Semarang, 8) Adi Sumarmo International Airport in Surakarta / Solo, 9) Adi Sutjipto International Airport in Yogyakarta/ Yogyakarta International Airport in Kulon Progo 10) Juanda International Airport in Sidoarjo, and 11) Supadio International Airport in Pontianak. *) Hang Nadim International Airport in Batam, *) Tjilik Riwut Airport in Palangkaraya, *) Syamsudin Noor International Airport in Banjarmasin and *) Ngurah Rai International Airport in Badung, Bali.
Sultan Hasanuddin International Airport (UPG) Makassar	15 airports: 1) Sultan Aji Muhammad Sulaiman Sepinggan International Airport in Balikpapan, 2) Tjilik Riwut Airport in Palangkaraya, 3) Syamsudin Noor International Airport in Banjarmasin, 4) Ngurah Rai International Airport in Badung, Bali, 5) Zainuddin Abdul Madjid Lombok International Airport in Mataram, 6) Eltari International Airport in Kupang, 7) Sam Ratulangi International Airport in Manado, 8) Djalaluddin Airport in Gorontalo, 9) Mutiara SIS Al-Jufrie Airport in Palu, 10) Tampa Padang Airport in Mamuju, 11) Haluoleo (Wolter Monginsidi) International Airport in Kendari, 12) Pattimura International Airport in Ambon, 13) Sultan Babullah International Airport in Ternate, 14) Sentani Airport in Jayapura, and 15) Rendani Airport in Manokwari.

*) Considering the 4 spoke airports that can make direct flights to 2 different hubs, namely Hang Nadim International Airport, Tjilik Riwut Airport, Syamsuddin Noor International Airport, and Ngurah Rai International Airport.

Aircraft Route Needs

Flight routes based on the hub and spoke airport network concept is presented in Table 3. The aircraft routes delivered are direct flight routes or point to point and two-way trips. We can use the aircraft route pattern of air cargo transportation for long-distance routes. For example, in the case of flights from Batam to Manado, the route that needs to be taken is Batam-Jakarta-Makassar-Manado. This means that the flight routes that occur are flight from Batam-Jakarta, flight from Jakarta-Makassar, and flight from Makassar-Manado. Flight routes needed to support air cargo transportation for the other intercity flight cases in Indonesia can be seen in Table 3.

TABLE 3. Identification of flight routes needs to support air cargo transportation.

No.	Hub Airport	Routes required
1.	Kualanamu International Airport (KNIA)	1. Medan - Banda Aceh (KNIA - Sultan Iskandar Muda International Airport) 2. Medan - Pekanbaru (KNIA - Sultan Syarif Kasim II International Airport) 3. Medan - Padang (KNIA - Minangkabau International Airport) 4. Medan - Batam (KNIA - Hang Nadim International Airport) 5. Medan - Jakarta (KNIA - Soekarno-Hatta International Airport)
2.	Soekarno-Hatta International Airport (SHIA)	6. Jakarta - Pangkal Pinang (SHIA - Depati Amir Airport) 7. Jakarta - Jambi (SHIA - Sultan Thaha Saifuddin Airport) 8. Jakarta - Bengkulu (SHIA - Fatmawati Soekarno Airport) 9. Jakarta - Palembang (SHIA - Sultan Mahmud Badaruddin II International Airport)
No	Hub Airport	Routes required
		10. Jakarta - Lampung (SHIA - Raden Inten II International Airport) 11. Jakarta - Bandung (SHIA - Husein Sastranegara International Airport) 12. Jakarta - Semarang (SHIA - Ahmad Yani International Airport) 13. Jakarta - Solo (SHIA - Adi Sumarmo International Airport) 14. Jakarta - Yogyakarta (SHIA - Adi Sutjipto International Airport (SHIA - Yogyakarta International Airport) 15. Jakarta - Surabaya (SHIA - Juanda International Airport) 16. Jakarta - Pontianak (Supadio International Airport) 17. Jakarta - Palangkaraya (SHIA - Tjilik Riwut Airport) 18. Jakarta - Banjarmasin (SHIA - Syamsuddin Noor International Airport) 19. Jakarta - Batam (SHIA - Hang Nadim International Airport) 20. Jakarta - Makassar (SHIA - Sultan Hasanuddin International Airport) 21. Jakarta - Denpasar (SHIA - Ngurah Rai International Airport)
3.	Sultan Hasanuddin International Airport Makassar (SHIAM)	22. Makassar - Balikpapan (SHIAM - Sultan Aji Muhammad Sulaiman Sepinggan International Airport) 23. Makassar - Palangkaraya (SHIAM - Tjilik Riwut Airport) 24. Makassar - Banjarmasin (SHIAM - Syamsuddin Noor International Airport) 25. Makassar - Denpasar (SHIAM - Ngurah Rai International Airport) 26. Makassar - Mataram (SHIAM - Zainuddin Abdul Madjid Lombok International Airport) 27. Makassar - Kupang (SHIAM - Eltari International Airport) 28. Makassar - Manado (SHIAM - Sam Ratulangi International Airport) 29. Makassar - Gorontalo (SHIAM - Djalaluddin Airport) 30. Makassar - Palu (SHIAM - Mutiara SIS Al-Jufrie Airport) 31. Makassar - Mamuju (SHIAM - Tampa Padang Airport) 32. Makassar - Kendari (SHIAM - Haluoleo (Wolter Monginsidi) International Airport) 33. Makassar - Ambon (SHIAM - Pattimura International Airport) 34. Makassar - Ternate (SHIAM - Sultan Babullah International Airport) 35. Makassar - Jayapura (SHIAM - Sentani Airport) 36. Makassar - Manokwari (SHIAM - Rendani Airport) 37. Makassar - Surabaya (SHIAM - Juanda International Airport)

From Table 3, it can be seen that the number of routes needed to form a hub and spoke system of cargo transportation according to the Indonesia National Logistics System or *Sistem Logistik Nasional* based on Presidential Regulation No. 26 of 2012 scheme is 37 routes (2-way trips). Five flight routes are needed to support air cargo transportation from Kualanamu International Airport (KNO), 16 flight routes from Soekarno-Hatta International Airport (CGK), and 16 flight routes from Sultan Hasanuddin International Airport (UPG). The result of this study is similar to Ref. [38] that combines airport selection, fleet routing, and timetable setting to develop an integrated scheduling model for aircraft routes [38]. The selection of the best air transport logistics distribution concept is one of the keys to success in reducing logistics and high economic costs [39]. The punctuality of air traffic is one of the most important criteria in selecting air services [35]. Parameters that are used to find efficient and effective routes by calculating flight distance, flight time and block fuel [40].

Air transport liberalization will benefit both consumers and the aviation industry in the region albeit not necessarily on an equal basis across or within groups [41]. Most air routes have high allocation efficiency and passenger transport efficiency, while they have low freight transport efficiency [42]. The network's physical topology and the functional network with traffic information are highly correlated to the Gross Domestic Product (GDP) of a country [43]. According to Bazargan, there are four stages of the flight planning management process, namely flight scheduling, fleet assignment, aircraft route determination, and crew scheduling [44].

CONCLUSIONS

Three airports that serve as hub airports in Indonesia are Soekarno-Hatta International Airport (CGK) in Cengkareng, Banten; Kualanamu International Airport (KNO) in Deli Serdang, North Sumatra, and Sultan Hasanuddin International Airport (UPG) in Makassar, South Sulawesi. The flight routes analysed are direct flight routes (point to point). The number of routes needed to form a hub and spoke airport network system of cargo transportation according to the Indonesia National Logistics System scheme is 37 routes.

ACKNOWLEDGMENTS

"This study is funded by the Ministry of Education, Culture, Research and Technology Republic of Indonesia for the approved fund of Basic Research in 2021 based on research contract No. 117/SP2H/LT/DRPM/2021". The authors are fully acknowledged for funding this research.

REFERENCES

1. F. Heinitz, M. Hirschberger and C. Werstat, The role of road transport in scheduled air cargo networks, Procedia Soc. Behav. Sci. **104**, 1198-1207 (2013). https://doi.org/10.1016/j.sbspro.2013.11.216.
2. D. Teodorovic and E. Kremar-Nozic, Multicriteria model to determine flight frequencies on an airline network under competitive conditions, Transp. Sci. **23** (1), 14-25 (1989). https://doi.org/10.1287/trsc.23.1.14.
3. W. E. Bendinelli, H. F. A. J. Bettini and A. V. M. Oliveira, Airline delays, congestion internalization and non-price spillover effects of low cost carrier entry, Transp. Res. A Policy Pract. **85**, 39-52 (2016). https://doi.org/10.1016/j.tra.2016.01.001.
4. S. Yan and C. R. Wang, The planning of aircraft routes and flight frequencies in an airline network operations, J. Adv. Transp. **35** (1), 33-46 (2001). https://doi.org/10.1002/atr.5670350104.
5. H. Matsumoto, International urban systems and air passenger and cargo flows: some calculations, J. Air Transp. Manag. **10** (4), 239-247 (2004). https://doi.org/10.1016/j.jairtraman.2004.02.003.
6. H. Matsumoto, International air network structures and air traffic density of world cities, Transp. Res. E Logist. Transp. Rev. **43** (3), 269-282 (2007). https://doi.org/10.1016/j.tre.2006.10.007.
7. K. Yamaguchi, International trade and air cargo: analysis of US export and air transport policy, Transp. Res. E Logist. Transp. Rev. **44** (4), 653-663 (2008). https://doi.org/10.1016/j.tre.2007.05.006.
8. R. T. Arendal, The role of RFS in the Europe of tomorrow, Cargo Network Solution FOCUS, **7** (2), 12-18.
9. J. de D. Ortùzar and L. G. Willumsen, Modeling Transport, Wiley: Chichester (2011).
10. P. S. Morell and T. Klein, Moving Boxes by Air: The Economics of International Air Cargo, Ashgate Publishing: Farnham Surrey (2011).
11. M. Diamond, Network Simulation Models. TRR E-C040: Aviation Demand Forecasting-A Survey of Methodologies, Washington (2002).
12. M. Lohatepanont, Airline Fleet Assignment and Schedule Design: Integrated Models and Algorithms, MIT Cambridge (2012).

13. D. Li, H. C. Huang, A. D. Morton and E. P. Chew, Simultaneous Fleet Assignment and Cargo Routing, OR Spectrum **28** (3), 319-335, (2006).
14. J. T. Bowen, The geography of freighter aircraft operations in the Pacific Basin, J. Transp. Geogr. **12** (1), 1-11, (2004). https://doi.org/10.1016/S0966-6923(03)00024-3.
15. F. Kupfer, R. Kessels, P. Goos, A. Verhetsel and E. V. de Voorde, The Airport Choice of Freighter Operators, in The 91st Conference Transportation Research Board (TRB) Washington (2012).
16. A. Franz, G. Selinka and R. Stolletz, Time-dependent performance approximation of truck handling operations at an air cargo terminal, Proceedings of the International Conference on Airport Operations Management, Munich (2012).
17. F. M. Heinitz and P. A. Meincke, Systematizing routing options in a global air cargo network model, Aerlines Magazine **49** (1), 1-5, Amsterdam (2011).
18. F. M. Heinitz and P. A. Meincke, Modeling framework of origin and destination air cargo routing, Transp. Res. Rec.: J. Transp. Res. Board. **2336** (1), 83-90 (2013). https://doi.org/10.3141/2336-10.
19. M. Abate, Economic effects of air transport market liberalization in Africa. Transport. Res. A Pol. Pract. **92**, 326-337 (2016). https://doi.org/10.1016/j.tra.2016.06.014.
20. A. Zhang, Y. V. Hui and L. Leung, Air cargo alliances and competition in passenger markets, Transport. Res. E Logist. Transport. Rev. **40** (2), 83-100 (2004). https://doi.org/10.1016/S1366-5545(03)00034-6.
21. P. A. Meincke, F. M. Heinitz and D. Steiger, Interaction of air cargo demand and global trade in the light of current modeling approaches, 11th Air Transport Research Society (ATRS) Conference, Berkeley CA, (2007).
22. C. C. Hwang and G. C. Shiao, Analyzing air cargo flows of international routes: an empirical study of Taiwan Taoyuan International Airport, J. Transp. Geogr. **19**, 738-744 (2011). https://doi.org/10.1016/j.jtrangeo.2010.09.001.
23. Ministry of Transportation Republic of Indonesia, *Lalu Lintas Angkutan Udara*. Jakarta: Directorate General of Air Transport Ministry of Transportation Republic of Indonesia, Retrieved on 2021-07-27, http://hubud.dephub.go.id/?id/produksi/index.
24. Ministry of Transportation Republic of Indonesia, *Peraturan Menteri Perhubungan Republik Indonesia Nomor PM 39 Tahun 2019 tentang Tatanan Kebandarudaraan Nasional*, Jakarta: Ministry of Transportation Republic of Indonesia (2019).
25. Ministry of State Secretariat of the Republic of Indonesia, *Peraturan Presiden Republik Indonesia Nomor 26 Tahun 2012 tentang Cetak Biru Pengembangan Sistem Logistik Nasional,* Jakarta: Ministry of State Secretariat of the Republic of Indonesia (2012).
26. G. Sugiyanto, P. B. Santosa and M. Y. Santi, Hub and spoke airport networks in Sulawesi Island, Indonesia based on freight ratio, ARPN J. Eng. Appl. Sci. **15** (10), 1101-1110 (2020). http://www.arpnjournals.org/jeas/research_papers/rp_2020/jeas_0520_8218.pdf.
27. G. Sugiyanto, P. B. Santosa, A. Wibowo and M.Y. Santi, Airport classification based on Federal Aviation Administration and freight ratio (case study in Indonesia), ARPN J. Eng. Appl. Sci. **12** (2), 579-587 (2017a). http://www.arpnjournals.com/jeas/volume_02_2017.htm
28. G. Sugiyanto, P. B. Santosa, Jajang, A. Fadli and M. Y. Santi, Evaluation of hub-spoke airport networks in Sumatra Island, Indonesia to increase efficiency of air transportation, MATEC Web Conf. **195** (04009), 1-9. (2018). https://doi.org/10.1051/matecconf/201819504009.
29. J. C. Martın and C. Roman, Analyzing competition for hub location in intercontinental aviation markets, Transp. Res. E: Logist. Transp. Rev. **40** (2), 135-150 (2004). http://dx.doi.org/10.1016/s1366-5545(03)00037-1.
30. G. Sugiyanto, Marshall test characteristics of asphalt concrete mixture with scrapped tire rubber as a fine aggregate. J. Teknol. **79** (2), 55-64 (2017). https://doi.org/10.11113/jt.v79.6965.
31. G. Sugiyanto, P. B. Santosa and M.Y. Santi, Determining the criteria of air hub in Indonesia using Analytical Hierarchy Process (AHP), Adv. Eng. Res. **187**, 20-24 (2019). https://doi.org/10.2991/icosite-19.2019.4.
32. J. -L. A. Navarro, M. -E. A. Martínez and J. -F. Trinquecoste, The effect of the economic crisis on the behaviour of airline ticket prices: A case-study analysis of the New York-Madrid route, J. Air Transp. Manag. **47**, 48-53 (2015). https://doi.org/10.1016/j.jairtraman.2015.04.004.
33. P. Rietveld and M. Brons, Quality of hub-and-spoke networks: the effects of time table co-ordination on waiting time and rescheduling time, J. Air Transp. Manag. **7** (4), 241-249 (2001). https://doi.org/10.1016/S0969-6997(01)00012-6.
34. G. Sugiyanto, P. B. Santosa, A. Wibowo and M. Y. Santi, Analysis of hub-and-spoke airport networks in Java Island, Indonesia based on cargo volume and freight ratio, Procedia Eng. **125**, 556-563 (2015). http://dx.doi.org/10.1016/j.proeng.2015.11.061.

35. M. E. O'Kelly, Air freight hubs in the FedEx system: Analysis of fuel use, J. Air Transp. Manag. **36**, 1-12 (2014). https://doi.org/10.1016/j.jairtraman.2013.12.002.
36. G. Sugiyanto, The effect of congestion pricing scheme on the generalized cost and speed of motorcycle, Walailak J. Sci. & Tech. **15** (1), 95-106 (2018). https://doi.org/10.48048/wjst.2018.2347.
37. G. Sugiyanto, A. Fadli and M. Y. Santi, Identification of black spot and equivalent accident number using upper control limit method, ARPN J. Eng. Appl. Sci. **12** (2), 528-535 (2017b).
38. S. Yan, S. C. Chen and C. H. Che, Air cargo fleet routing and timetable setting with multiple on-time demands, Transp. Res. E Logist. Transp. Rev. **42** (5), 409-430 (2006). https://doi.org/10.1016/j.tre.2005.02.002.
39. G. Sugiyanto, P. B. Santosa, A. Wibowo and M.Y. Santi, Hub and spoke airport networks in Indonesia based on Herfindahl-Hirschman Index (HHI), J. Eng. Appl. Sci. **11** (8), 1804-1810 (2016).
40. N. Feriyanto, C. Saleh, A. Fauzi, N. R. Dzakiyullah and K. R. Iwaputra, The route analysis based on flight plan, IOP Conf. Ser.: Mater. Sci. Eng. **114** 012147 (2016). https://doi.org/10.1088/1757-899X/114/1/012147.
41. N. Adler, X. Fu, T. H. Oum and C. Yu, Air transport liberalization and airport slot allocation: the case of the Northeast Asian transport market, Transport. Res. A Pol. Pract. **62**, 3-19 (2014). https://doi.org/10.1016/j.tra.2014.02.003.
42. Y. Shao and C. Sun, Performance evaluation of China's air routes based on network data envelopment analysis approach, J. Air Transp. Manag. **55**, 67-75 (2016). http://dx.doi.org/10.1016/j.jairtraman.2016.01.006.
43. S. Wandelt and X. Sun, Evolution of the international air transportation country network from 2002 to 2013. Transport. Res. E Logist. Transport. Rev. **82**, 55-78 (2015). https://doi.org/10.1016/j.tre.2015.08.002.
44. M. Bazargan, Airline Operations and Scheduling, Ashgate, Burlington, USA (2004).

The effect of novel coronavirus disease (COVID-19) on air transport

Cite as: AIP Conference Proceedings **2482**, 050019 (2023); https://doi.org/10.1063/5.0110645
Published Online: 21 February 2023

Gito Sugiyanto, Purwanto Bekti Santoso and Mina Yumei Santi

The Effect of Novel Coronavirus Disease (COVID-19) on Air Transport

Gito Sugiyanto[1, a)], Purwanto Bekti Santoso[1, b)], and Mina Yumei Santi[2, c)]

Author afiliations
[1] *Civil Engineering Department, Faculty of Engineering, Jenderal Soedirman University, Purbalingga, Central Java, Indonesia*
[2] *Health Polytechnic Ministry of Health of Yogyakarta, Indonesia.*

Author emails
[a)] *Corresponding author: gito.sugiyanto@unsoed.ac.id*
[b)] *purwanto1409@unsoed.ac.id*
[c)] *minayumeisanti80@gmail.com*

Abstract. On 11 March 2020, the World Health Organization (WHO) declared the Novel Coronavirus Disease (COVID-19) outbreak a pandemic. The air transport sector has remained one of the hardest-hit global industries since the outbreak pandemic. Since the COVID-19 outbreak started, the number of infected cases reached 198,074,040 on 31 July 2021 and 4,225,437 people have died worldwide due to this Novel Coronavirus Disease. The strict travel ban restrictions to reduce the spreading of disease further amplified the reduction of air passenger demand and resulted in a large number of flight cancellations. The method used in this study is a literature review. Based on International Civil Aviation Organization in 2021, the effect of novel coronavirus disease pandemic on world scheduled passenger traffic for the year 2020, compared to 2019 levels are reduction of 50 % of seats offered by airlines, reduction of 2,699 million passengers (decreased 60 %), and approximately USD 371 billion loss of gross passenger operating revenues of airlines. The International Air Transport Association expressed an overall reduction of 48 % in terms of Revenue-Passenger Kilometres and 55 % in passenger revenues for 2020. The highest decrease in the number of passengers carried occurred in Asia and the Pacific region by 921 million people, followed by the European region by 769 million people and the North America region by 599 million people. Furthermore, the effect of the COVID-19 pandemic on air transport in Indonesia, the number of air transport passengers in 2020 was recorded at 32.711 million people. This number decreased 57.76 % year on year from 2019 which was 76.69 million people. The COVID-19 pandemic has indeed limited people's mobility and made the air transportation sector the hardest hit. The actual impacts of the COVID-19 pandemic depend on the duration and magnitude of the outbreak and preventive measures, the consumer confidence degree for air travel, and economic conditions.

Keywords: air transportation, Novel Coronavirus Disease, pandemic, civil aviation, effect

INTRODUCTION

On 11 March 2020, the World Health Organization (WHO) declared the Novel Coronavirus Disease (COVID-19) outbreak a pandemic. The COVID-19 pandemic is affecting all countries in the world including Indonesia. The COVID-19 has affected many sectors such as transportation, health, economy, tourism, trade, and so on. The current Novel Coronavirus Disease outbreak is an unprecedented event in air transportation. The air transport sector has remained one of the hardest-hit global industries since the outbreak pandemic. The COVID-19 pandemic has resulted in a global transportation crisis [1]. Airports Council International published the result of the study about the economic impact of the COVID-19 pandemic, its effects on the global airport business, and the path to recovery [1]. Since the COVID-19 outbreak started, the number of infected cases reached 198,074,040 on 31 July 2021 and 4,225,437 people have died worldwide due to this virus. Based on the Ministry of the Health Republic of Indonesia until 7 August 2021,

The 3rd International Conference on Engineering, Technology and Innovative Researches
AIP Conf. Proc. 2482, 050019-1–050019-9; https://doi.org/10.1063/5.0110645
Published by AIP Publishing. 978-0-7354-4298-6/$30.00

in Indonesia, the number of infected cases COVID-19 reached 3,607,863 people, recovered from COVID-19 as many as 2,996,478 people and 104,010 people have died [2].

The increase of people mobility enabled by air transportation, owing to enhanced connectivity and efficiency [3-4]. Air mobility using aircraft has allowed more passengers to fly to more and remote destinations within a few hours at affordable prices [5-7]. It has also significantly contributed to the risk of spreading the novel coronavirus disease worldwide. It has been known that air transportation plays a critical role in the spread of contagious coronavirus diseases [8-10]. The strict travel ban restrictions to reduce the spreading of disease further amplified the substantial reduction of air passenger demand and resulted in a large number of flight cancellations. Although the total number of COVID-19 infected cases is surging, a few countries seem to have achieved certain or peak incidence [11].

The COVID-19 pandemic has had a major impact on the aviation industry. As of March 24, 2020, 98 % of global passenger revenue is accounted for by the air transport market with strict restrictions (e.g. quarantines for newly arrived passengers, partial travel bans, and border closures), many airlines reducing operations or even stopping operations [12]. The crisis due to the COVID-19 pandemic is rapidly spreading globally. Airports Council International (ACI) estimates that the COVID-19 pandemic will wipe out two-fifths of passenger traffic and half of the airport revenues by 2020 [13]. The relationship between aviation networks and global virus spread has been investigated by Wu in Ref. [14], Boldog in Ref. [15], Adiga and Venkatramanan [16]. Nikolaou and Dimitriou identified airports critical for global infection control of disease outbreaks in Europe [17]. Air travel data are used to estimate the size of the COVID-19 outbreak in Italy [18]. As of May 2020, most countries have active flight bans to reduce the spreading of disease. Several recent studies investigate how the air transportation mode and other modes do: land transportation mode, sea transportation mode, and train contribute to the spread of COVID-19? [19-21]. In this paper, we discuss investigating what is the effect of the COVID-19 pandemic on air transport that focused on global aviation.

The evolutionary dynamics of domestic airport networks are tightly correlated with the COVID-19 situation [11]. The COVID-19 pandemic has stronger impacts on international passenger traffic than a domestic flight of passengers [22]. In the study of the evolution of the international air transportation country network, nodes are countries and direct flights between countries represent links. Furthermore, in the domestic airport network, nodes are airports within a specific region and the direct flights between these airports in a country represent links [23]. The number of origin-destination pairs evolution and the number of aircraft in operation showed that the aviation industry has reacted to the COVID-19 pandemic with a delay of about two months [11]. With the knowledge degree about the novel coronavirus disease in early 2020, one would have expected a much more coordinated and informed global response [24]. Civil aviation is seen by most governments as a strategic sector closely linked with economic development [25]. Civil aviation policies reflect a balance between the consumers' interests and the aviation and tourism industries [26]. The support can be selective subsidies to operators, service providers, or manufacturers [27] or interventions that restrict market access to potential competitors [28] and create monopolistic bottlenecks [29].

This paper presents the effect of the COVID-19 outbreak on air transport. The effect of COVID-19 focused on the capacity decrease of seats offered by airlines, a decrease of passenger traffic, passenger revenue, and Revenue-Passenger Kilometres (RPKs).

METHODOLOGY

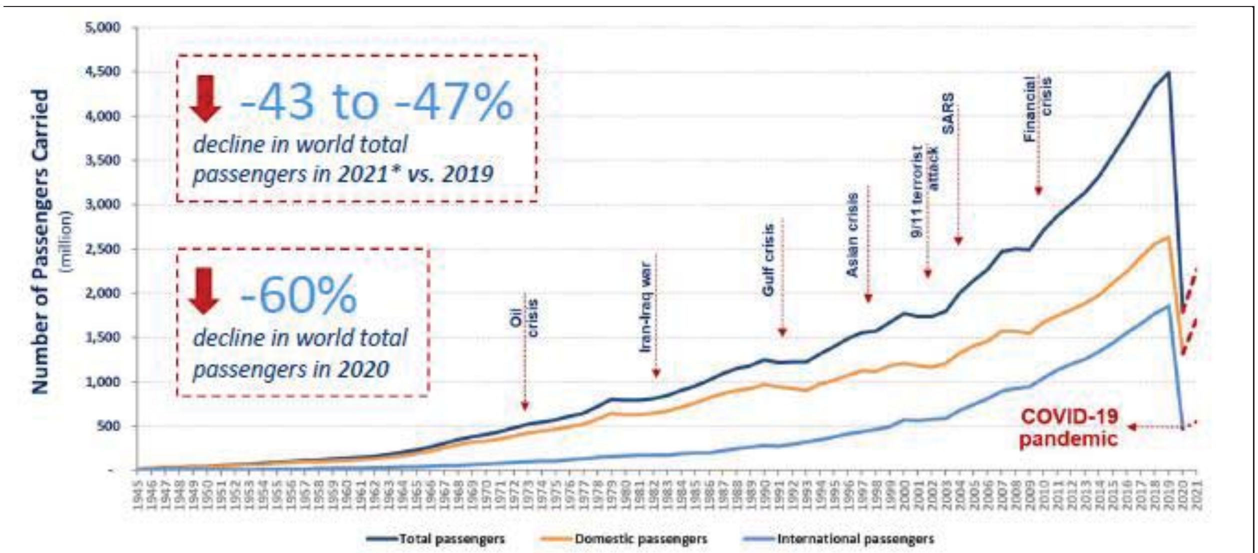
The methodology used in this study is a literature review and collecting data on the number of passengers for the domestic flights and international flights in Indonesia from the Directorate General of Civil Aviation, Ministry of Transportation Republic of Indonesia in 2019 and 2020 [30], PT. (Persero) Angkasa Pura I, and PT. (Persero) Angkasa Pura II. The effect of the COVID-19 pandemic focused on the capacity decreased of seats offered by airlines, decreased of passenger traffic, passenger revenue according to the International Civil Aviation Organization (ICAO) in six regions namely the North America region, Latin America and the Caribbean region, Europe region, Africa region, Asia and the Pacific region, and the Middle East region. The analysis of Revenue-Passenger Kilometres (RPKs) according to the International Air Transport Association.

RESULT AND DISCUSSION

Effect of Covid-19 on Air Transport

World Passenger Traffic Evolution

The COVID-19 pandemic has far-reaching implications for society. The aviation sector was particularly hit, according to the European Commission, with a 50 % decrease in the total number of flights globally during April and May 2020. Several countries saw their air transport activity decrease by over 90 % for two months or more [31]. According to the International Civil Aviation Organization (ICAO), the COVID-19 pandemic impact on world scheduled passenger traffic for the year 2020, compared to 2019 levels are overall reduction of 50 % of seats offered by airlines, an overall reduction of 2,699 million passengers (reduction of 60 %) and approximately USD 371 billion loss of gross passenger operating revenues of airlines [32]. The COVID-19 pandemic impact on world scheduled passenger traffic preliminary estimates for the year 2021, compared to 2019 levels are overall reduction of 35 % to 38 % of seats offered by airlines, an overall reduction of 1,949 to 2,116 million passengers (reduction of 43 % to 47 %) and approximately USD 289 to 312 billion loss of gross passenger operating revenues of airlines. According to the ICAO, the world passenger traffic evolution from 1945-2021 can be seen in Figure 1.



Source: International Civil Aviation Organization (ICAO), 2021 [32].

FIGURE 1. World passenger traffic evolution from 1945-2021.

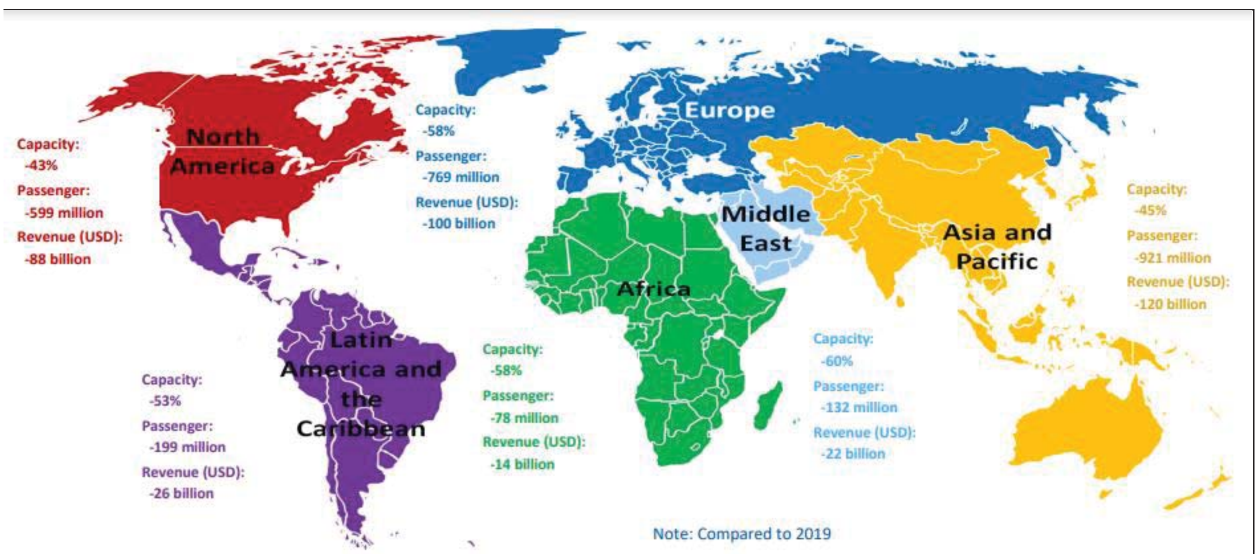
Based on Figure 1, the number of passengers carried for a domestic flight, international flight, and total passengers due to the COVID-19 pandemic, there has been a drastic drop or collapse. The decline in world total passenger is bigger than the volcanic ash of Eyjafjallajokull in Islandia in 2010 [33] or extreme weather [34], the oil crisis in 1973, the Iran-Iraq war in 1982, the Gulf crisis in 1991, the Asian crisis in 1997-1998, 9/11 terrorist attack on 11 September 2001, Severe Acute Respiratory Syndrome (SARS) in 2005, and financial crisis in 2010 [32]. The effect of the COVID-19 pandemic on air transport in Indonesia, according to the Directorate General of Air Transport Ministry of the Transportation Republic of Indonesia, the number of air transport passengers in 2020 was recorded at 32,711,088 people. This number decreased 57.76 % year on year from 2019 which was 76.69 million people [35]. The number of aircraft movement in 2020 is 432,864 unit and the total cargo is 436,048,954 kg. The revenue of PT Angkasa Pura in 2020 was recorded at IDR 3.92 trillion. This number decreased 54.4% year on year from 2019 which was IDR 8.6 trillion.

Domestic and International Passenger Traffic

According to the International Civil Aviation Organization, the COVID-19 pandemic effect on domestic passenger traffic (2020 versus 2019) is an overall reduction of 38 % of seats offered by airlines, an overall reduction of 1,323 million passengers (reduction of 50 %), and approximately USD 120 billion loss of gross operating revenues of airlines [32]. The impact of the COVID-19 pandemic on international passenger traffic (2020 versus 2019) is an overall reduction of 66 % of seats offered by airlines, an overall reduction of 1,376 million passengers (reduction of 74 %), and approximately USD 250 billion loss of gross operating revenues of airlines [32]. Risk aversion and self-imposed social distancing can modify current trends in aviation demand and user choices [36]. The COVID-19 pandemic will affect the capacity of airports and the level of services provided [37]. Managing seasonality in air transport service industries, the case of price and seat factor management in airlines, despite expected seasonal and weekly variations [38], the airport network was rather stable until the middle of March 2020. The actual impacts will depend on the duration and magnitude of the outbreak and containment measures, the degree of consumer confidence for air travel, and economic conditions, airport network [39-40]. The number and frequency of aviation connections are strongly correlated with economic growth [41] and hub and spoke airport networks [42]. Road infrastructure is one of the factors that must be considered in determining the location of the airport [43]. The application of hub and spoke airport networks can increase the efficiency of air transportation [44].

Capacity, Passenger Traffic and Revenues by Region

The COVID-19 pandemic impact on capacity (number of seats offered by airlines), number of passenger traffic, and revenue by region can be seen in Figure 2. There are six regions namely the North America region, Latin America and the Caribbean region, Europe region, Africa region, Asia and the Pacific region, and the Middle East region.



Source: International Civil Aviation Organization, 2021 [32].

FIGURE 2. Effect of COVID-19 on capacity, passenger traffic and revenues in six regions in 2020.

The effect of the COVID-19 pandemic in the North American region, decreased the capacity of 43 % of seats offered by airlines, the number of passengers carried decreased 599 million people, and approximately USD 88 billion loss of gross operating revenues of airlines. Furthermore, in Latin America and the Caribbean region, the capacity decreased 53 % of seats offered by airlines, the number of passengers carried decreased by 199 million people, and approximately USD 26 billion loss of gross operating revenues of airlines. In Asia and the Pacific region the capacity decreased 45 % of seats offered by airlines, the number of passengers carried decreased 921 million people, and approximately USD 120 billion loss of gross operating revenues of airlines. In the European region, the capacity decreased 58 % of seats offered by airlines, the number of passengers carried decreased 769 million people, and approximately USD 100 billion loss of gross operating revenues of airlines. In the Middle East region the capacity decreased 60 % of seats offered by airlines, the number of passengers carried decreased 132 million people, and approximately USD 22 billion loss of gross operating revenues of airlines. Furthermore, in the Africa region, the capacity decreased 58 % of seats offered by airlines, the number of passengers carried decreased 78 million people, and approximately USD 14 billion loss of gross operating revenues of airlines [32]. The highest decrease in seat capacity offered by airlines occurred in the Middle East Region by 60 %, followed by the European region by 58 % and the Africa region by 58 %. The highest decrease in the number of passengers carried occurred in Asia and the Pacific region by 921 million people, followed by the European region by 769 million people and the North America region by 599 million people. The highest loss of gross operating revenues of airlines occurred in Asia and the Pacific region by USD 120 billion, followed by the European region by USD 100 billion and the North America region by USD 88 billion. The COVID-19 pandemic impact on capacity, number of passenger traffic, and revenue in six regions can be seen in Table 1.

TABLE 1. The effect of COVID-19 pandemic on capacity, passenger carried, and revenues in six regions in 2020.

Name of Region	Decreased Capacity of Seats (%)	Decreased Passenger Carried (million people)	Decreased Revenue (Billion USD)
Asia and the Pacific Region	45	921	120
Europe Region	58	769	100
The North America Region	43	599	88
Latin America and the Caribbean Region	53	199	26
The Middle East Region	60	132	22
Africa Region	58	78	14

Source: International Civil Aviation Organization, 2021 [32].

Global Effect of COVID-19 Pandemic

The effect of the COVID-19 pandemic on air passenger traffic, airports, airlines, tourism, and trade in 2020 is as follow:

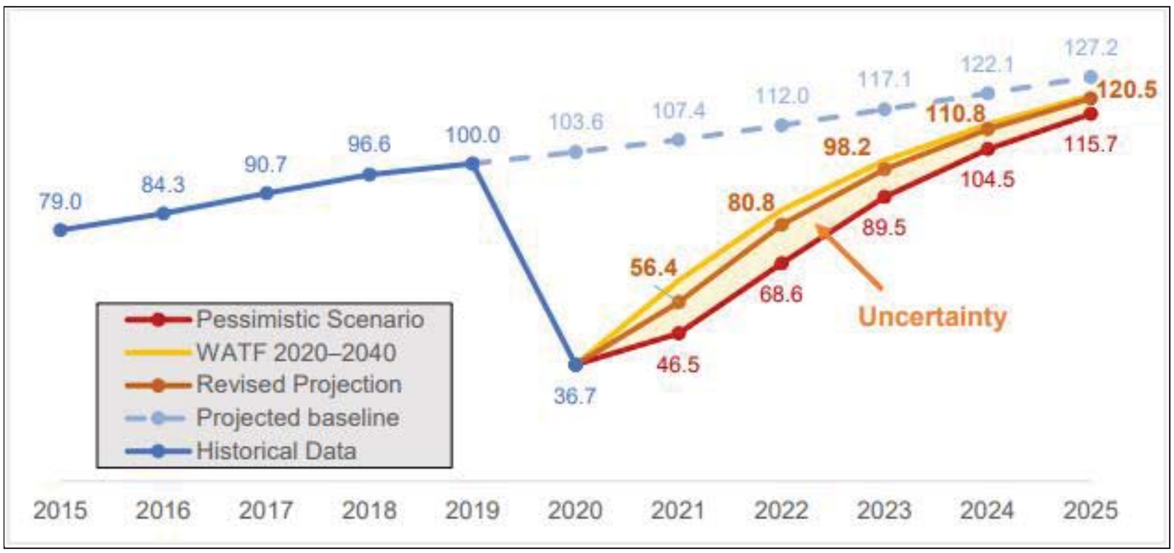
1. According to the study of the International Civil Aviation Organization, the effect of COVID-19 on global aviation focused on air passenger traffic is an overall reduction in the number of air passengers carried (both for the international flights and domestic flights) ranging from 60 % in 2020 compared to 2019 (year on year) [32].
2. According to the study of the Airports Council International, the effect of COVID-19 in airports is an estimated loss of approximately 64.6 % of passenger traffic carried and 66.3% or over USD 125 billion airport revenues in 2020 compared to business as usual [1].
3. According to the study of the International Air Transport Association (IATA), the effect of COVID-19 in airlines is a 65.9 % decline of revenue passenger kilometres or RPKs, both for the international flights and domestic flights in 2020 compared to 2019 (year on year) [45].
4. According to the study of the United Nations-World Tourism Organization (UNWTO), the effect of COVID-19 in tourism is a decline in international tourism receipts of USD 1.3 trillion in 2020, compared to the USD 1.5 trillion generated in 2019. The World Tourism Organization is the United Nations agency responsible for the promotion of responsible, sustainable, and universally accessible tourism.
5. According to the study of the World Trade Organization (WTO), the effect of COVID-19 in world trade is a fall of global merchandise trade volume by 5.3 % in 2020 compared to 2019 (year on year).

Traffic Projection and Path to Recovery

According to the Airports Council International the following related to traffic projection and path to recovery of airport passenger traffic in global aviation can be analysed in 3 scenarios, the first is according to The World Airport Traffic Forecasts (WATF) 2020-2040, the second is based on revised projection, and the third based on a pessimistic scenario as follows [1]:

1. The first scenario, if new variants of the COVID-19 are effectively contained, The World Airport Traffic Forecasts (WATF) 2020-2040 is still the most likely, resulting in a recovery in the number of global passenger traffic carried to 2019 level by the end of 2023 [1].
2. In the second scenario, under the baseline scenario, global passenger traffic is now expected to recover to 2019 levels in 2024 mainly driven by the recovery of domestic passenger traffic but now slightly dampened by a slower recovery of international travel. Domestic passenger traffic is expected to reach 2019 levels in the second half of 2023. The recovery of international passenger traffic is expected to reach 2019 levels in 2024.
3. The third scenario, a pessimistic scenario, is a delayed recovery with the appearance of new variants of the COVID-19 resulting in governments introducing more restrictive measures, creating new lockdowns and travel restrictions. Under the pessimistic scenario, the global passenger traffic will end in the year 2021 at only 46.5 % of the 2019 level, ending the year 2022 at only 68.6 % of the 2019 level. In the long run, it is predicted that the global traffic may take up to two decades to return to previously projected levels (pre-COVID-19 forecast).

The passenger traffic projection in global aviation according to the Airports Council International can be seen in Figure 3. The recovery of international passenger traffic or the number of air passengers carried will require one more year, thus getting back to 2019 levels only in 2024. By the end of 2021, the value compared with the 2019 level is only 56.4 %; in the end 2022 approximately 80.8 % of 2019 level; in the end 2023 approximately 98.2 % of 2019 level and at the end 2024 approximately 110.8 % of 2019 level [1].



Source: Airports Council International (ACI), 2021 [1]

FIGURE 3. The short-term global passenger traffic projection [1].

CONCLUSIONS

Based on the International Civil Aviation Organization, the effect of the COVID-19 pandemic on global aviation and world scheduled passenger traffic is a reduction of 50 % of seats offered by airlines, reduction of 2,699 million passengers (decreased 60 %), and approximately USD 371 billion loss of gross passenger operating revenues of airlines. According to the International Air Transport Association, an overall reduction of 48 % in terms of Revenue-Passenger Kilometres and 55 % in passenger revenues for 2020. The highest decrease in the number of passengers carried occurred in Asia and the Pacific region by 921 million people, followed by the European region by 769 million people and the North America region by 599 million people. The effect of COVID-19 on air transport in Indonesia, the number of air transport passengers in 2020 was recorded at 32.711 million people. This number decreased 57.76 % year on year from 2019 which was 76.69 million people. The COVID-19 pandemic has indeed limited people's mobility and made the air transportation sector the hardest hit. The actual impacts of the COVID-19 pandemic depend on the duration and magnitude of the outbreak and preventive measures, the consumer confidence degree for air travel, and economic conditions.

ACKNOWLEDGMENTS

"This study is funded by the Ministry of Education, Culture, Research and Technology Republic of Indonesia for the approved fund of Basic Research in 2021 based on research contract No. 117/SP2H/LT/DRPM/2021". The authors are fully acknowledged for funding this research.

REFERENCES

1. Airports Council International (ACI), ACI Advisory Bulletin: The impact of COVID-19 on the airport business and the path to recovery (2021). https://aci.aero/news/2021/03/25/the-impact-of-covid-19-on-the-airport-business-and-the-path-to-recovery/.
2. Ministry of Health Republic of Indonesia, Situation of COVID-19 per 7 August 2021 (2021), https://infeksiemerging.kemkes.go.id/
3. G. Sugiyanto, P. B. Santosa, A. Wibowo and M. Y. Santi, Analysis of hub-and-spoke airport networks in Java Island, Indonesia based on cargo volume and freight ratio, Procedia Eng. **125**, 556-563 (2015). http://dx.doi.org/10.1016/j.proeng.2015.11.061.
4. G. Sugiyanto, P. B. Santosa, A. Wibowo and M.Y. Santi, Hub and spoke airport networks in Indonesia based on Herfindahl-Hirschman Index (HHI), J. Eng. Appl. Sci. **11** (8), 1804-1810 (2016). http://medwelljournals.com/abstract/?doi=jeasci.2016.1804.1810.
5. M. Janic, An assessment of risk and safety in civil aviation, J. Air Transp. Manag. **6** (1), 43-50 (2000). https://doi.org/10.1016/S0969-6997(99)00021-6.
6. D. S. Lee, D. W. Fahey, P. M. Forster, P. J. Newton, R. C. Wit, L. L. Lim, B. Owena and R. Sausen, Aviation and global climate change in the 21st century, Atmos. Environ. **43** (22-23), 3520-3537 (2009). https://doi.org/10.1016/j.atmosenv.2009.04.024.
7. L. Diaconu, The evolution of the European low-cost airlines business models Ryanair case study, Procedia Soc. Behav. Sci. **62**, 342-346 (2012). https://doi.org/10.1016/j.sbspro.2012.09.054.
8. A. Likhacheva, SARS revisited, Ama J. Ethics Virtual Mentor **8** (4), 219-222 (2006). https://doi.org/10.1001/virtualmentor.2006.8.4.jdsc1-0604
9. A. M. Zaki, S. van Boheemen, T. M. Bestebroer, A. D. Osterhaus and R. A. Fouchier, Isolation of a novel coronavirus from a man with pneumonia in Saudi Arabia. N. Engl. J. Med. **367** (19), 1814-1820 (2012). https://doi.org/10.1056/NEJMoa1211721.
10. I. I. Bogoch, M. I. Creatore, M. S. Cetron, J. S. Brownstein, N. Pesik and J. Miniota, Assessment of the potential for international dissemination of Ebola virus via commercial air travel during the 2014 west African outbreak. Lancet **385** (9962), 29-35 (2015). https://doi.org/10.1016/S0140-6736(14)618286.
11. X. Sun, S. Wandelt and A. Zhang, How did COVID-19 impact air transportation? A first peek through the lens of complex networks, J. Air Transp. Manag. **89**, 101928 (2020) https://doi.org/10.1016/j.jairtraman.2020.101928.
12. P. S. Sanchez, A. V. Dortac and N. C. Escofet, An early assessment of the impact of Covid-19 on air transport: Just another crisis or the end of aviation as we know it?, J. Transp. Geogr. **86**, 102749. https://doi.org/10.1016/j.jtrangeo.2020.102749.
13. Airports Council International (ACI), ACI Advisory Bulletin: The impact of COVID-19 on the airport business, (2020).URL:https://aci.aero/wp-content/uploads/2020/03/200401-COVID19-Economic-Impact-Bulletin-FINAL-1.pdf.
14. J. T. Wu, K. Leung and G. M. Leung, Nowcasting and forecasting the potential domestic and international spread of the 2019-nCoV outbreak originating in Wuhan, China: a modelling study, Lancet **395** (10225), 689-697 (2020). https://doi.org/10.1016/S0140-6736(20)30260-9.
15. P. Boldog, T. Tekeli, Z. Vizi, A. Dénes, F.A. Bartha and G. Röst, Risk assessment of novel coronavirus COVID-19 outbreaks outside China, J. Clin. Med. **9** (2), 571-582 (2020). https://doi.org/10.3390/jcm9020571
16. A. Adiga and S. Venkatramanan, Evaluating the impact of international airline suspensions on COVID-19 direct importation risk, medRxiv (2020). https://doi.org/10.1101/2020.02.20.20025882.
17. P. Nikolaou and L. Dimitriou, Identification of critical airports for controlling global infectious disease outbreaks: stress-tests focusing in Europe, J. Air Transp. Manag. **85**, 101819 (2020). https://doi.org/10.1016/j.jairtraman.2020.101819.

18. A. R. Tuite, V. Ng, E. Rees and D. Fisman, Estimation of COVID-19 outbreak size in Italy, Lancet Infection Disease (2020). https://doi.org/10.1016/S1473-3099(20)30227-9.
19. P. Christidis and A. Christodoulou, The predictive capacity of air travel patterns during the global spread of the COVID-19 pandemic: risk, uncertainty and randomness, Int. J. Environ. Res. Publ. Health **17** (10), 3356 (2020). https://doi.org/10.3390/ijerph17103356.
20. M. Gilbert, G. Pullano, F. Pinotti, E. Valdano, C. Poletto and P.-Y. Boelle, Preparedness and vulnerability of African countries against importations of COVID-19: a modelling study. Lancet **395** (10227), 871-877 (2020), https://doi.org/10016/S0140-6736(20)30411-6.
21. Y. Zhang, A. Zhang and J. Wang, Exploring the roles of high-speed train, air and coach services in the spread of COVID-19 in China. Transport Pol. **94**, 34-42 (2020). https://ssrn.com/abstract=3600619.
22. S. Wandelt and X. Sun, Evolution of the international air transportation country network from 2002 to 2013, Transport. Res. E Logist. Transport. Rev. **82**, 55-78 (2015). https://doi.org/10.1016/j.tre.2015.08.002.
23. S. Wandelt, X. Sun and J. Zhang, Evolution of domestic airport networks: a review and comparative analysis, Transport. Bus.: Transp. Dyn. **7** (1), 1-17 (2019). https://doi.org/10.1080/21680566.2017.1301274.
24. D. Brockmann and D. Helbing, The hidden geometry of complex, network-driven contagion phenomena, Science **342** (6164), 1337-1342 (2013). https://doi.org/10.1126/science.1245200.
25. F. Zhang and D. Graham, Air transport and economic growth: a review of the impact mechanism and causal relationships, Transport Rev. **40** (4), 506-528 (2020). https://doi.org/10.1080/01441647.2020.1738587.
26. M. Abate, Economic effects of air transport market liberalization in Africa. Transport. Res. A Pol. Pract. **92**, 326-337 (2016). https://doi.org/10.1016/j.tra.2016.06.014.
27. S. Gössling, F. Fichert, P. Forsyth and H. M. Niemeier, Subsidies in aviation, Sustainability **9** (8), 1295 (2017). https://doi.org/10.3390/su9081295.
28. P. Christidis, Four shades of open skies: European union and four main external partners, J. Transport Geogr. **50**, 105-114 (2016). https://doi.org/10.1016/j.jtrangeo.2015.04.005.
29. G. Knieps, Market versus state in building the aviation value chain, J. Air Transport. Manag. **41**, 30-47 (2014). https://doi.org/10.1016/j.jairtraman.2014.06.013.
30. Ministry of Transportation Republic of Indonesia, Air Freight Traffic in Indonesia (*Lalu Lintas Angkutan Udara*). Jakarta: Directorate General of Air Transport Ministry of Transportation Republic of Indonesia, Retrieved on 2020-12-31, http://hubud.dephub.go.id/?id/produksi/index.
31. European Commission, Future of Transport: Update on the Economic Impacts of COVID-19, Policy Brief JRC120625 (2020). https://ec.europa.en/jrc/sites/jresh/files/202005_future_of_transport_covid_sfp.brief_.pdf.
32. International Civil Aviation Organization (ICAO), Effects of Novel Coronavirus (COVID-19) on Civil Aviation: Economic Impact Analysis. Canada, Montréal (2021).
33. U. Reichardt, G. F. Ulfarsson and G. Petursdottir, Developing scenarios to explore impacts and weaknesses in aviation response exercises for volcanic ash eruptions in Europe, J. Air Transport. Manag. **79**, 101684 (2019). https://doi.org/10.1016/j.jairtraman.2019.101684.
34. R. Merkert and L. Mangia, Management of airports in extreme winter conditions-some lessons from analysing the efficiency of Norwegian airports. Res. Transp. Bus. Manag **4**, 53-60 (2012). https://doi.org/10.1016/j.rtbm.2012.06.004
35. Ministry of Transportation Republic of Indonesia, Air Freight Traffic in Indonesia (*Lalu Lintas Angkutan Udara*). Jakarta: Directorate General of Air Transport Ministry of Transportation Republic of Indonesia, Retrieved on 2021-07-27, http://hubud.dephub.go.id/?id/produksi/index.
36. M. Abate, P. Christidis and A. J. Purwanto, Government support to airlines in the aftermath of the COVID-19 pandemic, J. Air Transp. Manag. **89**, 101931 (2020). https://doi.org/10.1016/j.jairtraman.2020.101931.
37. F. Serrano and A. Kazda, The future of airports post COVID-19, J. Air Transp. Manag. **89**, 101900, (2020). https://doi.org/10.1016/j.jairtraman.2020.101900.
38. R. Merkert and T. Webber, How to manage seasonality in service industries-the case of price and seat factor management in airlines, J. Air Transport. Manag. **72**, 39-46 (2018). https://doi.org/10.1016/j.jairtraman.2018.07.005.
39. G. Sugiyanto, P. B. Santosa, A. Wibowo and M.Y. Santi, Airport classification based on Federal Aviation Administration and freight ratio (case study in Indonesia), ARPN J. Eng. Appl. Sci. **12** (2), 579-587 (2017). http://www.arpnjournals.com/jeas/volume_02_2017.htm.
40. G. Sugiyanto, P. B. Santosa and M. Y. Santi, Hub and spoke airport networks in Sulawesi Island, Indonesia based on freight ratio, ARPN J. Eng. Appl. Sci. 15 (10), 1101-1110 (2020). http://www.arpnjournals.org/jeas/research_papers/rp_2020/jeas_0520_8218.pdf.

41. E. T. Njoya, P. Christidis and A. Nikitas, Understanding the impact of liberalisation in the EU-Africa aviation market, J. Transport Geogr. **71**, 161-171 (2018). https://doi.org/10.1016/j.jtrangeo.2018.07.014.
42. G. Sugiyanto, P. B. Santosa and M.Y. Santi, Determining the criteria of air hub in Indonesia using Analytical Hierarchy Process (AHP), Adv. Eng. Res. **187**, 20-24 (2019). https://doi.org/10.2991/icosite-19.2019.4.
43. G. Sugiyanto, Marshall test characteristics of asphalt concrete mixture with scrapped tire rubber as a fine aggregate. J. Teknol. **79** (2), 55-64 (2017). https://doi.org/10.11113/jt.v79.6965.
44. G. Sugiyanto, P. B. Santosa, Jajang, A. Fadli and M. Y. Santi, Evaluation of hub-spoke airport networks in Sumatra Island, Indonesia to increase efficiency of air transportation, MATEC Web Conf. 195 (04009), 1-9. (2018). https://doi.org/10.1051/matecconf/201819504009.
45. International Air Transport Association (IATA), Industry Losses to Top $84 Billion in 2020 (2020). https://www.iata.org/en/pressroom/pr/2020-06-09-01/.